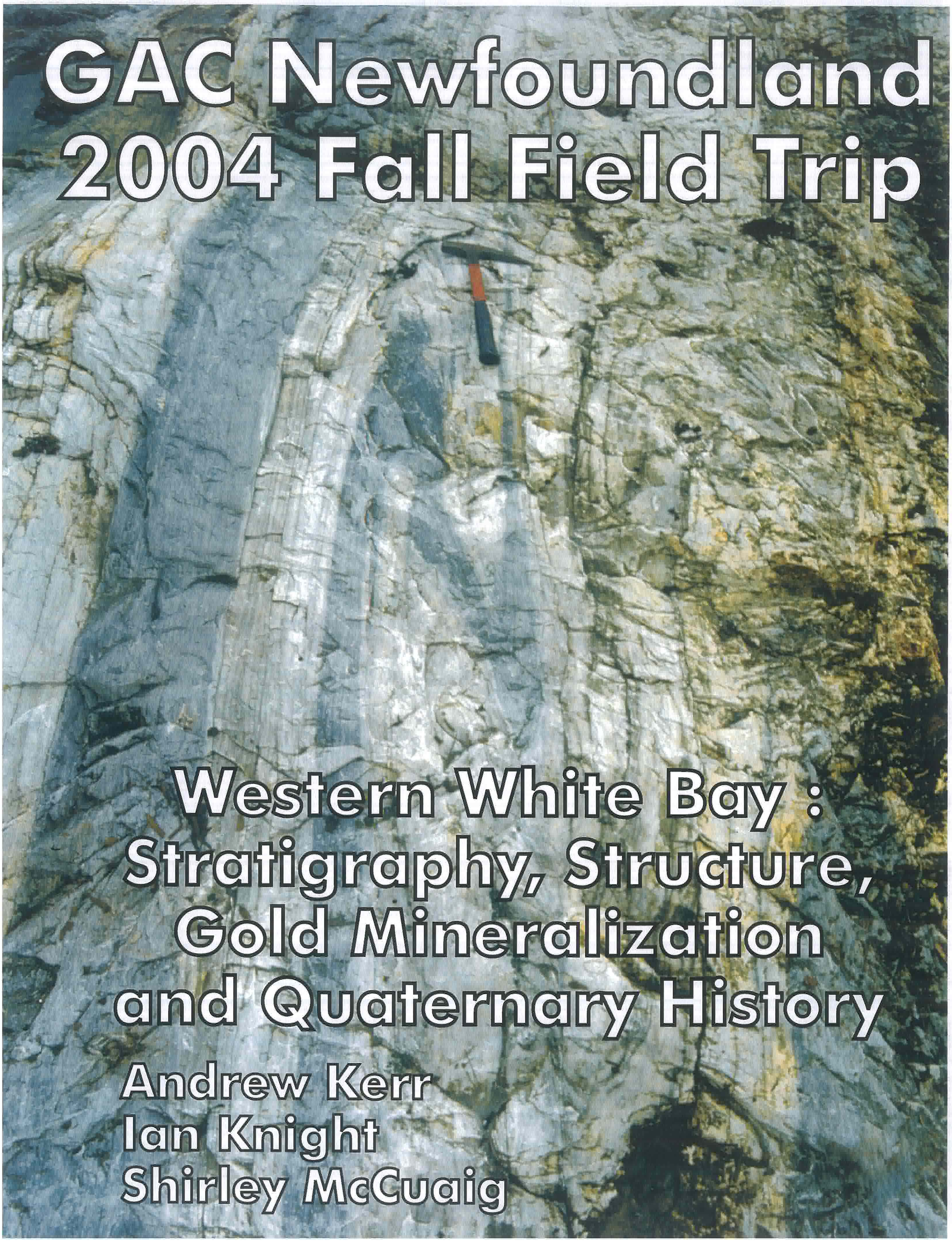

GAC Newfoundland 2004 Fall Field Trip

Western White Bay : Stratigraphy, Structure, Gold Mineralization and Quaternary History

Andrew Kerr
Ian Knight
Shirley McCuaig

GAC Newfoundland gratefully acknowledges our sponsors, who made this field trip possible

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NEWFOUNDLAND SECTION

2004 Fall Field Trip

WESTERN WHITE BAY : STRATIGRAPHY, STRUCTURE, GOLD MINERALIZATION AND QUATERNARY HISTORY

Andrew Kerr, Ian Knight and Shirley McCuaig

Geological Survey of Newfoundland and Labrador
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Cover illustrations

Front - mylonitized limestones, marbles and dolostones in the Apsy Cove fault zone
Back - sheeted auriferous veinlets with alteration haloes in Precambrian granite

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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.

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 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.

Specific Hazards

Most of the stops are reached by paved or gravel road from which they are easily accessible by foot, by either well-defined trails or short scrambles. Care should always be taken when visiting any site, especially those adjacent to the coast or in roadcuts, where the hazard of falling debris from the slopes above is a real one. In such situations, we advise participants not to put themselves in jeopardy by attempting to ascend such slopes, and to maintain a safe distance. In coastal settings, participants may be vulnerable to freak waves, and should maintain a safe distance from the high water line. Weather is unpredictable and participants should be prepared for a wide range of temperatures and conditions. Always take suitable clothing. A rain suit, sweater, sturdy footwear are essential at almost any time of the year. Do not walk straight down steep slopes if others are also on the slope below. Instead, proceed down slopes at an angle. Several stops are adjacent to highways, and participants must take great care in crossing them. Groups crossing together are particularly vulnerable, and each individual must take responsibility for their own safety. Some stops are at the top of steep cliffs or slopes. Participants should stay well back from the cliff edge at all times. Overhangs are common on unconsolidated cliffs, and often are not visible from above.

We strongly recommend sturdy footwear that provides adequate protection and ankle support. Two stops are in the valleys of brooks, and other stops may be in areas of wet ground. Participants may wish to bring spare footwear for use at stops in brooks, where there is a strong possibility of getting wet feet.

PART 1 : INTRODUCTION

OVERVIEW OF FIELD TRIP

Southwestern White Bay has a long history of geological investigation and mineral exploration. This commenced with work by Alexander Murray, Newfoundland's pioneering geologist and explorer, and his successor, James P. Howley. The area was also the site of the very first gold mining venture on the island of Newfoundland, at the short-lived Browning mine, south of Pollards Point. Alfred K. Snelgrove visited and described the area in his classic review of Newfoundland gold mineralization, published in 1935; this remains an important source for many of the mineralized localities. E. R. W. Neale, then with the Geological Survey of Canada, conducted regional mapping in the area in the 1960's, and more detailed mapping was carried out by Ron Smyth and Scott Schillereff of the Geological Survey of Newfoundland and Labrador (GSNL) in the early 1980's. Metallogenic studies, prompted by gold exploration activity, were partly completed by John Tuach and Cindy Saunders in the late 1980's. After a gap of almost 15 years, GSNL has recently resumed work in the area, with Quaternary studies by Shirley McCuaig, and geological mapping and mineral deposit studies by Andrew Kerr, with the assistance of Ian Knight.

Mineral exploration, mostly for gold, has been intermittent in this area since the earliest mining near Pollards Point. Major programs were mounted between 1970 and 1990 by Noranda exploration, Esso Minerals, and BP-Selco, amongst others. Following the discovery of disseminated gold mineralization in altered Precambrian granitoid rocks by the late Clyde Childs in the early 1980's, a large, low-grade gold resource was defined by BP-Selco in the Rattling Brook area. Interest in this deposit waned in the 1990's, but the mineral rights were subsequently acquired by South Coast Ventures, who proposed a new exploration model. This approach was based on comparisons with the the hugely productive "Carlin Trend" in Nevada, where gold occurs in platformal sedimentary rocks, but also in spatially associated granitoid rocks and dykes. The property was eventually optioned to Kermode Resources, who conducted systematic exploration over the last two years, including new drilling in the winter of 2003-04. However, gold deposits hosted by Silurian sedimentary and volcanic rocks of the Sops Arm Group have not yet attracted similar attention, and many of these have not been closely examined since the 1980's.

In the light of renewed exploration interest and recent geoscientific work, a GAC Newfoundland Section excursion to southwestern White Bay is a timely venture. The area is a microcosm of Appalachian tectonic evolution, having spectacular rocks set in rugged and beautiful scenery. This is the second such GAC excursion to the area, and its development was aided greatly by a previous guide written by John Tuach (Tuach, 1987a). Many of the field trip stops were visited previously in 1987, although the interpretation of some rock types and relationships may have changed over 17 years. However, some of the field trip stop descriptions are essentially unchanged from 1987. GAC Newfoundland section welcomes field trip participants to southwestern White Bay, and we hope that both return visitors and newcomers will find much of interest in this complex yet fascinating region.

Important themes for this trip are regional stratigraphy and structure, and the relationship between these and gold mineralization. In addition to the bedrock geology, several stops highlight significant aspects of the Quaternary evolution of the area and its landscape. The trip is organized into four separate sections. Enroute to Pollards Point on Day 1, several stops illustrate regional relationships and the complex geological history of the region. Day 2 is devoted largely to the area exposed along the Cat Arm hydroelectric project access road, that is dominated by Precambrian basement rocks, and parautochthonous Cambro-Ordovician sedimentary rocks equivalent to those of the west coast of Newfoundland. This is also the area in which the Rattling Brook gold deposit is located. Day 3 includes examination of transported Cambro-Ordovician rocks of the Southern White Bay Allochthon, followed by examination of the Silurian rocks of the Sops Arm Group. which unconformably overlies the allochthon. Some gold prospects in the Sops Arm Group, including Newfoundland's first gold mine, will be visited as part of this section. On the final morning of the trip, we will examine some other interesting and little-studied examples of Pb and Zn mineralization, before returning to St. John's.

This is not the kind of field trip in which definitive answers and interpretations are given for every feature that we visit and discuss. It is instead intended to summarize the diverse and spectacular geology of this area, and also highlight the many interesting and unsolved geoscientific problems that it contains. We hope that this excursion will stimulate much discussion, and perhaps ultimately lead to new research projects in a region that abounds with such opportunities.

ACKNOWLEDGMENTS

This field trip benefited greatly from direct and in-kind assistance from a variety of sources. In particular, we wish to thank the Professional Engineers and Geoscientists of Newfoundland (PEG-NL), the Chamber of Mineral Resources (CMR) and Petro-Canada for generous financial sponsorship. Kermode Resources Ltd are sincerely thanked for allowing us to visit and discuss their active exploration project, and also for providing partial sponsorship for an evening barbeque during the trip. Prospector Tom MacLennan, holder of the mineral rights to the Browning Mine area, is thanked for permission to visit his claims. The Geological Survey of Newfoundland and Labrador (part of the Department of Natural Resources) provided generous in-kind assistance in the form of vehicles and help with the production of the guidebook. The Department of Earth Sciences at Memorial University of Newfoundland is thanked for providing a subsidy that helps us provide a preferential rate for student participants. In western White Bay, thanks are due to Morris and Wyonetta Pittman of the Riversea Motel for abundant help, and also to Ryburn Brett, manager of the Clover Leaf Grocery Store, for keeping us supplied with food. Steve Colman-Sadd is thanked for reading the initial version of the guidebook and suggesting improvements. Chris Pereira is thanked for copy editing the guidebook and arranging for its publication.

PART 2 : A REVIEW OF THE GEOLOGY OF WESTERN WHITE BAY AND SURROUNDING AREAS

Andrew Kerr, Ian Knight and Shirley McCuiag

SUMMARY OF GEOLOGY

The field trip area is located along the eastern margin of the Long Range Mountains in western Newfoundland, mostly within NTS 1:50,000 map sheets 12H/10 (Hampden) and 12H/15 (Jacksons Arm). The location of the area in the context of simplified Newfoundland geology is depicted in Figure 1. The area lies within the Humber Zone, west of the Baie Verte lineament (which defines the western boundary of the Dunnage Zone). The area also contains the eastern margin of the Precambrian Long Range Inlier. Western White Bay contains an attenuated autochthonous Cambro-Ordovician platformal sedimentary sequence, and also allochthonous Cambro-Ordovician rocks that represent a "Taconic allochthon", transported westwards across the Laurentian continental margin. Western White Bay subsequently became a locus for bimodal volcanism and associated sedimentation during the Silurian period, when the Sops Arm Group was deposited. All of the above rocks were deformed during the Silurian and intruded by intermediate and granitic plutonic rocks. During the Carboniferous period, major transcurrent fault systems developed, probably by reactivation of older structures, and terrestrial, lacustrine and shallow marine sedimentary rocks accumulated in fault-bounded basins. The Carboniferous rocks are strongly tilted and locally folded, indicating that later deformational events affected them. Western White Bay contains Quaternary deposits and landscape features that record changing sea levels during deglaciation. The complex and protracted geological history of western White Bay is in many respects the entire history of west-central Newfoundland distilled into a single small area, and the area exhibits remarkable geological variety, and poses many interesting and unresolved problems. Perhaps the most critical is the timing and nature of the several Paleozoic deformational events recognized in the area, and the assignment of structural features to these events, particularly in older rocks. Despite its known gold mineralization, the Silurian Sops Arm Group has not been studied in detail, and would make an interesting project.

From a metallogenic perspective, southwestern White Bay is best known for its gold mineralization. Much of this consists of auriferous vein systems within the Sops Arm Group, but the most important gold prospect is partly hosted by Precambrian granites, and partly by Cambro-Ordovician sedimentary rocks. This latter gold mineralization is unusual, and has no clear analogues elsewhere in Newfoundland. Unusual base-metal mineralization (largely Pb and Zn) occurs within carbonate rocks of the Sops Arm Group. The area also includes a wide variety of minor mineral occurrences, including silver, copper, fluorite, and molybdenite. There are also potentially important deposits of limestone and marble.

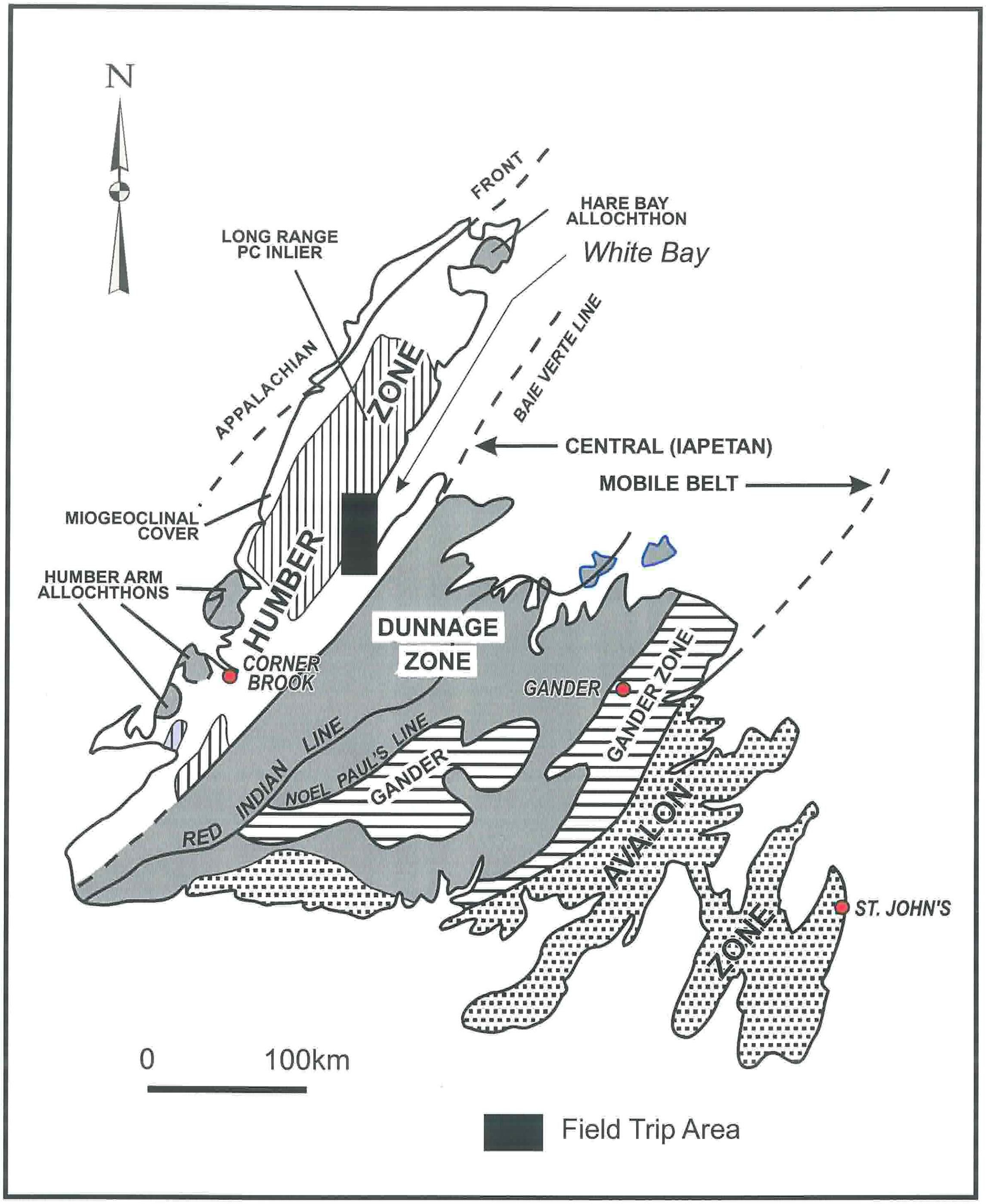


Figure 1 : Location of the western White Bay area in the context of major zonal subdivisions of the Newfoundland Appalachians, after Williams et al., 1988.

GEOLOGIC AND METALLOGENIC FRAMEWORK

Rocks ranging in age from Middle Proterozoic to Carboniferous occur in southwestern White Bay, and the area is geologically complex. Smyth and Schillereff (1982) described six main "packages" of rocks (Figure 2). Some of these are described in more detail in later sections of this account. These six major geological "packages" are discussed below in stratigraphic order.

Precambrian orthogneisses and granites: These rocks underly upland areas in the west, and are part of the southeastern Long Range Inlier, within the Grenville Province of the Canadian Shield. The gneisses date back to ca. 1500 Ma, and there were two discrete periods of granitoid magmatism, at 1032 - 1022 Ma, and 1000 - 980 Ma (Heaman et al., 2002). The gneisses and granites are intruded by Neoproterozoic diabase dykes (Long Range dykes) dated at ca. 615 Ma (Stukas and Reynolds, 1974; Bostock, 1983). The Precambrian Apsy Granite (Figure 2) is the host rock for the large disseminated gold deposit generally known as the Rattling Brook deposit (e.g., McKenzie, 1987a; Poole, 1991a; Saunders and Tuach, 1988, 1991; see below).

Cambrian and Ordovician sedimentary rocks: These form a narrow, linear belt along the western shore of White Bay, and represent autochthonous and parautochthonous cover rocks to the Precambrian. Their basal unconformity is well-preserved in the west, but they are mostly steeply-dipping to vertical in attitude, and locally are strongly deformed (Lock, 1969, 1972; Smyth and Schillereff, 1982; Kerr and Knight, 2004). The sedimentary rocks are cut by diabase dykes. The eastern boundary of these rocks is the major fault zone termed the Doucers Valley fault zone (Figure 1). There are also at least two important structures *within* the sedimentary sequence that probably originated as west-directed thrust faults (Kerr and Knight, 2004). Previous investigators termed these rocks the Coney Arm Group, but recognized that they were generally correlative with the undeformed platformal sequence of the west coast. Recent investigations now permit more detailed lithological correlations, and the stratigraphy of these rocks is now defined in terms of the better known Labrador, Port au Port, St. George and Table Head groups (Kerr and Knight, 2004). Previous exploration in the carbonate rocks has largely concentrated on high-purity limestone (e.g., Howse, 1995), but they also host disseminated gold mineralization close to their unconformable contact with the Apsy Granite, adjacent to the Rattling Brook deposit (Kerr, 2004). These prospects are an important part of this field trip.

Allochthonous Cambrian and Ordovician rocks : These, and associated units of mélange, lie east of the Doucers Valley fault zone in the north of the area, and structurally overlie the authochthonous sedimentary rocks described above (Figure 2). The allochthonous rocks were collectively termed the Southern White Bay Allochthon by Smyth and Schillereff (1982), and include several fault-bounded "slices", separated by mélanges. The highest structural slice includes gabbro, trondhjemite and tonalite of the Coney Head complex, interpreted to be of ophiolitic affinity (Williams, 1977; Dunning, 1987). Lower slices in the allochthon include greenschists of mafic volcanic parentage, associated with altered ultramafic rocks, and assorted siliciclastic sedimentary rocks. The Southern White Bay Allochthon is interpreted as a composite Taconic allochthon akin to those of the Humber Arm - Bonne Bay region (Smyth and Schillereff, 1982). However, in southwestern White Bay, later deformation (of Silurian and/or Carboniferous age) has rotated the allochthon from an original subhorizontal attitude to its present subvertical

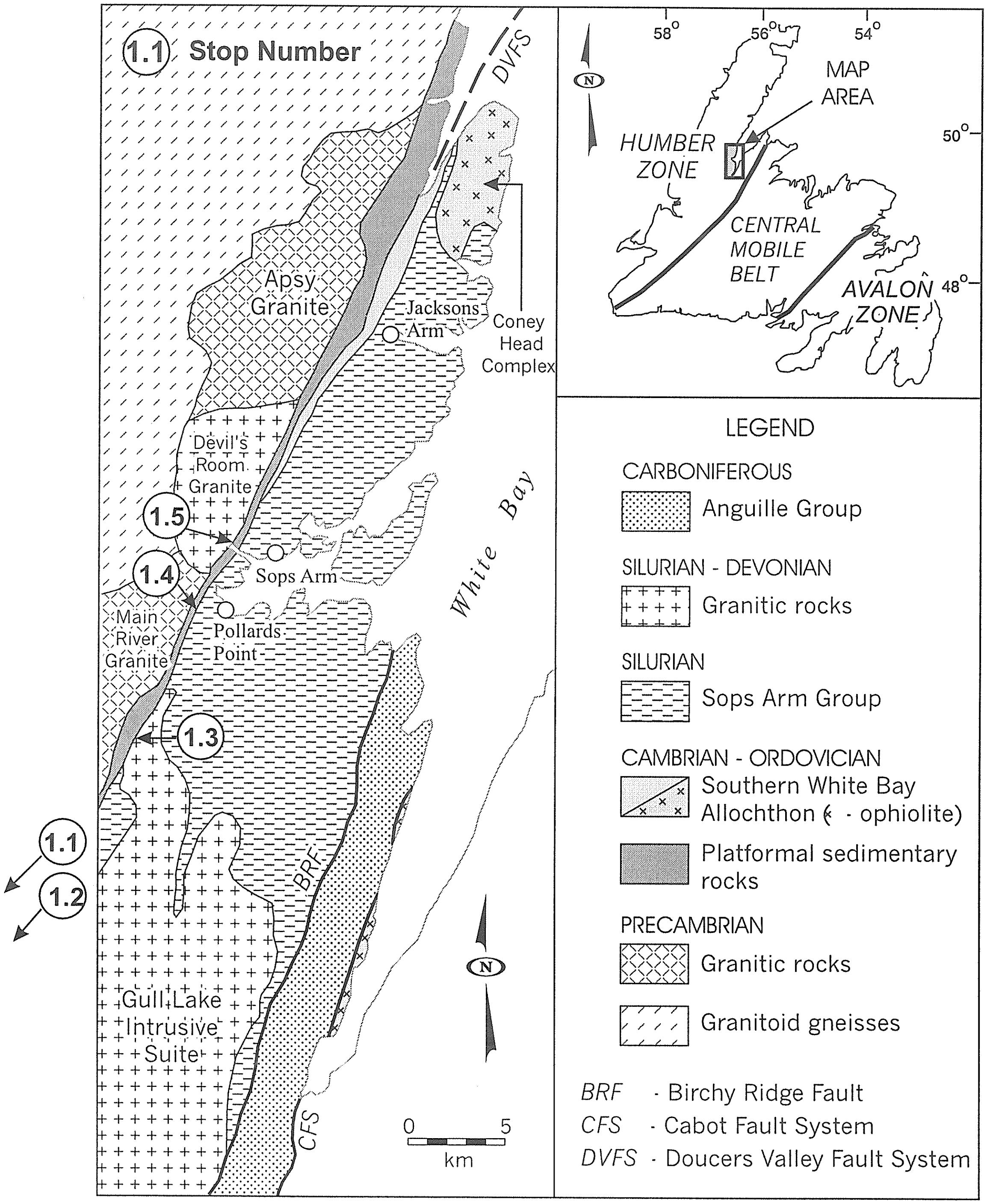


Figure 2 :Generalized geology of the western White Bay area, showing the six main geological packages summarized in the text.
After Smyth and Schillereff, 1982; diagram modified from Kerr and Knight (2004).

attitude. In the centre of the area, around Sops Arm, the Southern White Bay Allochthon is reduced to a narrow band of schists, and it is absent in the south, except as slivers exhumed along the Cabot Fault zone and the Doucers Valley fault zone (Figure 2). A few small gold occurrences are known in the Southern White Bay Allochthon (e.g., Saunders, 1991), but it has not been widely explored.

Silurian volcanic and sedimentary rocks : These form the Sops Arm Group (Lock, 1969; Smyth and Schillereff, 1982), which comprises subaerial felsic volcanics and shallow-marine to terrestrial sedimentary rocks. These younger rocks are most commonly in fault contact with the rocks of the Southern White Bay Allochthon (see below), but locally preserve an unconformable relationship. These rocks contain numerous gold occurrences, which are generally associated with quartz veins, and described as mesothermal and structurally controlled. Stratabound Pb mineralization also occurs in brecciated dolostones of the Sops Arm Group (e.g., Tuach, 1987b; Saunders, 1991) and there are more recent Zn discoveries of similar aspect. The Sops Arm Group was most recently explored for gold in the late 1980's. Some small-scale exploration has been conducted in more recent years.

Silurian and Devonian plutonic suites : These intrude all older rocks described above, and are termed the Gull Lake Intrusive Suite and the Devils Room Granite (Smyth and Schillereff, 1982; Figure 1). The two may have originally been contiguous, but displaced by post-Devonian dextral motions along the Doucer's Valley fault zone (Figure 2). The Gull Lake body has a poorly constrained age of ca. 400 Ma (Erdmer, 1986). The Devils Room Granite was recently dated at ca. 425 Ma (Heaman et al., 2002); this age supersedes the earlier estimate of 400 ± 2 Ma given by Erdmer (1986). The granites host minor fluorite and molybdenite mineralization (e.g., Saunders, 1991), and they have been implicated in the genesis of various styles of gold mineralization (Tuach, 1987b; Saunders and Tuach, 1991). The Devils Room granite is one of two Siluro-Devonian plutonic suites that intrude Precambrian rocks of the Long Range Inlier; the other is the Taylor Brook Gabbro (west of the area in Figure 2), which is now dated as Silurian (Heaman et al., 2002).

Carboniferous clastic sedimentary rocks : Rocks of the Anguille and Deer Lake groups are the youngest rocks in the area (Hyde, 1979). These are dominated by sandstones, conglomerates and slates. Conglomerates of the Deer Lake Group are separated from the older rocks described above by a spectacular unconformity. However, the Southern White Bay Allochthon, the Sops Arm Group and younger plutonic rocks have locally been thrust *over* the Carboniferous, indicating significant Carboniferous or younger deformation. Carboniferous rocks host minor Cu-Ag mineralization in the south of the area.

Including Precambrian events, western White Bay area has suffered or enjoyed at least five orogenic episodes over 1300 Ma. The middle Ordovician Taconic Orogeny is believed to have caused initial emplacement of the Southern White Bay Allochthon over autochthonous Precambrian and Cambro-Ordovician rocks (Smyth and Schillereff, 1982). The Silurian Salinic Orogeny and/or the Devonian Acadian Orogeny affected Silurian and older rocks and probably created much of the present geological architecture; these events were accompanied and followed by granitic plutonism. Many contacts between the Silurian Sops Arm Group and older rocks were interpreted as west-directed thrusts by Smyth and Schillereff (1982). Carboniferous or post-Carboniferous events (Variscan Orogeny) caused tight folding in the Anguille Group (Hyde, 1979), and also caused local thrusting of older rocks over the Carboniferous sequence (Smyth and Schillereff, 1982). The major north-northeast- trending fault systems that transect the area are interpreted to have had largely transcurrent motions during the Carboniferous, but it is likely that they had a complex and protracted earlier history, including Ordovician and Siluro-Devonian motions. The Doucers Valley fault zone has long been recognized as a major structure within the Newfoundland Appalachians, and it has been described as a long-lived structure that is both spatially and genetically associated with several styles of mineralization over a long period of time (Tuach, 1987b). It likely originated as the basal transport zone of the Southern White Bay allochthon, and has been repeatedly reactivated during younger events. Most of the major structures in the area have good evidence for Silurian motions, and many must also have been active as Carboniferous faults. Brittle deformation associated with these late events is ubiquitous in all units, and is particularly strong in the outcrops along much of Route 420, which follows a fault-controlled valley.

PRECAMBRIAN BASEMENT ROCKS

The granites and gneisses of the Long Range Inlier will not be examined in detail during this field trip, and are described only briefly. Owen (1991) and Heaman et al. (2002) outline their regional geology, and Saunders and Tuach (1988, 1991) provide detailed descriptions of the Apsy Granite in its context as a host to disseminated gold mineralization.

Precambrian rocks are well-exposed along the Cat Arm hydro access road in the area west and northwest of Coney Arm (Figure 2; see also Figure 5). The most detailed and varied transect is given by the northern section of the road, which climbs up to the dam site on the highland plateau of the Long Range mountains. In the north, Precambrian rocks are amphibolite-facies banded gneisses of broadly granodioritic composition. A greenish cast is common, and reflects the widespread development of epidote in response to later retrogression. Possible Long Range dykes occur in roadside outcrops north of Little Coney Arm, and around the Rattling Brook gold deposit. South of Little Coney Arm, the basement comprises deformed, variably altered K-feldspar megacrystic granite of the Apsy Pluton (Saunders and Tuach, 1988, 1991; Owen, 1991). Exploration company reports (e.g., McKenzie, 1987; Poole, 1991) generally refer to this unit as the *Rattling Brook granite*. The granite is cut by diabase dykes that postdate most of the deformation, but are themselves locally altered and deformed; some of these are Long Range dykes, but others are likely Paleozoic in age. The granite itself gives an imprecise lower intercept U-Pb zircon age of 1006 ± 82 Ma, but is considered to be a member of the younger (1000-980 Ma) group of Grenvillian plutons (Heaman et al., 2002). In the south of the area, the Apsy Granite is the host rock for disseminated gold mineralization, and is locally strongly altered and rusty-weathering. McKenzie (1987) and Saunders and Tuach (1988, 1991) describe the mineralogical and geochemical changes associated with mineralization in the granites. Further description is given in later sections of this guide.

