Laurentian University
SEG Student Chapter

Laurentian University
Université Laurentienne

HARQUAIL
EARTH SCIENCES

Field Trip Report

Newfoundland 2022
October 9th - 16th

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Contents

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Paul Robinson, Gold Island Inc.
Steve Windle, Gold Island Inc.

Acknowledgments

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We thank Dr. Marina Schofield (Buchans Resources) and Alicia Escribano (MUN) for introductions to mining companies and aid with logistics.

Summary

Seven graduate students from Laurentian University, one professional from Red Pine Exploration and three professionals from Gold Island visited the island of Newfoundland in Canada to learn more about its incredible and diverse geology. The field trip consisted of 7 days from October 9th to 16th, 2022 to travel across Newfoundland to visit orogenic gold and VMS deposits, and interesting geological sites. The field trip included the visit to three exploration projects: Queensway (owned by NewFoundGold), Valentine Gold (owned by Marathon) and Buchans (owned by Buchans Resources). In addition, a guided tour to the producing underground Ming Mine (Rambler Metals) and the visit to two UNESCO world heritage sites of geological significance (Mistaken Point and Gros Morne). For more information on the itinerary and geology please refer to the field guide included as an appendix.

Itinerary

	Site	**Company**	**Geologic interest**
Day 1	Mistaken Point UNESCO site		Ediacaran soft-bodied fossils
Day 2	Queensway Project	NewFoundGold	Orogenic gold
Day 3	Ming Mine Tilt Cove	Rambler Metals	VMS Cu-Zn
Day 4	Gros Morne		Green Point GSSP The Tablelands
Day 5	Valentine Gold	Marathon Gold	Orogenic gold
Day 6	Buchans Project	Buchans Resources	VMS Cu-Zn
Day 7	Gem exploration	Memorial University of Newfoundland	Dr. Phillipe Belley talk

Day 1

We travelled from St Johns, NL to Mistaken Point in the east coast of the Island to visit Mistaken Point: a UNESCO world heritage site . This natural reserve contains Ediacaran turbidites that preserve the fossils of one of the earliest known soft-bodies organisms on Earth. These fossils are delicately covered by volcanic ashes that permitted the preservations of this species that otherwise would have been lost (Fig. 1). This tour was possible thanks to the Natural Areas Program and the geologist Mark King that shared his valuable knowledge and permitted very interesting conversations. Afterwards, we drove to Gander, NL to stay overnight.

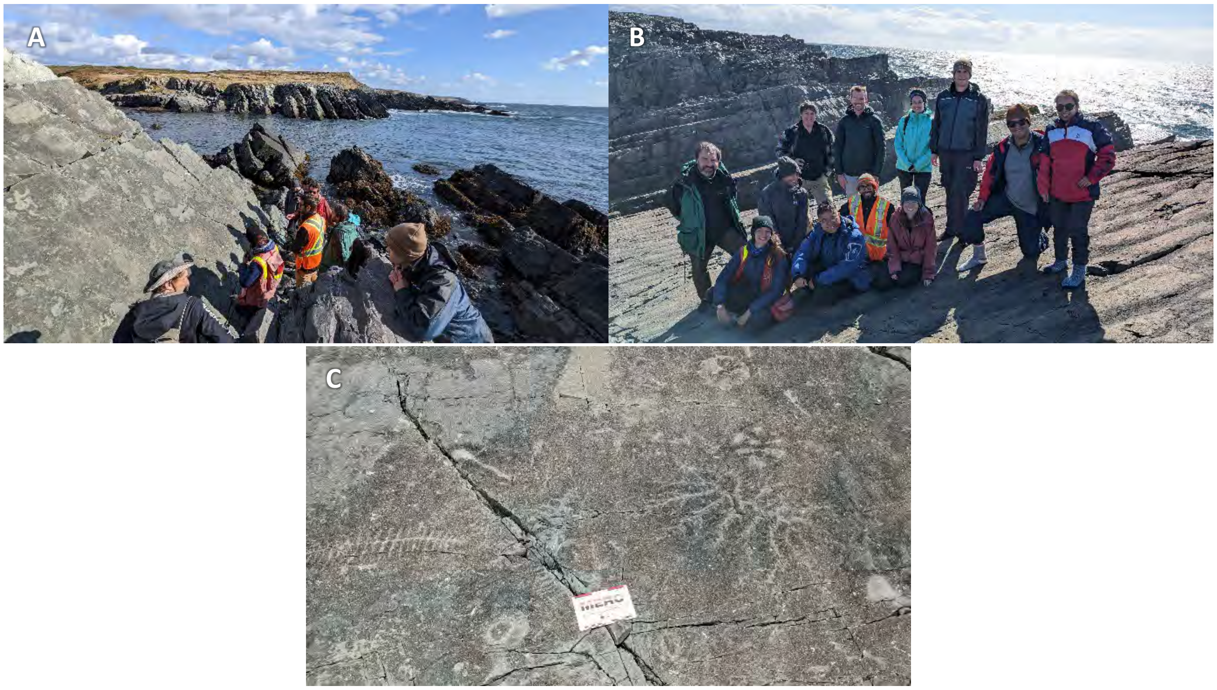

Figure 1. A) One of the fossil sites showing several different species on the face of a sandstone bed covered by very fine ash. B) The group on another fossil site just over the Atlantic Ocean. Note that everyone took their shoes off to help with the preservation. C) Close-up of several early animal species fossils that can be observed in Mistaken Point

Day 2

On day 2, we were received by NewFoundGold and Miguel Nassif who made an excellent presentation of the deposit, how it was discovered and how it has been explored including the structural setting of the deposit. The Queensway project consist of several quartz veins with epizonal to mesozonal textures with incredible gold grades accompanied by As, Sb and W minerals. After the presentation, we looked at the core where we could observe amazing intersections with visible gold and very educational textures (Fig. 2). After lunch, Miguel took us to a couple of rock outcrops where we could identify the structures in the area and how they affect the veins and the exploration efforts. In the afternoon we travelled to Springdale to stay for the night.

Figure 2. A) The group looking at the core at the Queensway project. B) Quartz veins and breccias cutting metasediments. These veins contained coarse visible gold and sulfosalts.

Day 3

On day 3, we travelled to the peninsula of Baie Verte, specifically to he producing mine owned by Rambler Metals: Ming Mine. This underground mine develops a Cu-Zn VMS system with several orebodies in the same horizon. First, we had a health and safety introduction to access the mine site. Afterwards, we divided in two groups to access both the core shack and the underground mine. In the core shack, we could observe the current exploration holes and the rock library to identify the different mineralization styles in the deposit. Underground, the company took us to one active front in the “stringer zone” to recognize the ore minerals and its relationship with the host rocks (Fig. 3 A and B). After finishing the visit, we went to Tilt Cove, a nearby historical mine where the relationship of a small orebody and the underlying and overlying volcanics could be observed (Fig. 3 C and D)

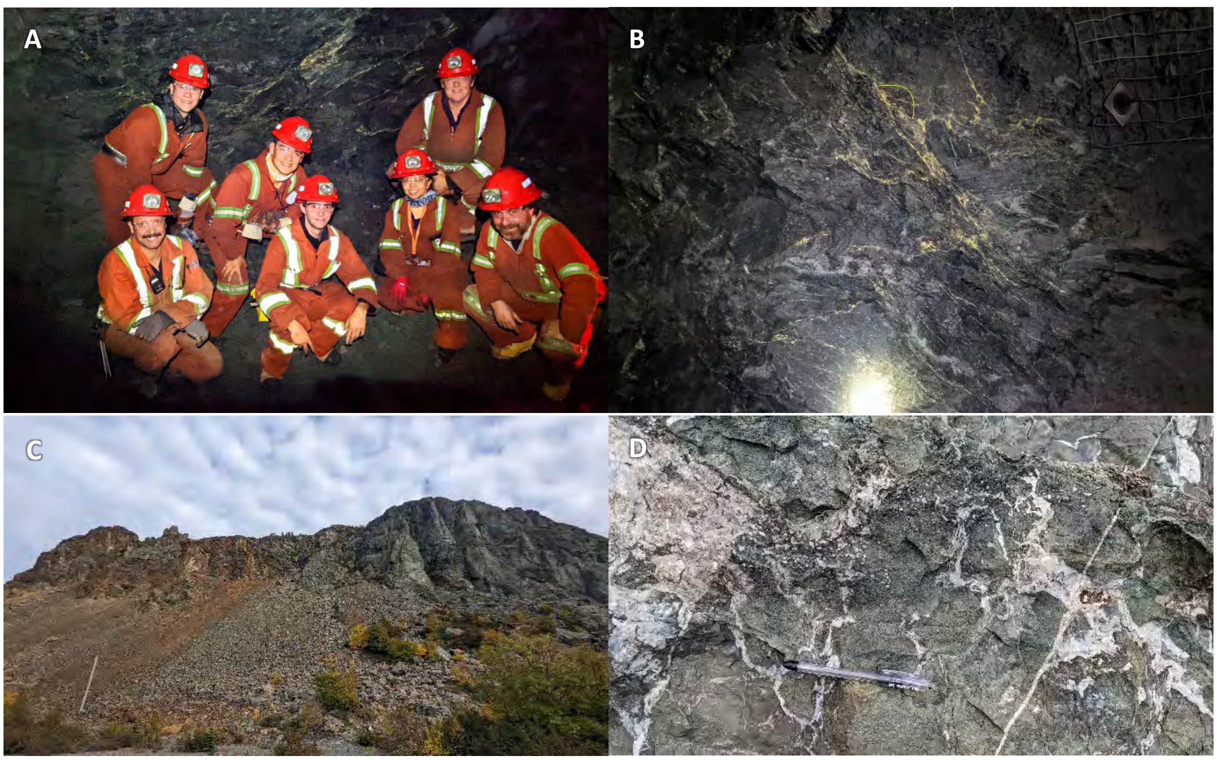

Figure 3. A) Participants in one of the active underground fronts at Ming Mine. B) Stringer zone composed of chalcopyrite and pyrite crosscutting a heavily chloritized basalt. C). A heavily oxidised basalt due to the presence of a small orebody overlying a series of green boninites on the right. D) Close up of pillowed boninites with latter calcite. Observe some calcite-filled amygdules in the border of the pillows.

Day 4

On day 4, we visited Gros Morne National Park on the west coast of Newfoundland. This amazing park have some unique geologic features that makes it a must-visit for every geologist. Early in the morning we visited Green Point which is the official GSSP for the Ordovician (Fig. 4A). Latter, we did a bunch of stops to understand the geology of the island, including how the Appalachians formed and the resultant sequence of rocks. In the afternoon, we hiked the Tablelands, one of the best exposed ophiolite sequences in the world where even tectonized mantle rocks can be observed (Fig 4.B and C). We were even lucky enough to have the visit of a couple of reindeers.

Figure 4. A) The group at the Ordovician GSSP in Green Point. The marker horizon is located just behind Laura. B). A spectacular overview of the Tablelands showing oxidised ultramafic rocks very poor in nutrients which makes it an inhospitable micro environment. C.) Tectonized hasburgite showing foliation and folding.

Day 5

On day 5 we travelled to Valentine Gold, the insignia project of Marathon Gold in Newfoundland. This project consists of orogenic gold veins formed during a very similar setting as those on the Queensway project. At Valentine Gold we were able to observe several representative holes at the core shack of the different targets they have on the property to recognize the mineralogy and structures that make up the ore deposit. Following the core visit, we visited one site that will become an open pit where the construction is currently undergoing. There we could observe outcropping veins and their relationship with the host rock, and recognize the structural controls on it. Finally, we visited a second site (that will become a pit too) to observe the regional trends (Fig 5.).

Figure 5. The group at one of the sites that are under construction to become an open pit, standing on felsic volcanics with narrow quartz veins. Due to company restrictions no more photos could be taken.

Day 6

On day 6, our friend and colleague Dr. Marina Schofield (Laurentian Alumni) received us at Buchans Resources project in the homonymous town. She guided us through several historical core with massive to semi massive sulphides, mainly chalcopyrite and sphalerite (Fig. 6A). Very importantly, she guided us through volcanic textures, how to identify them, their significance and how they correlate with mineralized horizons as some of the ore is transported in a turbulent marine environment. After checking the core, we visited some historical sites (Fig. 6B) with mineralized lenses of disseminated sulphides and baryte and to observe the regional geology. On the afternoon, we travelled back to St. Johns to do the Newfoundland traditional ritual of getting screeched.

