Cabox Aspiring Global Geopark

May 10, 2016

Prepared by: Paul Wylezol and Andy Kerr

Table of Contents

1.0 Overview

1.1 Geological Description

Cabox Aspiring Geopark is located on the west coast of the island of Newfoundland and spans a unique yet diverse corner of North America that records the closing of the Iapetus Ocean and formation of the Appalachian Mountains. It also plays a important role in the exploration and mapping of the New World, including the innovative maps of James Cook and Harold “Hank” Williams.

The following description of the region’s geology is drawn in large part from *The Geology of the Appalachian – Caledonian Orogen in Canada and Greenland*, edited by Hank Williams *(Geological Survey of Canada, Geology of Canada, Volume 6, 1995)*, with some additional material summarizing more recent work in the region, and in correlative parts of Europe.

Geographical Setting, Geological Setting and Global Significance

The Canadian Appalachian region includes the provinces of insular Newfoundland, Nova Scotia, New Brunswick, Prince Edward Island, and the southern part of Quebec along the south side of the St. Lawrence River (Fig. 1.1).

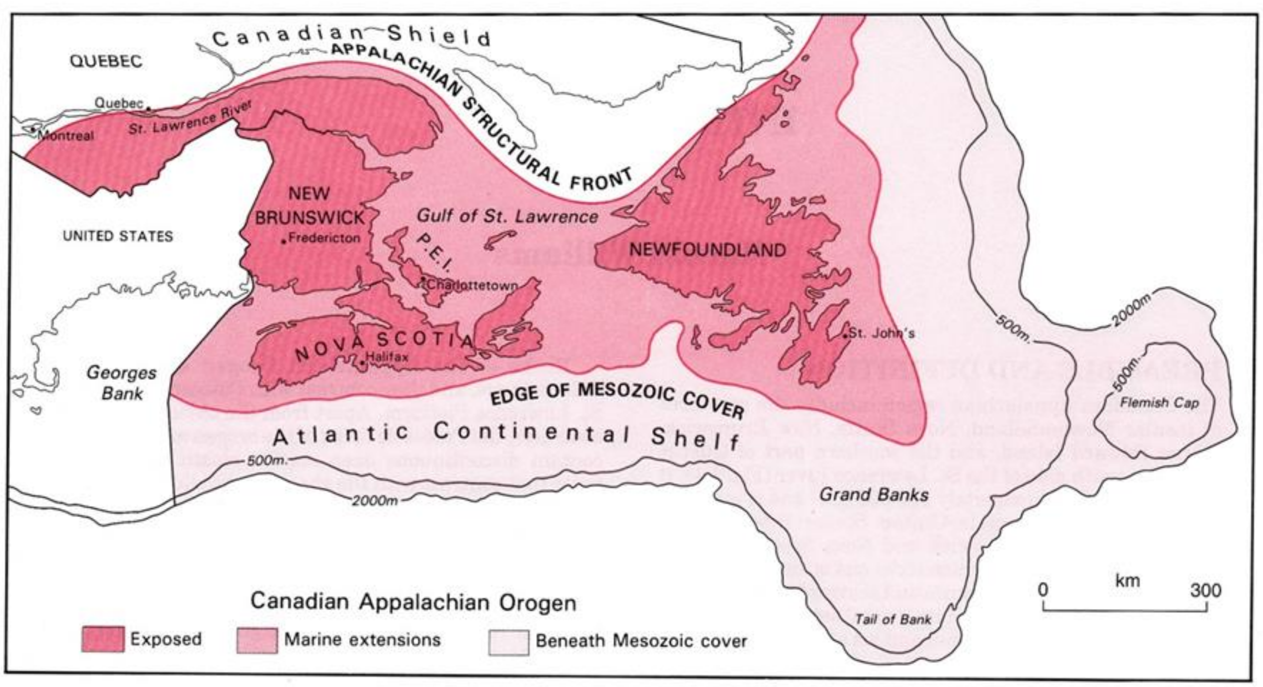


Figure 1.1. Canadian Appalachian region.

Most geological elements of this region continue through the wider Appalachian region to the southeastern United States, and possibly beyond. The Caledonian and Scandinavian mountains of northern Europe are the former continuation of the belt, which are now displaced by the opening of the modern Atlantic Ocean. The geological parallels between Newfoundland, Ireland and the UK are especially striking, and Newfoundland is widely regarded as the "type area" for the entire Appalachian – Caledonian mountain belt. The continuity of this belt across the modern Atlantic Ocean was an important argument in favour of continental drift, as originally formulated by Alfred Wegener.