AUTOCHTHONOUS CAMBRIAN AND ORDOVICIAN SEDIMENTARY ROCKS

Introduction

Autochthonous Cambrian and Ordovician rocks form a narrow belt about 50 km long (Figure 1). South of Jacksons Arm, the total width of this belt is only a few hundred metres. North of Jacksons Arm, the belt broadens to 3 km wide, and access is substantially better. There are good coastal exposures along the west side of Coney Arm and good outcrops of some units along the Cat Arm hydro access road.

Neale and Nash (1963) first noted the potential correlations of these formations with those along the shores of the Gulf of St. Lawrence. A general lack of macrofossils impeded subdivision and correlation. Figure 3 illustrates the stratigraphic nomenclature adopted by Heyl (1937), Neale and Nash (1963), Lock (1969, 1972), Smyth and Schillereff (1982) and most recently by Kerr and Knight (2004). The current treatment uses terminology derived from undeformed Cambrian and Ordovician rocks west of the Long Range Inlier (e.g., James et al., 1988; Figure 4). Thus, the former Coney Arm Group is here largely replaced by the Labrador Group, Port au port Group and St. George Group. A limestone unit towards the structural top of the sequence remains of rather uncertain affinity, but is here tentatively assigned to the Table Head Group. All of the individual formations within the Labrador, Port au port and St. George groups are recognized on lithostratigraphic grounds in western White Bay. Biostratigraphic studies were initiated during 2004, but unfortunately most of the samples proved to be devoid of conodonts, presumably a function of deformation and recrystallization (G. Nowlan, pers. comm. 2004).

Cambrian and Ordovician Stratigraphy of the West Coast of Newfoundland

A brief review of the Cambrian and Ordovician stratigraphy of the west coast of Newfoundland is provided here as background for subsequent descriptions and discussions of southwestern White Bay. The stratigraphy is summarized in Figure 4, reproduced from Kerr and Knight (2004). There are three sequences on the west coast of Newfoundland; a rift sequence, a shallow-water shelf sequence and a shallow to deep-water foreland basin sequence. Not all of these rocks occur in southwestern White Bay, but the Eocambrian to middle Ordovician part of the sequence is present. Viewed at a formational level, there are many regional variations in rock types and thicknesses that reflect lateral facies variations. The following account is of necessity simplified, and emphasizes the *general* lithostratigraphic features of the individual formations, rather than the subtle details.

The rift sequence consists of late Proterozoic and Eocambrian rocks of the lower part of the Labrador Group. These are dominantly coarse arkosic fluvial sedimentary rocks of the Bateau Formation and mafic volcanic rocks of the Lighthouse Cove Formation. These occur in southeastern Labrador, Belle Isle and around Canada Bay. They are not known in the White Bay area.

The shallow-water shelf sequence consists of the Cambrian rocks of the upper part of the Labrador Group and the Port au Port Group, overlain by the lower and middle Ordovician rocks of the St. George Group.

The upper Labrador Group records the establishment of a carbonate shelf, and the overlying rocks record several long-lived cycles of marine transgression and regression. The upper part of the Labrador Group is dominated by clastic sedimentary rocks that record regional marine flooding of the Laurentian margin. These were deposited in fluvial to a nearshore subtidal and intertidal settings, and form the Bradore Formation, Forteau Formation and Hawke Bay Formation, with a total thickness of about 500 m (Figure 4). The Bradore Formation is locally variable in thickness and rock types, but is dominated by arkosic sandstones, quartz arenites and minor pebble conglomerates. The Forteau Formation generally exhibits a threefold subdivision. The basal component is a thin succession of limestones and lesser dolostones, known as the Devils Cove Member. This is overlain by calcareous shales, in turn overlain by a mixed sequence of interbedded shales, thin sandstones and thin limestones. The Hawke Bay Formation is dominated by interbedded siliciclastic rocks, including shales, mudstones, siltstones, sandstones and (notably towards the top) quartzites and some limestones, including oolitic rocks and nodular dolomitic limestones. It records progressively more shallow-water paleoenvironments, and the eventual onset of significant carbonate deposition.

The Middle to Upper Cambrian Port au port Group is a 500 m thick sequence of limestones and dolostones that is is subdivided into the March Point, Petit Jardin and Berry Head formations. The Petit Jardin Formation is the thickest of the three formations. The March Point Formation contains dark grey, bioturbated, subtidal limestones of probable subtidal setting. These give way to massive dolostones and lesser limestones and shales of the Petit Jardin Formation. The metre-scale cyclic dolostone-dominated sequences within this formation are typical of those developed in lagoonal to tidal flat environments where stromatolites were abundant. The overlying Berry Head Formation represents a mixture of facies, and typically contains dolostones, limestones and cherty beds. Algal forms are also common within it.

The Lower Ordovician St. George Group represents two megacycles of marine transgression and regression. It is divided into the Watts Bight, Boat Harbour, Catoche and Aguathuna formations, and has an aggregate thickness of about 500 m (Figure 4). The stratigraphy of the St. George Group is more regionally consistent than that of the underlying rocks, because the shelf was by this time well developed. The initial transgression is recorded by the Watts Bight Formation, which comprises massive, extensively bioturbated, grey, subtidal limestones. The overlying Boat Harbour Formation is characterized by metre-scale cyclic sequences of limestone and dolomite, representing mixed peritidal environments formed during marine regression. The overlying Catoche Formation represents the transgressive phase of the next megacycle. It is again dominated by bioturbated, fossiliferous, dark grey limestones. Dolostones become more abundant towards its top, and are locally associated with a distinctive white limestone termed the Costa Bay Member. The uppermost strata, the Aguathuna Formation, are dominantly peritidal dolostones, and minor thin limestones, developed as sea level dropped again.

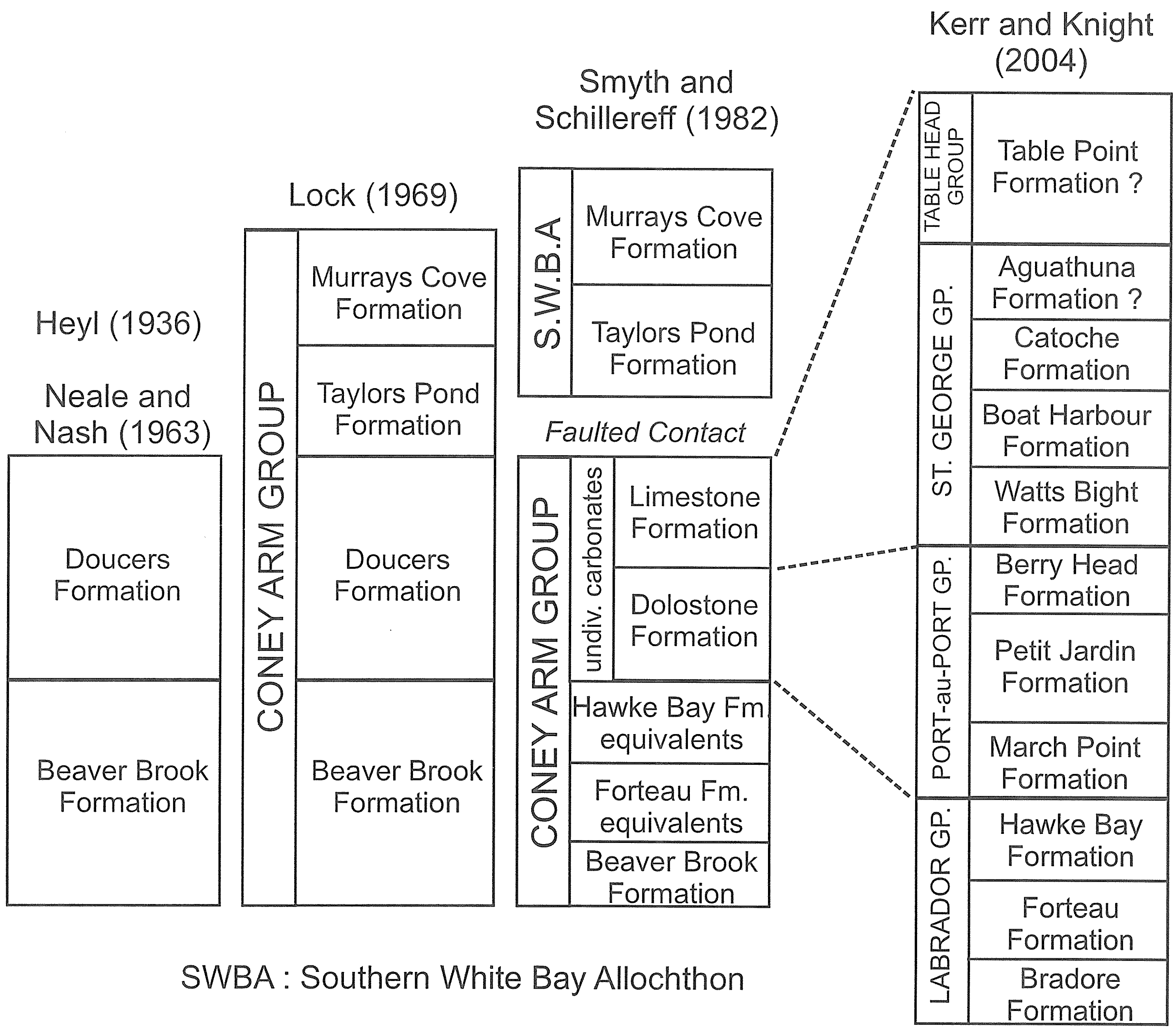


Figure 3 : Summary of stratigraphic nomenclature for Cambrian and Ordovician rocks in western White Bay, as employed by previous workers, and the most recent study by Kerr and Knight (2004).

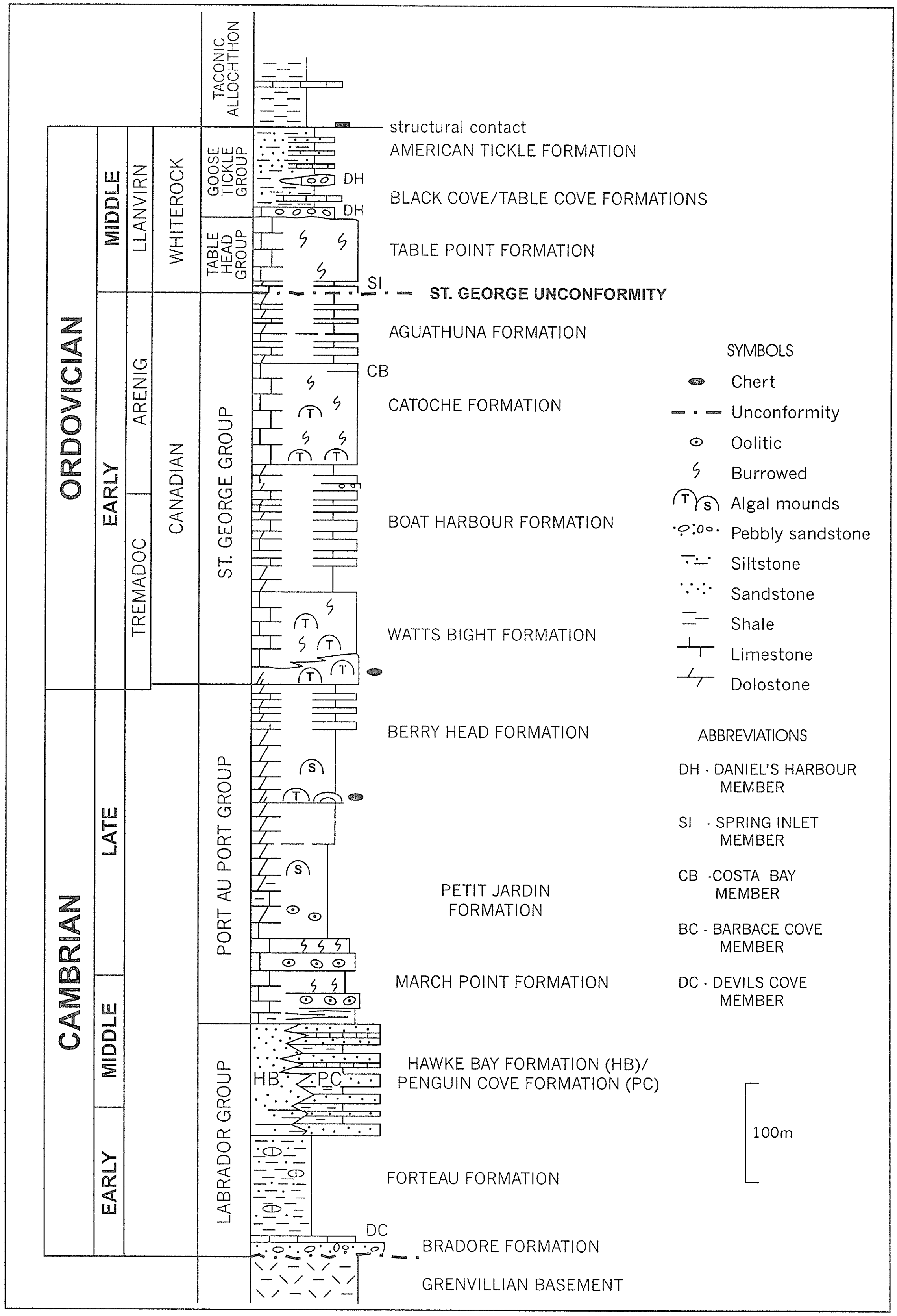


Figure 4 : A summary of the Cambrian and Ordovician stratigraphy of the west coast of Newfoundland. Diagram from Kerr and Knight (2004) based on numerous published and unpublished sources.

A major regional sequence boundary, the St. George unconformity, separates the shelf sequence from Middle Ordovician carbonates and siliciclastic rocks of the Foreland Basin sequence. It is characterized by erosion of the Aguathuna Formation, and the development of collapse breccias and other karst-related features. These features record the uplift of the shelf prior to its rapid subsidence in response to the Taconic Orogeny. The Foreland Basin sequence consists of two contrasting parts; a lower carbonate shelf sequence (Table Head Group) and an upper flysch sequence (Goose Tickle Group). The latter smothered the carbonates as the margin foundered and the basin deepened during the early stages of the Taconic Orogeny.

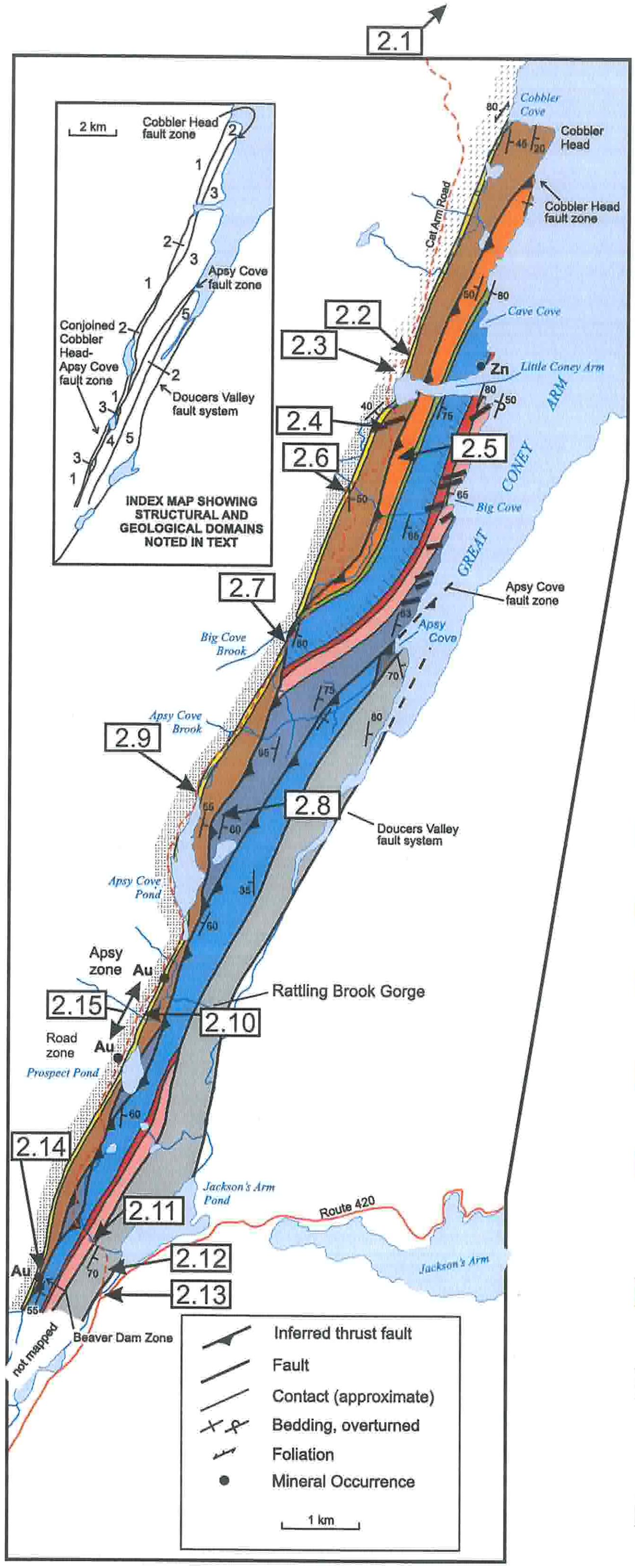
The lower Middle Ordovician Table Head Group is typically about 500 m thick, and records a rapid marine transgression related to subsidence of the shelf preceding the Taconic Orogeny. Block faulting relating to these effects led to significant local variations in the character and extent of the lowermost strata (James et al., 1988; Stenzel et al., 1990). These give way to a monotonous sequence of massive grey limestones that dominates the Table Point Formation. These locally display soft-sediment deformation and slump features indicative of tectonic instability. The upper parts of the Table Head Group (Table Cove Formation) are thinly-bedded and nodular limestones and shales of deeper water setting. Thin limestone conglomerate units were derived by erosion of the underlying Table Point facies, probably adjacent to active fault scarps. The Goose Tickle Group consists of a basal black shale unit, the Black Cove Formation, overlain by turbiditic sandstones and shales of the American Tickle Formation. The buried carbonate shelf was locally uplifted and eroded adjacent to active fault scarps; consequently, massive limestone conglomerates (e.g., the Daniels Harbour Member) were derived from the Table Head Group.

Flysch deposition ceased with the emplacement of the rocks of the Cow Head Group and its equivalents over the foreland basin during the middle Ordovician. The leading edge of the allochthon was then unconformably overlain by the Middle to Upper Ordovician Long Point Group in westernmost Newfoundland.

Geological and Structural Domains

The geology of the Cambro-Ordovician rocks of western White Bay is depicted in Figure 5. The current interpretation resembles that of Smyth and Schillereff (1982), but new stratigraphic subdivisions and structural features are recognized.

In a general sense, the area is divided into five domains, separated by an unconformity and important faults. In the west, Precambrian granites and lesser gneisses of the Long Range Inlier (domain 1) form high hills. A well-preserved unconformity separates these basement rocks from a narrow strip of Cambrian siliciclastic rocks (domain 2) that extends virtually the entire length of the area. The eastern boundary of the siliciclastic rocks appears to be largely a tectonic contact, along which they are juxtaposed with various Cambrian and Ordovician carbonate rocks; this structure is termed the *Cobbler head fault zone*, and it is a wide belt of deformation, rather than a single plane. Another important structure, termed the *Apsy cove fault zone*, runs from the coast southwards, and merges into the Cobbler head fault zone; in the south, the two fault zones are partially coincident. North of the Apsy cove fault zone (domain 3), there is a largely intact



IGNEOUS ROCKS (Age Unknown)

20 — Diabase dykes (not all examples are shown on the map)

CAMBRIAN AND ORDOVICIAN SEDIMENTARY ROCKS

TABLE HEAD GROUP ? (Middle Ordovician)

14 — Dominantly monotonous grey limestones, pervasively fractured and containing numerous calcite veins. The limestones are interbedded with minor dolostones (Spring Inlet Member) towards the base, and minor limestone conglomerates (Daniels Harbour Member) at the top. The unit displays characteristic karst weathering features in natural outcrops.

ST. GEORGE GROUP (Lower Ordovician)

13 — **Aguathuna Formation.** Interbedded grey, mottled dolostones and white to black limestones.

12 — **Catoche Formation.** Dominantly massive, bioturbated, grey limestones, with dolomitized burrows. The unit includes minor white limestones, marbles and buff dolostones (Costa Bay Member) towards the top.

11 — **Boat Harbour Formation.** Interbedded grey limestones and buff dolostones.

10 — **Watts Bight Formation.** Grey bioturbated limestones and lesser dolostones, locally stromatolitic.

PORT AU PORT GROUP (Middle and Upper Cambrian)

9 — **Berry Head Formation.** Grey to beige dolostones, stromatolitic dolostones, grey limestones, and cherts.

8 — **Petit Jardin Formation.** Massive grey to beige dolostones, dolomitic shales, and minor grey limestones.

7 — **March Point Formation.** Grey, bioturbated limestones.

LABRADOR GROUP (Lower Cambrian)

6 — **Hawke Bay Formation.** Pyritic slates, siltstones and dolomitic sandstones, overlain by a mixed sequence of siltstones, sandstones, quartzites and limestones.

5 — **Forteau Formation.** Dominantly phyllites containing thin limestone and dolostone beds. The unit contains a thin basal carbonate sequence (Devils Cove Member) in several areas. Contains numerous small faults related to the Cobbler Head fault zone.

4 — **Bradore Formation.** Quartzites, arkoses and local conglomerates.

PRECAMBRIAN

2 — **Apsy Granite.** Pink to greenish K-feldspar megacrystic hornblende-biotite granodiorite to granite, variably deformed. The unit displays strong potassic alteration and contains quartz-carbonate-sulphide veining in areas of gold mineralization.

1 — Granodioritic and granitic gneisses, locally showing well-developed compositional layering.

2.10 Field trip stop location (approximate)

Figure 5 : Simplified geology of autochthonous Cambrian and Ordovician platformal sedimentary rocks, and adjacent Precambrian basement, in the Coney Arm area. After Kerr and Knight (2004)

stratigraphic sequence, including the Labrador Group, Port au port Group and much of the St. George Group. South of the Apsy cove fault zone (domain 4), the Port au port Group and the lowermost St. George Group are structurally repeated, and placed above younger rocks. A third fault, here unnamed, probably defines the western boundary of an area dominated by massive limestones (domain 5), tentatively correlated with the Table Head Group. Throughout the area, the sedimentary rocks are steeply-dipping or vertical, and mostly dip to the east, although local west-dipping domains exist. Facing directions indicate that most of the beds young eastward. The Doucers Valley fault zone forms the eastern boundary of the Cambro-Ordovician sequence, but its precise position is locally debatable.

Labrador Group

The unconformity between Precambrian basement and the Cambrian Bradore Formation is superbly exposed in several locations, and conglomerates are locally developed. Drilling suggests that the basal unconformity is preserved through much of the belt, despite strong deformation in structurally overlying rocks. The Bradore Formation consists of light to dark grey sandstones and quartzites, commonly with blue-tinged quartz grains. These rocks are locally rich in magnetite, particularly towards the top of the formation. The Forteau Formation is mostly represented by a monotonous sequence of phyllitic rocks containing intercalated thin lenses and laminae of dark limestone, dolostone and siltstone. A basal limestone sequence (the Devils Cove Member) is locally exposed beneath these rocks, and has also been observed in drill core. The phyllitic rocks are almost continuous west of and within the Cobbler head fault zone. These phyllitic rocks are generally strongly deformed, and contain numerous small isoclinal folds defined by disrupted quartz veins and calcareous beds. As the phyllite unit is essentially coincident with the Cobbler head fault zone, and is probably imbricated by numerous minor faults, and/or repeated by small folds, its apparent thickness of 500 m or more at Cobbler Head is likely exaggerated. No realistic estimate of its thickness can be made elsewhere in the area.

The presence of the basal limestone unit of the Forteau Formation (Devils Cove Member) implies that there may be stratigraphic continuity between the Bradore Formation and the *base* of the Forteau Formation throughout much of the area. In the south of the area, the Forteau Formation is everywhere bounded to the east by younger rocks of the Port au port and St. George groups, and its boundary with them must be tectonic. As noted above, the Cobbler head fault zone, is essentially coincident with the Forteau Formation phyllitic rocks.

The Hawke Bay Formation is present in the north of the area. In the coastal section, it comprises a lower portion dominated by pyritic slates, and thinly-bedded brown-weathering dolomitic sandstones, siltstones and grey-green sandstones. The lower sequence passes upwards into a sequence of similar rock types that also includes white quartzites and grey limestones. The latter locally consist of well-preserved oolitic "grainstones", some of which contain oncolites. Psammitic rocks and quartzites also form a few outcrops in Rattling Brook gorge, where they structurally underlie carbonate rocks assigned to the Port au port Group, just east of the Apsy Cove fault zone. Their presence in the gorge was initially noted by Lock (1969), and they were correlated with the Hawke Bay Formation by Smyth and Schillereff (1982). It is suspected that the contacts of these quartzites with surrounding rocks are tectonic. Kerr and Knight (2004) also noted the presence of possible "retrogressed basement rocks" within the Forteau Formation phyllites; reexamination suggests that these could be tectonically interleaved Hawke Bay Formation rocks.

Port au Port Group

The Middle to Upper Cambrian Port au Port Group is dominated by the dolomitic rocks of the Petit Jardin Formation. The thinner sequences of the March Point Formation and Berry Head Formation are recognized in the northern part of the area, but cannot presently be separated in the south due to more limited outcrop.

The March Point Formation is a thin (< 100 m) sequence of grey bioturbated limestones containing prominent fossil worm burrows, which sits conformably above the Hawke Bay Formation on the coast. It is also recognized in a deformed state south of Little Coney Arm. The best exposures of the Petit Jardin Formation are around Little Coney Arm, where almost 400 m of dolostones and subordinate limestones are revealed in high cliffs and on a wave-cut platform. The valleys of Big Cove Brook, Apsy Cove Brook and Rattling Brook also expose thick sequences of dolomitic rocks, most of which are assigned to this formation (Figure 5); the latter two areas are east of (structurally above) the Apsy Cove fault zone. The Petit Jardin Formation consists of interbedded massive grey to beige dolostones, brown-weathering dolomitic argillaceous rocks, and lesser pale-grey to white limestones, some of which exhibit cross-bedding suggesting that they originated as lime sands. Cyclic sequences in which massive and laminated dolostones alternate are a common feature. The rocks are not fossiliferous, but algal laminations are common in the massive dolostones, and well-developed stromatolite mounds are present locally. Ripple marks and dessication cracks indicative of emergent conditions are common features, and paleokarst features are locally well developed. The Berry Head Formation is recognized on the north shore of Little Coney Arm, and in Rattling Brook Gorge. These rocks resemble those of the underlying formation, but burrowed limestone beds are more abundant, and there are numerous cherty horizons, which are extensively boudinaged. A bed within this formation shows spectacular stromatolite mounds, and provides a useful marker.

St. George Group

Carbonate rocks assigned to the Lower Ordovician St. George Group are best exposed along the coast from the mouth of Little Coney Arm to Apsy Cove. Isolated areas of grey limestone are located in the south of the area, where the Cobbler Head and Apsy Cove fault zones are partially coincident; these are considered to be fault-bounded lozenges of the St. George Group caught within the composite fault zone.

The Watts Bight Formation forms an important marker unit. It consists of approximately 65 metres of dark grey, bioturbated limestone, interbedded with a few thin dolostones, which are locally stromatolitic. The worm burrows are locally spectacular in size and extent. Smyth and Schillereff (1982) report that Svend Stouge (unpub. data) obtained conodonts indicative of a lower Ordovician age from the Little Coney Arm section, which is consistent with assignment to the St. George Group. Conodonts indicative of this age were also obtained during a more recent study by Godfrey Nowlan (pers. comm., 2004).

The Boat Harbour Formation is well-exposed on the coast, where it sits directly above the Watts Bight Formation. In the south of the area, it is recognized in roadside and hilltop outcrops northwest of Jacksons Arm Pond. The Boat Harbour Formation is characterized by metre-scale peritidal cycles of alternating beds of grey limestone and beige to white-weathering dolostone. The typical cycle comprises burrowed limestone, overlain by grainy limestone, and then capped by dolostone; a sharp contact separates the dolostone from the next burrowed limestone.

The Catoche Formation is a sequence of mostly massive grey limestones having an exposed thickness of about 250 metres, and forms the bulk of the St. George Group in the study area. In the coastal section, the lower part of the Catoche Formation comprises a lower sequence dominated almost entirely by massive grey limestones that are pervasively bioturbated, and in which the worm burrows are characteristically dolomitized. The upper portion of the Catoche Formation is lithologically more variable, and includes some pure-looking, white, stylolitic limestones, interbedded with white to beige, thinly-bedded dolostones. These record a change from subtidal to peritidal environments, and are believed to equate with the Costa Bay Member recognized elsewhere in western Newfoundland. Along the Cat Arm road, grey limestones locally occur where the Cobbler head fault zone and the Apsy cove fault zone merge, and partly coincide. These include intensely-deformed, mylonitic rocks that appear to contain flattened and stretched worm burrows, and also white-weathering stylolitic marble-like rocks that resemble those seen in the upper part of the coastal section. These rocks are interpreted to represent tectonic lozenges of Catoche Formation preserved within the composite fault zone.

The Aguathuna Formation may be present in the form of black and grey dolostones, showing distinctive colour mottling, that are exposed at at Apsy Cove. However, these could also represent the Petit Jardin Formation of the Cambrian Port au Port Group.