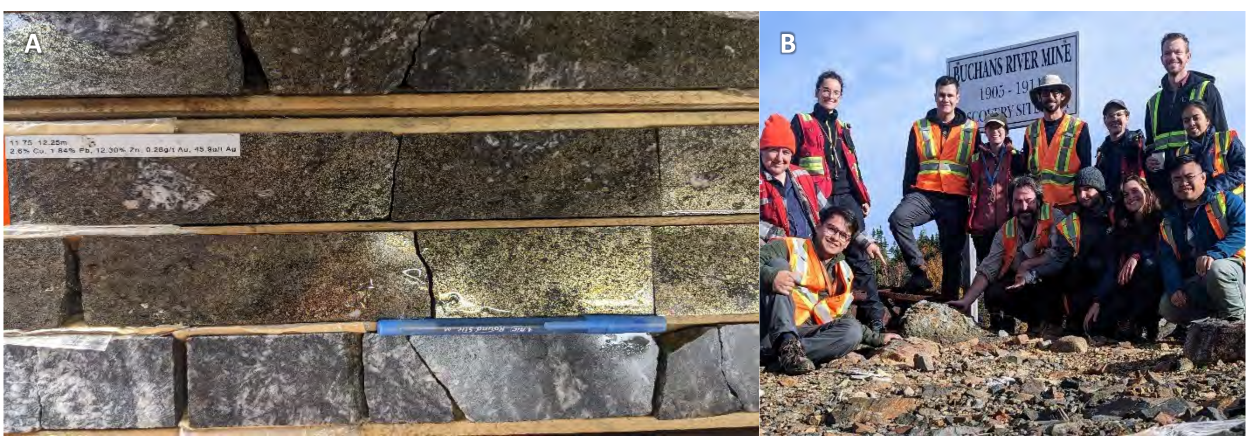

Figure 6. A) Core with massive sulphides composed mainly of chalcopyrite and sphalerite hosted by felsic volcanics with baryte (white). B) The group at the historical discovery site of the Buchans mine.

Day 7

On day 7, Dr. Phillipe Belley professor at Memorial University, gave us a talk about the exploration of gems across Canada, including his vast experience in British Columbia and Nunavut. After the talk, we had the chance to have a look at his collection that includes sapphires, garnets, rubies, among others.

Appendix: Field Trip Guide

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Newfoundland Field Trip

October 9th – 16th, 2022

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This field trip guide is based on a number of previous field trip guides and the numerous reports and papers published from the visited deposits.

Table of Contents

Newfoundland Geology - an overview

Newfoundland and Labrador is a spectacular province with some world-class geologic exposures. Geologists from across the globe visit the province to study the record of the earth's evolution preserved in its rocks. On this trip, you will see some of the oldest rocks in the world, and some unusual sequences of rocks which tell a fascinating tale of colliding continents and disappearing oceans in the geological past.

The province is divided three crustal blocks divided by faults and paleosutures showing the complex geological evolution of the island. The Avalon zone to the east is a part of the ancient microcontinent Avalonia and is composed of Late Proterozoic to Early Paleozoic sedimentary and volcanic rocks. The Central Block is divided between the Dunnage Zone and the Gander Zone. The Gander Zone is composed of mainly Cambro-Ordovician pelitic to psammitic rocks that can be heavily metamorphosed and migmatized. The Dunnage Zone is divided in the Exploits and Notre Dame subzones. The Exploits subzone is south of the Red Indian Line and is composed of Early Paleozoic sedimentary, ophiolitic and intrusive rocks. This subzone along the Gander zone is interpreted as Peri-Gondwanan arcs. In contrast, the Notre Dame Zone has a very similar lithology to Exploits subzone but was formed in opposite side of the Iapetus Ocean and with a Laurentian affinity. Finally, the Humber Zone is part of the Laurentia continental margin with a Grenville basement covered by a Paleozoic sedimentary sequence. (Figure 1). Figure 2 is a graphical evolution of Newfoundland, modified from – Colman-Sadd, Hayes and Knight (1990).

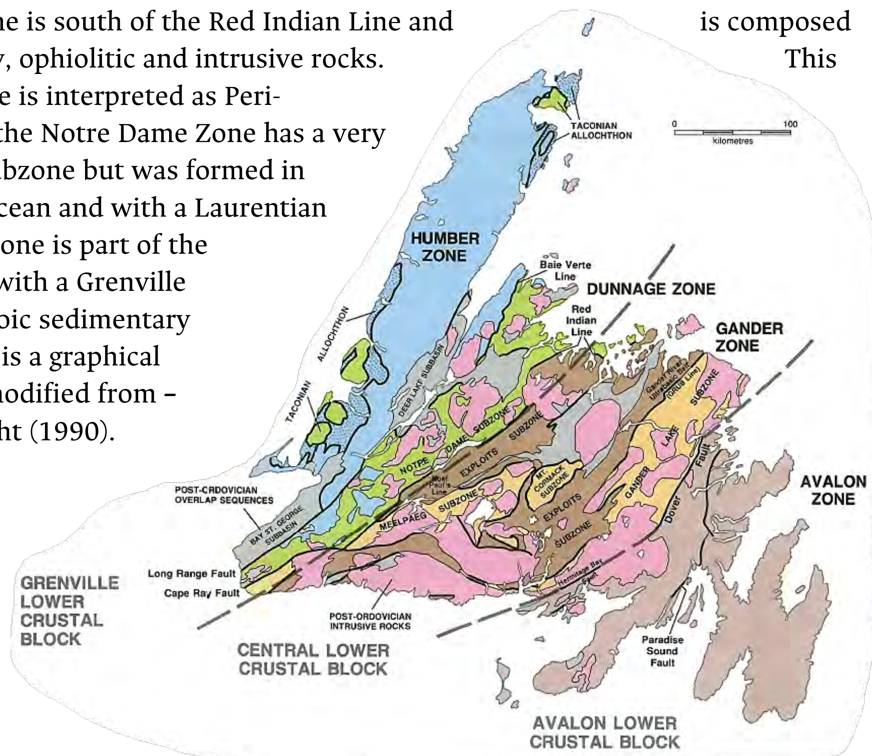
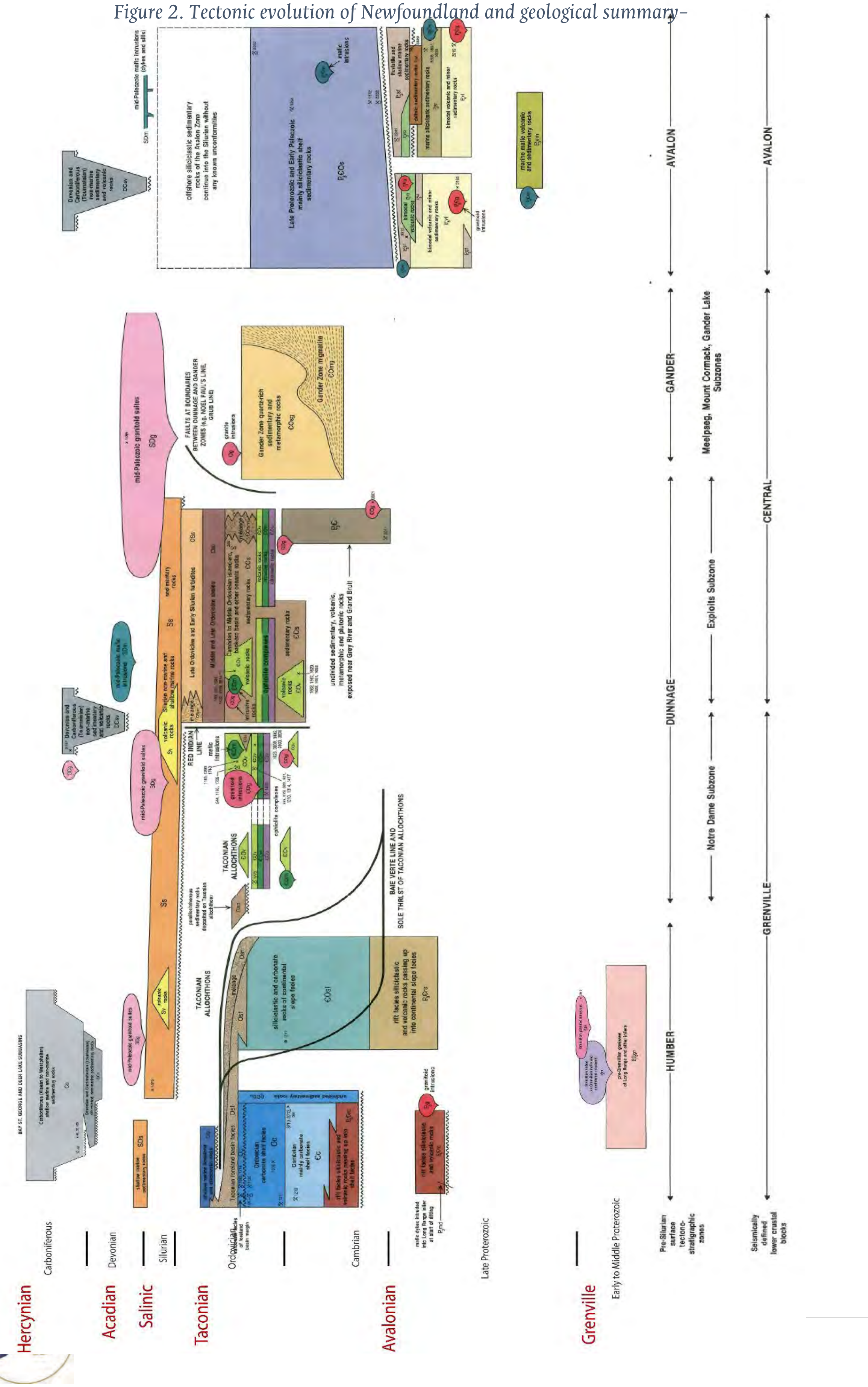


Figure 1. Principal tectonic division of Newfoundland

Figure 2. Tectonic evolution of Newfoundland and geological summary–



Day 1

1.1 Mistaken Point

Mistaken Point is designated as Canada's 18th World Heritage Site by the United Nations Educational, Scientific and Cultural Organization (UNESCO) in 2016. This stop is the oldest grouping of large, biologically complex fossilized creatures found anywhere in the world. The fossils date from 580 to 560 million years ago, when large, multicellular organisms began to appear.

The Mistaken Point Ecological Reserve sedimentary succession offers a crucial window into the rise and diversification of early animals. The fossils here are from the Ediacaran period, and range in age from approximately 580 to 560 million years old and are the largest collection of complex, multicellular Ediacaran-period animals anywhere in the world. There are 17 different species at this site, and the most common species are rangeomorphs. These fossils formed in a deep marine environment and were covered by a layer of volcanic ash, making them incredibly well preserved in their original location. The ideal preservation conditions, make this point a good replica of the sea floor from half a billion years ago.

Volcanic ash is ideal for radiometric dating, making these the oldest complex Ediacara-type fossils to be dated. Volcanic ash has preserved large numbers of fossils on individual bedding planes, providing the most accurate insight, to date on what the sea floor looked like. A study of the surrounding sedimentary rocks has shown that the Mistaken Point organisms lived in a deep-water environment, far below the depth to which sunlight or surface waves could have reached. This contrasts strongly our knowledge of most "Ediacaran" fossil assemblages, that were laid down in relatively shallow water.