The Appalachian region is part of an enormous mountain belt developed from late Precambrian to mid-Paleozoic times, largely by the sequential collision of continental blocks represented now by North America, Europe and Africa. This was just part of the wider assembly of Pangaea, which was the most recent of the many supercontinents now recognized in Earth History. Mountain belts, or orogens, are regions affected by long-lived folding, faulting, metamorphism, and igneous activity. The Appalachian – Caledonian Orogen records the formation and destruction of two oceans that were precursors to the modern Atlantic, known as the Iapetus Ocean and the Rheic Ocean. This orogen is of particular significance in that its European section was the birthplace of modern geological science, founded with the work of James Hutton in Scotland. Over the centuries, these ideas developed and expanded, and since about 1960, many concepts were revolutionized by the recognition of continental drift and global plate tectonics. The Appalachian part of the belt – notably in Newfoundland – then became the laboratory in which this new paradigm was tested, and proven as a process throughout Earth History. The importance of the Appalachian – Caledonian Orogen in developing modern geoscience cannot be overstated.

Main Tectonic Elements and a Summary of Geological Evolution

In North America, the Appalachian Orogen is peripheral to the stable interior craton, and essentially occupies the eastern coast of the continent (Fig. 1.2). … Within the Appalachian Orogen, Precambrian rocks equivalent to the Canadian Shield occur locally as 'inliers', and older rocks of less obvious affinity also occur locally.

Along the west flank of the Appalachian Orogen, Paleozoic sedimentary rocks overlie Precambrian rocks of the Canadian Shield, and are in part correlative with strata in the Interior Platform. This sedimentary sequence, known also as the *Appalachian Miogeocline,* records the initiation of the Iapetus Ocean and development of a wide continental shelf in low paleolatitudes. The central part of the Orogen consists largely of lower Paleozoic sedimentary and volcanic rocks that formed on the margins of the Iapetus Ocean, in part representing island arcs and sedimentary basins like those of the modern Pacific region. These were developed upon oceanic rather than continental crust, but also on scattered continental fragments originally located far from North America. These diverse terranes progressively collided with the ancient margin of North America from Cambrian to Devonian times, and were thus *accreted* as part of the growth of the continent. Newfoundland contains the largest remnant of an ancient ocean basin known anywhere in the world. The eastern part of the Appalachian Orogen consists of late Precambrian to Paleozoic rocks that originally formed parts of Europe and Africa, and these were also added (accreted) to North America as part of this sequential process. The recognition of the two-sided, symmetrical pattern of the northern

Appalachian Orogen by Harold (Hank) Williams in the 1960s was a critical step in understanding how plate tectonics might be applied to the geological record.

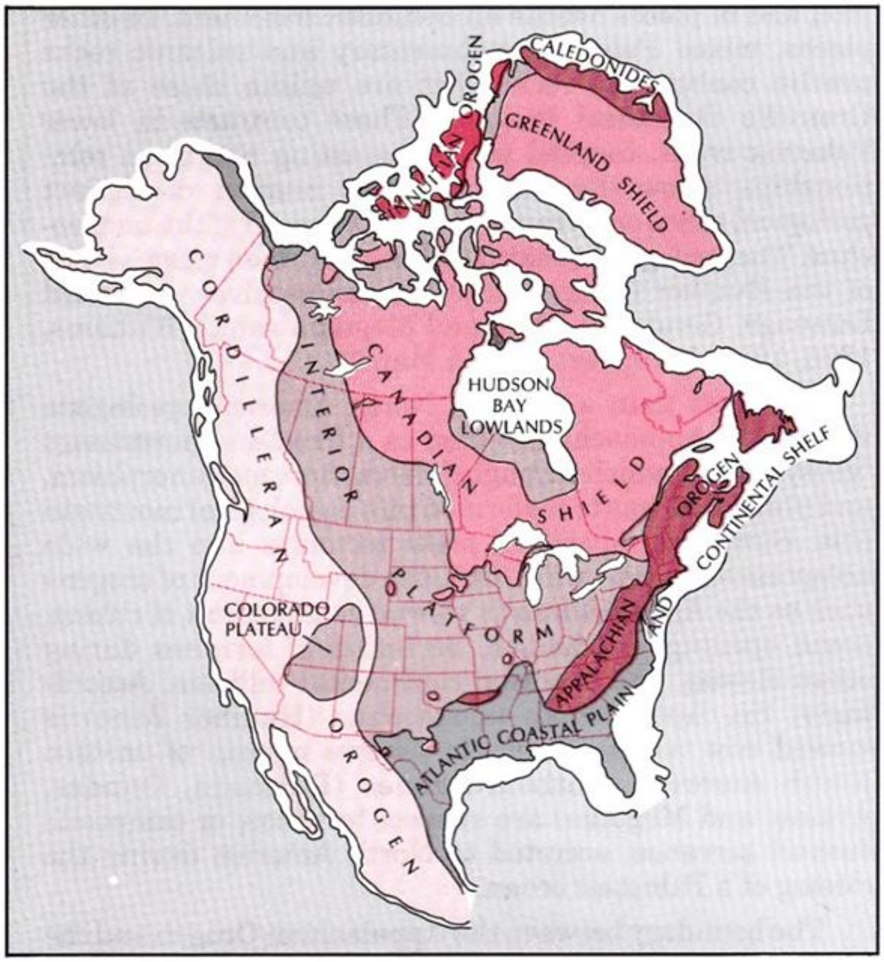


Figure 1.2. Phanerozoic orogens of North America.