Table Head Group

The easternmost carbonate unit in the area consists of massive, monotonous, grey limestones, with an apparent thickness of about 500 metres. This unit includes several possible deposits of high-purity limestone (Howse, 1995), and is here correlated with the Table Point Formation of the Table Head Group. None of the other limestone formations in the study area have comparable thickness or purity. The original features of these rocks are obscured by pervasive fracturing, local brecciation and widespread calcite veining, all of which are believed to be related to its proximity to the Doucers Valley fault zone. Coastal outcrops are characterized by spectacular karst weathering that produces features such as potholes, arches and sharp, knife-like outcrop surfaces. No other limestone unit in the area displays such weathering features, and these are presumably related to its relative purity. The rocks are massive, structureless, pale to dark grey limestones that generally lack clear sedimentary features. Lamination and bioturbation are locally visible, but can rarely be followed for more than a few metres; in places the rocks have a nodular appearance, but this may be imposed by fracturing. Calcite veining is pervasive, and has no preferred orientation. The roadside outcrop near Jacksons Arm Pond contains dolostone units towards its base, and limestone conglomerates towards its top.

ALLOCHTHONOUS CAMBRO-ORDOVICIAN ROCKS (SOUTHERN WHITE BAY ALLOCHTHON)

Introduction

The Southern White Bay Allochthon consists of metasedimentary, metavolcanic and plutonic rocks of Cambro-Ordovician age, which are everywhere in faulted contact with Precambrian basement and autochthonous Cambro-Ordovician sedimentary rocks described above. The term was proposed by Smyth and Schillereff (1982), following initial recognition by Williams (1977). For the most part, contacts between the Southern White Bay Allochthon and the Silurian Sops Arm Group (see below) are also tectonic in nature; however a likely unconformable relationship is preserved in coastal outcrops north of Jackson's Arm. Four main components are recognized within the Southern White Bay Allochthon, but these will not all be visited during the field trip. The general distribution of units within the Southern White Bay Allochthon is indicated in Figure 6. The following descriptions are largely adapted from Smyth and Schillereff (1982).

Taylors Pond Formation and Second Pond Mélange

The Taylor's Pond Formation consists of pyritic slates and phyllites, containing thin calcareous beds and disrupted quartz veins. Its general appearance is rather similar to the phyllites of the Forteau Formation, as exposed along the Cat Arm road. It is separated from massive limestones (probably equivalent to the Table Head Group) by the Doucer's Valley fault zone. The Taylor's Pond formation contains areas of mélange, which locally contain serpentinitic blocks. Smyth and Schillereff (1982) discussed several interpretations for the Taylor's Pond Formation, including correlation with autochthonous flysch of the Goose Ticke Group, or structural repetition of Forteau Formation phyllites. However, their preference was for inclusion within the allochthonous sequence. As discussed later (see Part 2), this issue is still problematic !

Greywacke, sandstone and slate (Maiden Point Formation equivalents)

These rocks consist of fine- to medium-grained sandstone, greywacke and slate. Sandstones and greywackes contain blue-tinged quartz grains, similar to those noted in the Bradore Formation. They form a discrete slice within the allochthon, and also occur as tectonic slivers in the shales of the Taylor's Pond Formation. Smyth and Schillereff (1982) correlated these rocks with the lower Cambrian Maiden Point Formation in the Hare Bay Allochthon of northernmost Newfoundland.

Murrays Cove formation

The Murrays Cove "schist", referred to here as the Murrays Cove formation, is dominated by greenish schists that represent metamorphosed mafic volcanic and tuffaceous rocks, with lesser amounts of red chert and metagabbro. The schists are intruded by grey felsitic dykes, which are

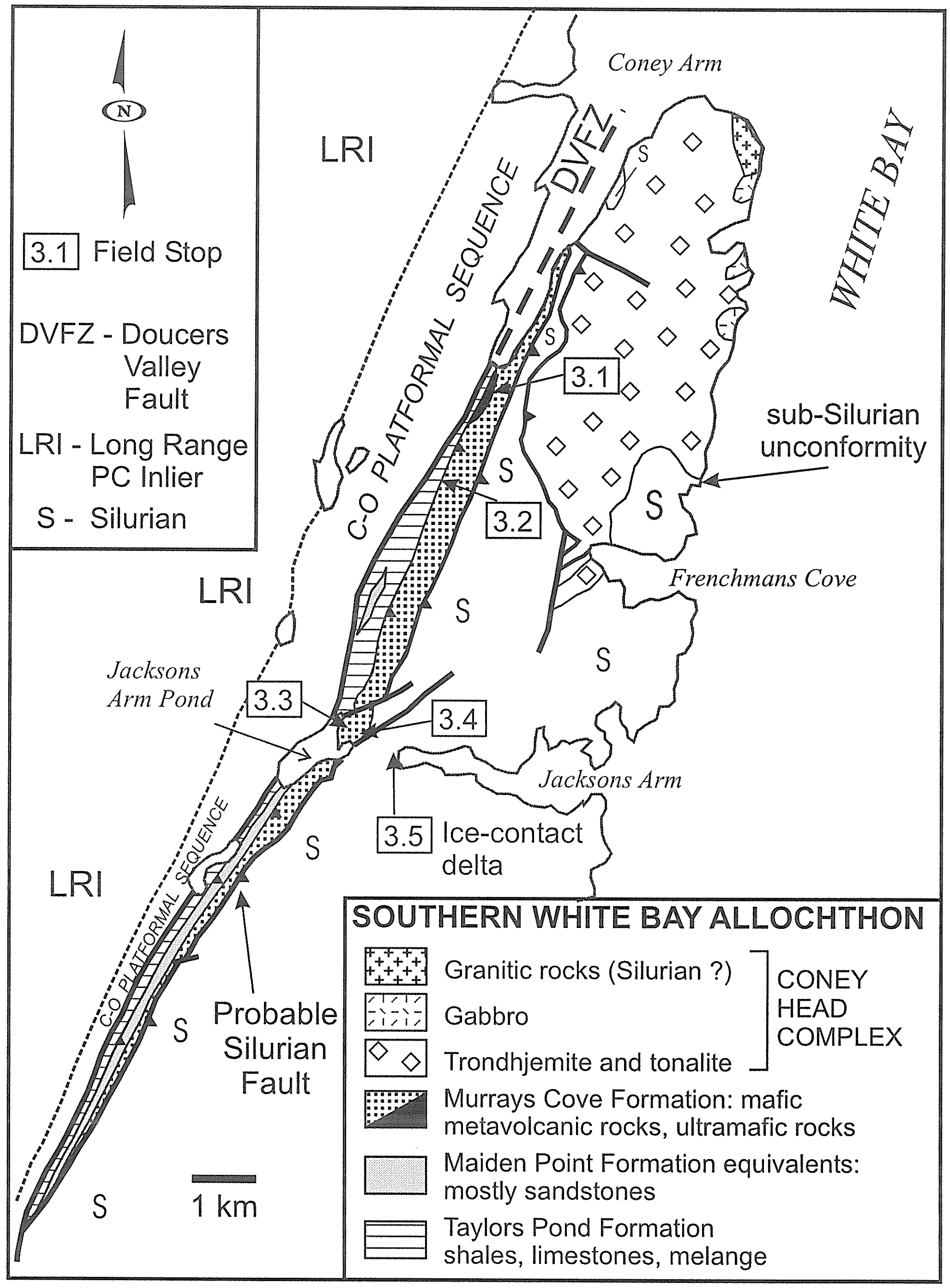


Figure 6 : Simplified geological map of the northern part of the Southern White Bay Allochthon, showing major geological units, and approximate locations of field stops. Geology modified after Smyth and Schillereff (1982).

also deformed and metamorphosed. Smyth and Schillereff (1982) considered the Murray's Cove formation to be identical to parts of the dynamothermal metamorphic aureole associated with ophiolitic rocks of the Hare Bay Allochthon. No ultramafic rocks were recorded in the Murray's Cove Schist by previous workers, but newly-created outcrops along woods roads east of Coney Arm suggest that they are present in the (structurally) lowermost part of the unit, or as a separate slice beneath it. The Murrays Cove formation has the distinction of being named after Alexander Murray, who first described these rocks on the east side of Great Coney Arm. As far as we know, it is the only geological unit in the province to bear his name.

Coney Head Complex

The Coney Head Complex, initially described by Williams (1977) includes a variety of igneous rocks, and is the most extensive component of the Southern White Bay allochthon. It occupies a large area north of Jacksons Arm (Figure 2, Figure 6), most of which is only accessible by boat. The most abundant rock type is coarse-grained trondhjemite to tonalite, but it also includes gabbro, quartz gabbro, granite, and mafic to silicic dykes. Gabbro appears to be the earliest component, and is cut by the trondhjemite, which commonly contains mafic inclusions. The granitic rocks and dykes appear to be the youngest components, and some of these may actually be Silurian in age.

The Coney Head Complex is believed to represent a sample of oceanic crust formed within Iapetus, and later transported westward as part of the Southern White Bay allochthon. It is lithologically similar to parts of the Little Port Complex of the Humber Arm Allochthon in western Newfoundland. U-Pb zircon dating suggests that the trondhjemites formed at 474 +/- 2 Ma, but that at least some of the granites in the Coney Head area are significantly younger at 432 +/ 2 Ma and are therefore possibly equivalent to the Sops Arm Group (Dunning, 1987).

SILURIAN SEDIMENTARY AND VOLCANIC ROCKS (SOPS ARM GROUP)

Introduction

Much of the eastern part of western White Bay is underlain by the Sops Arm Group, which consists of terrestrial to shallow marine sedimentary rocks, and mafic to felsic volcanic and pyroclastic rocks. The Sops Arm Group is one of three extensive Silurian volcano- sedimentary sequences that unconformably overly Cambro-Ordovician rocks in western and central Newfoundland (Figure 1). The geology and stratigraphy of the Sops Arm Group was established by the work of Heyl (1937), Lock (1969, 1972) and subsequent revisions by Noranda Exploration (e.g., Dimmell, 1979) and Smyth and Schillereff (1982). The stratigraphy of the Sops Arm Group is indicated in Figure 7, and the distribution of units is indicated in the simplified map in Figure 8. In general, the Sops Arm Group is believed to consist of a lower sequence of volcanic rocks, overlain by a middle sequence of varied sedimentary rocks, in turn overlain by an upper sequence of volcanic and pyroclastic rocks. Original conformable contacts between the various formations are uncommon, and there is no guarantee that the sequence shown in Figure 7 represents the

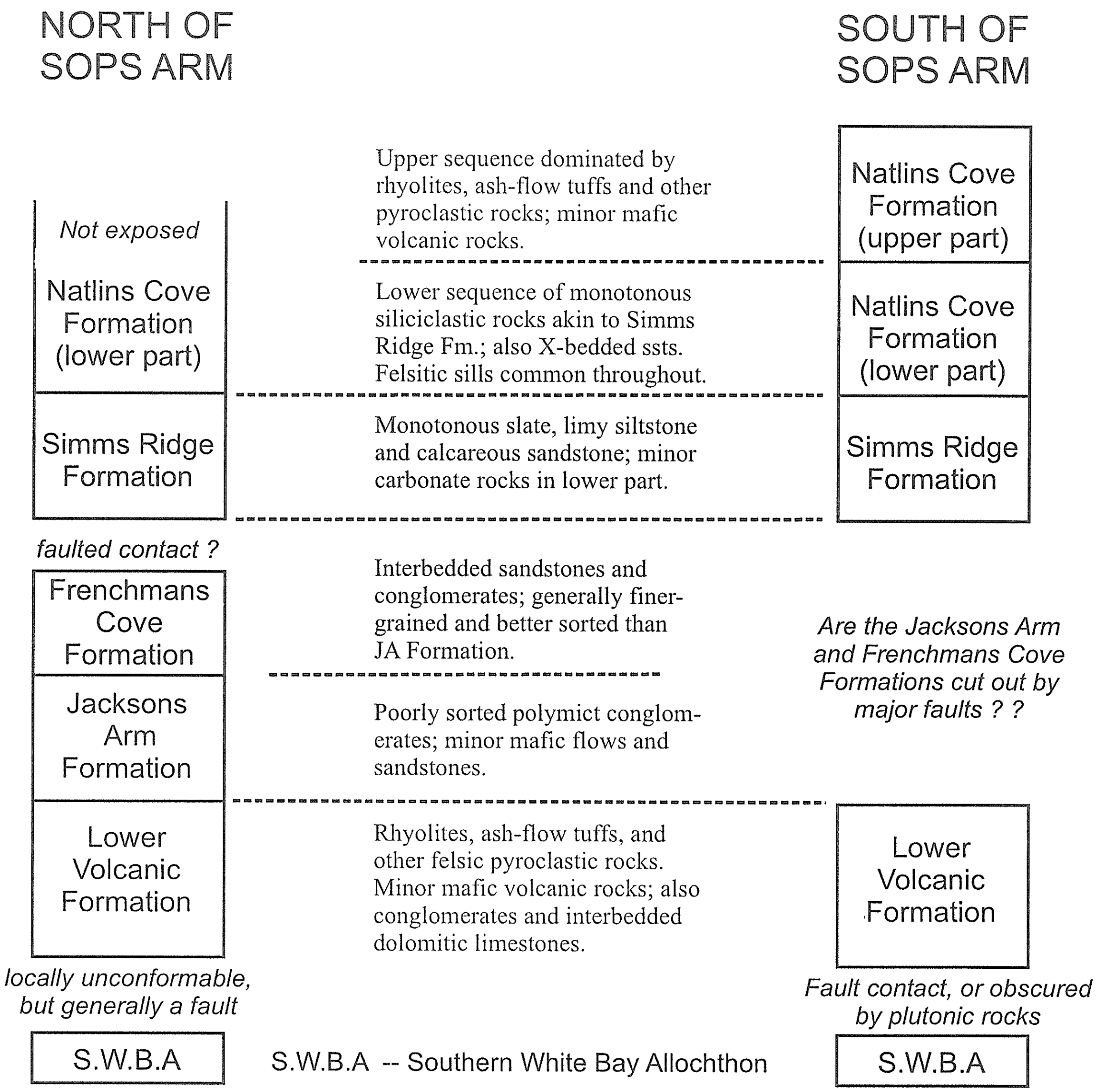


Figure 7 : Schematic illustration of the stratigraphy of the Silurian Sops Arm Group, illustrating variations observed between the northern and southern parts of the area.

original stratigraphic succession. The following descriptions are drawn largely from Smyth and Schillereff (1982).

Lower Volcanic Formation

Lock (1969) defined three units of volcanic rocks in the lower part of the Sops Arm Group, but suggested that these were lateral facies equivalents. Smyth and Schillereff (1982) subsequently grouped these formations into the Lower Volcanic Formation. The formation includes a wide variety of rock types, including rhyolitic flows, ash flow tuffs, mafic flows and minor sedimentary rocks (conglomerates, sandstones and dolostones). Felsic volcanic and pyroclastic rocks are dominant. A felsic pyroclastic breccia is in visible contact with trondhjemites of the Coney Head Complex on the coast north of Jacksons Arm. Interpretation of this contact is complicated by later deformation of the bounding units, but there is no sign of a discrete structural break at the boundary, and the irregularity of the contact suggests that it is indeed an unconformity. Conglomerates within the Lower Volcanic Formation are polymict, but their clast population is dominated by felsic volcanic and hypabyssal intrusive rocks; they resemble the Jacksons Arm Formation (see below). A dolostone unit within the Lower Volcanic Formation hosts subeconomic lead and zinc mineralization in the Turners Ridge area.

Jacksons Arm Formation

The Jacksons Arm Formation is mostly defined in the north of the area, and is dominated by poorly sorted, polymict conglomerates in which cobble- and boulder-sized clasts are prominent. Minor mafic flows and sandstone beds are also reported. These conglomerates are similar to thinner units associated with the lower Volcanic Formation in the south. The clast population is dominated by felsic volcanic and associated rock types, with rarer clasts of granite, gneiss, gabbro and sedimentary rocks. In the area around Jacksons Arm, the conglomerates are cut by felsitic dykes.

Frenchmans Cove Formation

The Frenchmans Cove Formation consists of interbedded sandstones and conglomerates, and is similar in many respects to the Jacksons Arm Formation, but is more regionally extensive, extending to the Sops Arm area. In the north, the boundary between the two formations is gradational, defined by decrease in clast sizes and an improvement in sorting and regularity of bedding. Smyth and Schillereff (1982) suggested that the Jacksons Arm and Frenchmans Cove formations were similar in many respects, and should perhaps be combined. However, there has been no formal revision of terminology.

Simms Ridge Formation

The Simms Ridge Formation occurs only in the south, around Sops Arm. It is the most economically important formation within the Sops Arm Group, as it hosts many of the gold occurrences. It is dominated by monontonous pale grey to brown, thinly-bedded slate, siltstone

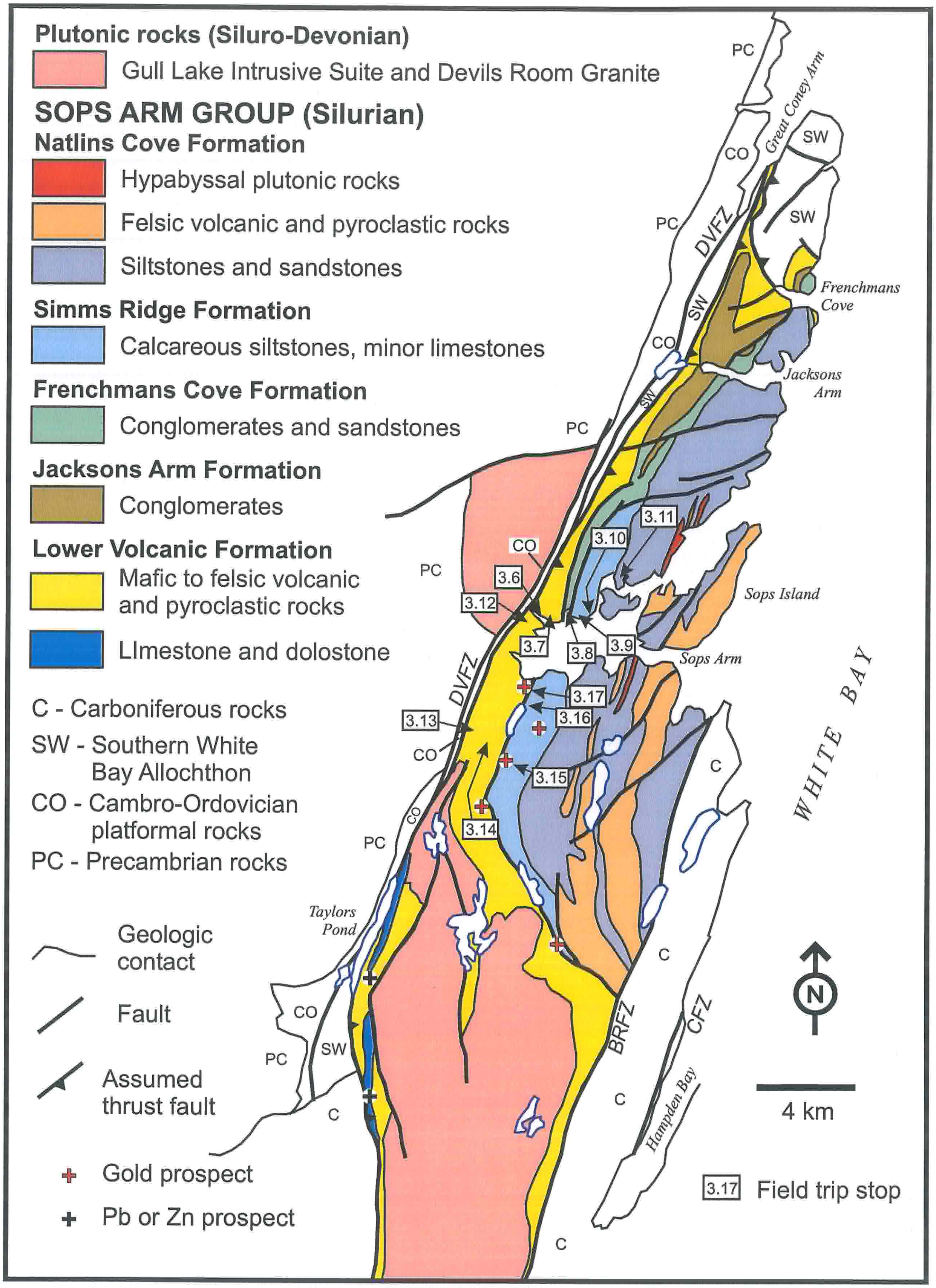


Figure 8 : Simplified geology of the Sops Arm Group, showing locations of important gold and base metal prospects, and the approximate locations of field trip stops.
Geology after Smyth and Schillereff (1982).

and calcareous sandstone, but includes some dolomitic carbonate beds in its lowermost section. In the south of the area, where the Jacksons Arm and Frenchmans Cove formations are absent, the Simms Ridge formation is in direct contact with the Lower Volcanic Formation. Where observed, this lower contact is a fault (Smyth and Schillereff, 1982; Tuach, 1987b), and there is typically strong deformation on either side of it.

Limestones in the lower part of the formation are locally fossiliferous and contain middle Silurian crinoids, gastropods and corals (Lock, 1969). The siltstones south of Sop's Arm are widely characterized by "siderite spots", which are brown-weathering, porphyroblast-like features of apparent posttectonic timing. It has been suggested that these are linked to gold mineralization (e.g., Tuach, 1986), although they appear to be developed on a regional scale south of Sops Arm. Saunders (1991) stated that the brown-weathering spots are actually limonitic, and developed by weathering of original dolomitic porphyroblasts. It is also possible that they reflect hornfelsing connected to nearby intrusive rocks of the Gull Lake Intrusive Suite (Figure 8).

Natlins Cove Formation

The Natlins Cove Formation is considered to be the uppermost sequence of rocks in the Sops Arm Group, and contains a mixture of shallow marine sedimentary rocks and subaerial volcanic rocks of largely felsic composition. The stratigraphic relationships between sedimentary and igneous components are uncertain, but the latter may form the upper part of the formation. Sedimentary rocks are mostly fine-grained grey sandstones and siltstones, with intercalated calcareous siltstones and thin limestones. Volcanic rocks include flow-banded rhyolites, ash flow tuffs, air fall tuffs and laharic breccias. Some of the volcanic rocks, notably on Sops Island, are very well preserved. These were described in detail by Lock (1969, 1972). Minor mafic volcanic rocks are also present.

Felsic Intrusive Rocks

Sill-like bodies of fine-grained felsic intrusive rocks, possibly hypabyssal in origin, are common within the Natlins Cove Formation; they have generally been described as of quartz monzonite composition, and appear to be pretectonic (Smyth and Schillereff, 1982). Their relationship to the spatially associated felsic volcanic rocks of the formation is uncertain, but they could represent feeder systems. Felsitic dykes and sills also intrude other formations of the Sops Arm Group.

CARBONIFEROUS SEDIMENTARY ROCKS (DEER LAKE AND ANGUILLE GROUP)

The western White Bay region forms the northern extension of the Carboniferous Deer Lake Basin (Hyde, 1982). Carboniferous rocks underlie the area north of Hampden, and also occur along the southern part of Route 420 (Figure 1; Figure 8). They are also believed to be present in offshore areas along the east side of the Great Northern Peninsula. Carboniferous strata in the field trip area are assigned to the Anguille Group, and the Deer Lake Group, respectively

(Smyth and Schillereff, 1982). The Anguille Group consists of fine- to coarse-grained sandstones, siltstones, slates, and pebble conglomerates. The younger Deer Lake Group consists of spectacular conglomerates, containing boulder-sized clasts, interbedded with red sandstones. The Deer Lake Group unconformably overlies the Sops Arm Group and rocks assigned to the Southern White Bay Allochthon. However, the Lower Volcanic Formation of the Sops Arm Group is interpreted to be locally thrust over the Carboniferous conglomerates. The Anguille Group sedimentary rocks are commonly subvertical in orientation, and are juxtaposed against allochthonous Cambro-Ordovician rocks on the coast north of Hampden. Hyde (1982) provides more detailed descriptions of the Carboniferous formations in the area.

Although Carboniferous rocks are restricted to the south of the area, there is some evidence that the Carboniferous erosion surface was relatively close to the present land surface elsewhere. Along the Doucers Valley fault zone, and adjacent to it, limestone and marble outcrops locally contain chaotic breccia zones where carbonate fragments are contained in red, hematitic, partially clastic cement, and numerous fractures within more massive carbonate rocks are stained red. The most spectacular breccias, containing a wide variety of foliated and massive carbonate clasts, occur in Rattling Brook Gorge. These features are believed to record deposition within Carboniferous cave systems.

PALEOZOIC INTRUSIVE ROCKS

Diabase Dykes in Cambro-Ordovician Rocks

Numerous diabase dykes cut Cambro-Ordovician sedimentary rocks on the shores of Coney Arm and a few are exposed along the Cat Arm road. The dykes consist of fine-grained to aphanitic green diabase of generally featureless appearance, locally containing small plagioclase phenocrysts. Chilled margins are uncommon, but some larger dykes contain coarser-grained centres that have larger (1 cm) plagioclase phenocrysts. Most of the dykes strike between 070° and 090° and are subvertical. They postdate almost all fabric development in their host rocks, but earlier fabrics show dextral deflection against dyke contacts (Kerr and Knight, 2004). However, two dykes in inland outcrops may be cut by early faults, suggesting that more than one generation is present. Geochemical data (A. Kerr, unpublished) do not indicate any differences between these apparent generations of diabase dykes. Their absolute ages are unknown, aside from the fact that they must be post Middle Ordovician, as they cut rocks equated with the Table Head Group. Fresh diabase dykes showing similar trends also cut the Precambrian granites in the area around the Rattling Brook gold deposit, and are presumed to be of Paleozoic age. They are distinct from the Precambrian Long Range dykes, which trend roughly north-south and are retrogressed and/or metamorphosed (see above).

Granitoid Rocks

Large areas south of Sops Arm are underlain by intrusive rocks assigned to the Gull Lake Intrusive Suite. This includes gabbro, diabase, granodiorite and granite, within which several discrete units were defined by Smyth and Schillereff (1982). These rocks intrude the Sops Arm

Group, and possibly also parts of the Southern White Bay Allochthon. The petrology and geochemistry of these rocks were also discussed in more detail by Saunders and Smyth (1990). The Gull Lake Intrusive Suite gave an imprecise U-Pb age of ca. 400 Ma (Erdmer, 1986).

In the northeast, the Devils Room Granite intrudes Precambrian basement rocks and is in fault contact with metamorphosed carbonate rocks representing the southern extension of the Cambro-Ordovician platformal sequence. It is dominated by medium- to coarse-grained biotite granite, variably K-feldspar porphyritic. The pluton is described in detail by Dunford (1984). The most recent U-Pb dating of the granite indicates an age of 425 Ma (Heaman et al., 2002), superseding the earlier estimate of ca. 400 Ma (Erdmer, 1986).

It has been suggested that the Gull Lake Intrusive Suite and the Devils Room Granite are portions of an originally continuous body, now displaced by post-Silurian motions along the Doucer's Valley fault system. If this is so, the Gull Lake Intrusive Suite must also be of Silurian age. Saunders and Smyth (1990) considered the Gull Lake Intrusive Suite and Devils Room Granite to be geochemically similar, post-collisional, "I-type" granites, but this description applies to the majority of Siluro-Devonian plutonic suites across Newfoundland.

QUATERNARY GEOLOGY

The Quaternary history of the White Bay area was initially studied by Heyl (1937) and MacClintock and Twenhofel (1940). The most recent study, which incorporates a review of previous work and studies in adjacent areas, is by McCuaig (2003a).

The regional topography, with a few exceptions, is strongly controlled by the north-northeast regional strike of major bedrock units and faults; however, bedrock is glacially smoothed and striated, and valleys are over-deepened. The region's till deposits are generally thin and discontinuous, and only one till unit is recognized. Thick, hummocky till containing abundant large boulders (2-4 m in diameter) is found in the Micmac Pond area. Cosmogenic dating of some of these large boulders is underway, and will provide an absolute age for deglaciation in this area (T. Bell and J. Gosse, in prep.) Glaciofluvial deposits are found in major river valleys, and both ice-distal and ice-contact deltas are recognized. Two types of glaciomarine sediments are present: ice-proximal glaciomarine diamicton and raised beach deposits. The steep topography of the White Bay region has resulted in many recent mass-wasting deposits, notably large rockfalls associated with coastal cliffs, some of which have been glacially oversteepened. Landslides are particularly common in the area around Coney Arm and Coney Head.