In the late Precambrian and for some time afterward, eastern Newfoundland and southern Britain, along with what is now the east coast of the United States as far south as Florida, were located near each other, along what is now the northwest coast of Africa. These pieces of land made up a "microcontinent" known as the Avalonian terrane. They were not connected to the continents that they are now part of; this would not happen until about 420 million years ago, as the supercontinent Pangaea was beginning to form

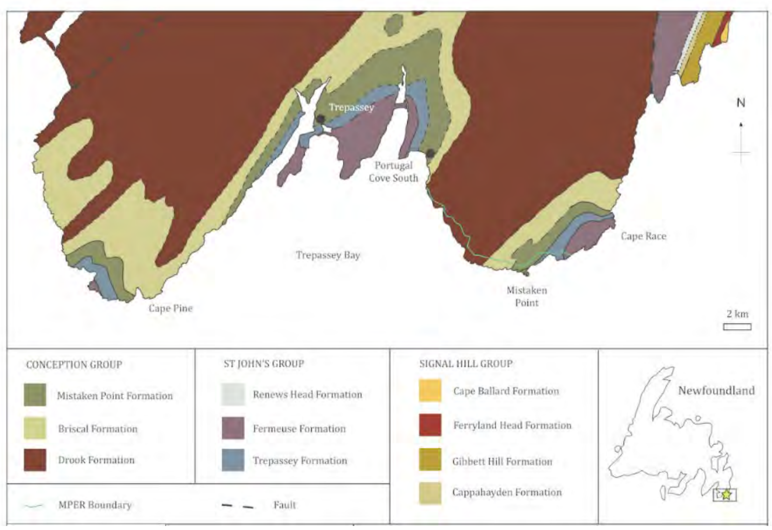


Figure 3 Geological map and stratigraphic diagram of the southern Avalon Peninsula, Newfoundland modified after King (1988).

This explains, the similarity of the Precambrian assemblages of east Newfoundland and England. It also explains the fact that later fossil assemblages, such as Cambrian trilobites, are also much more similar between eastern Newfoundland and England than, between east Newfoundland and the rest of North America.

Special thanks to Natural Areas Program, Newfoundland and Labrador, Department of Environment and Climate Change and the geologist Mark King for their educational tour in Mistaken Point.

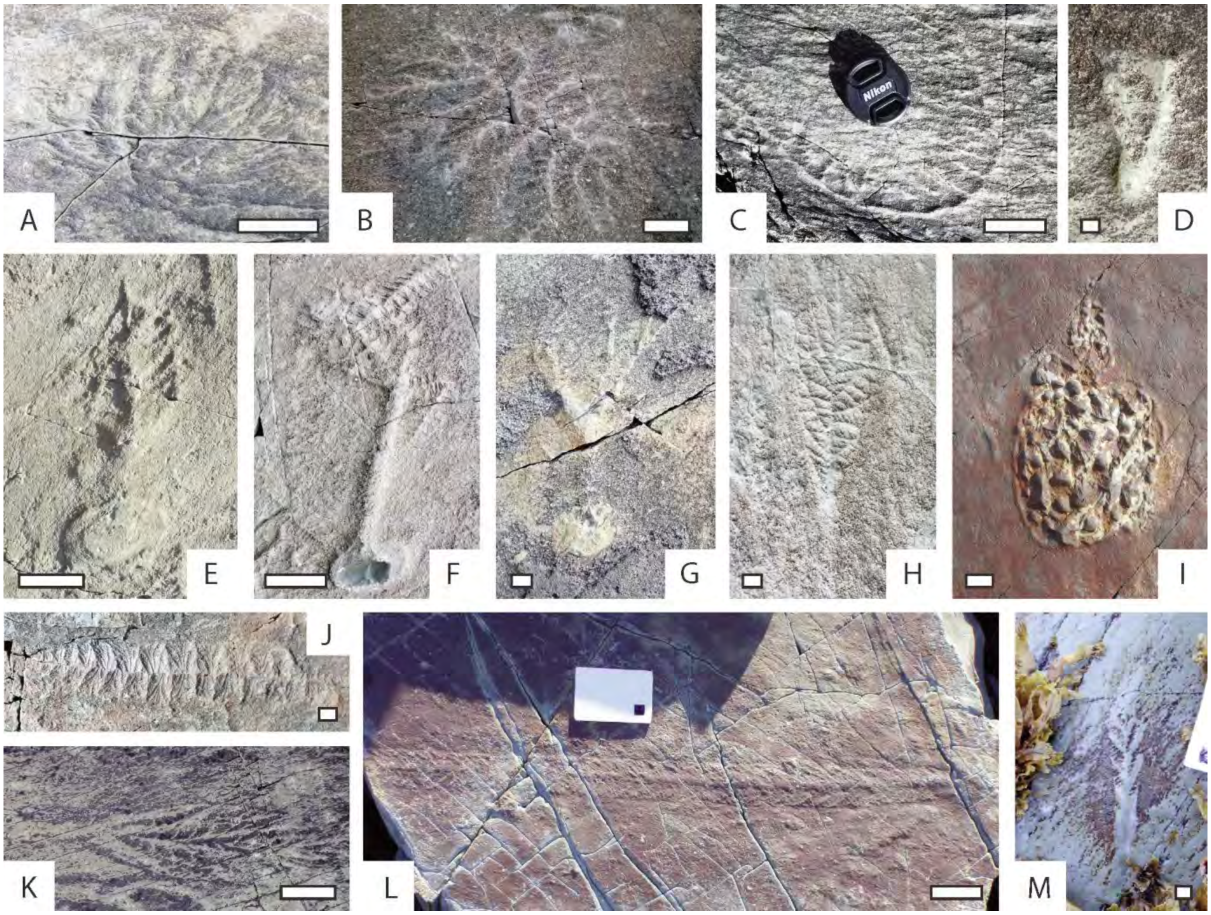


Figure 4. igure 3.A selection of the fossils commonly found within the Mistaken Point Ecological Reserve. A) Bradgatia sp.; B) Hapsidophyllas flexibilis; C) Pectinifrons abyssalis; D) Thectardis avalonensis; E) Charniodiscus spinosus; F) Charniodiscus procerus; G) Primocandelabrum sp.; H) Beothukis mistakensis (holotype); I) Ivesheadiomorph; J) Fractofusus misrai; K) Culmofrons plumosa (holotype); L) Trepassia wardae; M) Charnia aff. masoni. Scale bars in A–C, E–F, I, K–L = 50 mm, in D, G–H, J and M = 10 mm. All specimens occur on the upper surface of beds

Day 2.

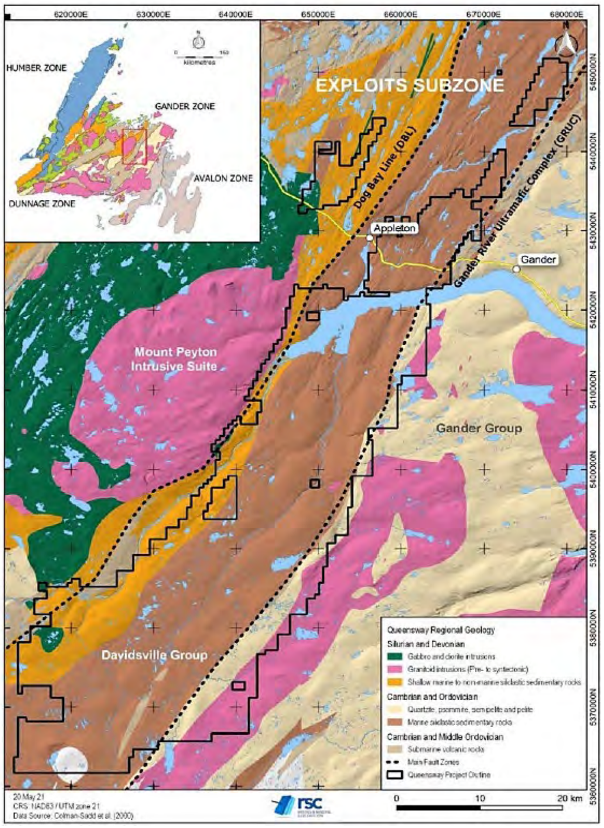


Figure 5. Geological map of the NFG property

2.1 Queensway Project – Newfound Gold Corp

Located on the Trans-Canada Highway, near the town of Gander to the Bay d'Espoir Highway. The project is divided by Gander Lake into Queensway North and Queensway South. NFG has 100% ownership of the exploration and mining rights.

The Queensway Project is located in the Exploits Subzone of the Dunnage Zone and is bounded by the “Gander River Ultramafic Belt” (GRUB) Line, which is the boundary between Dunnage and Gander zones and is associated with the Gander River Complex.

Host rock: Davidsville Group, which unconformably overlies the Gander River Complex in the east.

Davidsville Group consists of an interbedded succession of fossil-bearing mudstones, siltstones and sandstones that accumulated on the floor of the Iapetus Ocean.

Regional metamorphism: sub-greenschist to greenschist metamorphic grade.

Deformation: Progressive compression in the NW–SE direction, folding, and faulting. High-grade gold mineralization at Queensway focuses on small displacement accommodation faults.

The main NE-striking deformation corridors are the Dog Bay Line, the GRUB Line, the “Appleton Fault Zone” (AFZ), and the “Joe Batt’s Pond Fault Zone” (JBPFZ).

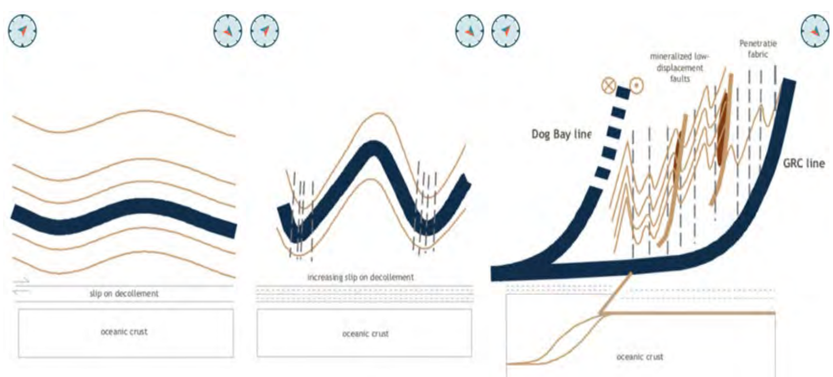


Figure 6. Deformation progression of the rocks in the Queensway Project.

The AFZ and the JBPFZ are associated with the main gold prospects discovered. These fault zones are considered crustal-scale and the primary conduits transporting gold-bearing fluids from a deep orogenic source to the upper crust.

Phases of deformation in AFZ: Early D1: NW-SE compressional event resulting from the accretion of the Gandaria plate to the Laurentian margin (Salinic Orogeny). This produced a penetrative S1 foliation, NE-plunging F1 folds and resultant fold-thrust thickening of the strata. Early stages of AFZ’s development with an injection of bedding-parallel barren quartz-carbonate veins. Followed by a transition to a transpressive regime resulting in the onset of strike-slip tectonics. This shift led to the early development of bedding-discordant dextral shear zones. To accommodate this strain, a conjugate orientation of sinistral shear zones striking approximately northwest to northeast developed. This phase of deformation is a low-grade gold mineralizing event producing the early gold-bearing structures adjacent to but trending at oblique angles to the AFZ and the mineralized shear zone network that comprises the JBPFZ.

The main high-grade gold mineralizing event corresponds with a brittle reactivation of these shear zones that were developed earlier. Brittle faults associated with high-grade vuggy massive, stylolitic and/or brecciated quartz veins formed within and adjacent to such structures and within the sedimentary stratigraphy surrounding the AFZ and JBPFZ.

<u>D2:</u> north-south compressional event related to Avalonia's collision with Laurentia (Acadian Orogeny). No penetrative regional fabric. Conjugate set of northeast-northwest strike-slip faults, a NW-directed spaced cleavage, dextral refolding of the S1 fabric producing steep plunging fold axes and sinistral reactivation of the S1 (NNE) resulting in block faulting of mineralized zones.