The contrasts in the nature of lower Paleozoic rocks across the orogen, coupled with the contrasting Precambrian basement types, leads naturally to the definition of distinct geological zones or *tectonostratigraphic terranes* that can be traced throughout the length of the belt. The definitions of these have changed slightly over time, but most workers recognize five broad divisions in Canada, i.e., the Humber Zone, Dunnage Zone, Gander Zone, Avalon Zone, and Meguma Zone (Fig. 1.3). Of these divisions, only the Humber Zone and the western part of the Dunnage Zone have strong links with North America; all the remaining areas have been added (accreted) to North America. The concept of tectonostratigraphic zones was also developed by Hank Williams, and expressed in his famous geological summary map, known informally as the map that moved mountains. The same zonal system is applied southwestward throughout the Appalachians, although it has not been as widely applied in Europe. The proposed Geopark is largely located within the Humber Zone, although it incorporates elements of the Dunnage Zone that were transported hundreds of kilometres towards the interior of North America.

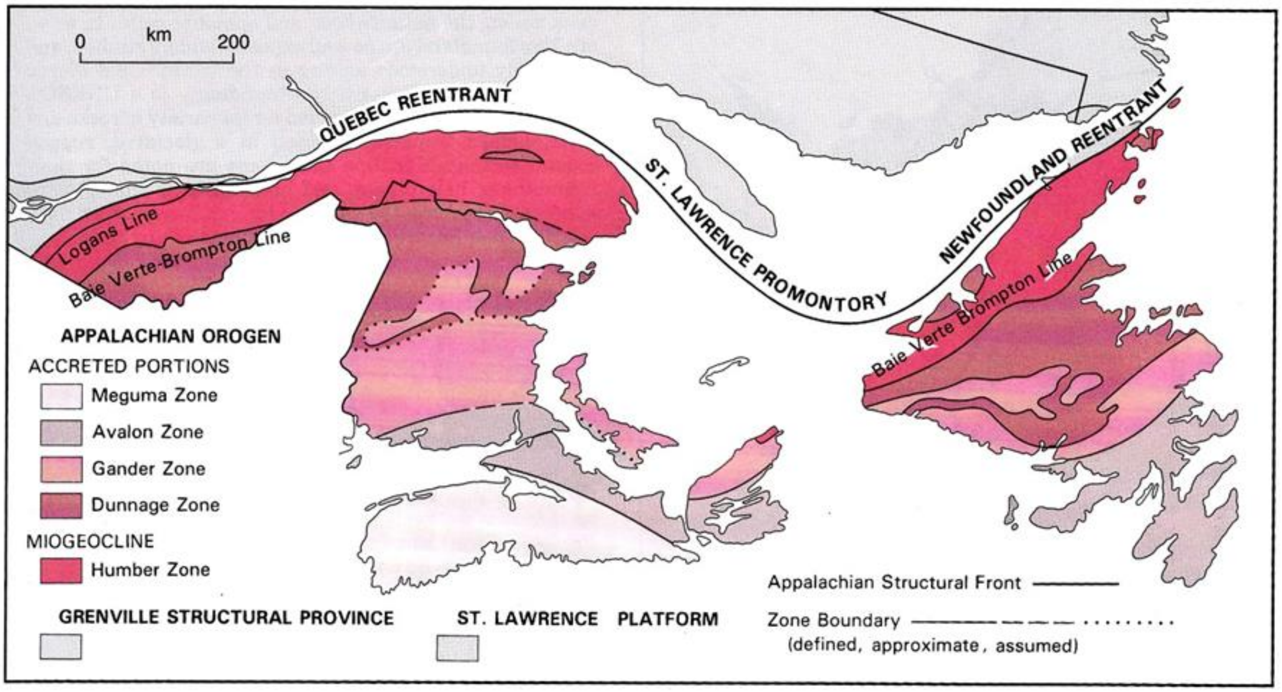


Figure 1.3. Simple zonation of the Canadian Appalachian region.