Striations record the ice flow directions of the most recent (Wisconsinan) glaciation. Ice flow directions changed gradually over time, forming various configurations as glaciation progressed. A major ice flow event was north-northeasterly, essentially parallel to the present orientation of White Bay and regional bedrock strike. There is local evidence of an earlier eastward flow, but the latest and most dominant flow was towards the bay from uplands to the east and west (Figure 9). The early eastward ice flow apparently did not cross White Bay, because no carbonate clasts were found in tills on the east side of the bay. It probably reflects one of the

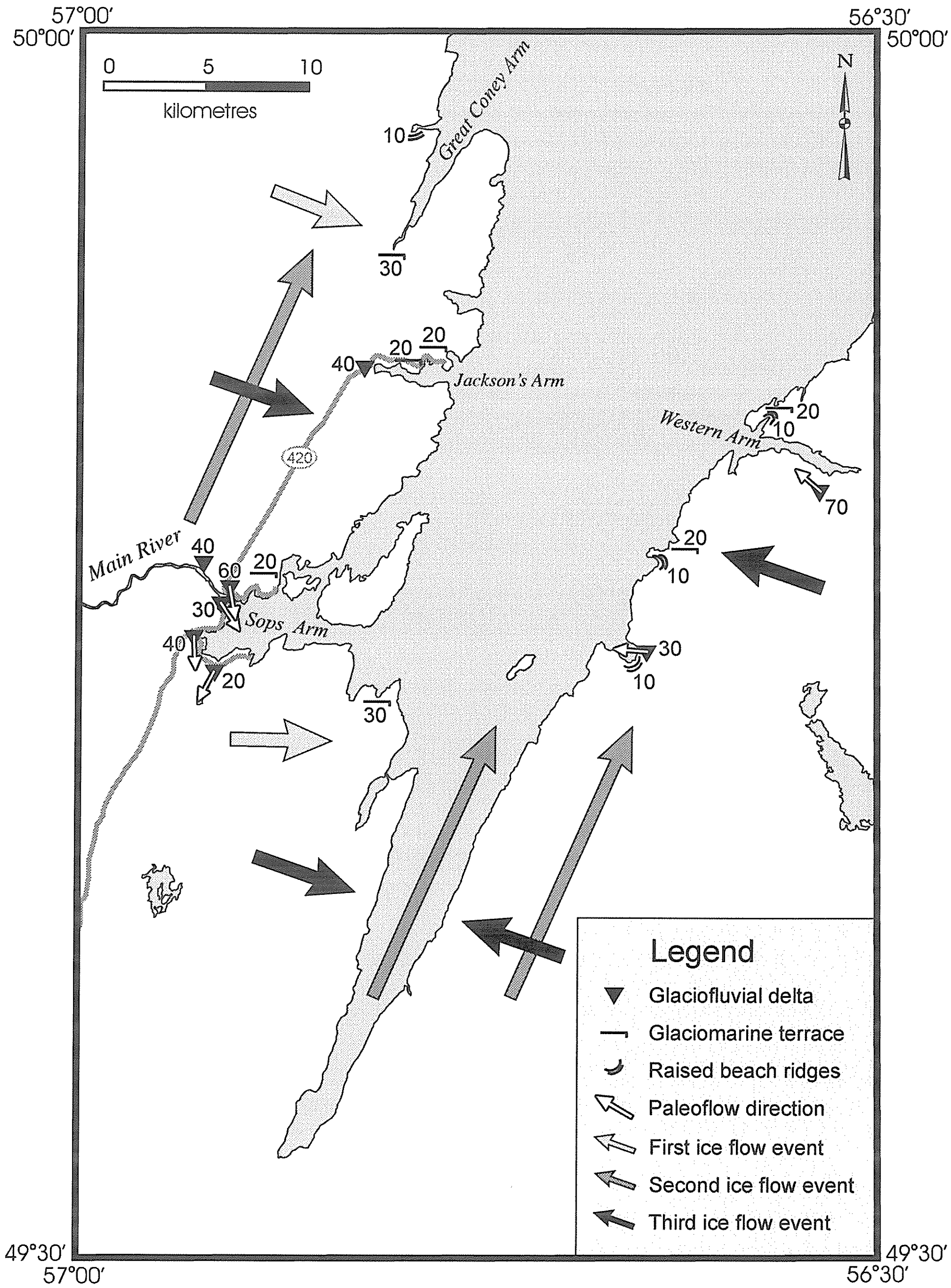


Figure 9. Ice flow directions and features recording sea level change in the White Bay area.

ice flow directions during ice build up, at the onset of glaciation. The second flow event was likely related to a major ice cap over central Newfoundland, and thus represents ice flow during the glacial maximum. The latest ice flow directions were probably related to smaller remnant ice centres in highland areas on either side of White Bay. These would have formed during deglaciation (McCuaig, 2003a).

There is widespread evidence for higher postglacial sea levels in the form of raised deltas and other features situated at intervals between 70 and 10 m above sea level (Figure 9). ^{14}C dating (summarized by McCuaig, 2003a) suggests that 40 m and 30 m sea level stands occurred ca. 11,200 and 10,200 radiocarbon years ago, respectively. A 41 m ice-contact delta, which underlies the town of Jackson's Arm, contains marine shells which were dated at 11 200 ± 100 yr BP. The younger dated site, near Corner Book Pond, is now grown over. Deltaic sediments in the Corner Brook Pond area have southerly paleocurrent directions, opposite to the present drainage direction. Ice in White Bay may have dammed the small valley, creating short-lived glacial lakes and causing meltwater to flow southward, away from the sea. Alternatively, there may have been a powerful southerly flow of meltwater from Doucers Valley, across Sops Arm.

Regional till sampling was conducted throughout the area as an aid to mineral exploration, and results are summarized by McCuaig (2003b). The geochemistry suggests that gold mineralization is likely present around the northern part of the Doucers Valley fault zone, which is highlighed by Au, As and Sb anomalies. Sb and As are more reliable geochemical indicators, due to the possible nugget effect of Au in till. However, a sample that gave very high gold and arsenic values was re-analyzed, and produced essentially the same results, ruling out the nugget effect. Follow-up soil geochemistry by Kermode Resources, based on this data, yielded 23 targets for further exploration. The regional till geochemistry data also suggests the possibility of gold mineralization in the Carboniferous Anguille Group, near Hampden, an area that remains untested. Anomalous values of copper, lead, zinc, iron and manganese are found in both areas. The distribution of Cr, Mg and Ni define smooth dispersal fans originating from mafic Dunnage Zone rocks to the southeast. For further discussion, and maps of till geochemistry results, see McCuaig (2003b).

STRUCTURAL EVOLUTION AND STRUCTURAL PROBLEMS

Introduction

The western White Bay area was subjected to at least five orogenic events between the Mesoproterozoic and the Carboniferous. In this light, it is hardly surprising that both regional and local structural patterns are complex, or that many aspects of the structural evolution of the area remain unclear. The separation of possible Taconic (Middle Ordovician), Salinic (Silurian) and/or Acadian (Devonian) fabrics and events is a particularly vexing problem, further exacerbated by widespread brittle deformation of presumed (but not proven) Carboniferous age along major fault systems, that masks much of their earlier history. The following treatment of structural geology is organized according to the ages of the rocks involved, and emphasizes the Paleozoic events. It draws upon previous discussions (Smyth and Schillereff, 1982; Owen, 1991) and upon work conducted in the last two years (Kerr and Knight, 2004; Kerr, unpublished data).

Structural Patterns in Precambrian Basement Rocks

The geological history of the Grenvillian Long Range Inlier is discussed in detail by Owen (1991) and Heaman et al. (2002), who recognize three periods of deformation and metamorphism at > 1032 Ma, 1022 Ma and 989 Ma, respectively. The latter events are synchronous with the emplacement of the two main groups of Precambrian plutons. A fourth episode is recorded by more local brittle-ductile shearing of the ca. 615 Ma Long Range dykes, and is thus likely of Phanerozoic age. However, the absolute age of this deformation is unknown, although it is presumed to predate the ca. 425 Ma Devil's Room granite (Owen, 1991).

Structural Patterns in Autochthonous Cambro-Ordovician Rocks

The narrow belt of platformal clastic and carbonate rocks along the western shore of Coney Arm is structurally complex. It has been previously discussed by Lock (1969) and Smyth and Schillereff (1982); the following description reflects a revised interpretation presented by Kerr and Knight (2004).

The five domains outlined in the context of regional geology (Figure 5) are also structural domains, although domain 1 (Precambrian basement) and domain 2 (basal Cambrian strata) have common characteristics. Domains 1 and 2 are separated by the sub-Cambrian unconformity, but all other interdomain boundaries are major faults (Figure 5). The most fundamental is a wide zone of strong deformation associated with the phyllites of the Forteau Formation, here termed the Cobbler head fault zone. This is a zone of structural imbrication, rather than a single discrete structure. A second major fault zone, termed the Apsy cove fault zone, merges with the Cobbler head fault zone in the south, and a third fault zone defines the western boundary of rocks assigned to the Table Head Group. In general, the strata dip steeply east, and also face in that direction, although there are local exceptions to both rules. The major structures that separate various domains also generally dip eastward, or are subvertical. Between the major faults, the original features and stratigraphy are well-preserved, but there are local zones of strong deformation, notably around major lithological boundaries.

The Cobbler head fault zone represents the major detachment within the sequence. Moving southward along this zone, the upper part of the Labrador Group, the entire Port au Port Group, and the basal part of the St. George Group are progressively excised, until the middle part of the St. George Group (Catoche Formation) is juxtaposed directly against the Forteau Formation phyllites. To the east, the Apsy cove fault zone places Cambrian rocks of the Port au Port Group structurally above the Ordovician St. George Group on the coast, suggesting that it was originally a thrust fault. In the south of the area, the Cobbler Head and Apsy Cove fault zones zones are partially coincident, and lozenges of presumed St. George Group limestones (and probably other rock units) are locally trapped between them. Figure 5 is undoubtedly a gross oversimplification in this part of the area.

Siliciclastic and carbonate rocks have well-developed cleavages and foliations that in most cases are subparallel to bedding. Strong mylonitic fabrics are developed in fault zones, notably in the Apsy cove fault zone, which appears to have avoided most later brittle deformation. The fault zone is developed largely within the upper Catoche Formation, and calcareous mylonites developed by extreme stretching of bioturbated limestones and dolostones are common within it. The Cobbler head fault zone and the Forteau Formation phyllites within and beneath it contain minor folds that suggest westward or northwestward transport of cover rocks over the Precambrian basement. The most obvious structures elsewhere in the carbonate rocks are generally suggestive of dextral transcurrent motions, but this is likely just the latest event in the deformation sequence, and postdates the development of the strong fabrics and the fault zones. In the Apsy cove fault zone, on the coast, there are suggestions of an earlier (?) sinistral shearing, but kinematic analysis is complicated by a lack of lineations and wide variations in fold hinge plunges (Kerr and Knight, 2004). Gently-plunging lineations are recognized in some rocks derived from bioturbated limestones. Undated diabase dykes mostly crosscut the strong foliations, and also cut minor structures believed to record later dextral shearing. However, dextral motions were associated with the emplacement of many of the dykes, because earlier fabrics are deflected into parallelism with their margins. There are, however, examples of possible early dykes that are cut by faults interpreted as thrusts.

Overall, the structural patterns in these rocks imply at least two major periods of ductile deformation. The first likely involved northwestward transport of cover over the basement rocks, and the development of low-angle thrust faults. The major detachment surface developed within the weakest component of the original stratigraphy, (the Forteau Formation shales) and the basal unconformity was preserved. The second event involved steepening of the rocks to their present attitude, accompanied and/or followed by dextral shearing. The earlier thrusting event may be recorded by variably preserved indications of earlier sinistral motion and/or east-side-up motion. Diabase dykes were emplaced after dextral shearing, but continued (or renewed) dextral motions occurred along their margins. Smyth and Schillereff (1982) also noted the possibility of early thrusting, and suggested that this early event was related to the Ordovician Taconic Orogeny. It is tempting to view the major two deformational episodes as Ordovician and Siluro-Devonian respectively, but there is no firm evidence as to absolute timing, and both events could be Siluro-Devonian. Clearly, dating of the dykes could shed light on this problem, and some other problems discussed below.

The eastern boundary of the platformal sequence is formed by the Doucers valley fault zone (Figure 5). In most areas this zone is characterized by intense brittle deformation, and provides little information about earlier events. However, in the lower part of Rattling Brook Gorge, the rocks fault is defined by mylonites believed to represeent transposed carbonate and siliciclastic rocks. It is suggested that the Doucers valley fault zone originated as a major thrust fault of the same generation as the Apsy Cove fault zone and the Cobbler Head fault zone. As suggested by Smyth and Schillereff (1982), it may originally have been the basal emplacement structure for the Southern White Bay Allochthon.

All of the major structures within the Cambro-Ordovician sequence have been subjected to later brittle deformation, and such effects are pervasive along the Cobbler Head and Doucers Valley fault zones. The Table Head Group limestones are tectonically brecciated adjacent to the latter structure, and riddled with late calcite veins. This likely accounts for the development of karst weathering forms over this unit.

Structural Patterns in the Southern White Bay Allochthon

Smyth and Schillereff (1982) suggested that allochthonous and autochthonous Cambro-Ordovician rocks should have a common structural history. This idea is difficult to verify, because the rocks in the lower part of the Southern White Bay Allochthon are strongly affected by brittle deformation, and the massive igneous rocks in its upper part are generally unresponsive to deformation.

The Murrays Cove formation contains a well-developed schistosity and exhibits compositional layering derived by stretching and transposition of original volcanic heterogeneities. The epidote-rich and hematite-rich bands and lenses are typical of deformed pillow lavas and pillow breccias. Relict pillow structures are visible in some outcrops, and varioles and/or amygdules within them have been stretched. Steeply-plunging lineations appear to be most common, and some outcrops have a distinctly "rodded" appearance. Trondhjemites of the Coney Head complex have a strong cataclastic to ductile fabric adjacent to their unconformable contact with the Sops Arm Group (see below). However, no argument can be made that the unconformity truncates an earlier fabric in the trondhjemites, because the felsic rocks are equally deformed. The age of deformation at this site is thus certainly post-Silurian, and there is a strong, steeply-plunging downdip lineation, which resembles fabrics observed in the Murrays Cove formation, and in some Silurian units (see below). At the present time, most of the fabrics and structures in the allochthon are viewed as Silurian or younger, although there must be an earlier history, possibly locally preserved within the Doucers valley fault zone (see above).

Structural Patterns in Silurian Rocks

The deformation state of the Silurian Sops Arm Group is highly variable. Many volcanic rocks and conglomerate units have well-preserved primary volcanic and sedimentary features. However, these rocks usually contain a well-developed cleavage, and locally they exhibit strong penetrative fabrics with intense flattening or stretching. Finer-grained siliciclastic and volcaniclastic rocks show a similarly wide range in deformation state, but are commonly more cleaved and deformed than their more massive counterparts. Most outcrops contain only a single obvious penetrative fabric, but there is local evidence for more than one event.

In a regional sense, the Sops Arm Group mostly dips eastward, and faces in the same direction, but Smyth and Schillereff (1982) mapped open folds in the east of the area, notably north of Jacksons Arm (Figure 8), which lead to reversals of this pattern. The folds become tighter to the west, towards the Doucer's Valley Fauly system, and the axial planes become inclined to the west. In general, the degree of metamorphism and deformation also increases from east to west, and the metamorphic grade increases southward. The boundaries between various units within the Sops Arm Group are generally not exposed, but many are interpreted as faults (Smyth and Schillereff, 1982; Figure 8). Strongly deformed zones are located adjacent to some of these unit boundaries, also implying that they are tectonized. In most cases, strongly deformed rocks exhibit strong downdip linear fabrics. In conglomeratic and/or fragmental units, this downdip lineation is manifested by locally intense stretching of clasts. The magnitude and sense of motions along these internal faults are essentially unknown. As discussed subsequently, some of these faults may have an important control upon gold mineralization.

In the north of the area, around Coney Head, the ophiolitic rocks of the Coney Head Complex are apparently thrust over a quartz-sericite schist believed to represent altered felsic volcanic rocks of the Sops Arm Group (Smyth and Schillereff, 1982; Figure 8). Local imbrication of the Southern White Bay Allochthon and Sops Arm Group along the Doucers Valley Fault System (Smyth and Schillereff, 1982) also indicates that this zone has an important Silurian history in addition to the possible Ordovician emplacement of the allochthon over the platformal rocks. The majority of the Paleozoic plutonic rocks are massive and undeformed, aside from brittle deformation adjacent to major faults. However, granodiorite of the Gull Lake Intrusive Suite is locally foliated, implying that this large plutonic body was in part syntectonic (Smyth and Schillereff, 1982; Saunders and Smyth, 1990). It is clear that Siluro-Devonian deformation, generally labelled as "Salinic" and/or "Acadian" was important and widespread, and must also have affected Ordovician rocks and reactivated major structures within these older rocks.

Structural Patterns in Carboniferous Rocks

Tight upright folds of the Anguille Group (Hyde, 1979) indicates that Carboniferous or younger deformation was also important. The younger Deer Lake Group was apparently not affected in the same way (Hyde, 1979), and it is possible that its deposition postdates this deformation. The Silurian Sops Arm Group has, however, been thrust over the Deer Lake Group in the area around the Turners Ridge lead deposit (Dimmell, 1979; Saunders, 1991). Brittle deformation, manifested largely by intense fracturing, tectonic brecciation, crenulation of older fabrics and disharmonic chevron-style folding, is widely associated with the Doucers Valley Fault zone and (to a lesser extent) with other regional faults. All of these faults are inferred to have been sites of strike-slip motion during the Carboniferous (Hyde, 1979; Smyth and Schillereff, 1982).

ECONOMIC GEOLOGY

Introduction

Western White Bay contains a wide variety of metallic and nonmetallic mineral occurrences. The area has a long history of exploration activity and was the site of both the first gold discovery in Newfoundland (the West Corner Brook prospect) and our first producing gold deposit (the Browning Mine). Much of the following is drawn from previous accounts by Snelgrove (1935), Smyth and Schillereff (1982), McKenzie (1987), Tuach (1987a, b), Poole (1991), Saunders and Tuach (1988, 1991) and Saunders (1991). Discussion of sedimentary-rock-hosted gold mineralization is based upon more recent work by Kermode Resources (unpublished) and by Kerr (2004). The locations of important mineral prospects are indicated in Figure 10, adapted from Tuach (1987b)

Gold Mineralization in Precambrian granites and Cambro-Ordovician Sedimentary Rocks

In the early 1980's, prospector Clyde Childs discovered auriferous gossans in Precambrian granites along the Cat Arm hydro access road. Almost ten years later, similar mineralization was discovered in the unconformably overlying quartzites and carbonate rocks. This extensive zone of disseminated Au mineralization, termed the Rattling Brook gold deposit, is the most important occurrence in the area in terms of total resources. The deposit is now attracting renewed attention, with current exploration focused largely in the sedimentary rocks, for which a Carlin-type exploration model has been proposed (e.g., Wilton, 2003). The Rattling Brook Gold Deposit contains four main zones. The *Road Zone* and *Incinerator Trail Zone* are hosted entirely by the Precambrian Apsy Granite, whereas the *Beaver Dam Zone* is hosted almost entirely by Cambrian sedimentary rocks. The *Apsy Zone* is hosted by both granites and adjacent sedimentary rocks, and mineralization is continuous across the unconformity that separates them. Most previous descriptions of mineralization (McKenzie, 1987; Tuach and Saunders, 1988, 1991; Poole, 1991) emphasize the granitoid-hosted environment. Field work in 2003 and 2004 emphasized sedimentary-rock-hosted mineralization in the Apsy and Beaver Dam zones (Kerr, 2004)

The granitoid-hosted mineralization is similar in all areas. It is dominated by disseminated pyrite and minor arsenopyrite, associated with a complex network of tiny fractures and thin veinlets that also contain quartz and Fe-carbonate. It is in many respects more like "porphyry-style" mineralization, and discrete megascopic mineralized veins (typical of most mesothermal gold deposits) are conspicuously absent. Typical mineralization contains only a few percent dispersed sulphides. Mineralization also occurs in "pretectonic" mafic dykes that cut the granites; these are considered to be Long Range dykes. The mineralized dykes are strongly sericitized and pyritized, and appear superficially felsic where strongly altered. The general range of grades is only 0.5 to 2 ppm Au, with local enrichment up to 4 - 6 ppm Au, notably where dykes are present. These low average gold grades represent the most significant obstacle to further exploration and development. Figure 11a shows a cross section through the Road Zone. Here, the mineralization is extensive, and individual drill intersections range up to 67 metres at 1.1 ppm Au, with local sections containing up to 5 ppm Au. Saunders and Tuach (1988, 1991) linked physical

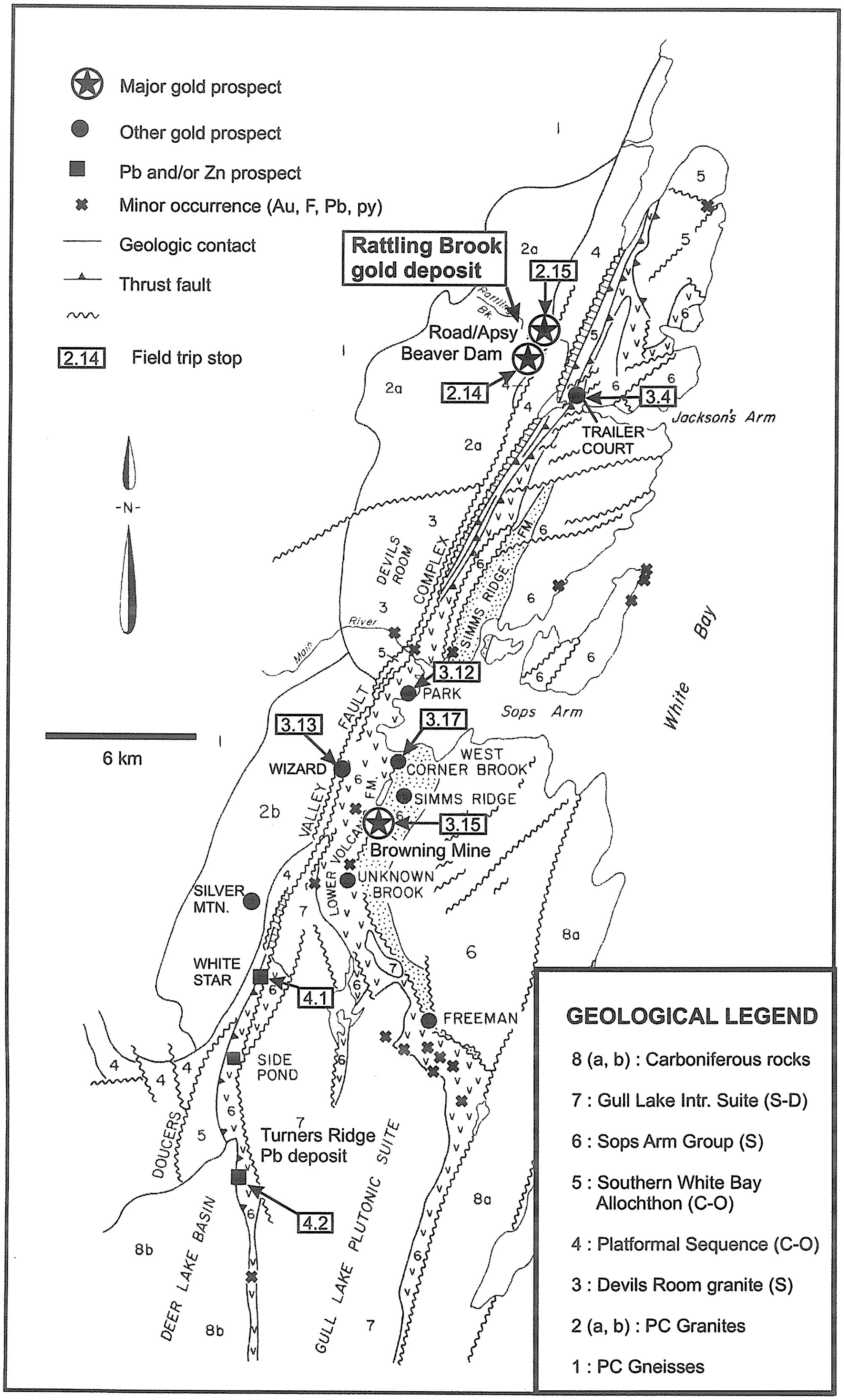


Figure 10 : Locations of important mineral prospects and showings in western White Bay, indicating locations of field trip stops. Diagram modified after Tuach (1987b).

and mineralogical changes in the host rocks to geochemical patterns, and established the timing of alteration events. They demonstrated that intense potassic alteration of the original granodiorites is an early large-scale metasomatic event, which is generally not associated with Au enrichment where present alone. This regional alteration is them overprinted by more localized effects, notably Na-metasomatism, spatially associated with the auriferous vein and fracture systems. The sulphides are mostly pyrite and arsenopyrite, with minor pyrrhotite, galena, chalcopyrite and tennantite; the minor sulphides generally form inclusions in the pyrite. Gold was observed only very rarely, as clusters of small grains ranging from < 1 μm to around 15 μm in diameter, generally bound within pyrite. It is not firmly known if "invisible" (refractory) gold is present in the pyrite or arsenopyrite, but metallurgical test results reported by BP-Selco in the late 1980s suggest that this is possible. Diabase dykes of presumed Paleozoic age cut the mineralized zones and appear unaltered and unmineralized; however, they also remained undated, and do not (yet) provide any age constraints.

Cross-sections of the Beaver Dam and Apsy Zones are shown in Figures 11b and 11c. Mineralization in Cambrian sedimentary rocks is close to the sub-Cambrian unconformity, and generally localized between this zone and major faults (conjoined Cobbler Head and Apsy Cove fault zones) that define the structural base of grey to buff dolostones, assigned to the Petit Jardin Formation of the Cambrian Port au Port Group. Locally, grey limestones of probable Ordovician age form the hanging wall; these are probably tectonic lozenges caught within the fault zones. The distribution of gold mineralization in sedimentary rocks at the Beaver Dam and Apsy zones is not strictly controlled by stratigraphy or rock type (Poole, 1991; Kerr, 2004). It is present in the Forteau Formation carbonate rocks, Bradore Formation quartzites, and also within altered granite beneath the unconformity at the Apsy Zone (Figure 11). However, there is some stratigraphic influence, because the strongest Au enrichment is generally within the calcareous, magnetite-rich rocks that occur at the transition between Bradore Formation and Forteau Formation. The highest gold assays commonly correspond with "calcareous ironstones", in which magnetite is variably replaced by pyrite (Poole, 1991). There is a strong correlation between gold and arsenic, and arsenic profiles are essentially identical in shape to the gold profiles. However, high As values are locally present in the upper dolostones, accompanied by only trivial Au enrichment. Arsenic is thus a fellow traveller with Au, but not necessarily a pathfinder on a local scale.

In drill core, the auriferous zones are mostly characterized by fine-grained disseminated pyrite, and lesser cross-cutting pyritic veinlets. Magnetite-rich rocks near the Bradore-Forteau formational boundary commonly show partial to complete replacement of magnetite by pyrite. Pyritic limestones are cut by silica veinlets, and may be partly silicified, but there is little or no sign of alteration in mineralized quartzites. A pink mineral observed in small crosscutting veinlets is suspected to be K-feldspar, and a soft, white "clay-like" alteration is locally evident in mineralized carbonate rocks. Mineralization hosted by granitoid rocks in the lowermost sections of holes at the Apsy Zone closely resembles its counterparts in the Road Zone. The grades of sediment-hosted gold mineralization are in generally higher than those recorded from granite-hosted mineralization. For example, grab samples of pyritic quartzite from the Beaver Dam Zone contain up to 35 ppm Au. Drill intersections from BP-Selco work in the late 1980s include 3.5 m of 5.5 ppm Au, including 2 m of 7.5 ppm Au, and 2.1 m of 7.3 ppm Au (Poole, 1991). Previous results from the Apsy Zone include 2.5 ppm Au over 6.5 m, and 4.1 ppm Au over

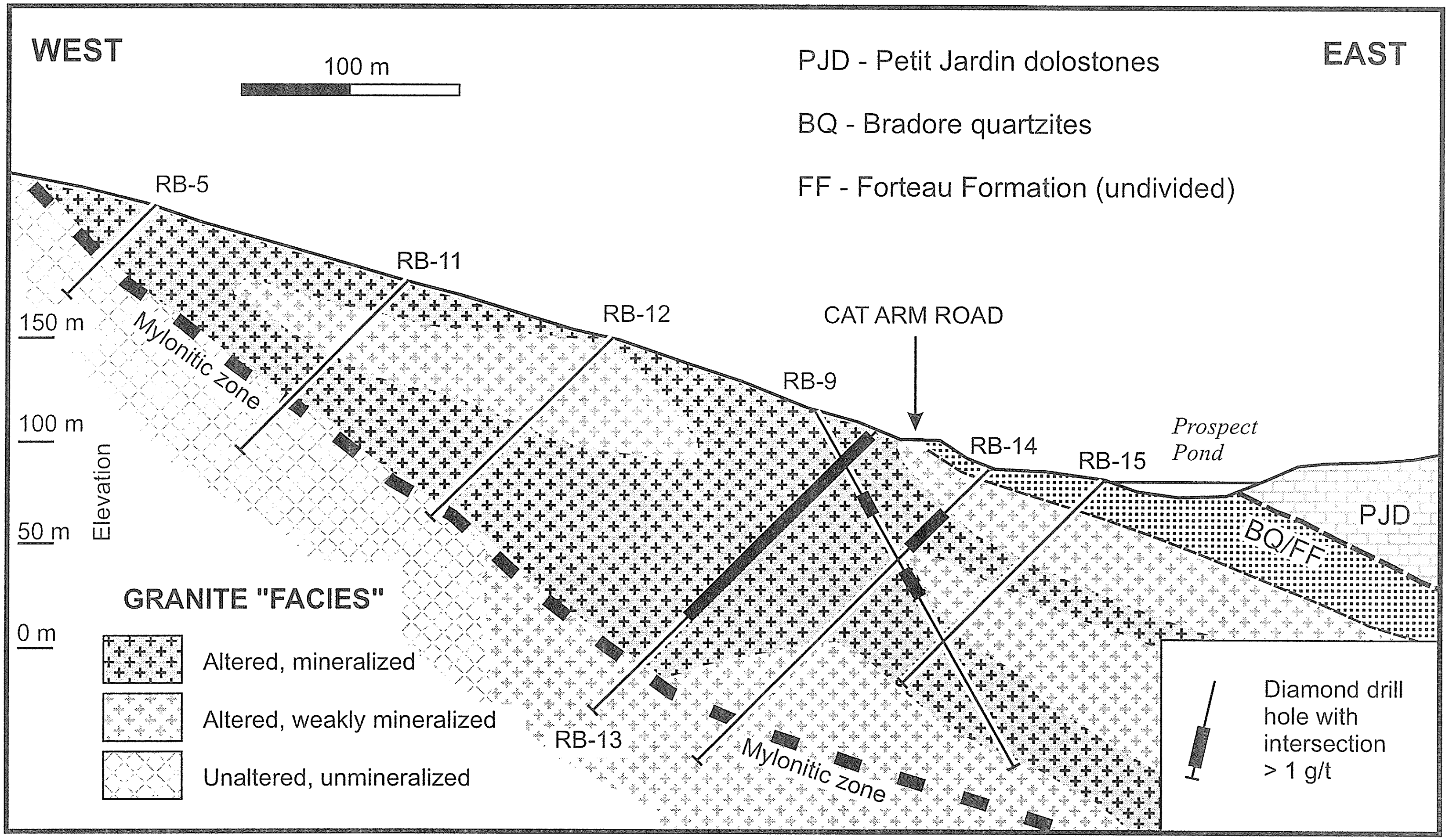
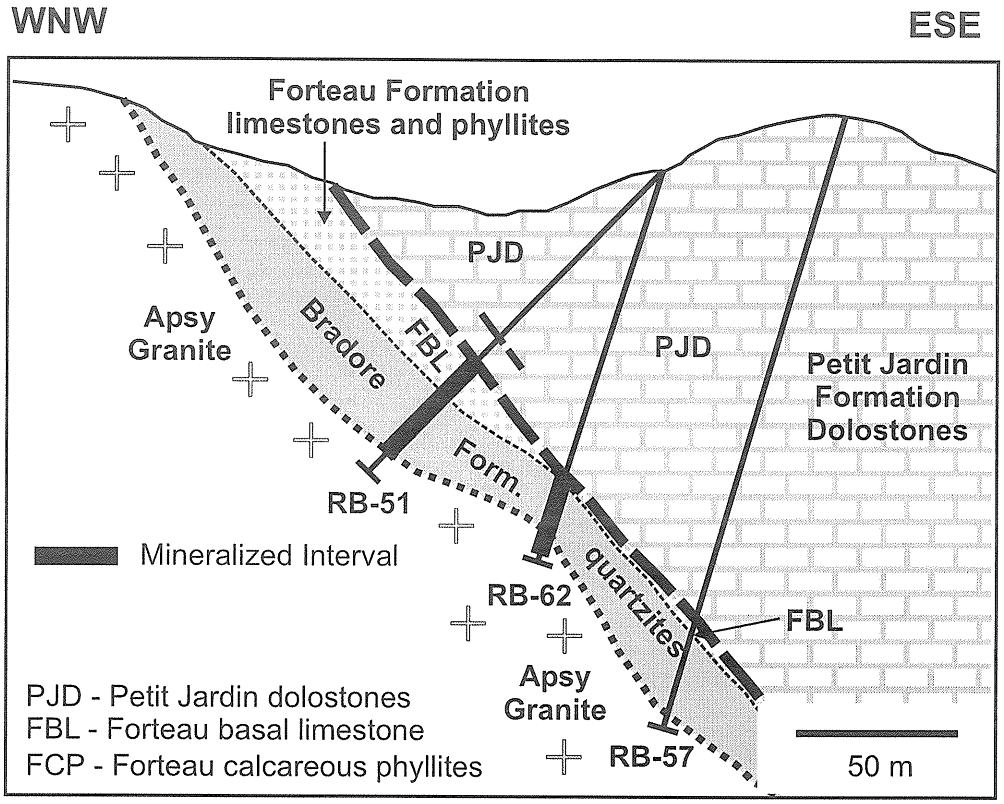


Figure 11(a) : Simplified cross-section of the Road Zone prospect at the Rattling Brook gold deposit. Based upon cross-sections prepared by South Coast Ventures and Kermode Resources, using data from BP-Selco Exploration programs in the late 1980s.