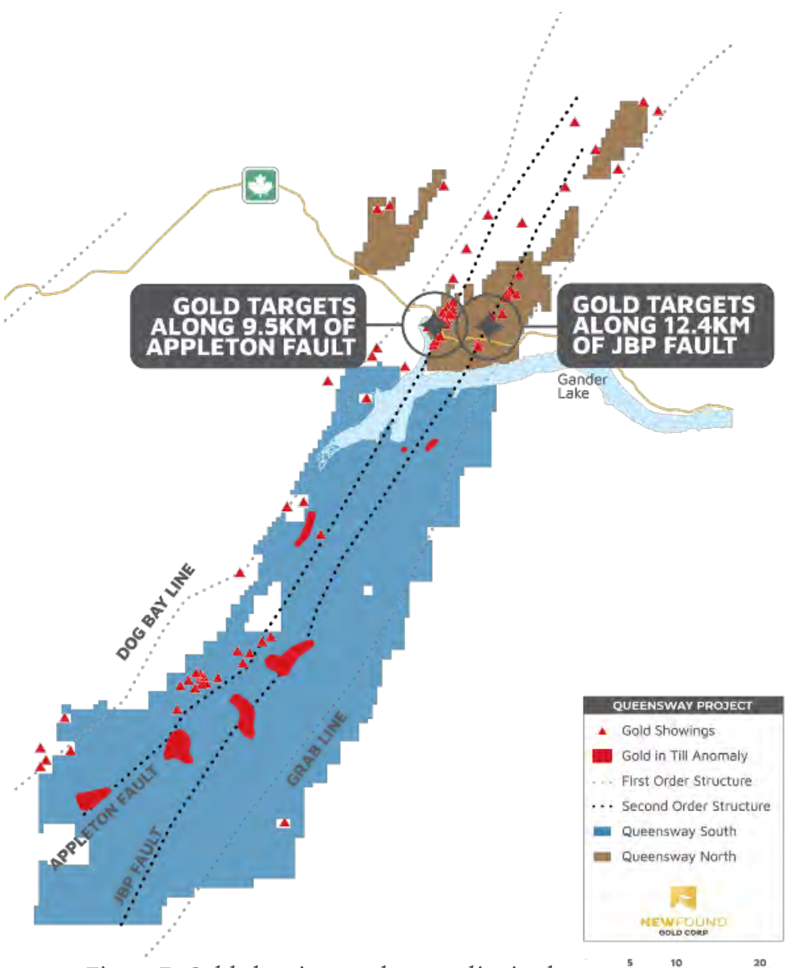


Figure 7. Gold showings and anomalies in the Queensway property

Deposit Type: Epizonal to mesozonal deposit. Orogenic quartz-vein-hosted gold mineralization with As, Sb and W.

High-grade gold mineralization occurs in closely spaced quartz veins associated with fault and fracture zones.

Gold typically occurs as coarse grains of free gold in quartz-carbonate veins that are brecciated, massive-vuggy, laminated, or that have a closely spaced stockwork texture. Gold is commonly associated with arsenopyrite, chalcopyrite, boulangerite, pyrite and NH4 muscovite.

Main Targets zones: high-grade targets were identified along the Appleton Fault and the JBP Fault.

In Queensway North: Keats Zone, Lotto Zone, Golden Joint Zone, Pocket Pond Zone, and H-Pond. (Drilled zones)

In Queensway South: Paul's Pond Zone, Aztec Zone, Eastern Pond Zone, and Greenwood Pond Zone. (Trenched zones)

Day 3. VMS deposits of the Baie Verte Peninsula

3.1 Ming Mine Deposit

The Rambler property is a mineral land assembly located approximately 17km E of the town of Baie Verte, on the North coast Of Newfoundland, registered in the name of Rambler Metals and Mining Canada Limited. It contains the former Ming and Ming West producing mines. The Ming Mine was discovered in 1970 by helicopter borne AEM system operated until 1982, when due to low Cu prices activity ceased, and because the deposit crossed over into land owned by BP Selco. The surface outcrop of the Ming deposit is located at 565910m E, 5529370m N (NAD83, UTM Zone 21).

The Baie Verte Peninsula has been targeted for base-metal exploration for over 150 years and has been the location for the discovery of some of the first volcanogenic massive sulfide deposits (VMS) in North America. The Baie Verte Peninsula runs along the western margin of the predominantly volcanic, Lower Paleozoic, Central Mobile Belt of Newfoundland, and is underlain by two different structural and lithological belts (the Humber and the Dunnage tectonostratigraphic zones) separated by a major structural zone named the Baie Verte Line (BVL). The rocks to the West of the BVL belong to the Humber zone and the rocks to its East belong to the Dunnage zone. Overall, rocks in the Baie Verte Peninsula have been affected by at least four different phases of regional deformation and most of the deformation has been inferred to be domanial. The D2 is associated with the main tectonometamorphic phase present in most parts of the Baie Verte Peninsula and its fabrics have been interpreted to be related to ductile to brittle-ductile, moderately N-dipping, S-directed shear zones. The D2 regional deformation of the Baie Verte Peninsula has been associated with a Silurian sinistral transpressive deformation regime restricted along the BVL and subsidiary faults.

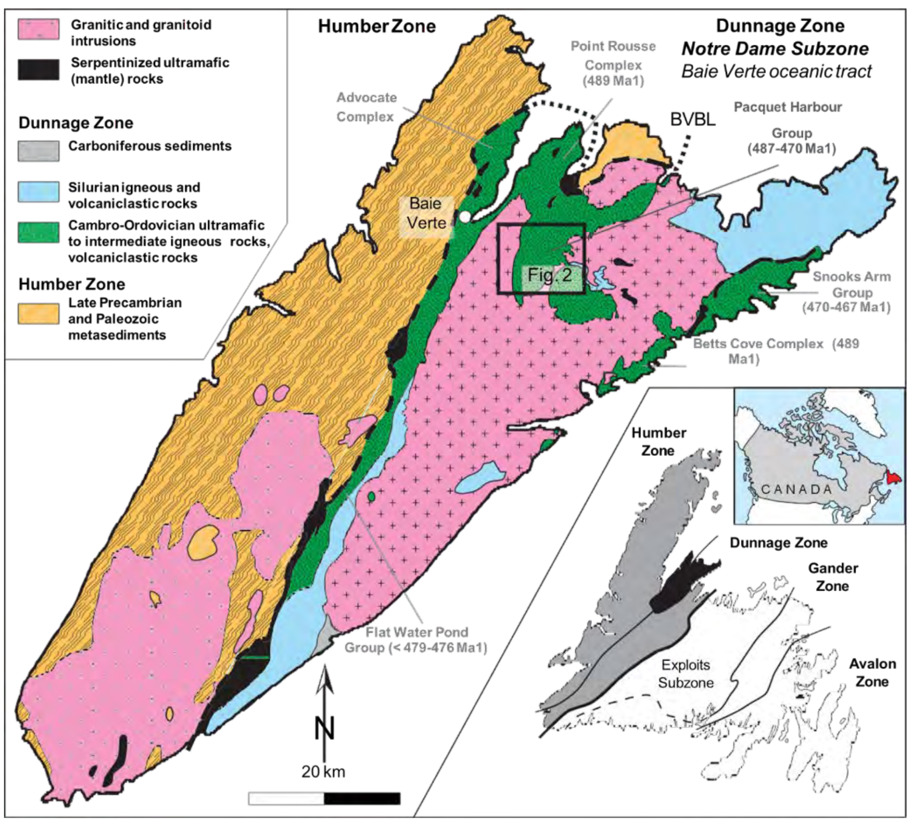


Figure 8 Simplified geological map from the Baie Verte Peninsula, after Hibbard (1983) and Brueckner et al., (2014).

The Rambler area is located within the Dunnage Zone, an important VMS district, consisting dominantly of ophiolites and volcanic and sedimentary back-arc to island-arc affinity rock types developed during the opening and later closure of the Iapetus Ocean in the late Precambrian and early Paleozoic. The Ming Mine consists of an Early Ordovician (approximately 487 Ma) structurally modified bimodal-mafic polymetallic (Cu-Au-(Zn-Ag) volcanogenic massive sulfide (VMS) deposit located in the Rambler Area, which occurs at the flank of a felsic dome. Together with the past-producing Rambler deposit, the Ming deposit is hosted within the upper parts of a sequence which comprises bonititic, quartz-phyric, rhyodacite, felsic volcanoclastics commonly referred to as the Rambler rhyolite. The Rambler Rhyolite, in turn, is found in the lower parts of the deformed and metamorphosed (upper greenschist to amphibolite facies) volcanic and sedimentary Ordovician rocks that form the Pacquet Harbour Group, defined by Hibbard, 1983. This group is inferred to be correlated to the Betts Cove Ophiolitic Complex and has an unknown thickness of >15km.

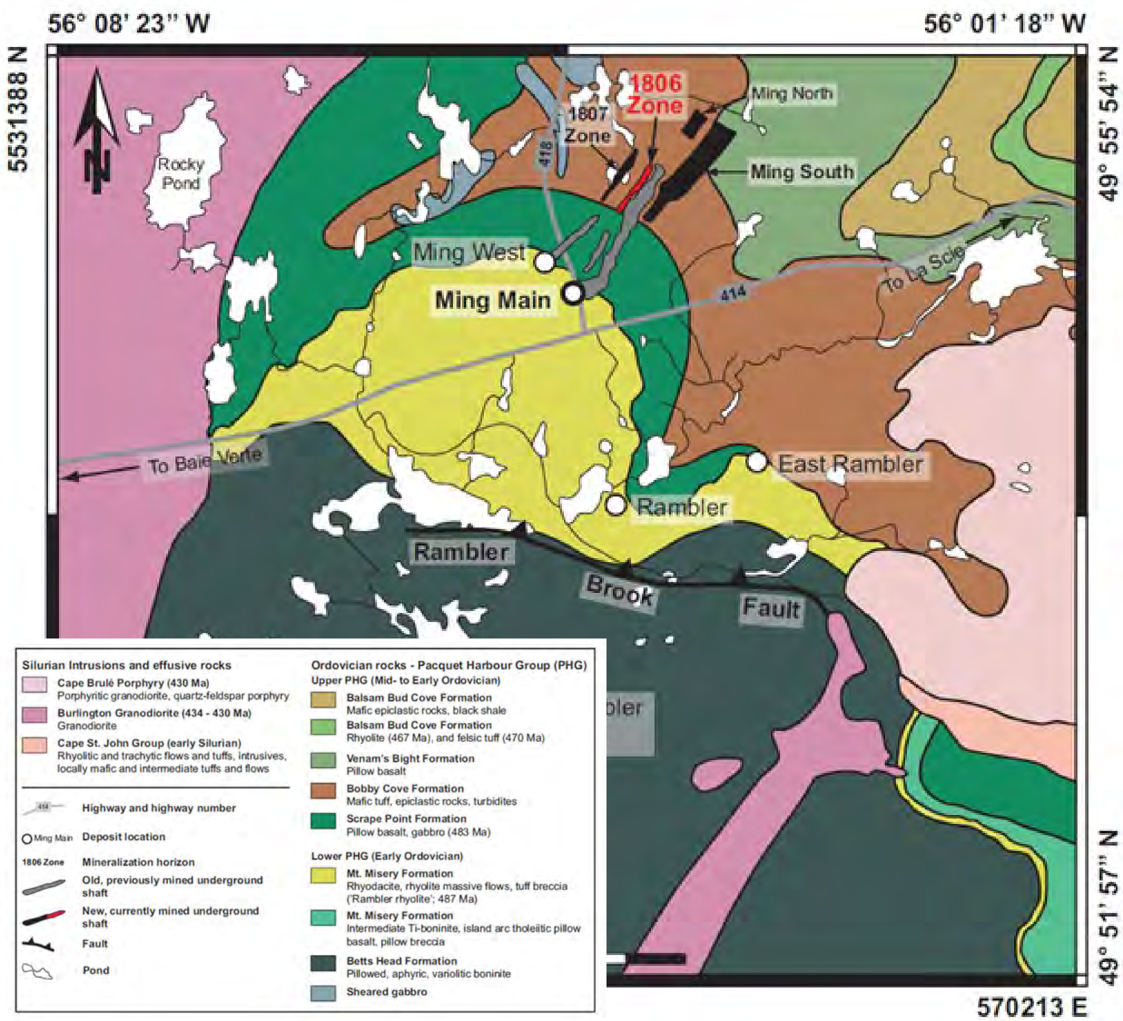


Figure 9. Detailed geological map surrounding the Ming (Main) Mine, the Rambler Property and the Pacquet Harbour Group.

The surroundings of the Ming Mine are divided into two major lithological packages: 1) the Hangingwall sequence, which consists of dominantly basaltic flows, lesser volcanoclastics and associated volcanogenic sediments and minor iron formation and 2) the underlying Mineralized Sequence, which is mainly composed of altered and locally mineralized quartz-phyric felsic volcanic rocks with minor basalt. The contact between both packages consists of a metre scale brittle-ductile shear zone parallel to the L-S of the underlying rocks and both sequences are crosscut by numerous gabbroic dikes and sills. Though the sulfide deposits belonging to the Pacquet Harbour Group have experienced at least 4 deformation phases, D2 was the most important. Both the Ming and Rambler mine areas D2 is characterised by a strong L>S fabric which is manifested as NE-plunging mineral/stretching lineations defined by deformed cigar-like clasts and pillow structures. In addition, the Ming ore bodies present their long axes oriented parallel to the L2 lineation.

The primary ore minerals at the Rambler deposits consist of Cpy, Sph, Bo, Mt, Py and Po and most mineralization is localised in strongly lineated, weakly pyritic, sericitized rhyolite or at its overlying contact with pillowed basalt. Sulfide mineralization in the Rambler area can be classified into 1) stratiform volcanogenic massive sulphide (MS) dominantly composed of massive to banded Py ore, massive Cpy-Po ore and breccia ore which tend to occur directly below the sheared contact between the Hangingwall and the Mineralized Sequences with a relatively constant thickness, 2) disseminated, often discontinuous, Py-Cpy>Sph-Ga-Po-Apy stringers with highly variable Cu grades crosscutting altered felsic>mafic volcanics making up the footwall zone (MFZ). Alteration in this area is primarily sericitic in areas with poor mineralization and chloritic in areas with rich Cu grades; 3) epigenetic, usually shear-hosted mineralization often found overprinting MS and MFZ mineralization. In addition, though the VMS deposits in the Baie Verte Peninsula are known to generally be gold-rich, those belonging to the Rambler ores may display locally very high concentrations of free gold which is generally associated to the altered felsic volcanic lithologies (seritized-pyritized felsic unit with ± fuchsite) proximal to massive sulfides. The Ming mine and other Rambler VMS deposits form part of a special class of VMS which are rich in gold.

3.2 Tilt Cove Deposit

Tilt Cove deposit was one of the first Cu-producing VMS deposits in Newfoundland and around the beginning of the 19th century it became one of the world's largest Cu producers. Discovered in 1857, the Tilt Cove deposit produced between 1864-1917 and 1957-1967 around 8,160,000 tonnes of ore grading between 1.25% to 12% copper and 42,425 ounces of gold. The deposit is located in the northeast of the Baie Verte Peninsula, in the Western margin of the Notre Dame Bay, within the Dunnage tectonostratigraphic zone. The deposit is hosted in the upper sections of the Cambrian to Early Ordovician Betts Cove ophiolite Complex, which occupies an arcuate belt that stretches from Tilt Cove - in the north, to Betts Cove - in the south. Upadhyay (1973) pointed out that the Betts Cove ophiolitic

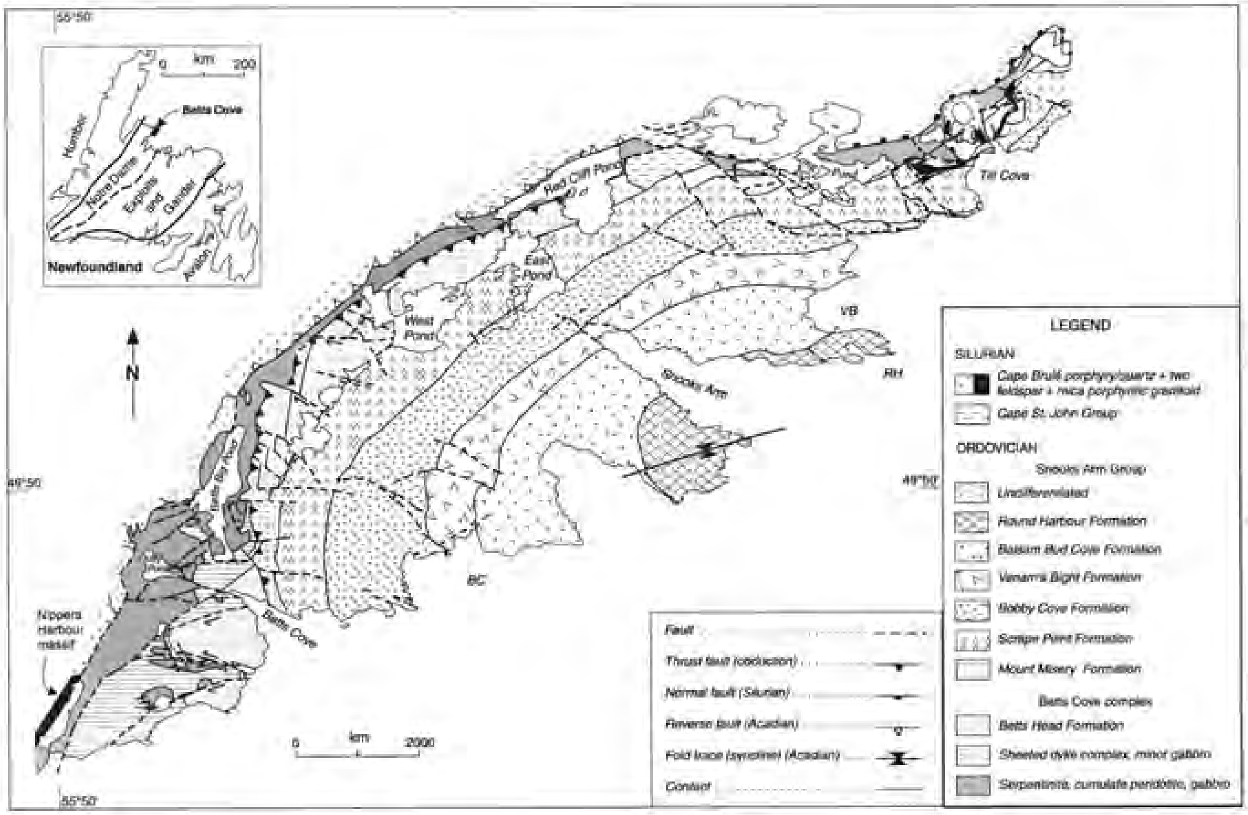


Figure 10. The Betts Cove Ophiolite. Modified from Bedard, 2000, in Spicer et al., (2010)

sequence narrows from 3km at the South (Betts Cove area) down to 750 m at the North (Tilt Coves area) and that its dip changes from 45 degrees up to sub-vertical.

Within the ophiolitic sequence, the Tilt Cove deposit sits within the Mount Misery Formation. This Formation has been inferred to represent juvenile island arc crust that developed on top of boninitic volcanic rocks. Other interpretations such as defined by Bedard et al., (1999) include the Mount Misery Formation within the basal sections of the ophiolite's volcanic and sedimentary cover sequence, the Snooks Arm Group. The top of this Formation is separated from the overlying Snooks Arm Group by an angular unconformity.

The Mount Misery Formation is composed of plagioclase-phyric, pillowed island arc tholeiitic (IAT) basalts which transition chemically to intermediate TiO_2 boninites. Locally, the IAT basalts are interbedded by these boninites. The top of the formation presents local sediments comprising mafic to ultramafic-derived breccia and conglomerate.

The Cyprus-style, Cu (± Au) rich VMS Tilt Cove sits within the strongly chloritized, sheared, and brecciated pillow lavas and pillow breccias of the Mount Misery Formation. The deposit presents a strong stratigraphic control on its mineralization: this occurs in the commonly faulted breccia zones at

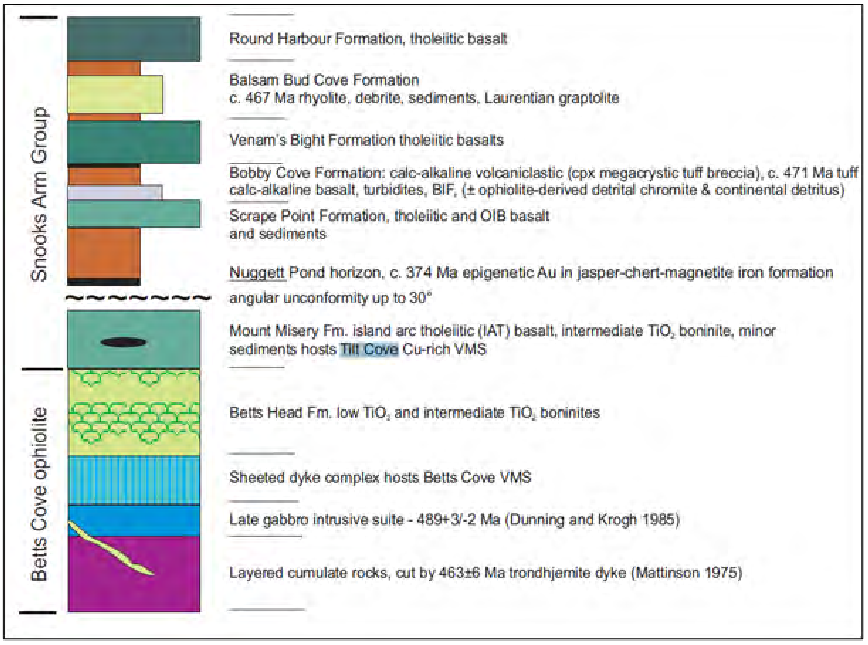


Figure 11.Geology of the Betts Cove Ophiolite (Spicer et al., 2009). Fig 2. Detailed stratigraphy of the geology in the Betts Cove area; modified after Bedard et al., (1999). The approximate ages presented in this study come from unpublished U/Pb zircon geochrono

the interface between the sheeted dike and pillow lava. The Tilt Cove deposit ore bodies display mineralization in the form of 1) massive, fine-grained, steeply dipping Py-Cpy bodies and 2) lower grade disseminated to stockwork-type deposits where mineralization is found predominantly forming Py-Cpy veins, stringers, and disseminations. Subordinate minerals include Mt, Sph, Po, native Ag and Au. In addition, the Tilt Cove hosts a small high-grade zone of Nickel mineralization located at the contact between the chloritized "andesite" and serpentinized peridotite

3.3 Fuchsite hunting

(548912E, 5516165N)

Time to help Derek!

Ultramafic rocks of the Advocate ophiolite complex along the Baie Verte–Brompton Line everywhere show some degree of alteration, generally to serpentinite, but also to talc-magnesite and quartz-magnesite. A somewhat unusual alteration assemblage of magnesite-quartz-fuchsite is locally referred to as virginite; named by local prospector Norman Peters.

Virginite, on fresh surfaces, is easily recognized by a streaked emerald green and white appearance and abundance of milky white quartz veins. Weathered outcrops are rusty brown instead of emerald green, but the quartz veining readily identifies them. Virginite consists primarily of pale green breunnerite (a variety of magnesite containing 5-30% iron), with lesser quartz and 1-2% of. Virginite is generally enclosed by a metre wide zone of carbonate serpentine-talc rock which in turn passes into schistose serpentinite. The formation of talc and carbonate-rich assemblages and virginite is attributed to metasomatic reaction of serpentinite with H2O-CO2 fluids passing along structural zones.