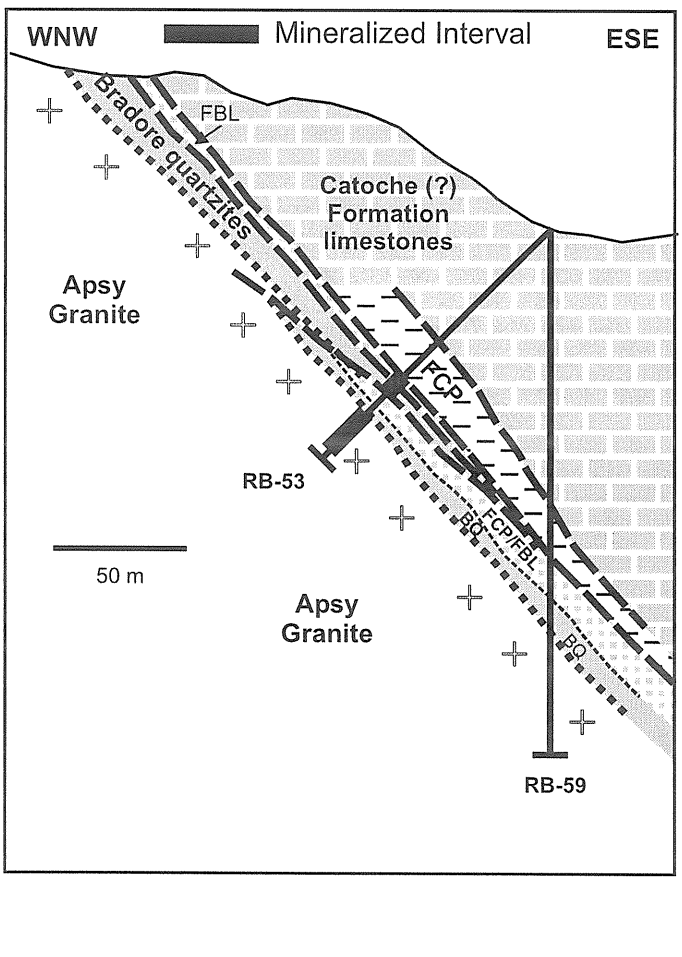


Figure 11 (b). Simplified cross-sections through mineralized zones at the Beaver Dam Prospect.

Upper diagram shows southern part of the zone; lower diagram shows northern part of the zone.

After Kerr (2004)

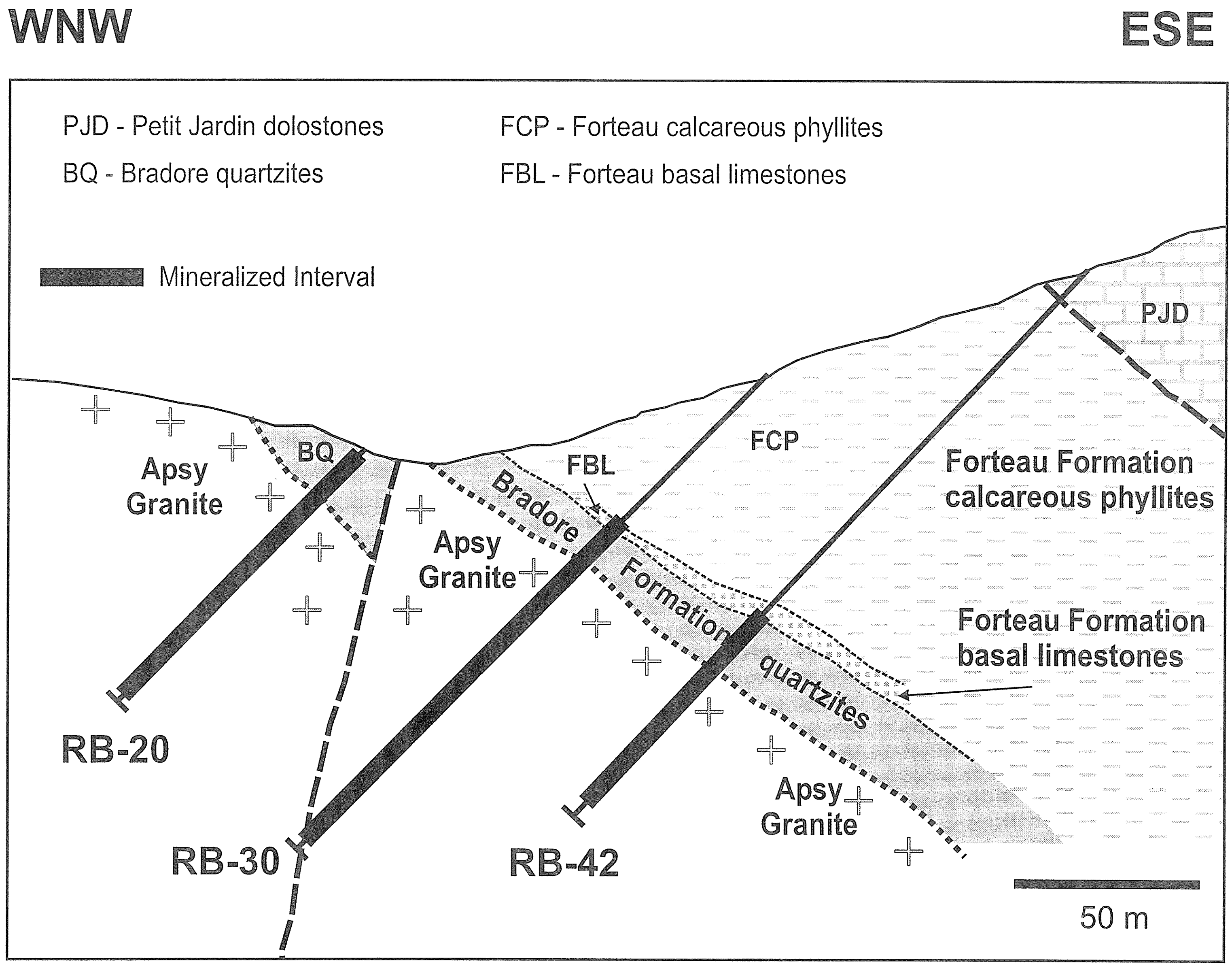


Figure 11(c). Simplified cross-section through the Apsy Zone of the Rattling Brook gold deposit, showing mineralization in the Apsy Granite and in overlying sedimentary rocks.
After Poole (1991) and Kerr (2004).

3 m (Poole, 1991). Renewed drilling in both areas in 2003-04 produced similar intersections, with grades of over 10 ppm Au over narrow widths within them (Kermode Resources, press releases, 2004). Individual mineralized samples analyzed by Kerr (unpublished data) contain grades in excess of 16 ppm Au. Kermode Resources have also drilled some holes within sedimentary rocks outside the main area of mineralization, and some of these contain anomalous Au values (up to 0.5 ppm Au) in higher phyllitic parts of the Forteau Formation.

Disseminated sulphides of supposedly similar type, associated with variable Au enrichment, also exist at the Silver Mountain prospect, within the Precambrian Main River Granite (Figure 10).

Gold Mineralization in the Sops Arm Group

Vein-hosted gold mineralization has been known in the Sops Arm area for over a century, and has been previously described by Snelgrove (1935), Smyth and Schillereff (1982), Tuach (1987b) and Saunders (1991). Some of these occurrences were reexamined briefly in 2004, but much of the following account is drawn from the sources listed above, with minor revisions. From a regional perspective, most of the gold occurrences are located within the Lower Volcanic Formation or the overlying Simms Ridge Formation (Figures 8 and 10), and there may be a spatial association with the boundary between these units, which is believed to be a fault.

The best-known deposit is the former Browning Mine, located a few kilometres south of Pollards Point, in the valley of Corner Brook. This short-lived deposit produced some 150 troy ounces of gold in 1903 and 1904, but attempts to reactivate it in the 1930s by Hans Lundberg (Lundberg, 1936) were unsuccessful. Today, the original adit remains, but there is almost no trace of mining infrastructure; three shafts were recently filled in by the Mineral Lands Division, and little remains of the waste dumps. The gold mineralization was hosted by quartz-carbonate veins up to 1 m in width, which contained disseminated pyrite, chalcopyrite, sphalerite, and galena. The veins reportedly contained free gold as wires and nuggets. Much of the finer-grained gold was apparently associated with sphalerite and galena (Murray and Howley, 1918, referenced by Saunders, 1991). There is little information about ore grades, but Saunders (1991) reports values of 4.8 to 7.2 ppm Au from limited exploration work conducted in the 1980s by BP-Selco. High Ag values were also reported by the early workers. The veins are hosted by calcareous sedimentary rocks of the Simms Ridge Formation, and appear to be localized above a shallow-dipping, schistose zone interpreted as a fault; some veins appear to be folded and boudinaged, but the majority are discordant and rectilinear, but at low angles to the local cleavage in this zone. The contact with the Lower Volcanic Formation occurs a short distance to the west of the deposit. Alteration around and structurally below the vein system is described as carbonate- and sericite-dominated, with minor disseminated pyrite. Brown spots (termed siderite spots) are a common feature of the Simms Ridge Formation in the area around the mine, but it is hard to demonstrate a clear spatial relationship to the veins. However, there may be more pervasive Fe-carbonate alteration haloes superimposed upon this texture around some of the veins, and there are local areas where carbonate alteration is intense around closely sheeted veins.

The Unknown Brook prospect is hosted by similar quartz-carbonate (+/- feldspar) - dominated veins that cut a conglomeratic unit at the top of the Lower Volcanic Formation, near its contact with the overlying Simms Ridge Formation. These are described as syndeformational (Saunders, 1991) as they vary from concordant to discordant with respect to cleavage. Veins at Unknown Brook contain pyrite, galena and rare stibnite, and gold is present largely as electrum (Burton, 1987, referenced by Saunders, 1991). Grades are locally very high, up to 79 ppm Au; the best intersection reported from previous drilling was 8.6 ppm Au over 2.6 m (Saunders, 1991). There is a zone of intense deformation, sericitic alteration and pyritization located structurally below (west of) the quartz vein system, but this is not reported to be auriferous. The protolith for this zone is believed to be a felsic volcanic or tuff. This rock type exhibits a strong fabric with the well-developed downdip lineation characteristic of many deformed zones in the Sops Arm Group.

Other Au occurences in this part of the Sops Arm Group include the Simms Ridge and Freeman Prospects (in the Simms Ridge Formation), the West Corner Brook prospect (Lower Volcanic Formation) and several other smaller occurrences near highway 420. Details of these are reviewed by Saunders (1991), and they have much in common with the above deposits. Saunders (1991) also reported auriferous quartz veins within the posttectonic Big Davis Pond granite of the Gull Lake Intrusive Suite, adjacent to its contact with the Sops Arm Group.

Other Gold and Silver Occurrences

Minor Au mineralization is reported from the Murray's Cove formation of the Southern White Bay Allochthon, where it is associated with quartz-carbonate-fuschite alteration of metavolcanic rocks. Small-scale Au and Ag mineralization is reported from quartz veins and pegmatites cutting massive igneous rocks of the Coney Head Complex, but there is little information on these and at least one reported instance (Dossenger Cove showing) proved impossible to relocate in 2004. Quartz veins within a quartz monzonite sill in the Natlins Cove Formation of the Sops Arm Group contain minor argentiferous galena at the Schooner Cove showing (Figure 10).

Lead and Zinc Mineralization in the Sops Arm Group

The Turners Ridge Prospect (Figure 10) is a subeconomic Pb deposit hosted by a dolomitic limestone unit within the Lower Volcanic Formation of the Sops Arm Group. It was originally discovered by prospecting and drilling carried out by Noranda Exploration, and was subsequently excavated during upgrading of Route 420; it now forms a spectacular roadside gossan. The deposit is estimated to contain some 200,000 tons of 3 to 4 % Pb. Lead mineralization is in the form of vein- and stockwork-like galena in strongly brecciated dolostone that is variably replaced by calcite. Minor mineralization also occurs in associated rhyolites. Minor pyrite, barite and sphalerite are also reported (Tuach, 1987b; Saunders, 1991). A schematic cross-section through the deposit is shown in Figure 12; the host limestones are interpreted to have been thrust over boulder conglomerates of the Carboniferous Deer Lake Group. Minor Pb mineralization of similar type (but lower in grade) occurs at the Side Pond showing, a few kilometres along strike from Turners Ridge. Saunders (1991) suggested that the Pb mineralization could be of Carboniferous age, perhaps introduced by metalliferous brines expelled from the Deer

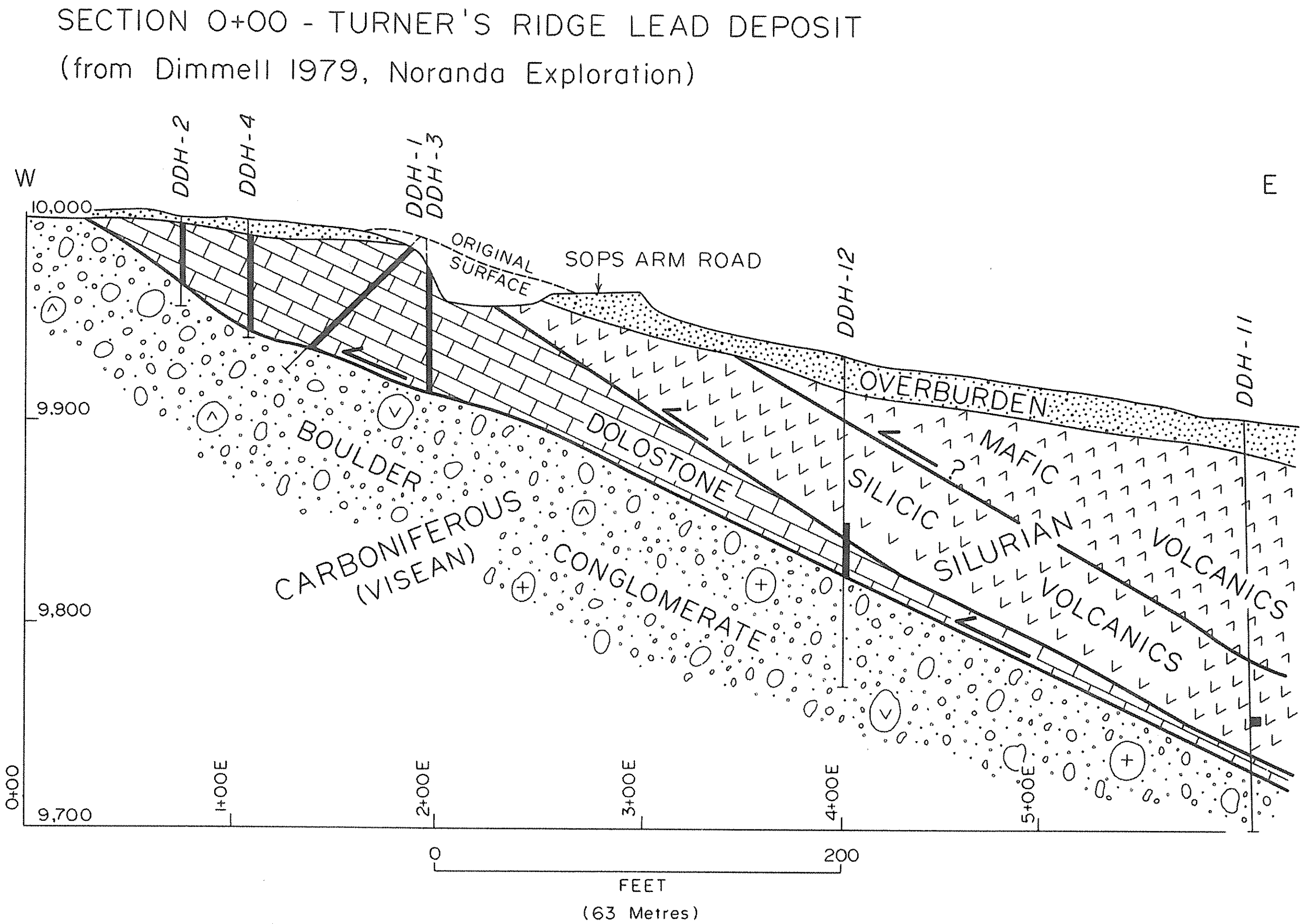


Figure 12 : Cross-section of the Turners Ridge lead deposit, showing the thrust contact between Silurian volcanic and carbonate rocks, and Carboniferous conglomerates of the Deer Lake Group.

From Saunders (1991), modified from Dimmell (1979).

Lake Basin to the south. The principal argument for a Carboniferous age is that mineralization appears to transgress a rhyolite-dolostone contact interpreted as a Carboniferous thrust; however, mineralization is apparently truncated by the more significant fault that juxtaposes the dolostones with boulder conglomerates of the Deer Lake Group (Figure 12). Recently discovered Zn mineralization at the Whitestar prospect, north of Turners Ridge, is hosted by similar carbonate rocks, and appears to be similar in overall style.

Other Metallic and Nonmetallic Mineralization

Fluorite, molybdenite and chalcopyrite are reported from some of the plutonic rocks in the area (Smyth and Schillereff, 1982; Saunders, 1991). The limestones here assigned to the Table Head Group have received some attention due to their relative purity, and test extraction has been carried out on Coney Arm, which is a natural deep-water harbour (Howse, 1995, and references therein). Several small occurrences of marble are present along the Doucers Valley Fault system, within tectonic slivers of Cambro-Ordovician platformal rocks. Some of these display interesting textures that reflect Carboniferous paleokarst development and groundwater flow. These have been used as ornamental stone in various craft applications by Meyer's Minerals of Pasadena. Thin sulphide-bearing veins in some of the limestones drilled in the Rattling Brook area also contain significant amounts of Zn (up to 5% Zn over narrow widths; Kerr, unpublished data). A zinc showing was reported by Tuach (1987b) in limestones at Little Coney Arm, and consists of sulphides associated with quartz-carbonate veins; however, samples collected in 2004 were only weakly anomalous in zinc, suggesting that the reported galena and sphalerite must be very localized within the zone.

SUMMARY AND DISCUSSION

Introduction

The preceding sections of this document attest to the geological diversity and complex evolutionary history of the western White Bay area. This final brief section attempts to highlight some of the key aspects of the geology, and introduce some of the interesting unresolved problems. It also provides a review of ideas concerning the genesis of mineralization.

Cambro-Ordovician Stratigraphy

It has long been recognized that the Cambrian and Ordovician sedimentary rocks exposed along the west side of Coney Arm were generally correlative with the less-disturbed platformal sedimentary rocks of the west coast (Neale and Nash, 1963; Smyth and Schillereff, 1982), but detailed correlations have not previously been made. Recent work (Kerr and Knight, 2004) has shown that almost all of the "classic" platformal stratigraphy can be recognized in White Bay on lithostratigraphic grounds. In terms of sedimentary facies association, the stratigraphic sequence recognized in White Bay area most closely resembles that defined in the Canada Bay area, which represents a more distal environment compared to the Gulf of St. Lawrence area. This improved understanding of the stratigraphy in western White Bay provides important keys to understanding the structural evolution of these rocks, although many difficult problems remain. Biostratigraphic control is still lacking for much of the sequence, as macrofossils are rare, and most of the samples collected in 2003 lacked conodonts, probably due to pervasive recrystallization.

Affinity of Sedimentary Rocks in the Southern White Bay Allochthon

The Southern White Bay Allochthon is poorly known compared to the classic allochthons of the Humber Arm area. The largely massive intrusive rocks of the Coney Head Complex are dominated by quartz-rich trondhjemites and tonalites that resemble Cambro-Ordovician intrusions in the Dunnage Zone (e.g., the Twillingate pluton) and igneous rocks in higher slices of the Humber Arm Allochthon (e.g., the Little Port Complex). However, U-Pb geochronology (Dunning, 1986) demonstrates that at least some granitic rocks in the Coney Head Complex are of Silurian (ca. 430 Ma) age, and must therefore postdate emplacement of the allochthon. The Murrays Cove formation appears to be largely of metavolcanic origin, and the recent recognition of altered ultramafic rocks associated with it strengthens its connection with oceanic crust.

Although the igneous and metaigneous rocks are good candidates for transported Dunnage Zone rocks, the affinities of some of the sedimentary rocks in the Southern White Bay Allochthon are less clear, because some of them are not dissimilar to parts of the platformal sequence immediately to their west. In particular, the units immediately adjacent to the authochthonous sequence contain carbonate beds in addition to siliciclastic material. Smyth and Schillereff (1982) considered the possibility that these were actually part of the autochthonous sequence, but rejected this interpretation. The highest part of the platformal sequence in western Newfoundland consists of deep-water limestones and black shales in the upper part of the Table Head Group, followed by flyschoid clastic sedimentary rocks of the Goose Tickle Group, that were derived from the approaching allochthons. Outcrops in Rattling Brook Gorge and near the junction of the Cat Arm Road and Route 420 could be interpreted to represent these uppermost strata. This revised view requires that the course of the Doucers Valley fault zone be adjusted by a few hundred metres in some areas. However, it does *not* imply that all of the sedimentary rocks in the Southern White Bay Allochthon should be reassigned, because other allochthons in Newfoundland contain deep-water pelagic shale-carbonate assemblages (e.g., the Cow Head Group, in Gros Morne National Park).

Stratigraphy and Setting of the Sops Arm Group

Until recently, the Sops Arm Group was the *only* Silurian cover sequence in Newfoundland that was actually known to host precious metal and base metal mineralization. Despite this attribute, and the presence of many well-exposed coastal sections, the Sops Arm Group remains poorly known compared to the Springdale and Botwood groups of central Newfoundland. The Sops Arm Group covers a relatively small area, and is in general much better exposed than the other sequences, albeit more strongly affected by deformation. It also differs from the Springdale and Botwood groups in that it does not contain any sedimentary rocks of red-bed type.

Although there is a formal stratigraphy for the Sops Arm Group (Figure 7), it is by no means clear if this sequence is complete or even in stratigraphic order, because many of the boundaries between the formations are known to be or suspected to be faults. West-directed Silurian thrusting and/or reverse faulting has been suggested by several previous workers, and raises the possibility that some of the supposedly younger components in the east could be equivalent in age to, or perhaps older than the formations in the west. It has also been suggested that the Sops Arm Group represents a "caldera sequence", largely by analogy with the better-known Springdale Group (Coyle and Strong, 1987; Tuach, 1987a, b). Although no attempt has ever been made to place the various formations of the group formally into such a context, this interpretation implies strong lateral facies variations. There are also virtually no published geochemical studies of the volcanic rocks of the Sops Arm Group, nor are there any geochronological data from them. Saunders and Smyth (1990) suggested that some parts of the Gull Lake Intrusive Suite might represent plutonic equivalents to the volcanic suites, but there are few data that can be used to assess this idea. The Sops Arm Group thus represents an interesting avenue for future research, particularly if there is sustained interest in its gold potential.

The Importance of Carboniferous Tectonics and Processes

The evolution of the Newfoundland Appalachians is dominated by Ordovician, Silurian and Devonian events, and the Carboniferous is commonly viewed as a footnote in our tectonic history. However. the geology of western White Bay indicates that deformation of this age (termed Variscan or Hercynian) was locally very important. The major fault systems in the area were sites of Carboniferous transcurrent motions, but the magnitudes of such displacements are not well constrained. Restoration of the Devil's Room granite to a position opposite the Gull Lake Intrusive Suite implies displacements of 20 km or less, but the case for equivalence of these plutonic suites is not particularly strong. Thus, the magnitudes of Carboniferous displacements along fault systems such as the Doucers Valley fault zone and the Cabot Fault zone are not well constrained. Carboniferous surface processes may also have played an important role on a more local scale. There is good evidence for the existence of Carboniferous paleokarst deposits in the carbonate rocks of the Coney Arm area, and deep surficial weathering of the Turners Ridge lead deposit may also reflect such processes.

Unresolved Problems in Structural Evolution

The details of structural and tectonic evolution in western White Bay continue to be elusive and confusing. Excluding Precambrian events recorded in the Long Range Inlier, there appear to have been three broad "stages" in evolution. The most prevalent must be of Silurian or younger age, as it affects the Sops Arm Group. This involved tight upright folding, and possibly west-directed thrusting or reverse faulting. The strong downdip lineations observed in many deformed rocks in the Sops Arm Group imply (but do not prove) that vertical motions were an important part of this. Most of the fabrics in the Southern White Bay allocthon also appear to be of this age.

Earlier events are probably recorded in the deformed platformal rocks, where there appears to be evidence for originally low-angle thrust faults that were once sites of west or northwest-directed motion of the cover rocks over their basement. It is appealing to think of these as related to Ordovician events that predate deposition of the Sops Arm Group, and this is the traditional view of Appalachian evolution. However, there is no firm evidence for pre-Silurian timing. The "early" dykes noted locally in the carbonate rocks are indeed truncated by possible thrust faults but, given the likelihood that most early faults were reactivated in later events, dates from these would still not provide absolute answers. The "later" dykes would, however, provide an upper limit for most of the intense deformation in the platformal rocks, and possibly also for some gold mineralization (see below) the timing of any post-Silurian events is also poorly constrained. There is obviously Carboniferous and younger deformation, but there may also have been events of Devonian age.

The structural evolution of this area is a very interesting topic for further research, with particular emphasis upon the Cambro-Ordovician rocks, within which evidence about early events should be preserved. There is certainly enough here for a Ph.D. thesis Project !

The Timing of Gold Mineralization

Gold mineralization in western White Bay occurs in several different settings, in rocks that range in age from Precambrian to Silurian. There is no guarantee that all of these occurrences formed during a single event, although such an interpretation is clearly permissible, and favoured by some. Clearly, vein-hosted Au mineralization in the Sops Arm Group *must* be of Silurian or younger age, but several different possibilities exist for the Rattling Brook gold deposit.

Following the initial discoveries and early exploration, Tuach and French (1986) suggested that the gold mineralization at Rattling Brook could be of Precambrian age, and different in character to the vein-hosted gold mineralization of the Sops Arm Group. A central argument in this view was the apparent absence of any mineralization in Cambro-Ordovician sedimentary rocks. The subsequent discovery of gold in quartzites and carbonate rocks adjacent to the Apsy Granite led to revision of this view, because it indicates post-Cambrian gold deposition. This conclusion assumes, however, that the mineralization above and below the unconformity represents the same event. There is as yet no compelling reason to separate the two, and there is a strong association with As in both environments, but local remobilization of Precambrian mineralization cannot yet be completely ruled out. It is interesting in this context that sulphide mineralization is also developed in Cambrian quartzites at Little Coney Arm, where the basement rocks below the unconformity are unmineralized gneisses, rather than altered and mineralized granites. However, there is no gold in the sulphide-bearing quartzites in the Little Coney Arm area. If any of the gold mineralization at Rattling Brook *is* truly of Precambrian age, it must have formed in latest Precambrian times, because the ca. 615 Ma Long Range Dykes are altered and auriferous. The prevailing view of the last 15 years is that mineralization at Rattling Brook is of Paleozoic age, and possibly related to hydrothermal systems driven by Paleozoic plutonic complexes such as the Gull Lake Intrusive Suite and Devils Room Granite (Tuach, 1987b; Saunders and Tuach, 1991; Saunders, 1991). This is certainly possible, although there is a notable absence of younger post-tectonic granitic rocks in the area around the deposit, aside from a few small quartz-feldspar veins recently observed in drill core. There are, however, post-tectonic, cross-cutting diabase dykes that appear unaltered and unmineralized; these may provide the best route to further constrain the timing of mineralization. A further complication is provided by the manner in which a zone of strong deformation ("mylonitic zone") appears to terminate granite-hosted mineralization (Figure 11b). Direct dating of the mineralization using Re-Os systematics of pyrite and arsenopyrite is currently in progress, and may answer some of these questions (R. Creaser, in prep.).