Day 4. Gros Morne National Park

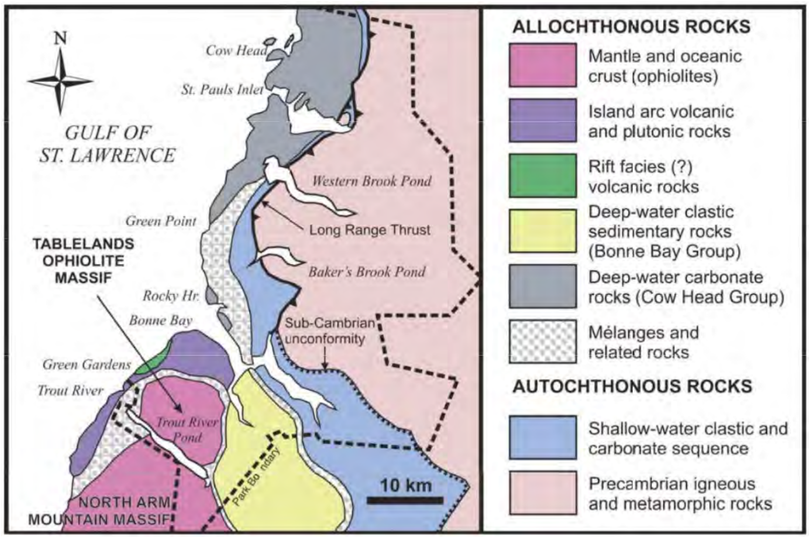


Figure 12. Gros Morne National Park generalized geology

The park's area contains Precambrian basement rocks and a section through the Cambrian–Ordovician continental shelf sedimentary sequence. Sitting structurally above these are the allochthonous rocks transported from the deeper parts of the continental shelf and the Iapetus Ocean, represented by the Humber Arm Allochthon. Other allochthonous components include mafic volcanic rocks and plutonic rocks formed in an island arc and deep-water sedimentary rocks of both clastic and carbonate affinity. These sedimentary rocks represent the ancient continental slope and adjacent basin and contain remarkable fossil assemblages that help to constrain geologic time. They include the Global Stratotype Section for the Cambrian–Ordovician boundary, located at Green Point.

Geological evolution

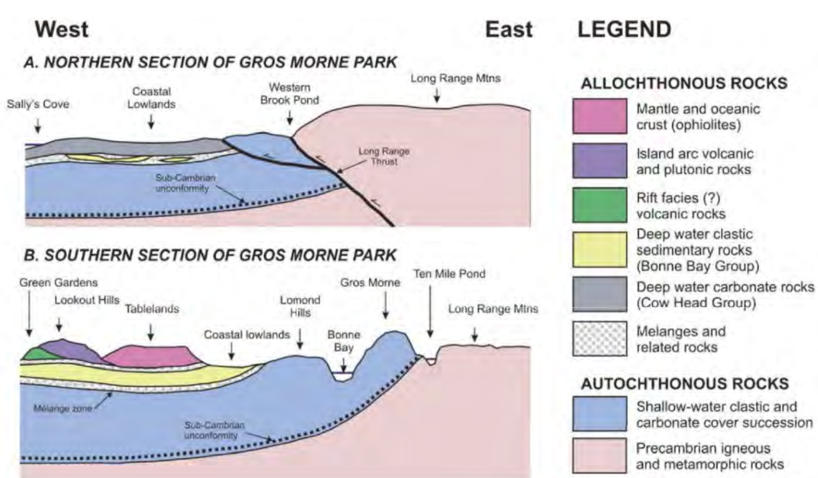
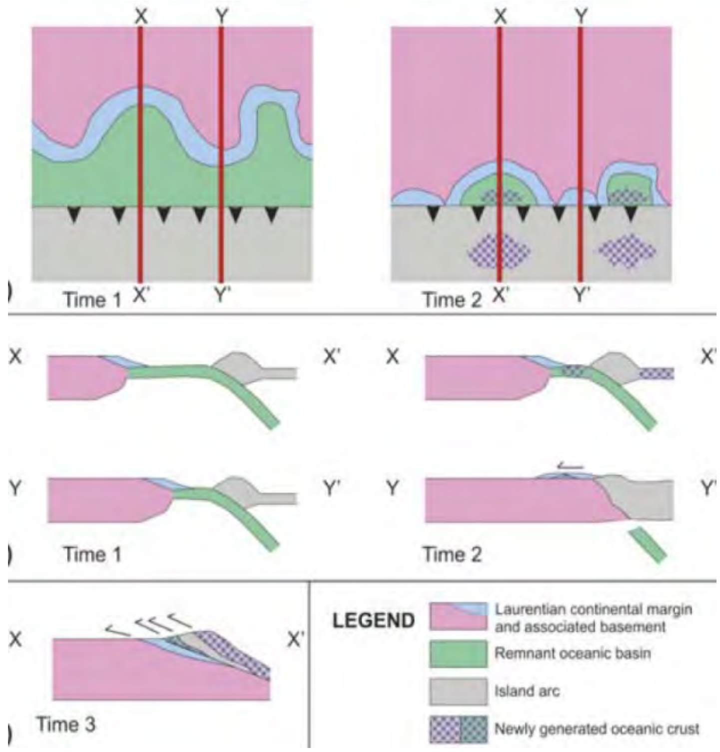


Figure 13. Cross sections of the Gros Morne Park

The Long-Range mountains were formed during the Grenville orogeny and are composed of gneisses and granites. The Grenville Province rifted apart during Late Proterozoic evidenced by the diabase dykes observed throughout the park. The rifting created oceanic crust and ophiolitic sequences in the Iapetus Ocean basin.

During the Cambrian and Ordovician periods, Laurentia and what is now Gros Morne National Park drifted northward. A broad continental shelf was deposited in this basin, the first progression is marked by the now quartzites of the Gros Morne Mountain. Further progression permitted the deposition of limestones and calcareous shales with gastropods, brachiopods, trilobites and algal. Near the edge of this shelf,deeper turbidite sequences with limestone breccias and shales were deposited.

Figure 14. Graphical geological evolution of Gros Morne Ophiolites form in places where oceanic crust remains trapped in embayments of the continental margin after adjacent promontories enter the subduction zone. (B) The tectonic architecture along lines X–X' and Y–Y' is shown for Time points 1 and 2. At Time 2, continued subduction of the trapped oceanic crust and fore-arc extension generates new oceanic crust, which is hot and buoyant, and is emplaced onto the continental margin at Time 3 (C), in conjunction with adjoining sedimentary and igneous rock assemblages.



When the Iapetus Ocean began to close due to subduction, ophiolites sequences were obducted forming zones as the Tablelands with good representation of mantle rocks, peridotites, gabbros, sheeted dykes and pillowed basalts. The trail of this slowly obducting ophiolites is marked by green sandstone and mélange.

Stop 4.1 Discovery Centre

Quick stop to buy the Day Permits for the park and to get familiar with the Gros Morne National Park.

Stop 4.2 The Tablelands

Moderate hike trough the Tablelands to observe the different rocks that make up the ophiolites there, including upper mantle rocks, peridotites, pillowed basalts and the metamorphic aureola around it. The stops are the suggested by Kerr (2019) on excursion 2.

Stop 4.2.1 Peridotite and alkaline spring

(430635E, 54797909N)

Hike to the viewing platform of the Tablelands trail towards scenic views of the Winterhouse brook canyon. At the end of the platform some dunites with serpenite-coated fractures can be observed. 75m north of the platform, there is an alkaline spring with travertine deposits formed by high-pH groundwater formed during serpentinization reactions.

Stop 4.2.2 Depleted, deformed Harzburgites and Pyroxenites

(430433E, 5479744N)

Follow a faint trail towards the west (the base of the cliffs). The northern edge of the outcrops at the base of the cliff is the interesting area. Outcrops of “mantle tectonites” which are extremely deformed harzburgites and pyroxenites showing metamorphic layering. Dykes with dunitic and pyroxenitic composition can be observed cutting the rocks. Some tight isoclinal folding can be observed.

Stop 4.2.3 Harzburgites with serpentinite veining

(431018E, 5479860N)

Walking back to the platform, cross the brook. Walk towards the east towards a partially tree-covered hill with a grey colour. 500 m from the brook, there is a low broad ridge where harzburgites are outcropping without compositional layering. Instead, intense serpentinite veining can be observed.

Stop 4.2.4 Serpentinized ultramafic rocks

(431753E, 5480319N)

Continue walking for about 700 m to the same hill. Outcroping of similar rocks as before but more intensely serpentinized. This could be because this outcrop is much closer to the fault between the ophiolite and the melange units.

Stop 4.2.5 Amphibolites of the metamorphic aureole

(432083E, 5480329N)

Walk southeast crossing more outcrops as 4.2.4; turn northwards to ascend a ridge with small scrubby trees. Head towards two pyramid-shaped peridotite boulders, climbing just before where trees are. The upper part of the small hill consists of amphibolites from the metamorphic aureole beneath the ophiolite. They are not easy to identify but consist of strongly deformed mafic amphibolites.

Very good views of the surrounds, including the Peak of Tenerife which is also part of the metamorphic aureole.

Stop 4.2.6 Outlook and severely sheared ultramafic rocks

(431448E, 5480643N)

Go back to stop 4.2.4 and then head northwest towards a low rubbly hill with a meadow on the west side. Ouctrop of strongly sheared ultramafic rocks. However, amazing views of Bonne Bay and Gros Morne Mountain.

Stop 4.2.7 Xonotlite Layer

(430728E, 5480484N)

Continue northwest to an abandoned telephone line. Just before scrubby vegetation, there is a westward flowing stream. Follow the stream to the Winterhouse brook canyon. Watchout for spectacular fibrous blue-green serpentine. Just downstream of the junction, a wall-like Xonotlite layer is outcropping. This layer is at the faulted contact with sediments and contain the rare and hard xonotlite mineral. This rock is a Ca-metasomatized ultramafic rock.

Crossing the Brook and climbing the slope, turn upstream and walk south to rejoin the old road to the parking area,

Stop 4.2.8 Ophiolite upper cover

(430301E, 5481149N)

Opposite to the parking lot, outcrop of the upper part of the ophiolite sequence showing pillowed basalts, pillow breccia and red-cherty sediments.

Stop 4.3 Precambrian-Cambrian unconformity

(452323E, 5479003N)

Unconformity between Grenville basement rocks (meta-plutonic gneisses) and Lower Cambrian conglomerates, sandstones and carbonate rocks. The unconformity itself is located about 25m uphill from the sign indicating the hiking trail to Southeast Brook. This unconformity has a difference in time of more than 500 Ma.

Stop 4.4 Ordovician GSSP

(430292E, 5503643N)

This tectonically deformed yet virtually intact sequence of Lower to Middle Ordovician strata is a large, disrupted raft within the Rocky Harbour Melange (Williams et al., 1986) which structurally underlies the Cow Head thrust complex to the north. The entire section of Cow Head Group and overlying Lower Head Formation here is Arenig (late Canadian or Ibexian to early Whiterockian) in age. The basal part of the section is proximal facies of the Cow Head Group and can be correlated, both in terms of lithology and biostratigraphy, with beds 9, 10 and part of Bed 11 on Cow Head Peninsula. The upper part of the section consists of interbedded dolostone and shale and is unlike any other sequence in the Cow Head Group. These upper beds are defined as the Lobster Cove Member of the Shallow Bay Formation (James et al., 1987) and are interpreted to have been deposited downslope from a drowned platform margin as

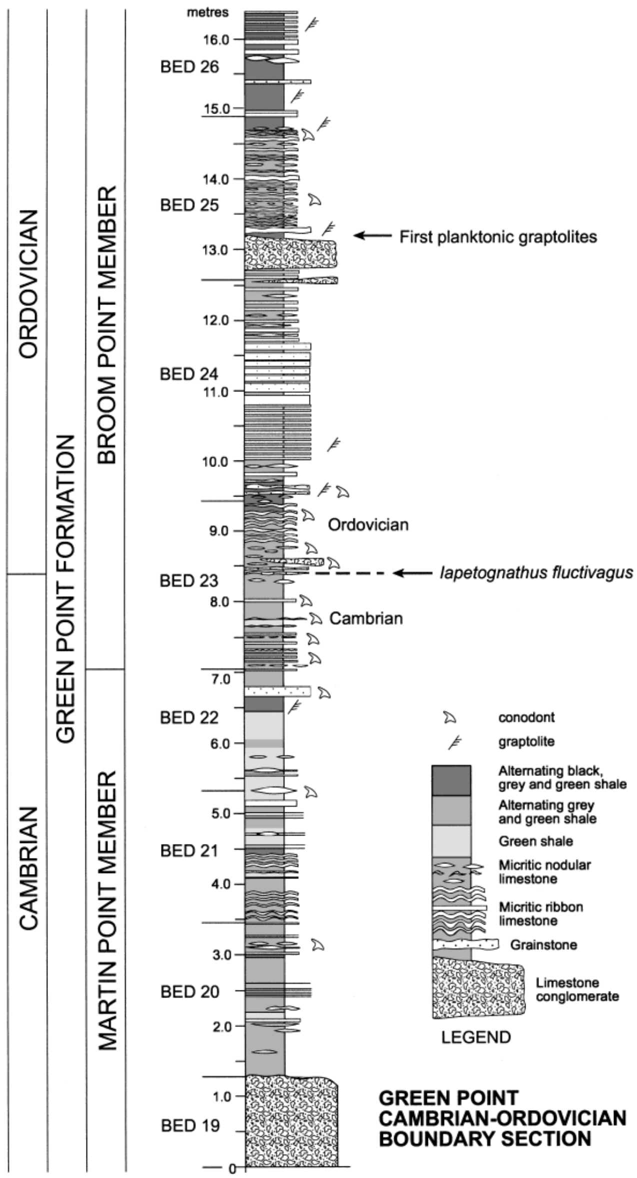


Figure 15. Detailed straigrahpic column of the Cambrian - Ordovician Boundary at Green Point

dilute turbidites of mud and detrital dolomite under dysaerobic conditions. Contact between the two sedimentary packages is marked by a faunal break and coincides with emplacement of megaconglomerate Bed 12 at Cow Head.

This break marks the change from a uniform to complex carbonate platform and is interpreted to be the result of synsedimentary faulting. The margin upslope from Cow Head remained in shallow water during the final stages of Cow Head Group deposition whereas that upslope from Lobster Cove Head was drowned and shed little sediment into deep water. The syn-sedimentary faulting, which led to rapid subsidence and platform margin upslope from Lobster Cove Head and probably the deposition of mega-conglomerate Bed 12 at Cow Head, coincides with the onset of the Taconic Orogeny in western Newfoundland.

Upper beds of the Lobster Cove Member grade up section into greywackes of the Lower Head Formation, which are being deposited ahead of the advancing allochthons. Basal beds of the Lower Head sandstone contain bedded intervals of dolostone and shale, as below, locally tilted and rotated as blocks and displaying later injection of sandstone. This sort of disrupted contact is common at the base of the Lower Head sandstone elsewhere in the Humber Arm Allochthon. Sediments above this disrupted zone are graded sandstone with minor shale interbeds.

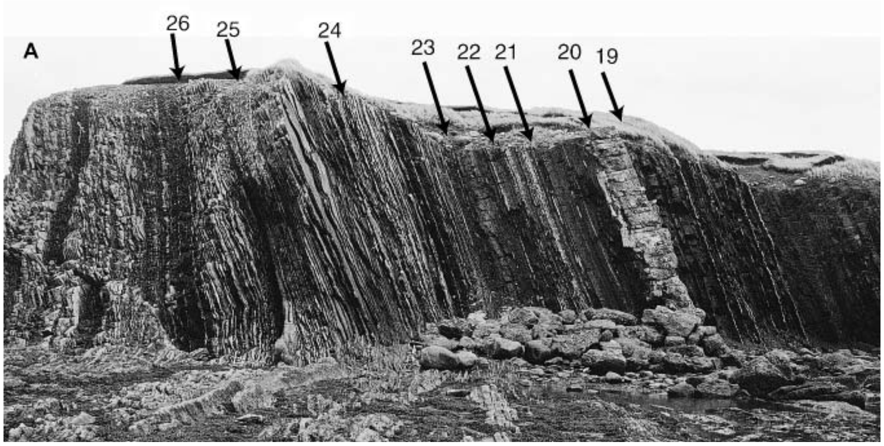


Figure 16. Outcrop photo showing the location of the beds in figure 14

Stop 4.5 Cow Head (depending on time)

(441526E, 5529816N)

The Cow Head Peninsula includes rocks from Upper Cambrian to early Middle Ordovician age. The sediments of the Cow Head Group are consistently coarse grained limestone conglomerates , representing either a more proximal part of the slope to the continental margin, or a portion of the margin that received coarser-grained debris because of sedimentary processes. The Group is divided into two formations: the most proximal, coarsest boulder conglomerates and interbedded sediments constitute the Shallow Bay Formation. Somewhat more distal successions are assigned to the Green Point Formation The actual Point of Head is formed by lowermost Ordovician limestone conglomerate.

Day 5.

5.1 Buchans VMS deposit

The Buchans camp comprises one of Newfoundland's largest and highest-grade polymetallic (-Pb-Cu-Ag-Au) VMS camps within the Appalachian orogenic belt. Between 1928 and 1984, 16 MT @ 14.5% Zn, 7.6% Pb, 1.3% Cu, 126 g/t Ag and 1.4 g/t Au was historically mined by Asarco Inc., primarily by underground methods, which positions it as one of the highest-grade VMS deposits ever mined. Currently, Buchans Resources Limited is exploring and developing several prospects, including the Lundberg brownfields deposit, which contains indicated open pit-constrained resources of 16.7 MT @ 1.53% Zn, 0.64% Pb, 0.42% Cu, 5.69 g/t Ag, 0.07 g/ Au. The Red Indian Line, a major geologic break, separates the Buchans camp from the Victoria Lake camp to the south, which also hosts several Cambro-Ordivician VMS deposits.

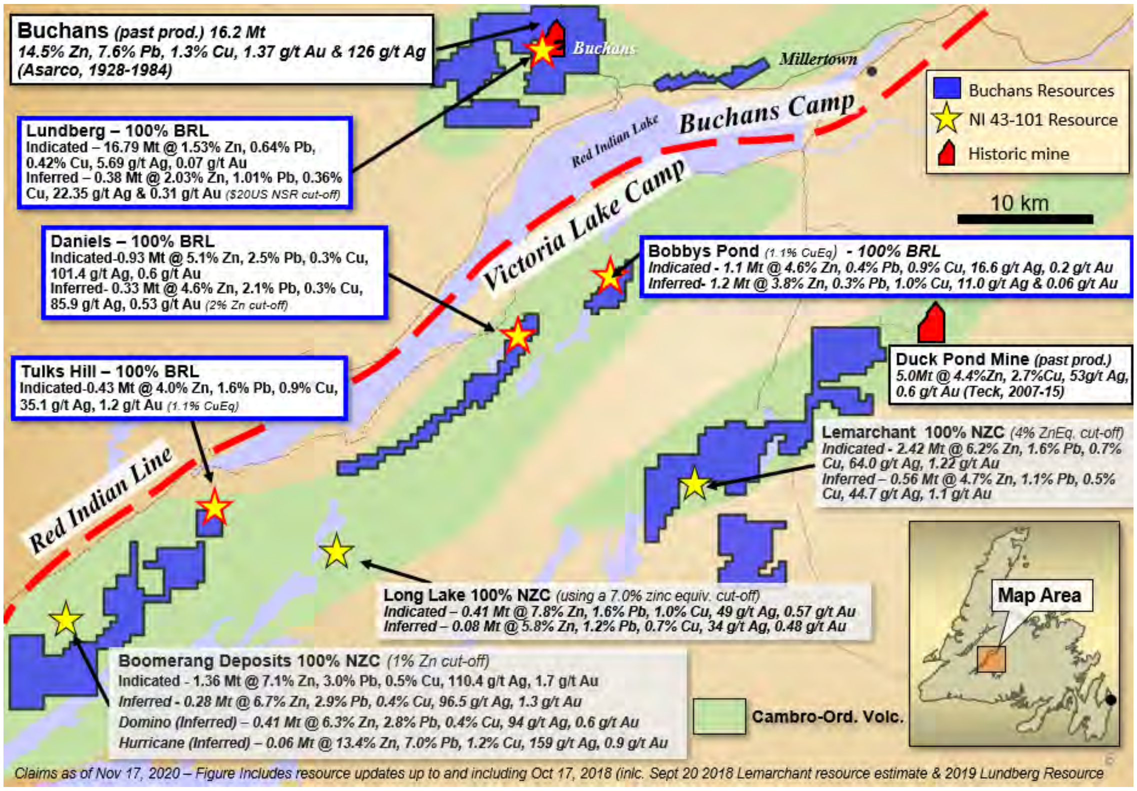


Figure 17. Buchans and Victoria Lake camp VMS deposits (Buchans Resources Limited, 2022).

The deposits within the Buchans camp are hosted by the Buchans Group volcanic assemblage, a subaqueous, calc-alkaline, Lower Ordivician (485-443 Ma) bimodal volcanic sequence dominated by felsic units with subordinate mafic units. Baritic base metal mineralization at Buchans was first identified in 1905 outcropping at surface along the Buchans River by prospector Matty Mitchel. Subsequently, in 1926, Asarco began undertaking exploration efforts in the area, largely aided by the implementation of Self-Potential (SP) geophysical surveys led by Hans Lundberg, which led to the discoveries of the Lucky Strike and Oriental deposits. Several styles of mineralization occur within the camp, including in-situ ore, stockwork zones, and transported ore, associated with silicification and chlorite alteration. Lundberg primary contains stockwork mineralization composed of sulphide-rich vein networks and is interpreted to represent the feeder system to the overlying in-situ massive sulphide style of mineralization found at Lucky Strike and illustrated below. The transported ore style of mineralization is interpreted as a debris flow containing abundant clasts of brecciated and transported coeval (synvolcanic) to earlier (now eroded) high-grade massive sulfide lenses

The main favourable VMS horizon occurs along the Buchans River formation, a felsic pyroclastic unit comprising both in-situ and transported ore, which overlies massive to pillowed basaltic to andesitic flows of the Ski Hill formation. The baritic signature of the mineralization is considered a regional feature along said horizon, owing to reworking and distribution during transport, and considered important in discriminating between the host unit and other similar unmineralized pyroclastic deposits. Regionally, this horizon has been interpreted to be structural duplicated by thrusting across the camp, which, together with its underlying stockwork zone represent significant exploration targets for discovery and delineation of new deposits in the camp. Despite the recognition of thrust imbrication, metamorphic facies in the camp is considered low grade (prehnite-pumpellyite facies) and favourable for preservation of mineralization.