Mineralization in the Sops Arm Group is clearly Silurian or younger, and has been linked by Tuach (1987b) and Saunders (1991) to hydrothermal systems developed around major plutonic suites. Tuach (1986) initially suggested that some of this gold mineralization could represent an "epithermal-fumarolic" environment, but many of the typical features of high-level hydrothermal systems (e.g., extensive brecciation, gas cavities, chalcedonic silica, etc.) are lacking from the gold-bearing quartz vein systems. There is thus no clear evidence to suggest an epithermal-type environment for known mineralization, but this does not rule out the presence of epithermal mineralization elsewhere in the volcanic sequences of the Sops Arm Group. Indeed, if the caldera model proposed by Coyle and Strong (1987) is accepted, such synvolcanic mineralization should be expected.

Origins and timing of Zn-Pb mineralization in the Sops Arm Group

Lead mineralization at the Turners Ridge and Side Pond prospects, and a possible Zn-rich equivalent at theWhitestar prospect, represent an interesting style of mineralization that has yet to be studied in detail, and consequently remains poorly understood. Although these occurrences are also hosted by the Sops Arm Group, they are completely different in character to the vein-hosted gold mineralization seen elsewhere, and presumably of different age. Saunders (1991) suggested that metalliferous fluids might have migrated from Carboniferous sedimentary rocks of the Deer Lake Basin, and precipitated Pb in older brecciated dolostones that provided structural and chemical traps. However, the evidence for a Carboniferous or post-Carboniferous age at Turners Ridge is equivocal, and there have (to our knowledge) been no attempts at direct dating using galena. Detailed studies of the character and possible timing of this mineralization represent a potentially interesting research project.

PART 3 : FIELD TRIP STOP DESCRIPTIONS

Andrew Kerr and Shirley McCuaig

SUMMARY OF FIELD TRIP ITINERARY

On the first half day, the trip will visit some key regional exposures along Route 420, and provide an overview of the geology. Day two will be a more detailed examination of Cambro-Ordovician stratigraphy and structure, and gold mineralization in these rocks, emphasizing recent work (Kerr and Knight, 2004; Kerr, 2004; BP-Selco and Kermode Resources, unpublished work). Day three will provide an overview of the Silurian rocks (largely after Smyth and Schillereff, 1982), and will visit representative examples of gold mineralization, including the Browning Mine (after Tuach, 1987a,b; Saunders, 1991). The final half day of the trip will include a brief examination of Zn and Pb mineralization in the southern part of the area, prior to returning to St. John's. In addition to examination of bedrock geology, the field trip will also highlight some selected Quaternary features that are important in terms of glacial history, mineral exploration and geological hazard assessment. The Quaternary geoscience component is derived from work by McCuaig (2003a).

The idealized itinerary above is, as always, subject to Newfoundland weather, and it may be necessary to adjust the order of stops, or exchange Days 2 and 3 to make the best use of the ambient conditions. Most stops are close to vehicle access in the form of roadside, riverside and shoreline outcrops, but many require short walks (5 minutes or less). The aim of the field trip guide is to present as complete a picture as possible, with information that will allow self-guided excursions. It is doubtful that all of the stops described below will be visited in 2004, due to time constraints.

Roadside stops are largely located using odometer readings. Our experience has shown that odometers may vary by up to 10% between vehicles, and these may therefore not be precise. If conducting an independent excursion, we suggest that the vehicle odometer be calibrated against the distance from the TCH/Route 420 junction to the Route 420/421 junction, which we log as 9.5 km. It may be necessary to adjust distances between stops slightly to correct for differences between vehicles.

DAY ONE: THE ROAD TO POLLARDS POINT

General Overview

Route 420, between the Trans-Canada Highway and Pollards Point - Sops Arm, crosses a wide variety of geological units. Unfortunately, it also follows major faults for much of its course, and thus many of the roadside outcrops are intensely fractured, brecciated and altered. The first half day of the trip includes Carboniferous rocks, the sub-Carboniferous unconformity, Silurian felsic volcanic and granitoid rocks, an interesting marble outcrop used for ornamental stone and the Doucers Valley fault zone.

Stop 1.1 : Anguille Group Sedimentary Rocks

These outcrops occur on both sides of Route 420, approximately 10.5 km from the TCH, and 1 km north of the Route 421 (Hampden) junction. *Watch for traffic !*

The outcrop on the west side of the road is slightly easier to view. This long outcrop reveals a series of near-vertical, well-bedded clastic sedimentary rocks. These include laminated siltstones and shales, pale grey sandstones and fine-grained "gritty" conglomeratic beds. The shale beds locally contain sulphides. There is no strong cleavage development. The attitude of the beds, and the folding reported elsewhere by Smyth and Schillereff (1982) attest to Carboniferous deformation within the area.

Stop 1.2 : Sub-Carboniferous Unconformity

This outcrop is located on the west side of the road, approximately 17 km from Stop 1.1 and 28.5 km north of the TCH. *Watch for traffic ! Also, be very careful in approaching the outcrop as it is overhanging and locally unstable. Fresh falls of large boulders have been noted on many previous visits to this site !*

This is a spectacular outcrop that reveals the profound unconformity between the Silurian Sops Arm Group (north end of roadcut) and the North Brook Formation of the Carboniferous Deer Lake Group (most of the roadcut). The latter are the youngest rocks exposed within the field trip area. The outcrop was previously described by Tuach (1987a) and the following description is modified from that source.

Buff-coloured schistose rocks at the north end of the outcrop are interpreted as volcaniclastic rocks of felsic composition, which are interbedded with pale pink limestones. They belong to the Lower Volcanic Formation of the Sops Arm Group. The rocks are tightly folded, and extensively crenulated; they are cut by small quartz-carbonate veins, and locally contain minor pyrite. At the unconformity surface itself, folding of these rocks has greatly reduced the angular discordance with the overlying boulder conglomerates. Reddening of the schists below the unconformity is interpreted to reflect Carboniferous groundwater circulation and related oxidation.

Above the unconformity are spectacular southwest-dipping boulder conglomerates and breccias, interpreted as debris flow deposits. These are interbedded with red sandstones and finer-grained conglomerates of probable fluvial origin. The boulder conglomerates are generally clast-supported, and are very poorly sorted. Clasts range from rounded to variably angular. The most abundant clast types are mafic to felsic plutonic rocks that resemble local intrusive suites. Regional studies (Smyth and Schillereff, 1982) suggest that the clast population is also dominantly local in other areas where the underlying rocks are different to those around here. Other clast types are felsic volcanics, schists and altered green fault-gouge like material.

The boulder conglomerates are believed to have been deposited as debris fans on the edges of the Deer Lake Basin. The presence of fault gouge clasts (Tuach, 1987a) suggests a spatial relationship to active fault scarps. Although this is a very clear and obvious unconformity, there was some Carboniferous or younger deformation, because rocks of the Sops Arm Group have been thrust over similar Carboniferous conglomerates at the nearby Turners Ridge lead deposit (see Stop 4.2).

Stop 1.3 : Gull Lake Intrusive Suite granitoid rocks

From Stop 1.2, drive approximately 10 km north, and turn right into a parking area by a prominent pile of granitic boulders that form a colluvial apron on the east side of the road. This outcrop reveals strongly fractured, reddened and altered coarse-grained granite of the Gull Lake Intrusive Suite. There is no outcrop here, but there are outcrops on the hillside above. These are some of the freshest examples of this unit available in the area around Route 420. These granites are correlated with the Devils Room Granite on the opposite side of the Doucers Valley fault zone, which will be visited shortly at Stop 1.5. If this is correlation is valid it suggests post-425 Ma dextral displacements of some 15 km along the fault. Bring a small sample for comparison !

Stop 1.4 : Doucers Valley Fault Zone

From Stop 1.3, continue north for approximately 7.3 km, to the outskirts of Pollards Point. This outcrop is located on both sides of the road, about 45.8 km from the TCH. *Watch for traffic ! The road is narrow here, and there is a steep grade, so be very careful !*

These outcrops expose part of the Doucers Valley fault zone, which here separates marbles of the autochthonous platformal sequence from felsic volcanic rocks of the Sops Arm Group. The outcrop on the west side of the road mostly exposes white, banded to locally mylonitic marbles. containing numerous red-stained fractures. As at stop 1.5 (see below), this is inferred to reflect circulation of Carboniferous groundwaters, but is not as well developed. This marble is interpreted to be derived from Ordovician rocks of the upper Catoche Formation, but has not been constrained biostratigraphically. The outcrop on the east side of the road exposes beige to yellowish, sericitic felsic rocks of volcanic and/or volcaniclastic origin at its northern end, and in the higher parts of the outcrop face. These form part of the Lower Volcanic Formation of the Sops Arm Group. The remainder of this outcrop consists of brown to black (graphitic ?) shales and schists, showing intense fracturing and brittle deformation. These represent part of the fault zone, and their parentage is uncertain; however, they could represent melanges of the

Taylor's Pond Formation (part of the Southern White Bay allochthon) which abuts the fault farther to the north (see Day 3).

The shales and schists that define the fault zone contain many small faults, including high-angle structures and moderately north-dipping structures. They exhibit chaotic deformation, including disharmonic and chevron-style folds, generally associated with small faults and gouge zones. The attitudes of fold hinges within the outcrop are highly variable. The Doucers Valley Fault Zone is an important structure that is considered to have a complex early history, possibly originating as an allochthon boundary thrust. However, no vestiges of earlier events remain here. The brittle deformation is assumed to largely be of Carboniferous age.

Stop 1.5 : Main River marble, Devils Room granite and Pleistocene Raised Deltas

Continue northward from Stop 1.4, through downtown Pollards Point, and across Main River. Approximately 1.1 km north of the steel bridge over Main River, turn left onto the Main River woods road and park in the large gravel pit.

This locality is similar in some respects to stop 1.4. Outcrops on the east side of Route 420 opposite the junction consist of felsic volcanic rocks assigned to the Sops Arm Group, and an adjacent grey schist possibly represents the attenuated extension of the Southern White Bay allochthon, now obscured by brittle deformation associated with the Doucers Valley fault zone. On the west side of the road, in the gravel pit, there is a prominent marble outcrop, and granites outcrop a short distance to the west. The outcrops were previously described by Tuach (1987a); the following is an expanded description. Glaciofluvial sediments are also well-exposed in the pit.

The marble is a spectacular rock due to two characteristic features. It has a banded to mylonitic fabric defined by white and grey bands, and locally shows tight to isoclinal folding. The rock resembles strongly deformed white marbles seen at Stop 1.4, and also along the Cat Arm road; the banding is believed to be derived largely from intensely flattened burrows. The foliation in the marble trends at 310°/75° NE, which is anomalous, because most other rock units in the area strike roughly north-south. The outcrop shows a dense network of red-stained fractures, with a wide range of orientations. These are again believed to record the effects of Carboniferous groundwater circulation and staining, suggesting that the unconformity surface was not far above the present land surface. However, not all parts of the outcrop display a strong fabric. There appear to be narrow discordant zones of more homogeneous limestones, which display pale grey weathered surfaces. These have a brecciated appearance, but it is not clear if this is a primary depositional texture or later faulting-related brecciation. These zones cut across the mylonitic fabric of the marble in several areas. These zones are interpreted as karst cavities that have been filled with resedimented limestone, or with sandy material cemented by carbonate. Curiously, no fragments of the mylonitic limestone have been observed in these zones, which suggests derivation of any primary fragments from other units. These are presumed to also be Carboniferous features, possibly deep fissures and solution cavities developed below the sub-Carboniferous unconformity. The anomalous attitude of the fabric in the mylonitic limestones may indicate rotation of this outcrop within the Doucers Valley fault zone. A prominent pale grey hill on the other side of Main River is a similar marble, but it is not known if the unit is continuous between the two. It is possible that both represent relatively competent lozenges within the fault zone. The marble has been used widely by Meyer's Minerals for the production of various craft items. However, it is no longer exploited at this locality due to its proximity to the Main River protection zone.

The Devils Room granite is a pink to red, coarse-grained, biotite-hornblende granite that is slightly brecciated at this locality. Better outcrops occur further to the west along the Main River woods road; these are variably porphyritic and locally display rapakivi (mantled K-feldspar) textures. The granite is cut by pegmatitic and aplitic zones. The red colour is generally more strongly developed adjacent to fractures, suggesting that it is in part a function of alteration. Note the similarity of the granite to the granites of the Gull Lake Intrusive Suite visited at Stop 1.3.

This locality provides good views of the rugged hills that surround Pollards Point and Sops Arm. The prominent high hill to the southwest is known as the "*Devil's Dressing Place*"; the origin of this unusual name is unknown. It also provides good views of Pleistocene raised deltas. Both ice-contact and ice-distal glaciofluvial and glaciomarine deposits are present in the western White Bay area. A number of glaciofluvial terraces and ice-distal glaciomarine deltas mark sea level fall in Sops Arm. The delta at this stop is graded to 62 m asl; two other deltas at Sop's Arm and another at Jackson's Arm formed at the next sea level stand, which was about 40 m asl. A 30 m and a 20 m stand are also recorded in this area by deltas and by raised marine terraces (Figure 9). The 20 m stand may have been the longest-lived sea level stand in the White Bay area, as it is represented by six different features, mainly terraces cut into glaciomarine sediments (Figure 9). The paleoflow directions of these deltas are southeast, south and southwest, which is unexpected if the Main River valley was the main source of meltwater. This will be discussed in more detail at Stop 3.16.

Large, dipping beds interpreted as foreset beds are exposed at this location. Laminations of sand (all grain sizes) at lower stratigraphic levels grade upward to pebble, cobble and boulder gravel, indicating a prograding delta. Beds range from very well sorted to moderately sorted. A few horizontal beds at mid-level elevations may be topset beds formed at lower sea level stands. About 1.3 km up the Main River woods road is a delta or fan that is perched 40 m above the Main River. This feature is at the end of a large meltwater channel and contains very large subround boulders (up to 2 m in diameter) in its uppermost crudely stratified beds. The size of the boulders attests to the high volume of meltwater flow during deglaciation. The delta at Stop 1.5 is situated at the southwestern end of an even larger meltwater canyon and is a much larger feature.

DAY TWO : THE PRECAMBRIAN BASEMENT AND AUTOCHTHONOUS PLATFORMAL ROCKS : GEOLOGY AND GOLD MINERALIZATION

General Overview

Day 2 is largely devoted to an examination of the autochthonous Cambro-Ordovician platformal sedimentary rocks exposed along the west side of Great Coney Arm (Figure 5) and gold mineralization hosted by these rocks and the adjacent Precambrian granitoid rocks. The geology is summarized in Part 1 of the guide, and is discussed in detail by Kerr and Knight (2004); the gold mineralization is described by several workers (Tuach, 1987a, b; McKenzie, 1987; Poole, 1991; Saunders and Tuach, 1991; Kerr, 2004).

Note that the Cat Arm road is a dangerous road, with numerous blind hills, sharp turns and frequent steep drops on its east side. It may appear to be well-maintained, but the surface can deteriorate rapidly, especially on bends and hills, leading to loss of control of your vehicle. Note that logging trucks may be coming in the other direction, in addition to recreational traffic. The road should be driven with caution, and speeds less than 60 km/hr are recommended in all areas.

Pollards Point to the Cat Arm road

From Pollards Point, drive north on Route 420 for almost 13 km. The road runs along the trace of the Doucers Valley fault zone, and the rock outcrops are badly fractured; however, there are some interesting till exposures enroute. The matrix of tills along the Doucers Valley fault zone is calcareous due to the carbonate bedrock sources here. Limestone and marble clasts are present in the till, along with several other non-carbonate rock types. Boulders 2 to 4 m in width are not uncommon in the White Bay region, and the largest boulders are generally found in the upper part of the till and on the ground surface. This relationship is visible in the large till exposures on the east side of the road. These large boulders likely represent the englacial load (i.e., they were carried at higher levels in the ice) and were thus the last debris to be released from the melting ice sheet.

Stop 2.1 : Precambrian banded gneisses at Powerhouse Junction

The Cat Arm road leaves Route 420 just before Jacksons Arm, and is marked by a blue equipment shed. Turn left on to the Cat Arm road and drive northward to a point 20.8 km north of the junction. Admire the spectacular scenery enroute. This stop is located at the road junction where the reservoir access road leaves the road to the power station at Devil's Cove. Park in the widened area at the junction.

This location provides spectacular views across White Bay and allows most elements of the geology to be seen. The shoreline outcrops directly below the viewpoint are banded gneisses and granitoid rocks, similar to those at this stop (see below). The headland to the south is Cobbler Head, and is formed by autochthonous Cambro-Ordovician rocks, specifically phyllites derived from the Forteau Formation. The dark cliffs west of Cobbler Head, which are visibly east-dipping,

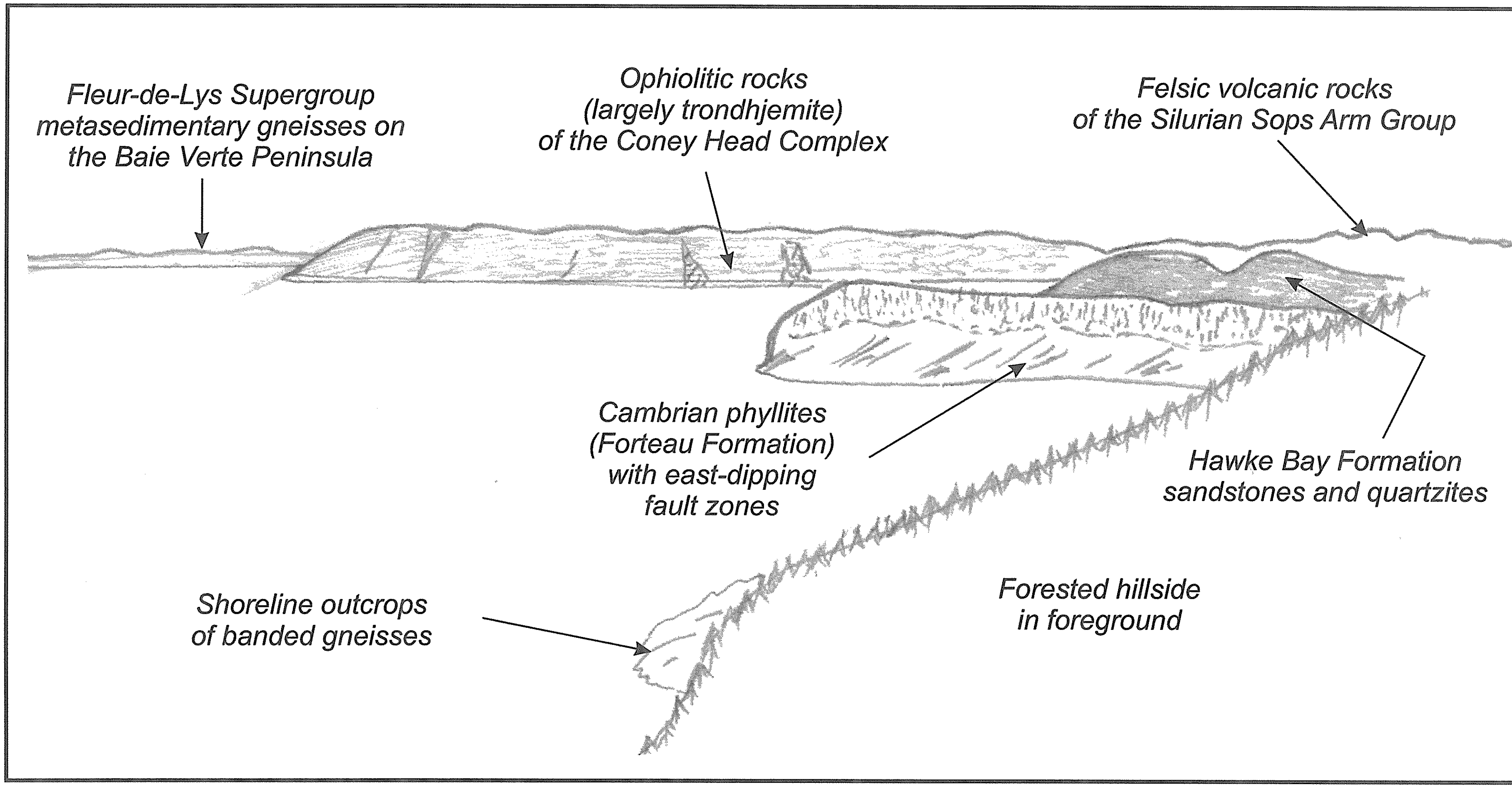


Figure 13 : Sketch of Panoramic view from the junction of the reservoir and pwer station roads, several kilometres north of Little Coney Arm, on the Cat Arm Road. The view is east-south-east, and includes most of the geological components of Western White Bay.
Sketch by A. Kerr. See text for discussion.

represent the complex imbricated zone beneath the Cobbler Head fault zone. The slightly higher rounded hills beyond Cobbler Head represent more resistant rocks of the Hawke Bay formation, structurally above the fault. On the far side of Coney Arm, the high grey cliffs and rugged terrain of Coney Head are formed from intrusive rocks of the Coney Head Complex (Williams, 1977; Dunning, 1986), which represent the main ophiolitic component of the Southern White Bay allochthon. These are dominated by trondhjemitic rocks, with lesser gabbro and granite. Outcrops further south on the east shore of Great Coney Arm represent the metavolcanic rocks of the Murrays Cove formation, also part of the allochthon. Higher hills visible on the horizon southward from Coney Head are mostly felsic volcanic rocks of the Silurian Sops Arm Group. The far side of White Bay, which is generally visible, consists of pelitic and psammitic metamorphic rocks of the Fleur-de-Lys supergroup, believed to be derived from the deep-water clastic equivalents of the autochthonous rocks in the foreground. The Coney Head Complex is probably of island arc origin, like other Newfoundland ophiolites, and was transported *over* the Fleur-de-Lys Supergroup from the Iapetus Ocean; it may have originated from the Baie Verte line, now some 40-50 km east of here (but originally much further away). The panorama from Powerhouse Junction is indicated in Figure 13.

Outcrops of gneiss just north of the junction are typical of those in this part of the Long Range Inlier. This is a well-banded, variably epidotized rock in which gneissic banding is defined by grey granodioritic paleosome and pinkish granitic neosome. Parts of the outcrop contain rootless intrafolial folds, that indicate the presence of a composite fabric and a complex early history. Later pink granitic veins are weakly discordant to the layering. Biotite-rich, melanocratic gneisses can be seen in other outcrops around the junction, but their relationship to the banded orthogneiss is unclear.

Stop 2.2 : Long Range Dyke, Sub-Cambrian unconformity and Bradore Formation

These outcrops are located approximately 6.2 km south of Stop 1.1, on both sides of the Cat Arm road, in a long roadcut north of Little Coney Arm. The Long Range dyke is exposed at the top of the roadcut on the west side of the road; the unconformity is close to the lower end of the roadcut. These outcrops were previously described by Tuach (1987a); the following is a modified description.

Most of the rocks in the northern part of the roadcut are banded gneisses akin to those visited at Stop 2.1, but they are not as well preserved. These are cut by a mafic dyke whose contact is actually subparallel to the road. The dyke contains amphibole, and has presumably been retrogressed during one or more Paleozoic events. A good chilled contact is developed, and a weak foliation is present in the margin of the dyke.

On the surface of the outcrops are striations from the first and second ice flow phases shown in Figure 9. The first represents ice flow toward White Bay as ice built up during ice sheet inception. The later set shows glacial flow at the ice sheet maximum – it is approximately parallel to White Bay. The third phase of deglacial flow is not seen here.

The sub-Cambrian unconformity is exposed on both sides of the road near the bottom of the hill, and the lower section of the roadcut is dominated by east-dipping, well-bedded quartzites and sandstones. Quartz pebbles are visible just above the unconformity on the west side, but the exact position of the contact is hard to locate, largely because the gneissic banding is here subparallel to bedding in the quartzites. The unconformity is easier to position on the east side of the road, and pebble conglomerates are sporadically developed above the basal surface. The overlying quartzites display cross-bedding. Blue-grey quartz grains are a prominent feature of the quartzites, and they are locally magnetite-rich. The quartzites represent the Bradore Formation of the Labrador Group (Figures 3 and 4), and are about 15 m thick at this location. At the top of the cliff on the east side, the quartzites pass upward into brownish-yellow weathering carbonate rocks, that represent the base of the overlying Forteau Formation, specifically the Devils Cove limestone member. These in turn pass upward into phyllitic rocks at the very top of the exposure.

Sulphide mineralization is present in the quartzite in a rusty zone in the southeast part of the outcrop; this is dominantly pyrite in the form of small veinlets and disseminated material, locally associated with specularite and hematitic alteration. The style of this mineralization resembles that of quartzite-hosted gold mineralization to the south (see later discussions), but no gold is reported from the Little Coney Arm outcrops.

Stop 2.3 : Views of Little Coney Arm

Views over the community of Little Coney Arm are best from the Cat Arm road, about 0.6 km south of Stop 2.2. The sheltered harbour of Little Coney Arm is a well-known local beauty spot. It has no *obvious* geological cause, as there is no lateral displacement of Cambro-Ordovician formations across the harbour; however, there is a contrast in dip direction from east-dipping on the north side to locally west-dipping and overturned near the entrance on the south side; thus, a normal fault may exist. Quartzites exposed in one of the brooks feeding the bay strike at 040°, rather than the typical 010°-020° strike seen elsewhere, and could be deflected against a fault.

Mass wasting is a significant process in the hilly White Bay area. Rockfalls are the most common type of mass wasting, but debris flows and other processes are also active. In Little Coney Arm, cabins have been built on the base of bouldery rockfall rubble below a scarred rockfall slope. The Cat Arm road has been built above this area, and may have removed the steep rock face that was the source of the landslide, however, it may have introduced a new threat by the addition of loose debris as road fill in this rockfall-prone location. The rockfall debris has built out over a suite of raised beaches that are graded to about 10 m above present sea level. Raised beaches at this elevation are also found on the other side of White Bay, at Western Arm and Westport, and also at Great Coney Arm, where raised sea caves are also present at similar elevations. Collectively, these represent the last higher sea level stand attained before present sea level was reached sometime in the Holocene. A lack of glaciofluvial features related to the 10 m stand may mean that glaciofluvial deposition had ceased by this time.

Liverman (1994) showed that the White Bay area had a type B sea level curve, i.e., rapid sea level fall followed by lesser sea level rise caused by forebulge migration. If this is the case, then sea level fell an unknown amount beyond the 10 m stand before acquiring its present level.

Stop 2.4 : Forteau Formation phyllites and possible "early dyke"

These outcrops form a long and narrow roadcut where the road climbs southward out of Little Coney Arm, located about 0.7 km south of Stop 2.3. It is best to park a little bit beyond this point, at the top end of the roadcut and walk back, so that vehicles are visible to northbound traffic. This stop was described by Tuach (1987a); the following is an augmented description. *Watch for traffic at this location, as the road is narrow and visibility is poor !*

This entire roadcut consists of strongly deformed phyllites considered to represent the shales of the Cambrian Forteau Formation, now caught up in a zone of imbrication associated with the Cobbler Head fault zone. The phyllites are variably calcareous, and contain discrete thin beds of dark limestone, which are commonly disrupted. White-weathering quartz veins are abundant, and are typically black in colour where fresh; most of these are also disrupted and/or folded. The phyllites contain minor pyrite, and are locally rusty. At the south end of the outcrop on the west side of the road, a vertical face shows disrupted and boudinaged quartz veins and contains westward-overturned folds. The foliation is in turn affected by later crenulation and chevron-style folds.

A vertical diabase dyke, about 3 m wide, trends at about 060° across the road; it intersects the east side of the roadcut about 75 m south of the "Narrow Bridge" sign, but can be very difficult to see. The dyke is truncated near the top of the outcrop face by a schistose zone, above which are phyllites similar to surrounding rocks. The schistose zone is interpreted as an east-dipping thrust, but there is no kinematic data. This relationship has been noted before (Tuach, 1987a; Owen, 1991) and it is generally assumed that the structure that truncates the dyke must be relatively young, i.e., post-Silurian. However, there are no constraints on the age of the dyke, and thus no constraints on the age of the fault. The dyke is chemically similar to diabase dykes that cut carbonate rocks in coastal outcrops, that appear to postdate most structural development; however, there could still be two generations of diabase dykes in the area.

Stop 2.5 : Hawke Bay Formation

These outcrops are located on the power transmission line. Continue southward on the Cat Arm road from Stop 2.4 for 0.5 km, and turn left into an open area, usually full of wood piles. An access road leads from this area to the power line, where prominent white outcrops are visible just across a small swampy spot.

The white outcrop is massive recrystallized quartzite of the Hawke Bay Formation. This sits above a slaty siltstone unit with a well-developed cleavage. Relict cross-bedding is locally visible in the quartzite. Both units dip ESE at about 40°. There is an overgrown trail leading south from these outcrops along the power line. About 25 metres to the south are outcrops and boulders of "ribbon limestone" consisting of grey limestone thinly interbedded with sandstone and siltstone. This rock type is also common in the Hawke Bay Formation at coastal outcrops.

Stop 2.6 : Sub-Cambrian unconformity and Apsy Granite

This outcrop is located 0.4 km south of Stop 2.5, on the west side of the road. It is an excellent example of the basal unconformity, but here the underlying rocks are coarse-grained, K-feldspar megacrystic granodiorite of the Apsy Granite, rather than banded gneiss, as at Stop 2.2.

The southern part of the outcrop is granite, and the northern part is quartzite and conglomerate. The conglomerates are developed above the unconformity surface, as at Stop 2.2. One of the conglomerates has a clast population dominated by K-feldspar pebbles that are only marginally rounded, accompanied by blue-grey quartz. This arkosic rock is essentially a resedimented granite, suggesting very local derivation. Other clast types include massive quartz, and a purplish aphanitic rock that resembles a felsic volcanic. The Apsy Granite is the main host for gold mineralization to be visited later today.