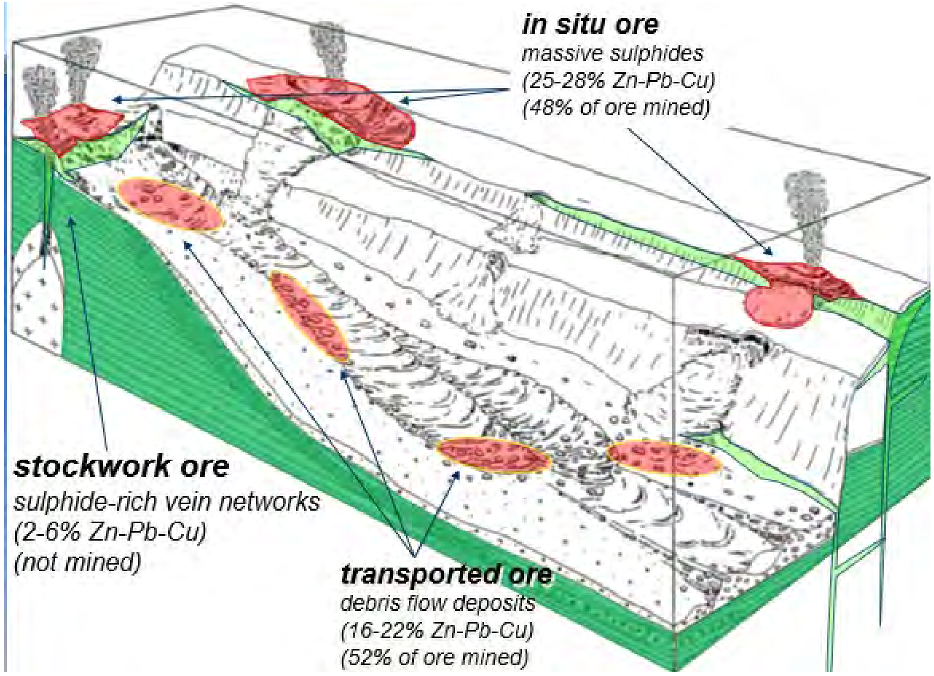


Figure 18. Summary of ore style genetic model for the Lucky Strike area

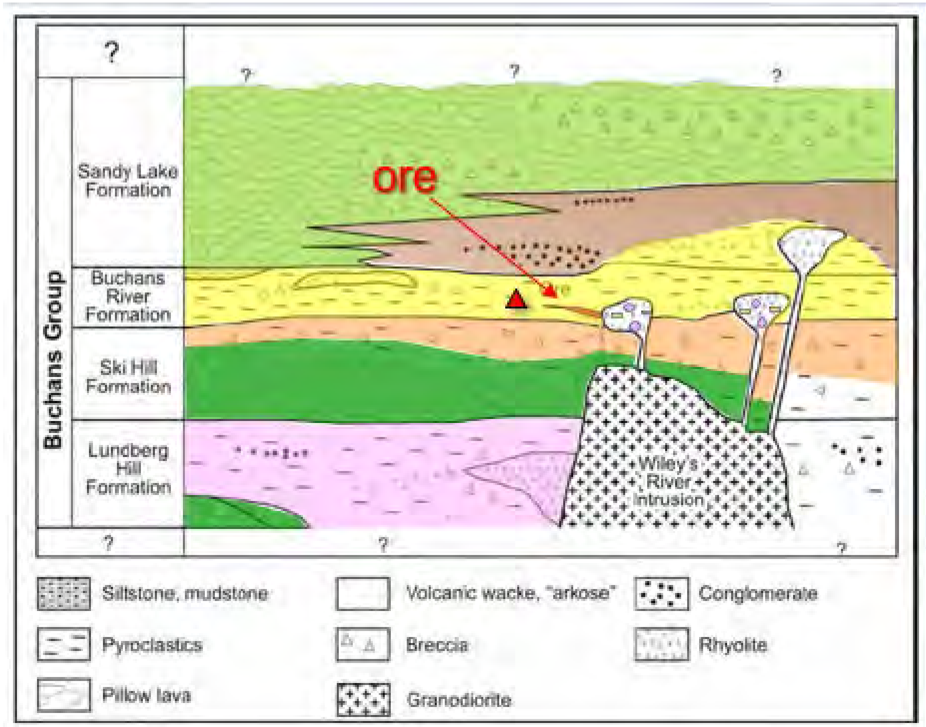


Figure 19. Stratigraphy of the Buchans Group assemblage

Day 6

5.2 Valentine Gold Project

The Valentine Lake property is 100% owned by Marathon Gold and hosts five gold deposits, namely Leprechaun, Marathon, Sprite, Victory and Berry, and some early-stage gold prospects. The property has historically been explored since the 1960s.

The Valentine Lake property is located within the Exploits Subzone of the Dunnage tectonostratigraphic zone of Central Newfoundland, part of the Newfoundland Appalachian system.

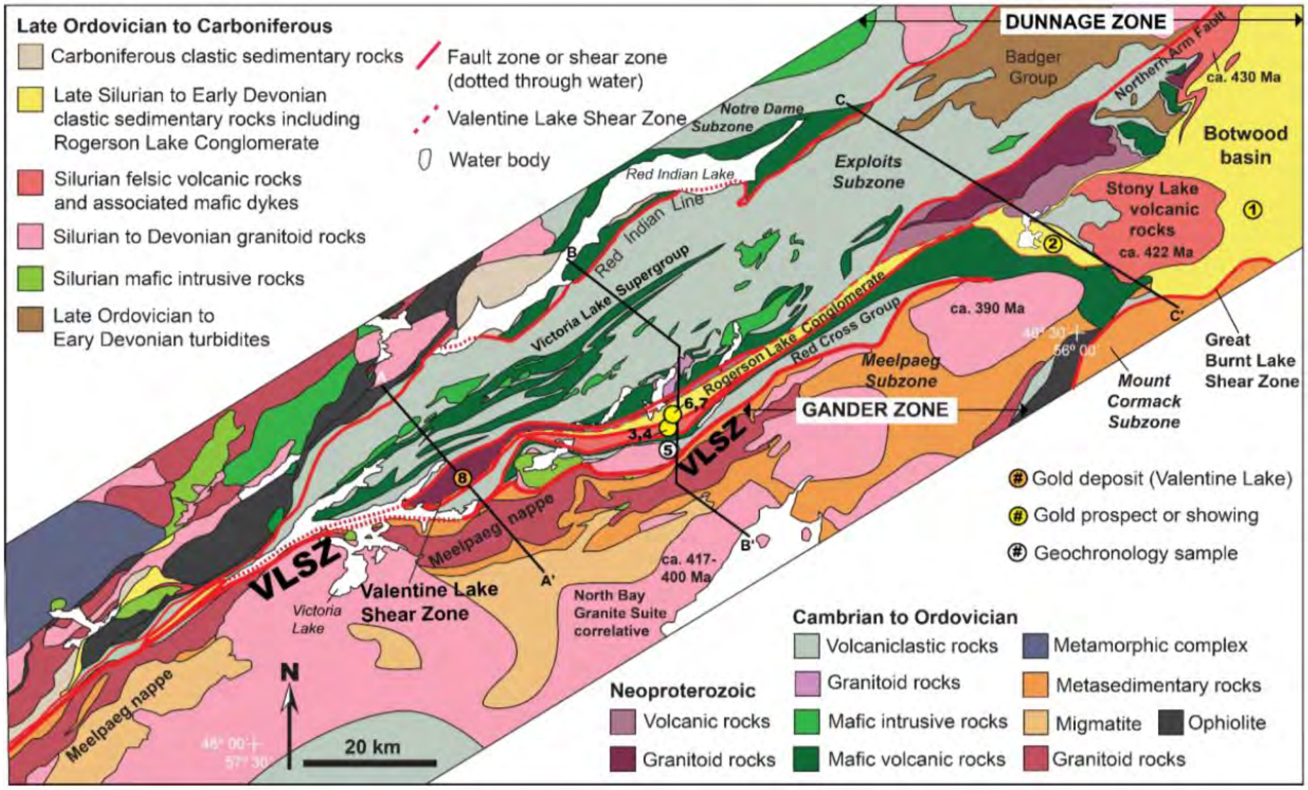


Figure 20. Geology of the Marathon Gold property around Valentine Lake

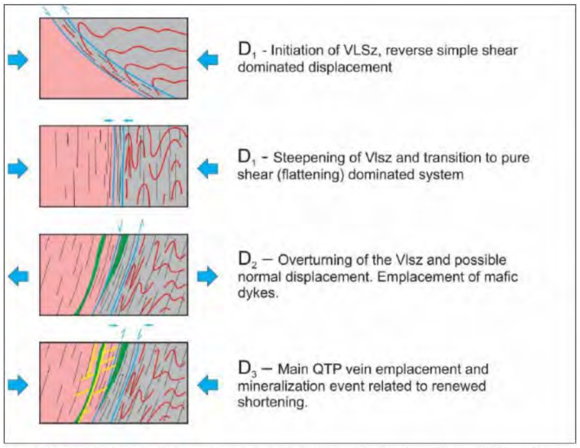
Host rock: Neoproterozoic Valentine Lake Intrusive Complex, which intrudes on the contact between the Victoria Lake Supergroup to the northwest and the Silurian -Rogerson Lake Conglomerate to the southeast. This contact correlates with a NE-SW litho-tectonic boundary, the Valentine Lake Shear Zone.

The Valentine Lake Intrusive Complex comprises an elongate northeast-trending body of igneous rocks consisting of dominantly fine- to medium-grained trondhjemite and quartz-eye porphyry units with lesser aphanitic quartz porphyry, gabbro, and minor pyroxenite units.

The Rogerson Lake Conglomerate is interpreted to have infilled a fault-bounded paleo-topographic depression. It is composed of glacial till between 1 and 5 m thick, as well as boggy areas and ponds.

Regional metamorphism: From lower to upper greenschist facies with the higher grades in the south.

Deformation: In Valentine Lake Intrusive Complex is ductile transitioning to late-stage brittle deformation associated with the initiation of the Valentine Lake Shear Zone (VLSZ). The Rogerson Lake Conglomerate exhibits a strongly developed pervasive foliation, isoclinal folding and flattened primary clasts indicative of a pure shear crustal shortening regime.



Notes: This schematic illustrates the kinematic evolution of the VLSZ along the boundary of the VLIS (pink) and Rogerson Lake Conglomerate LC (grey). The red lines represent the trace of bedding (S_0) and black lines represent the S_1 foliation. Source: Kruse, 2020.

Figure 21. Deformation progression in the deposit

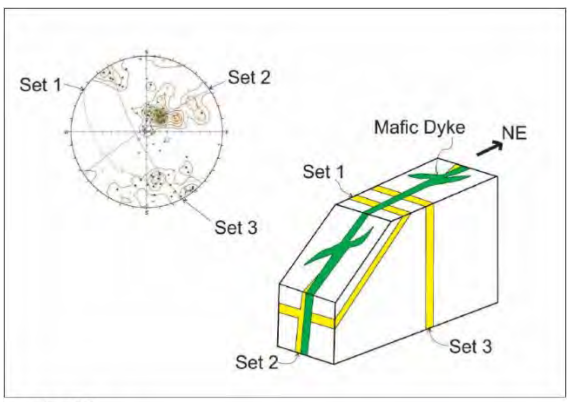
Phases of deformation: D1: crustal shortening phase is characterized by a strong S1 foliation and L1 stretching lineation. These fabrics are observed in both host units with an SW strike and steep dip to the NW, paralleling the larger structure.

D2: Period of regional relaxation.

D3 phase of renewed crustal shortening; is correlated with Quartz-Tourmaline-Pyrite (QTP) vein sets developed within the Valentine Lake Intrusive Complex where the gold mineralization occurs.

D4: late crenulation fabric overprinting the previous ones.

D5: brittle fault set.



Source: Kruse, 2020.

Figure 22. Schematic diagram of the structures in thje deposit

Deposit Type: mesothermal gold deposit associated with Salinic aged crustal shortening and deformation; structurally controlled - QTP-Au veining: En-echelon stacked SW dipping extensional vein sets (Set 1) and shear parallel vein sets (Set 2) proximal to the VLSZ.

Significant QTP-Au veining occurs dominantly within the trondhjemite, quartz-eye porphyry and lesser mafic dike units along and proximal to the sheared contact with the Rogerson Lake conglomerate.

Visible gold in the QTP veins occurs as grains, from <0.1 mm and up to 1-2 mm, hosted by quartz, tourmaline masses, within and along the margins of coarse cubic pyrite, or associated with minor tellurides. The highest gold grades are commonly associated with large (1 to 3 cm) cubic pyrite within the QTP veining.

The relationship between high-grade gold mineralization and the location of the dykes supports the theory that the mafic dykes provide a rheologic contrast that (1) promotes brittle fracturing of the granitoid unit and therefore, acts as a controlling factor of mineralized fluid flow, and (2) incites the eventual emplacement of zones of gold enrichment.

Mineral Resource:

Measured & Indicated Mineral Resource Estimate - All Deposits									
Category	Open Pit			Underground			Total		
	Tonnes	Grade	Gold	Tonnes	Grade	Gold	Tonnes	Grade	Gold
	(t)	(g/t)	(oz)	(t)	(g/t)	(oz)	(t)	(g/t)	(oz)
Measured	32,076,000	1.797	1,853,400	511,000	4.054	66,600	32,587,000	1.833	1,920,000
Indicated	23,411,000	1.526	1,148,900	658,300	3.277	69,300	24,069,300	1.574	1,218,200
M+I	55,487,000	1.683	3,002,300	1,169,300	3.616	135,900	56,656,300	1.723	3,138,200
Inferred Mineral Resource Estimate - All Deposits									
Category	Open Pit			Underground			Total		
	Tonnes	Grade	Gold	Tonnes	Grade	Gold	Tonnes	Grade	Gold
	(t)	(g/t)	(oz)	(t)	(g/t)	(oz)	(t)	(g/t)	(oz)
Inferred	26,537,000	1.523	1,299,200	3,048,000	3.469	339,800	29,585,000	1.723	1,639,000

**Marathon Deposit has the biggest mineral resource estimation.

Day 7.

Gemstone exploration talk by Dr. Phillipe Belley at Memorial University of Newfoundland.

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