Stop 2.7 : Port au Port Group dolostones, calcareous mylonites

These outcrops are located approximately 2 km south of Stop 2.6. Park vehicles just before the long roadcut outcrop. The first part of the stop is back along the road; after visiting this, walk northward past the larger outcrops and a small quarry to outcrops located at the junction with a small road that leads to the power line. All of these outcrops are interpreted to be part of the Cambrian Port au Port Group, which here is in fault contact with a thin sequence of Forteau Formation phyllites, underlain by Bradore Formation quartzites. The Hawke Bay Formation and most of the Forteau Formation are missing here. These outcrops were also described by Tuach (1987a); the following is an augmented description.

A small outcrop on the west side of the road, about 200 m back, shows pale, beige-weathering dolostones containing numerous blue-grey quartz veins. In addition to the veining, the dolostone appears to be hard and silicified. This outcrop has been considered by exploration companies to represent a partially formed "jasperoid", i.e., a silicified carbonate rock commonly associated with Carlin-style gold mineralization in the southwestern USA. Quartz veining is common in dolostones in the field trip area, reflecting their tendency towards brittle behaviour, but silicification is rare.

The main part of the roadcut outcrop consists of light grey to beige recrystallized dolostones, typically thickly bedded, which are assigned to the Petit Jardin Formation of the Port au Port Group. A small quarry provides a good view of these rather featureless rocks. A small outcrop of quartzite occurs on the west side of the road, opposite the quarry. The phyllites are not exposed here, but are present in drill core.

An outcrop of grey limestones just north of the road junction was described by Tuach (1987a) as a "ribbon limestone", but is now believed to be a mylonitized grey limestone, sitting structurally beneath the dolostones; the mylonitic unit trends across the road. This rock type is believed to represent the lowermost formation of the Port au Port Group, the March Point Formation, where it is subjected to strong deformation related to the Cobbler Head fault zone. The "laminated" appearance of the outcrop is believed to record extreme stretching of burrows in the original limestones. Rocks of similar appearance have been traced laterally into bioturbated limestones in several areas, and the March Point Formation contains rocks of this type. A short distance up the side road, which leads to two Kermode Resources drill sites, are small outcrops that contain abundant minor structures. Some of these (overturned folds and small thrusts) indicate westward or northwestward transport, but others indicate extensional motions; the timing relationships of these are not clear. The side road ends on the power line, where massive dolostones outcrop around the drill sites. The two holes completed at this site represent the most northerly point at which the sedimentary rocks have been tested for mineralization. Neither hole contained high-grade mineralization, but both contained anomalous gold (up to 0.5 ppm Au) in phyllitic rocks (Kermode Resources, press releases, 2004).

Stop 2.8 : Catoche Formation limestones

From Stop 2.7, drive 2.9 km south on the Cat Arm road to a point just north of Apsy Cove Pond. Turn left onto a side road that leads to a small sawmill operation, and follow this road up to the power transmission line. There is one rough section that may be impassable for low-clearance vehicles. If you park near the sawmill, the walk takes just a few minutes.

These outcrops expose limestones and dolostones interpreted as the the upper part of the Catoche Formation, which is part of the Ordovician St. George Group. The underlying formations of the St. George Group (Watts Bight and Boat Harbour formations) are poorly exposed on the power line north of here. The rock types included bioturbated (burrowed) limestones, pure white limestones with distinctive "fractal" stylolite patterns, and thin brown-weathering dolostones. All of these rock types are typical of the upper part of the Catoche Formation in coastal outcrops. The carbonate rocks are structurally underlain by Forteau Formation phyllites; thus, the upper part of the Labrador Group and the entire Port au Port Group are missing.

About 1 km north of this stop, a second major fault zone, the Apsy Cove fault zone, merges with the Cobbler Head fault zone. The Apsy Cove fault zone is a thrust that brings dolostones of the Cambrian Port au Port Group over the Ordovician carbonate rocks seen at this stop.

Stop 2.9 : "Green rapakivi granite" outcrop

Return to the Cat Arm road, and drive south for about 0.3 km. The outcrop is on the west side of the road.

The outcrop consists of coarse-grained K-feldspar megacrystic granodiorite that has been saussuritized and epidotized. This alteration has converted most of the plagioclase to a green mixture of epidote, sericite and carbonate. Combined with the pink potash feldspar and the blue quartz, this creates a most attractive effect. Some of the K-feldspars have mantles of plagioclase (rapakivi texture), which are now bright green. There are plenty of loose pieces for souvenir hunters. Unfortunately, the Apsy Granite is generally too fractured and jointed to have potential as dimension stone, although this particular outcrop might have potential for craft applications.

Stop 2.10 : Rattling Brook Bridge

Drive south for approximately 2.4 km to the steel bridge over Rattling Brook and park on the north side of the bridge. The brook (and a very nice swimming hole) are accessible upstream from the bridge. This is an excellent spot for lunching. The outcrops here are Apsy Granite, which shows pervasive potassic alteration, but is not mineralized. The main attraction here (aside from swimming) is the spectacular view from the bridge. *Be careful on the bridge, because there is a large gap between the bridge deck and the parapet; a fall here would probably be fatal !*

There are high hills across the valley, cut by the narrow cleft of Rattling Brook Gorge, which is negotiable only when water levels are low. These hills consist mostly of well-bedded dolostones of the Petit Jardin Formation (Port au Port Group), and the gorge provides an excellent section through these rocks and the overlying Berry Head Formation to the base of the St. George Group. These Cambrian dolostones lie across a composite fault zone created by the merger of the Apsy Cove fault zone and the Cobbler Head fault zone. The prominent knob of grey limestone across from the small power station is one of several lozenges of presumed Ordovician limestones caught within this fault zone. Granites throughout this area are widely mineralized (albeit at low grades) and it is an area of mineral exploration interest. The Apsy gold prospect, hosted by both granite and unconformably overlying sedimentary rocks, lies just north of here and will be visited later in the trip. The exposed rock in the waterfalls below the bridge is all granite; however, the basal Cambrian quartzites and the unconformity are exposed not far from the power station, on the west side of the faults.

Stop 2.11 : Boat Harbour Formation, Carboniferous paleokarst deposits

From the bridge at Rattling Brook, drive 3.2 km south. The road leaves the basement rocks for the last time, and then essentially runs along the trace of a fault zone past a large outcrop of phyllites, and then into dolostones of the Port au Port Group. These are overlain by the St. George Group, and this outcrop of interbedded limestones and dolostones is assigned to the Boat Harbour Formation. The outcrop was previously described by Tuach (1987a).

The outcrop is deformed and visibly folded. It has a distinctive red colour compared to other outcrops in the area. Closer examination reveals that fractures, presumably related to minor faults, contain red, hematitic material that looks like sandstone. Across the road and slightly to the north is a spectacular boulder of limestone breccia that consists of varied carbonate fragments in a red sandy matrix. It is clast supported, and many clasts are highly angular. Nevertheless, the boulder is well-graded. There is also a small outcrop of closely similar limestone breccia alongside the road, suggesting that this boulder was locally derived.

These breccias are interpreted as Carboniferous cave fill deposits, and further suggest that the Carboniferous land surface was not far above the present level of exposure. Similar breccias are developed in Rattling Brook Gorge at the same relative position, near the trace of the presumed fault that forms the western boundary of rocks assigned to the Table Head Group. This contact may have controlled the development of paleocaves, because the latter unit is composed of high-purity, more soluble limestones compared to the rocks to the west of it.

Stop 2.12 : Table Head Group (?) limestones

From Stop 2.11, drive 0.6 km southward. The road crosses a small valley interpreted as the trace of a fault, and then passes a long outcrop of grey limestones. These rocks are in generally poorly-preserved, but do show some lamination and traces of bioturbation. They have suffered tectonic brecciation, and are cut by numerous calcite veins. At this location, the outcrop contains breccias that may be primary debris-flow deposits similar to those known in parts of the undisturbed Table Head Group. These same limestones outcrop all along the west side of the Coney Arm river valley, and on the shore of Great Coney Arm. Natural outcrops display modern karst development, probably reflecting their relative purity and fractured nature. The shoreline outcrops on Great Coney Arm have been evaluated for commercial use (Howse, 1995).

Stop 2.13 : Interesting Outcrops at the start of the Cat Arm road

From Stop 2.12, drive approximately 0.4 km southward to the bridge over the Coney Arm River. Park on the south side of the bridge and descend to the river; if the water is low enough, it should be possible to cross the river and examine outcrops in midstream.

This outcrop exposes the eastern contact of massive limestones assigned to the Table Head Group. In the river, they are in sharp contact with a strongly deformed argillaceous limestone that contains thicker limestone beds. This represents the trace of the Doucers Valley fault zone on geological maps. Although the argillaceous rocks are strongly deformed, they do not have a mylonitic appearance, and there is no strong brittle deformation. An alternative interpretation, discussed also by Smyth and Schillereff (1982) is that these rocks are equivalent to deep-water limestones and calcareous shales that overly the Table Head Group on the west coast of Newfoundland. In this context, an outcrop on the east side of the road, south of the bridge, is also of interest. This consists of well-bedded sandstones that lack intense deformation. This could represent flyschoid sedimentary rocks of the Goose Tickle Group, which eventually inundated the carbonate shelf on the west coast. Both of the above rock types also occur in the lowermost part of Rattling Brook Gorge, but in the gorge they are more strongly deformed, and possibly tectonically interleaved.

If the interpretations discussed above are preferred, the Doucers Valley fault zone must lie on the east side of this outcrop, along Route 420, where there are indeed outcrops of mélange that have suffered extensive brittle deformation.

Stop 2.14 : Beaver Dam Zone Gold Prospect

The field trip now retraces its steps in order to examine gold mineralization in the Precambrian granites and overlying Cambrian sedimentary rocks. Turn around in the wider area south of the bridge, and head north again up the Cat Arm road. Continue to a road junction located approximately 1 km north of the bridge over the Coney Arm River. If time permits, walk up the side road, through an unofficial dump site, to drill sites located about 400 metres from the junction. This is the site of the Beaver Dam gold prospect; however, there are no mineralized surface outcrops that can be conveniently examined.

The Beaver Dam prospect was discovered by prospecting in the stream valley below the road, where pyritic quartzites locally contained up to 35 ppm Au. The area of interest was further defined through soil geochemistry, which defined a zone of Au-As enrichment, and by induced-polarization (IP) surveys (Poole, 1991). It was drilled in 1990 by BP-Selco, and additional holes were completed by Kermode Resources in 2004. Mineralization is described by Kerr (2004) and summarized in Part 1 of the guide. The gold is associated with heavily disseminated and veinlet-style pyrite developed in Bradore Formation quartzites and carbonate rocks assigned to the base of the Forteau Formation. The rocks seen around the drill sites along the road are dolostones of the Petit Jardin Formation (Port au Port Group), which form the hanging wall to the mineralized zone (Figure 11). Some of the drill holes in the northern part of the zone intersect a different hanging-wall sequence dominated by grey limestones, interpreted to be of Ordovician age. Granitoid rocks below the basal unconformity have not been tested by deep drilling at this location, but they do contain anomalous gold values, that locally exceed 1 ppm.

The nature of mineralization at the Beaver Dam showing is best revealed in diamond drill core from the recent Kermode Resources exploration program, which will be examined later. Hole JA-04-03 is described in detail below.

Stop 2.15 : Road Zone and Apsy Zone Gold Prospects

The final stop consists of a 1 km walk along the Cat Arm road, which here cuts through several outcrops of auriferous granite, and reveals interesting and controversial field relationships. This area was also described by Tuach (1987a), and the following is a modified and expanded treatment. The starting point is the Road Zone Prospect, which is located approximately 2.6 km north of the turnoff for Stop 2.14 (see above). The outcrop is a prominent rusty zone on the west side of the road. From this outcrop, walk northward along the road, across the steel bridge, and continue to the final outcrop, which is the Apsy Zone prospect. Several outcrops of interest are mostly located on the west side of the road, and are described in sequence below. The locations and main features of the outcrops are also located in Figure 14, modified after Tuach (1987a).

The Road Zone gold showing is the original discovery outcrop (location 1 on Figure 14). It is a fairly small outcrop, and is friable; climbing up on the outcrop is not recommended. Loose blocks demonstrate the typical appearance of auriferous granites, which contain widespread disseminated pyrite. The pyrite is locally visibly associated with grey siliceous veinlets, but the latter are not always evident in hand samples. Arsenopyrite is present, but is generally fine-grained and difficult to identify. The most strongly altered and pyritized granites appear greyish in colour and appear fine-grained. White quartz veins cut the outcrop, but do not appear to contain mineralization. Just north of the Road Zone outcrops is another outcrop that contains foliated amphibolites, which probably represent Late Precambrian "Long Range dykes". A marked

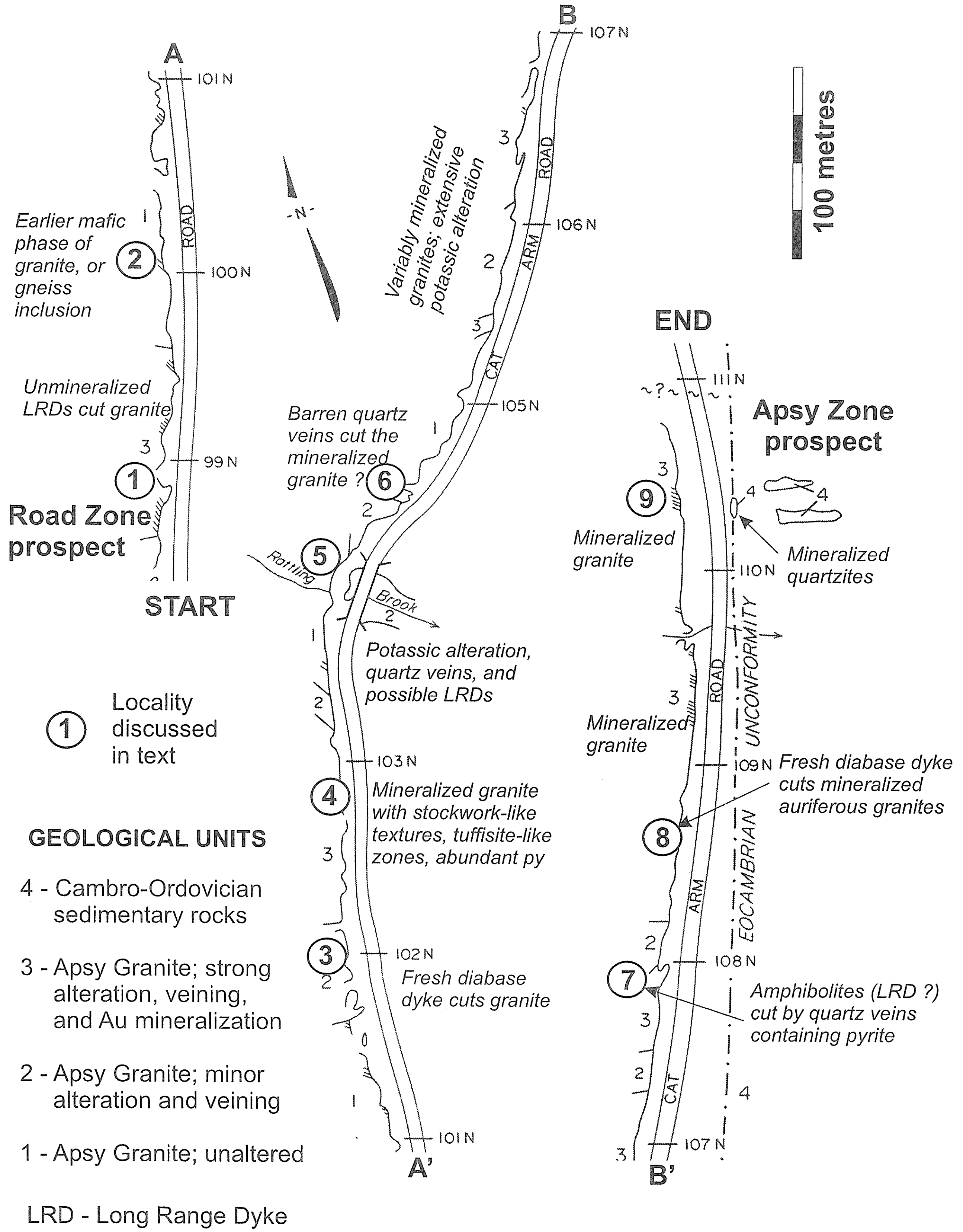


Figure 14 : Detailed sketch map of Stop 2.15 (Rattling Brook alteration zone), showing main features of interest and specific localities discussed in the text.
Modified after Tuach (1987a).

cataclastic fabric is developed in the granite, and appears to be parallel to the dyke contacts in some areas. This fabric, and the foliation in the amphibolites, probably records Paleozoic deformation. The site of drillhole JA-04-12, described below, is located slightly to the north of here, and the amphibolites are probably equivalent to the mineralized dykes noted in the core (see below). However, there is no evidence of mineralization in the surface outcrop.

The next large outcrop (location 2 on Figure 14) contains an obvious white quartz vein that dips gently to the west. Much of this outcrop consists of a relatively homogeneous coarse-grained mafic or intermediate orthogneiss, that is cut by a vein of more typical Apsy Granite. The more mafic rock was described as a xenolith of "Grenvillian gneiss" (Tuach, 1987a), but could also be an earlier, less evolved, phase of the Apsy Granite. It does not resemble the banded gneisses seen north of Little Coney Arm (Stops 2.1, 2.2). The "gneiss" is cut by thin quartz-carbonate veinlets that have narrow alteration haloes, containing disseminated pyrite. Similar dark-coloured metaplutonic rocks occur in hole JA-04-12 (see below) and contain similar veins and alteration features associated with gold mineralization, locally containing up to 6 ppm Au.

Continue for about 200 m along the road, passing some outcrops of granite that contain sporadic and discontinuous zones of gold mineralization. A smaller outcrop (location 3 in Figure 14) reveals a fresh, cross-cutting diabase dyke trending at 070°, an orientation typical of dykes that cut Cambro-Ordovician sedimentary rocks. The dyke has chilled margins, and contains small phenocrysts of plagioclase. It does not appear to be mineralized or altered; however, the surrounding granites are also unmineralized at this locality.

Approximately 100 m to the north, beyond an unexposed stretch, there is a large outcrop of mineralized granite (location 4 in Figure 14) that contains abundant pyrite, much of it associated with a network of cross-cutting siliceous veinlets. Locally, where such veining is intense, the rock resembles a "tuffisite" in that the host granite appears brecciated; however, such textures do not necessarily indicate the actions of a gas phase, as suggested earlier (Tuach, 1987a). The outcrop also contains prominent white quartz veins.

At the bridge over Rattling Brook (locality 5 in Figure 14), the granites are not mineralized, but they do show potassic alteration, and are cut by barren white quartz veins. The same white quartz veins are visible in around the penstock for the power station, just south of the bridge. North of the bridge, there is another amphibolitic unit, which is interpreted as a Long Range Dyke. The dyke contains some minor sulphide mineralization associated with cross-cutting fractures. The grain size in the amphibolite diminishes towards the contact with Apsy Granite on its western side; this may indicate a relict chilled margin. The rock type here appears closely similar to "mineralized dykes" intersected in hole JA-04-12 (see below). Potassic alteration of the granite can be seen easily in outcrops just slightly to the north. The contacts between "normal" Apsy Granite (typically granodiorite to monzogranite) and the pink or red potassic varieties are locally sharp, but more commonly gradational. The alteration of the granite is discussed by Saunders and Tuach (1988, 1991).

About 50 m north of the bridge (location 6 in Figure 14), there is an outcrop of mineralized granite that contains prominent white quartz veins. The quartz veins appear to cut the mineralization, but are unmineralized. The next 250 metres of outcrops reveal variably mineralized potassic granites, similar to those observed south of Rattling Brook Bridge. Beyond these, an interesting outcrop (location 7 in Figure 14) contains an amphibolitic zone that resembles other rocks interpreted as Long Range Dykes. A quartz-carbonate vein cuts the amphibolite and adjacent granites; this contains disseminated pyrite and chalcopyrite. It is not presently known if this vein-hosted mineralization is auriferous.

About 75 m farther to the north (locality 8 in Figure 14), there is an obvious fresh diabase dyke in a mineralized outcrop. This is not easy to climb up to, but it does possess chilled margins, and it has the ENE trend typical of other known Paleozoic dykes. Loose pieces of the dyke in the ditch have a fresh appearance quite unlike that of the Long Range Dykes, and are slightly plagioclase - porphyritic. Although the granites that surround it are rusty and pyritic, there is no sign of alteration or mineralization in the dyke, suggesting that it postdates the mineralization. Regrettably, there is no direct age information on these dykes, although dykes of similar aspect and orientation do cut rocks assigned to the Table Head Group, implying that they are post-Middle Ordovician.

The final stop on the traverse is the Apsy Zone prospect (locality 9 in Figure 14). This consists of a large outcrop on the west side of the road, and a much smaller outcrop on the east side of the road. The former outcrop is mineralized granite and the latter outcrop is mineralized quartzite. The granite-hosted mineralization was recognized and drilled in 1986. The topography dictated that some drillholes were collared in Paleozoic sedimentary rocks, and gold mineralization was also discovered in these (McKenzie, 1987; Poole, 1991). The gold mineralization is hosted by altered granites, Bradore Formation quartzites and Forteau Formation basal carbonate rocks, i.e., the same rock units seen at the Beaver Dam prospect (see above). In places, mineralization is continuous across the basal unconformity separating the quartzites and granite, but elsewhere there is a barren or weakly-mineralized "gap" in the lower part of the quartzite sequence. Forteau Formation phyllites above the basal carbonate rocks are barren or only faintly anomalous in Au; these are in fault contact with a hanging-wall sequence dominated by massive dolostones of the Petit Jardin Formation (Port au Port Group). As at the Beaver Dam prospect, probable Ordovician limestones occur locally in the hanging wall sequence; the large grey outcrop south of the prospect is a large tectonic lozenge of this material within the composite fault zone. The mineralization in the sedimentary rocks is described by Poole (1991) and Kerr (2004), and is summarized in Part 1 of the guide.

The mineralized granite outcrop on the west side of the road resembles those seen earlier in the traverse, but mineralization is more extensive and locally might even be described as "spectacular", depending on your frame of reference for such terms! The mineralized quartzite outcrop on the other side is certainly not spectacular, and much of the rusting superficially appears to be confined to fractures and joint faces. However, finely disseminated pyrite is present in the quartzite, and grab samples of this material contain about 1 ppm Au.

Description of Diamond Drill Core

As is commonly the case, the features of the mineralization are displayed better in diamond drill core than in outcrops. BP-Selco drill core from the 1980s is not particularly informative, due to its small diameter and generally poor core recovery. Also, the best intersections of mineralization in sedimentary rocks were retained by the company and are no longer available for study. More recent drill core from the 2003-04 Kermode Resources program is wide-diameter (NQ) material with much better core recovery and integrity, and it has been processed with a rock saw, rather than a core splitter. The drill core display features material from holes JA-04-03 (Beaver Dam Zone) and JA-04-12 (Road Zone), which have now been donated to the Department of Mines and Energy core library in Pasadena. Note that the following descriptions are based purely on visual examination in 2004; no petrographic or geochemical data (aside from company assays) are yet available from these drill cores.

Drillhole JA-04-03 : This hole, from the Beaver Dam Zone, intersected a typical sequence of upper dolostones (Port au Port Group) underlain by a fault zone, beneath which is a limestone unit considered to be the base of the Forteau Formation, and Bradore Formation quartzites. The latter are underlain by granite. Most of the gold mineralization is in the limestones and the upper part of the quartzites, collectively represented by the selected interval.

The limestones are cut by, and locally "brecciated" by siliceous veins. Disseminated pyrite is locally spatially associated with these veins, and the silica appears to have exploited brittle fracturing of the carbonate rocks. Some of the siliceous veinlets are associated with a pink to orange mineral, which is too hard to be a carbonate, and may be a potassium feldspar. The limestones contain pyrite throughout, but are strongly pyritic towards their base, where they contain up to 3.7 ppm Au. In the high-grade interval, sulphides again appear to be associated with siliceous veins, of several generations. Arsenopyrite needles and prisms are visible locally, but most of the sulphide is pyrite. Quartzites beneath this interval are also heavily mineralized, and contain both clotty disseminated pyrite and vein-style pyrite. The clots of pyrite may represent complete replacement of original magnetite. A sulphide-rich interval contains 11.6 ppm Au. Light coloured silica veinlets cut through mineralized core, but there are darker siliceous veinlets that are commonly associated with disseminated sulphides. The lower section of the quartzite is not as strongly mineralized, but does contain minor disseminated pyrite and is cut by dark pyritic veins. Some siliceous veins contain a pink mineral interpreted as feldspar. These quartz-feldspar veins are locally associated with pyrite and arsenopyrite. The lowermost section of the quartzite includes some conglomerates.

Drillhole JA-04-12 : This is a vertical hole drilled within the Road Zone that exhibits some very interesting textures and relationships. The section chosen for display represents several rock types, including the Apsy Granite, Long Range Dykes and mafic plutonic rocks interpreted as a more primitive phase of the Apsy Granite. These correspond to rock types seen on surface at Stop 2.15 (see above). The drill core also contains numerous quartz and quartz-feldspar veins.

The first part of the hole (not displayed) consists of poorly mineralized Apsy Granite. This gives way to a complex interval that contains mineralized mafic dykes, which reveal different stages of alteration associated with gold mineralization. The mineralized dykes contain some of the better gold grades encountered from this hole (~ 3 ppm Au), suggesting that more mafic rock types were more effective in precipitating gold. Where fresh, the dykes are black and foliated, with the foliation oriented subparallel to the core axis; they are considered to be Long Range Dykes. Dykes display variable but locally strong sericitic alteration, ranging from sheeted yellowish veins to near-total transformation. This sericitic alteration is overprinted by a second stage of alteration that creates greenish to pale brown zones of harder, siliceous material, commonly containing disseminated sulphides. These silicified zones are commonly separated from unaltered dyke material by sericitic zones, indicating that the two stages of alteration may be progressive and related. Locally, silicified zones include "islands" of variably sericitized rock. The silicification is associated with thin quartz (+/- feldspar ?) veinlets that have haloes of disseminated pyrite. There may actually be two generations of veinlets associated with silicification and pyritization; an early set oriented roughly parallel to the core axis (i.e., aligned with the fabric in the dyke) and a later set of more random orientation. Gold enrichment is associated with this second stage of alteration and sulphide deposition.

Quartz veins are common throughout the interval containing the dykes, and there may also be two types of these. Massive milky white quartz veins seem to be barren, and these visibly cut sericitic alteration zones in the mineralized dykes. There is no sign that they are cut by pyritic veinlets. Other quartz veins contain pink and white minerals believed to be feldspars, suggesting a link to granites, and these veins contain sulphides, including euhedral arsenopyrite needles and prisms. Intervals containing sulphide-bearing quartz-feldspar veins contain up to 6.5 ppm Au. These quartz-feldspar veins are locally cut by the thin siliceous veinlets that contain sulphide, but elsewhere appear to truncate such veinlets in the surrounding core. This suggests a close temporal relationship between them.

These rather confusing relationships eventually give way to more continuous Apsy Granite, which also contains numerous thin siliceous, sulphide-bearing veinlets in random orientations. This material typically contains 0.5 to 1.5 ppm Au. At greater depths, the granite gives way to a coarse-grained, dark grey, foliated plutonic rock that is interpreted to be a more mafic phase of the Apsy Granite, perhaps akin to the rock type discussed at Stop 2.15 (location 2 in Figure 14). This more mafic rock type is cut by pale grey altered zones that have outer sericitic portions and inner zones of silicification associated with disseminated pyrite and arsenopyrite. One of these pale grey alteration zones cuts across the contact between the more mafic rock and typical Apsy Granite. The silicified and pyritic zones correspond with strong gold enrichment, up to 6.4 ppm Au.

The core from hole JA-04-12 demonstrates the alteration processes at Rattling Brook, indicating an early period of potassic alteration, followed by silicification and gold deposition with pyrite and arsenopyrite. These correspond with stages described by Saunders and Tuach (1988; 1991), but are perhaps easier to see in the mafic dykes than in the granites. It also illustrates that more mafic host rocks generally correspond with stronger gold enrichment, which has implications for future exploration.

DAY THREE : THE SOUTHERN WHITE BAY ALLOCHTHON AND THE SILURIAN SOPS ARM GROUP : GEOLOGY AND GOLD MINERALIZATION

General Overview

Day three of the field trip commences on the eastern side of Coney Arm, with a brief examination of some components of the Southern White Bay allochthon. It continues with an examination of the Silurian volcanic and sedimentary rocks of the Sops Arm Group, which are well-exposed in and around the town of the same name. In the afternoon, the field trip will visit examples of largely vein-hosted gold and base metal mineralization, including the Browning Mine, which was the first producing gold deposit in Newfoundland. Some interesting glaciofluvial features will also be visited, including a fossiliferous ice-contact delta, and the so-called "backwards delta", where meltwater apparently flowed uphill.

Many of today's stops are on public roads. These are generally not busy, and traffic is generally slow-moving. However, participants should pay careful attention to passing traffic and avoid standing in the middle of the road to hold discussions !

Stop 3.1 : Altered ultramafic rocks, Coney Arm River

These outcrops are located at the end of a logging road on the east side of Great Coney Arm. From Pollards Point, drive northward, past the Cat Arm road junction, and then turn left on a side road labelled "Trailer Court" on the outskirts of Jackson's Arm. If you miss the first turn, you can take a second left turn just before the Sealer's Lounge. Continue, and turn northward on to a logging road that starts just opposite a small playground. Follow this road, (keep left at the first junction) for approximately 5.8 km. The road is generally in good condition, although parts of it are rutted and should be driven with caution in low-clearance vehicles. *Watch for traffic coming the other way, especially logging trucks !*

Outcrops along the road here reveal variably altered ultramafic rocks of the Southern White Bay Allochthon, which are here considered to be part of the Murray's Cove formation, dominated elsewhere by metavolcanic rocks (see Stop 3.3 below). However, the ultramafic rocks could be a separate structural slice. Outcrops in the ditch at the lower part of the roadcut are serpentinized ultramafic rocks that have spectacular green serpentine minerals developed on fracture surfaces. Most of the roadcut consists of variably altered ultramafic rocks in which talc is widely developed in the form of veinlets and pervasive zones. One part of the outcrop preserves lenticular zones of fresher ultramafic rock containing obvious pyroxene crystals. About 300 m south of the main part of the outcrop, green fuschite-carbonate-quartz alteration ("virginite") is locally developed. Outcrops just to the south of this zone are compositionally layered, epidotized rocks interpreted as strongly-deformed pillow lavas. Time may not permit examination of all parts of these outcrops.

These outcrops reveal interesting rock types that confirm the presence of altered oceanic crust and subjacent mantle within the Southern White Bay allochthon. The present proximity of these “Iapetus” rocks to the ancient continental margin of North America is particularly striking, because grey limestones assigned to the Table Head Group sit just a few hundred metres to the west, across the Coney Arm River. Not even in Gros Morne National Park can one stand on oceanic crust that is directly juxtaposed against a carbonate shelf of similar age !

Stop 3.2 : Calcareous shales and thin limestones, Taylors Pond Formation

From Stop 3.1, turn around, and then drive southward for approximately 1.4 km. Outcrops on the east side of the road consist of calcareous shales and phyllites, containing thin beds of grey limestone, and some disrupted quartz veins. These outcrops are part of the Taylors Pond Formation, as described by Smyth and Schillereff (1982), and they illustrate the difficulties in interpreting such rocks. The outcrops are not dissimilar to the Forteau Formation phyllites exposed along the Cat Arm road, although the degree of metamorphism appears greater in that area. Similarly, they resemble rocks exposed in the Coney Arm River along the supposed trace of the Doucers Valley fault zone (see Stop 2.13).

If the rocks at this stop are part of the Southern White Bay allochthon, they likely represent deep-water, pelagic limestone and shale originally formed in a deep water continental slope setting, akin to the Northwest Arm Formation of the Hare Bay Allochthon (Smyth and Schillereff, 1982) or perhaps parts of the Cow Head Group in the Humber Arm Allochthon.

Stop 3.3 : Deformed pillow lavas, Murrays Cove Formation

From Stop 3.2, drive southward for approximately 4.0 km, and stop by a large outcrop on the east side of the road, overlooking Jacksons Arm Pond on the west side of the road. *There is a steep drop on the west side of the road here, so be careful parking or turning. Try not to block the road as logging trucks may need to pass by. Parts of the outcrop are overhanging and unstable, and should be approached with caution, and should not be hammered.*

This large outcrop reveals typical "greenschist" of the Murrays Cove formation. It is not entirely green, but has a mottled green and maroon appearance reflecting superimposed epidote-chlorite and hematite alteration. Rounded, flattened and stretched masses of greenish material are remnants of original pillow structure, and commonly have hematitic rims derived from altered glassy pillow rims. Several parts of the outcrop show a relict variolitic texture defined by greenish epidote patches. There is abundant carbonate veining, and some of the veins are concordant with the fabric, suggesting that they are early. The outcrop is schistose and locally folded, and the relict pillows have an elongated "rod-like" shape, that defines a downdip lineation. Although this particular outcrop is presumed to be Ordovician, fabrics of this type are typical of many Silurian rocks to be seen later today.

As at Stop 3.1, these "Iapetan" volcanic rocks, probably of arc affinity (by analogy with other allochthons) are juxtaposed against the Laurentian carbonate shelf along the Doucers Valley fault zone. The grey outcrops on the other side of Jackson's Arm pond, far below the road, are correlated with the Table Head Group.

Stop 3.4 : Trailer Court showings, Jacksons Arm

From Stop 3.3, continue southward to the Trailer Court subdivision, and park by the playground. The outcrop located between the woods road and the house contains the Trailer Court showings, previously described by Tuach (1987a). The following description is largely adapted from that source.

The host rocks here are interpreted to be metavolcanic rocks of the Murrays Cove formation, but are more strongly deformed compared to stop 3.3. These are cut by brown-weathering zones of carbonate alteration, associated with quartz veins and sericite. Tuach (1987a) also reports the presence of Fuschite (bright green chrome mica), but this is not easy to find. The quartz veins have been disrupted and folded, although there are some later cross-cutting quartz-carbonate veins also. If the alteration is linked to the quartz veining, it appears to be pretectonic or syntectonic. Sulphides consist of disseminated pyrite. Tuach (1987a) does not quote any gold analyses, and data from the 2004 season have not yet been received. However, alteration of this general type is associated with gold mineralization in Archean gold deposits, and also with gold mineralization in younger ophiolitic ultramafic rocks.

Stop 3.5 Jacksons Arm ice-contact delta and marine fossils

From Stop 3.4, return to Route 420, and continue eastward towards Jacksons Arm. Turn right into the fish plant, which is at the water's edge. Park near the base of the large gravelly exposure. The town of Jackson's Arm is built on an ice-contact delta, a convenient flat building site in this otherwise steep, rocky area. The delta consists of sandy pebble gravel, cobble gravel, fine and medium sand, and minor poorly-sorted diamicton. There are recumbent folds in some of the sand beds. The folding and presence of diamicton illustrate glaciotectonic activity (overriding and/or pushing by the valley glacier just to the west), as well as ice-marginal melting. The valley glacier retreated up Jacksons Arm toward Jacksons Arm Pond before the delta formed. This is shown by striations at 98° and 104° along and near the sides of the valley and embayment that contain Jackson's Arm. The delta dams Jackson's Pond to the west along its ice-contact face, with the result that the pond drains northeastward to Great Coney Arm, instead of toward Jackson's Arm, as it would have otherwise.

Marine bivalves (*Mya truncata*) are found in probable bottomset beds of sand and silt near the base of the exposure. A radiocarbon date of 11 200 ±100 yrs BP (GSC-4247) on these shells provides a minimum age for deposition of this feature, and the regional sea level stand of 40 m (the delta sits at 41 m asl). Grant (in Blake, 1988) suggests that the delta may represent a Younger Dryas stillstand.

Stop 3.6 : Conglomerates in the Lower Volcanic Formation, Sops Arm Group

These outcrops are located on the side of route 420 and along Main River northwest of Sops Arm. From Stop 3.5, return to Route 320 and drive south for approximately 10.8 km to a point about 0.4 km beyond the Main River woods road (Stop 1.5). Here, there are roadside outcrops, opposite a small turnout, where there is a sign indicating "The Salmon Hole". If time is short, the roadside outcrops suffice to indicate the rock type, but the best outcrops are by the river, and were described by Tuach (1987a). Follow the right hand branch of the trail by the signpost, to a large outcrop above a deep and inviting pool in the river. *This outcrop has many steep, smooth surfaces that can be very treacherous and slippery, even when dry. A fall from some parts of the outcrop will very quickly end in more than 10 feet of cold water. Use caution in moving around this outcrop, and stay away from the steepest parts !*

This outcrop represents spectacular conglomerates that are interbedded with volcanic rocks in the lowermost formation of the Sops Arm Group, and form thick units above them in the north of the area. This outcrop resembles the Jackson's Arm Formation, which is well-exposed on Route 420 northeast of the Cat Arm road junction. The conglomerate is clast-supported and very poorly sorted. It contains a wide variety of clast types, but the most abundant are fine-grained felsic igneous rocks of volcanic or hypabyssal origin. There are also coarse-grained granitoid clasts, but these do not obviously resemble local Precambrian igneous rocks; however, gneissic clasts have been reported elsewhere (Smyth and Schillereff, 1982). Other clast types include mafic volcanic rocks, and siliciclastic sedimentary rocks. Carbonate clasts that might equate to rocks seen on Day 2 are conspicuously absent. Some of the clasts are remarkably angular and a few could be accurately described as rectangular; however, most clasts are well-rounded. Bedding in the outcrop is poorly defined, but a finer-grained conglomerate unit suggests that it strikes roughly north-south. A second outcrop, located downstream beyond a small beach, is dominated by purple felsic volcanic rocks, but these are far better displayed in nearby roadcuts (see below).

Stop 3.7 : Felsic volcanic rocks, Sops Arm Group

This outcrop is located at the junction of Route 420 and the road leading to the town of Sops Arm. From Stop 3.6, continue southward for approximately 0.6 km, and park in the cleared area at the road junction, just north of the steel bridge. A long roadside outcrop exposes felsic volcanic and pyroclastic rocks; the best part is at the eastern end. These outcrops were previously described by Tuach (1987a), and the following is a modified description.

The easternmost part of the outcrop is a massive, homogeneous, purple rock with small grey spots that may be relict phenocrysts or amygdules. This gives way westward to purple rhyolitic outcrops in which flow banding is well developed and spectacular. The western end of the outcrop is more heterogeneous, and includes well-preserved and spectacular fragmental rocks, considered to be of pyroclastic origin. The outcrop contains west-dipping quartz veins, and east-dipping schistose zones interpreted by Tuach (1987a) as minor thrusts. Buff zones of sericite and minor epidote are developed adjacent to some of the quartz veins. Tuach (1987a) considered these to be similar to marginal alteration associated with auriferous quartz veins at the Park showings (see below; Stop 3.12)

Stop 3.8 : Frenchmans Cove Formation, Sops Arm Group

These outcrops are located on the shore of Sops Arm. From Stop 3.7, drive east for 1.2 km. Park by a grey house with a roadside garage, and walk down a path to the shore of a small inlet.

These outcrops represent the Frenchmans Cove Formation, a sedimentary unit that overlies the Lower Volcanic Formation, and underlies the Simms Ridge Formation. The black rocks on the other side of the inlet are calcareous siltstones of the latter. The shoreline outcrops here are strongly deformed polymictic conglomerates, but these are generally better sorted than those seen at Main River (Stop 3.5). The clast population is dominated by felsic volcanic material, but other rock types are also present. Conglomerates are underlain by buff-coloured sericitic siltstones and sandstones that exhibit numerous "siderite spots", which are more likely composed of limonite pseudomorphing dolomite crystals (c.f., Saunders, 1991). These rocks are strongly reminiscent of those assigned to the Simms Ridge Formation around the Browning Mine (see later description). Quartz-carbonate veins containing minor sulphides cut the outcrops, but it is not known if these are auriferous.

The strong fabric in the metaconglomerates is in part defined by stretching or "rodding" of individual clasts, which defines a strong downdip lineation. The strong deformation suggests that the contact between the Frenchmans Cove and Simms Ridge formations is an important fault at this locality, and possibly elsewhere.

Stop 3.9 : Simms Ridge Formation limestones, Sops Arm Group

From Stop 3.8, continue eastward for 0.5 km, turning right onto the shoreline road through Sops Arm. Park by a well-bedded outcrop that contains prominent white-weathering beds near its base.

This outcrop reveals very typical bedded calcareous siltstone and slate of the Simms Ridge Formation, and also shows one of the limestone units typical of its lower section. The brown weathering carbonate unit is probably a bioturbated limestone, in which the grey ovals and streaks represent flattened burrows. The outcrop may also be fossiliferous, and some possible fragments show a honeycomb-like texture suggestive of an organic origin. The fragments could be corals or perhaps bryozoa (?). Boulders and flagstones of very similar carbonate rocks occur around the Browning Mine (see later discussion) and are also fossiliferous.

Stop 3.10 : Simms Ridge Formation siliciclastic rocks, Sops Arm Group

From Stop 3.9, continue eastward for 0.5 km, and park on the hill just beyond a house with pale pink siding. Descend to the shoreline and walk westwards, crossing a large quartz vein, and then a small beach to some more extensive shoreline outcrops. This location was previously described by Tuach (1987a) under the name "Eli Decker's stage", but the locational information is now obsolete because the houses have been renovated in different colours ! The following is a modified description.

The outcrops consist of interbedded siltstones, sandstones, slates and rare thin limestone beds. Brown-weathering sideritic or limonitic spots occur locally, but are nowhere near as abundant as around the Browning Mine. The pitted appearance of the coastal outcrops suggests that they are calcareous. Bedding-cleavage relationships are locally visible, and in general cleavage is steeper than bedding, suggesting that the rocks are right-way-up. However, nearby outcrops show subparallel bedding and cleavage, suggesting that there may be tight asymmetric folds in the section. Lenticular quartz veins are present, and a wide quartz vein is present at the east end of the beach. Tuach (1987a) reports assays of 0.17 ppm Au and 1.1 ppm Ag from one quartz vein that contained minor sulphide, but the location of this sample is uncertain. Rocks assigned to the Simms Ridge Formation contain gold-bearing veins south of Pollards Point (see later discussion).

Stop 3.11 : Natlins Cove Formation, Sops Arm Group

From Stop 3.10, continue eastward for approximately 3.6 km, to a large outcrop on the east side of the road. This consists of well-bedded pale grey to greenish sandstones of the Natlins Cove Formation, representing the "Lighthouse Member" of Lock (1969). These rocks are not fully typical of the sedimentary rocks of the Natlins Cove Formation, as these generally resemble the rather boring rocks of the underlying Simms Ridge Formation. The volcanic rocks of the Natlins Cove Formation are not easily accessible and will not be visited on the field trip.

From Stop 3.11, continue to the end of the road at Schooner Cove, turn around, and drive back to route 420, then cross the steel bridge to eat lunch at the Sops Arm Park, located on an island in Main River.

Stop 3.12 : Park Showing

From the park, continue southward on route 320 for 0.5 km, across a bridge, to where there are some outcrops on the northwest side of the road, opposite a house with a very large and lush lawn. These are the Park showings, previously described by Tuach (1987a). The following description is taken largely from that source. *Watch out for traffic at this location, which is on a curve !*

A vertical quartz vein up to 30 cm wide and several smaller veinlets outcrop over 20 m in the roadcut, where they are hosted by felsic tuff of the Lower Volcanic Formation of the Sops Arm Group. Minor pyrite is present in the veins, and the host tuff is locally sericitized adjacent to them. A second parallel vein outcrops about 25 m west of the road and contains minor pyrite and galena. The larger vein in the roadcut gave assays of 0.2 and 0.54 ppm Au, but a sample from the galena-bearing vein contained 2.7 ppm Au (Tuach, 1987a). The mineral occurrences are small and low-grade, but they typify the style of mineralization in the volcanic rocks, seen also at the West Corner Brook Prospect.

Stop 3.13 : Mafic metavolcanic rocks and the Wizard Showing

From Stop 3.12, continue southward on route 420, through downtown Pollards Point, to the Pinksen's Forest Resource Road, located approximately 3.5 km from the Pollards Point road junction. Turn left, and park at the start of the road, and then walk southward on Route 420 for about 150 metres, to a roadcut outcrop on the west side of the highway. This location was also described by Tuach (1987a), and the following is a modified description. *Watch out for traffic at this location, where the road is narrow !*

The roadcut outcrop reveals green, chloritic, schistose rocks that are probably derived from mafic volcanic or tuffaceous rocks of the Lower Volcanic Formation of the Sops Arm Group. Mafic rocks are generally subordinate to those of felsic aspect, and this is one of a few locations where they can be easily seen. There are no obvious primary volcanic features here, and the rocks are suspected to be metatuffs. At the south end of the roadcut, a strongly foliated, 3 m wide, sericite tuff unit is exposed within more mafic tuffs on both sides of the road. The sericitic unit contains minor disrupted and tightly folded quartz veins that contain minor pyrite and traces of galena; a grab sample of vein material assayed 6.1 ppm Au. This outcrop is a little bit too close to the Doucers Valley fault zone for comfort, and the strong fracturing, crenulation and local folds are likely related to late fault movements, as seen at Stop 1.3.

Stop 3.14 : Felsic subvolcanic intrusive rocks (?), Sops Arm Group

From Stop 3.13, drive along the Pinksen's resource road for approximately 1.8 km, to an outcrop located on the south side of the road. *The road is in good condition, but watch for occasional large potholes, not to mention oncoming logging trucks !*

These outcrops consist of relatively homogeneous pink felsic rocks that show variable but locally intense sericitization. A lack of flow-banding or other obvious extrusive features, coupled with the presence of relict quartz-porphyritic textures, suggests that these rocks represent high-level (subvolcanic ?) intrusive rocks rather than true rhyolites. The outcrop is cut by numerous narrow grey quartz veins, in a wide variety of orientations, that locally create a pink and grey net-veined texture. There does not seem to be a spatial relationship between the sericitization and the quartz veins, suggesting that the latter are relatively late in timing. It is not presently known if the sericitic material is anomalous in gold.

Stop 3.15 : The Browning Gold Mine Area

From Stop 3.14, continue eastward on the Pinksen's resource road for approximately 1 km, until the road crosses Corner Brook. Just beyond the culvert, there is a crossroads, where a right turn provides access to a wide parking area, from which an old overgrown road heads south on the east side of Corner Brook. There are two possible routes to the Browning Mine from here. If water levels are low, it is possible to walk up Corner Brook for about 300 metres to the site. A quicker route is to walk up the old road for about 300 m to a clearing on the west side of the road where the old shafts have recently been filled in for safety reasons. Some dumped waste remains on the far side of this clearing, from where it is possible to descend the banks of Corner Brook to the original adit. *This is a steep descent, but there are enough trees to provide handholds. Make your way down slowly, and be especially careful in the lowermost section, where the surface is locally very loose and gravelly. If water levels are high, the various outcrops described below cannot be examined without getting wet feet. Participants might consider bringing some old footwear for this stream traverse.*

The Browning Mine area was described previously by Tuach (1987a) and parts of the following description are adapted from that source. Saunders (1991) provides an excellent summary of the history of the deposit, and many aspects of its geology. The mineral rights are presently held by Mr. Tom MacLennan of Grand Falls. The following field description of outcrops is in three parts; the first describes the immediate adit area, the second describes a short traverse upstream, and the third describes a short traverse downstream. All three areas will be examined if time permits. The dominant rock types throughout the Browning Mine area are beige to pinkish, sericitized calcareous siltstones and sandstones assigned to the Simms Ridge Formation, which are here a short distance to the east of the contact between this formation and the Lower Volcanic Formation (see earlier stops). The contact is not exposed, but is considered to be a fault. Corner Brook runs at a very slight angle to the strike of the beds, which dip moderately (20-40°) eastward.

The remaining waste dumps above the mine area, where shafts were once located, provide the best opportunity for collecting mineralized samples, but much of the material contains only minor sulphides. The most obvious sulphides are pyrite, chalcopyrite and galena; sphalerite and specular hematite are also reported (Saunders, 1991). The adit runs for approximately 10 metres into the bank of the river, but the old workings and shafts beyond the entrance are no longer accessible; it appears to be fairly secure, and can be entered with caution. It is located above a prominent schistose zone at the base of the cliff, that can be traced both upstream and downstream. Within the adit, several cross-cutting quartz veins are clearly visible in the walls and roof, but these were apparently not the main gold-bearing structures, as they were not excavated. Quartz veins are also present in the schistose zone below the adit, where they are generally concordant with the fabric and locally appear to be folded. In addition to quartz, white to brown carbonate gangue is common in the veins. There are some smaller excavations just upstream from the adit, but these evidently proved too small for further development, or are barren. Very little information is available concerning grades during the period of active mining, but Saunders (1991) reports values of 4.8 to 7.2 ppm Au from various unpublished sources connected to later exploration and survey work.

Walking upstream from the adit, the siltstones and sandstones of the Simms Ridge Formation contain prominent brown spots, generally known as "siderite spots", although Saunders (1991) reports that they consist of limonitic alteration of dolomite porphyroblasts. These are common throughout this part of the formation. Several variably discordant quartz-carbonate veins cut the sedimentary rocks upstream from the adit. There are also many flat boulders and slabs of pale brown to beige, variably dolomitic carbonate rocks, many of which contain grey calcite nodules. These probably are derived from carbonate rocks that occur towards the base of the Simms Ridge Formation in this area, but no actual outcrops of this material have been located near the mine site. They are reported to occur some 500 m upstream (Tuach, 1987a) but have not yet been reexamined. Some of the grey nodular features probably represent burrows, as seen in roadcut outcrops this morning (see Stop 3.9), but others may actually be poorly-preserved fossils. Surface patterns on some of these show a honeycomb-like pattern that may indicate the presence of corals and/or bryozoa, and spiral shapes suggestive of gastropods have also been observed; some examples located by G. Squires will be examined (if we can find them again). For about 125 m upstream from the adit, the strongly schistose zone noted earlier remains on the east bank of Corner Brook, but it eventually crosses the brook, trending at about 020°, and dipping some 40° east. The calcareous siltstones structurally below this zone contain numerous pyrite cubes and have intensely developed "siderite spots". There are also quartz veins in this area, which have a similar strike, but dip more steeply than the cleavage in their host rocks. The quartz veins are discontinuous and lenticular, suggesting that they have been boudinaged. The strongly deformed siltstones and sandstones contain small rootless isoclinal folds, that indicate a more complex structural history in this zone than one might at first think. From this point, return downstream to the adit again.

Walking downstream from the adit, the calcareous siltstones and sandstones are again characterized by numerous siderite spots, but there does not appear to be any spatial link between the intensity of spot development and proximity to quartz veins. About 75 metres downstream from the adit, there is an outcrop that shows particularly intense quartz veining, in which the host rocks have been pervasively altered to brown iron carbonate-rich material. Downstream from here, there are numerous quartz-carbonate veins ranging from a few centimetres to 0.5 metres in width. In many areas, brown iron carbonate alteration haloes are developed around individual veins, but it is not clear if these actually overprint the siderite spots. However, the latter are invisible where alteration is intense. These relationships imply that marginal iron carbonate alteration is associated with the veins. Many of the veins appear barren, although some do contain minor pyrite; it is not presently known which, if any, are auriferous. The schistose zone that sits beneath the adit continues to crop out on the east bank of Corner Brook throughout this section. About 125 metres downstream from the adit, there are some prominent folds within this zone, and the hinges of these folds plunge downdip, and they are locally overturned to the south, with a "Z" geometry. These folds are believed to record a later phase of motion than the "early" rootless folds noted in the upstream section. This late folding is considered to be the episode that affected quartz veins in the immediate mine area, and they were probably emplaced synchronously with it, but perhaps controlled by a pre-existing structure. From this location, the road bridge over Corner Brook is accessible easily if water levels are low; if not, it may be necessary to return to the adit and climb up the steep bank. If you already have wet feet, it is probably just as easy to continue downstream to the vehicles.

Stop 3.16 : "The Backwards Delta"

From the parking area near the Browning Mine, cross over the Pinksen's Resource Road, and drive northwards along the road that runs parallel to the east bank of Corner Brook for approximately 2.7 km to a prominent gravel pit on the west side of the road.

At this location, a delta with distinct topset and foreset beds is exposed in a gravel pit. The sediments are moderately to well sorted and finer beds are found at lower stratigraphic levels as well as to the southwest. The topset and foreset beds consist of interbedded silty fine to coarse sand and sandy gravel that ranges from granules to cobbles. Clasts are subangular (range subround to very angular), indicating a short transport distance. The delta is graded to a 20 m sea level stand.

This 'Backwards Delta' is problematic in that the foreset beds dip southwest, which means that water flowed upvalley. This is an unusual situation, as glaciers generally retreat upvalley, and their meltwaters flow downvalley toward the sea. The result is a delta with foreset beds that dip towards the ocean. The foresets of the 'Backwards Delta', however, dip *away* from the ocean, indicating that this was not actually the case.

If there was ice in Sops Arm when the Backwards Delta formed, it would deflect glacial meltwater along Corner Brook Valley, which would account for an upvalley flow direction. However, the presence of glaciomarine terraces graded to 20 m and a delta terrace graded to 30 m on the opposite side of Sops Arm suggest that Sops Arm was ice-free during formation of the Backwards Delta. Another possible scenario is that there was a major meltwater river issuing from the valley northeast of the Sops Arm delta, along the trace of the Doucers Valley fault zone. The Main River meltwater river would have flowed to the southeast, as the Main River does today. The other meltwater river would have flowed to the southwest. The combined vector flow would have been roughly south, and a very large delta would likely develop. If that is the case, then a major delta was forming in the Sops Arm area throughout deglaciation and continued to prograde and incise itself as sea level fell. This would explain the numerous deltaic features and the associated paleoflow vectors that are all mainly southward in the Sops Arm area (Figure 9). Such a delta would have begun forming prior to 11 200 ±100 BP, the time of the 40 m marine sea level stand (see Stop 3.5). The delta was building out toward the Corner Brook Pond area at 10 200 ± 100 years BP, when sea level was about 30 m above present, based on a ^{14}C date on *Mya truncata* shells (Blake, 1988). Some time after this, sea level fell to 20 m above present, and the delta had built at least as far south as Corner Brook Valley. The southern part of the delta built out toward what is now Corner Brook Pond, effectively damming this area and creating a glacial lake. The modern pond is a remnant of this lake. In Holocene time, much of the Sop's Arm delta must have been eroded away.

Stop 3.17 : West Corner Brook Prospect

From Stop 3.16, continue northward along the gravel road. In less than 1 km, the road joins the Pollards Point road just opposite the Riversea Motel; parking is available at the junction or at the motel. Walk southward back along the gravel road for about 250 m, and then cut westwards through spruce and alder bush to the river, following a flagged line that (unfortunately) is not cut. There is a rough exploration adit on the west bank of the river and a pile of variably mineralized material on the east bank. The West Corner Brook prospect has been previously described by Tuach (1987a) and Saunders (1991). It was the first recorded instance of gold mineralization in Newfoundland.

The prospect consists of quartz (+/- feldspar) veins that cut rhyolites of the Lower Volcanic Formation. The veins are gently west-dipping to flat-lying, and are best exposed just outside the adit; entry into the adit is not recommended. The iron carbonate alteration seen at the Browning Mine is not present here, suggesting that alteration assemblages are in part controlled by the host rock assemblages. The mineralized material is largely pyritic, but chalcopyrite and galena are also reported, and grab samples contained up to 1 ppm Au (Tuach, 1987a). From this stop, return to the Riversea Motel at your convenience!

DAY FOUR : BASE METAL MINERALIZATION IN CARBONATE ROCKS OF THE SOPS ARM GROUP

General Overview

The final morning of the field trip includes visits to two interesting and little-studied base metal prospects near to Route 420 in the south of the area. One example, the Turners Ridge deposit, has been known since the 1970s, and probably would have been mined if it had been discovered early in the last century. The other example, the Whitestar prospect, is a recent discovery about which little is known. Both of these are hosted by carbonate rocks intercalated within the Lower Volcanic Formation of the Sops Arm Group, but the sulphide mineralization in each is different.

Stop 4.1 : The Whitestar Zinc Prospect

These outcrops are located on the east side of Route 420, approximately 10.0 km south of the road junction in Pollards Point. Turn eastwards onto the old road, and drive a very short distance into a quarry. From here, a rough tractor trail leads east towards the power line; the zinc showing is located on the first bend in the trail, where brown-weathering carbonate rocks are visible. This is a new discovery that was drilled in late spring 2004 by Rubicon Minerals. There are no published descriptions of the geology, and the following is based on a brief visit by the senior author on a very rainy day in late summer.

The quarry exposures consist mostly of bluish shales, with a very strong cleavage. On the east side of the quarry, and along the tractor trail are brown-weathering, dolomitic carbonate rocks that contain variable amounts of dark sphalerite; locally the sulphides are semi-massive. In much of the material, the sphalerite seems to form a network of fractures in greenish or brownish recrystallized host rock. The overall style of mineralization appears similar to that seen at the Turner's Ridge deposit, discussed below. The host rocks are considered to be a thin carbonate unit within the Sops Arm Group.

Stop 4.2 : The Turners Ridge Deposit

From Stop 4.1, return to Route 420, and drive southward for approximately 9.4 km. The Turners Ridge deposit is located approximately 1.4 km south of the large outcrop of the Carboniferous unconformity (Stop 1.2). It is impossible to miss because the outcrops are strongly gossaned, and a large area has been excavated due to their unstable nature. The outcrops were described previously by Tuach (1987a); the following is a modified description. *Note that these outcrops are friable and unstable, and that the scree slopes may be very loose; climbing is not recommended, and outcrops should be hammered with caution.*

Upgrading of Route 420 has now removed significant amounts of the deposit, which was originally defined by mapping and drilling in the 1970s (Dimmell, 1979). The mineralization and the host rocks are best observed north of the prominent deeply-weathered zone, in the central part of the exposure. Several large blocks of high-grade material are present in this area, and it is relatively safe to hammer these and surrounding smaller blocks. The host rock is a grey-green, hard, carbonate rock believed to be a dolostone unit within the Lower Volcanic Formation of the Sops Arm Group. It is variably altered to calcite, but generally does not respond to HCl. The host rocks are extensively brecciated, and the fractures are filled with galena, accompanied by minor barite and calcite. In places, galena makes up 30-50% of the rock, but more typically it constitutes less than 10%. Work by Noranda in the 1970s indicated a resource of some 0.2 million tonnes of 3-4% Pb. No significant Zn is reported.

There is a prominent deeply-weathered zone in the outcrop. This is associated with high-angle faults, and at least in part corresponds with a zone of altered rhyolite. The latter is a pinkish brown siliceous rock that contrasts with the grey dolostone, and it locally displays flow-banding (G. Squires, pers. comm., 2004). The rhyolite is less strongly mineralized, but loose blocks do contain altered and fresh galena veinlets. This region of the outcrop probably represents a downfaulted section of an overlying rhyolite unit indicated by drilling (see Figure 12). Drilling by Noranda also indicated the presence of minor mineralization in the rhyolites, which they believed to be in fault contact with the dolostone (see Saunders, 1991; Figure 12). This region of the outcrop exhibits very deep weathering, and unusual yellow staining on many blocks probably indicates the presence of secondary lead carbonates and sulphates.

Exploration drilling by Noranda in the 1970s shows that the mineralized Silurian dolostones are structurally above Carboniferous boulder conglomerates, indicating that they have been thrust over the latter. Contacts between dolostone and overlying rhyolites were also interpreted in this way (Figure 12). The age of the mineralization at Turners Ridge is not well constrained. Tuach (1987b) and Saunders (1991) considered the presence of galena in the rhyolites to indicate post-thrusting mineralization (i.e., Carboniferous or younger). However, there is no evidence that lead mineralization extends into the boulder conglomerates, across the most significant structure, and it could therefore predate this thrusting. If this is the case, perhaps some of the deep weathering seen in parts of the deposit is actually of Carboniferous age. The mineralization has not been studied in detail, and no attempts have been made to date it directly. In conjunction with the possibly similar Whitestar prospect, it would make an interesting thesis project.

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