For more than a century, geologists viewed the Appalachians, and other mountain belts, as geographically 'fixed' regions in which sedimentary and volcanic rocks accumulated, and were later subjected to deformation, metamorphism, and plutonism to create mountains. These were called *geosynclines*, but a convincing explanation for the upheavals involved proved elusive. The recognition and acceptance of continental drift and plate tectonics in the 1960s provided new understanding of mechanisms, and the development of orogenic belts is now viewed as a progressive sequence involving continental rifting, ocean opening, volcanism related to subduction, the accretion of oceanic terranes to continental margins, and climactic continental collision. Viewed in this framework, the Appalachian Miogeocline (Humber Zone) represents the ancient continental shelf of eastern North America. The Dunnage Zone is mostly the remains of the Iapetus Ocean and its associated basins. The Gander Zone is a partially discrete small continental block that originally lay on the other side of the Iapetus Ocean, and the Avalon Zone is a larger continental block that subsequently also collided with North America. ...

The history and development of the Appalachian Orogen is complex, but the varied crustal elements that did not originally belong to North America were added in four main events. The Early-Middle Ordovician (Taconic) event records the collision of early island arcs, and the following Silurian (Salinic) event records the closure of the main tract of the Iapetus Ocean. The Devonian (Acadian) event records the addition of the region now represented by the Avalon Zone. The final orogenic event (Alleghanian) came in late Carboniferous times, and records the destruction of the Rheic Ocean and collision between composite North America-Europe and Africa….

Mesozoic and Cenozoic Dispersal of the Orogenic Belt

The opening of the present North Atlantic Ocean during the Mesozoic was initiated in several locations displaced from the line along which the ancient Iapetus and Rheic Oceans had previously closed, and the eventual Atlantic rifting zone was oriented at an oblique angle to the Paleozoic orogenic belt. Thus, geological terranes that developed on the North American side of the belt are now stranded in parts of Europe, and terranes that developed on the European or African side are now stranded in parts of North America (Fig. 1.4). For example, the ancient continental shelf of North America (the Humber Zone) is directly equivalent to sedimentary sequences in Scotland and Norway. The Avalon Zone of Newfoundland and eastern North America similarly represents a continental block that correlates closely with rocks now exposed in Europe and North Africa (Fig. 1.4).

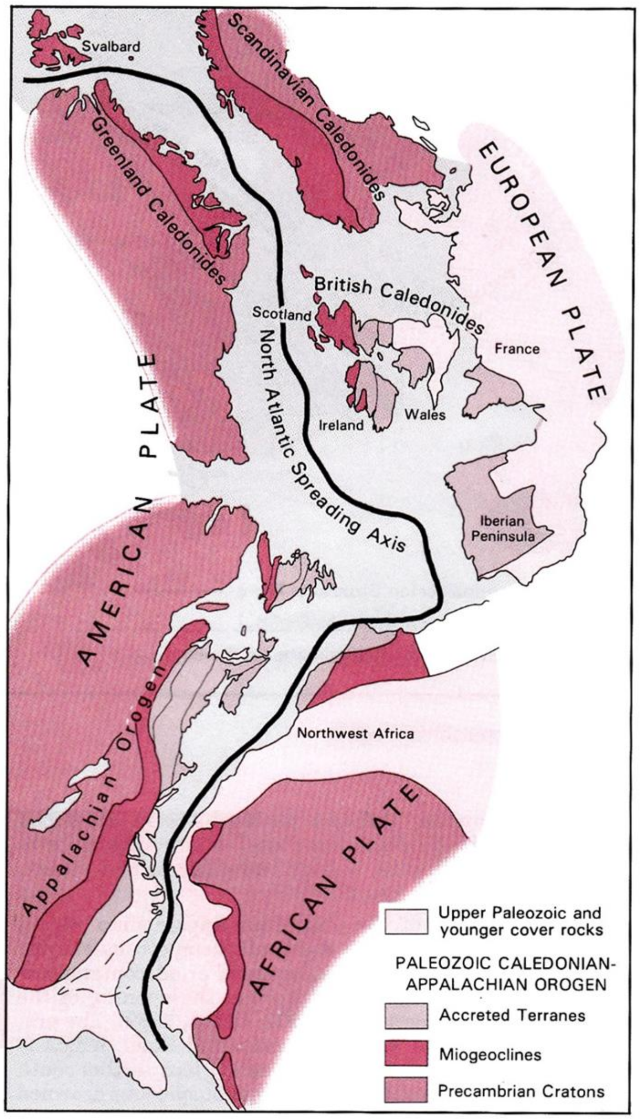


Figure 1.4. Tectonic elements of the restored North Atlantic region (after Williams, 1984).

The Caledonian Belt of east Greenland is also part of the ancient continental shelf of North America, but it was displaced by thousands of kilometres following the Cenozoic opening of the Labrador Sea. Although eastern North America, northern Europe and Greenland are now dispersed around a vast ocean basin, they all share a common geological heritage.

Geological Elements of the Aspiring Geopark

The Humber Zone represents the ancient continental shelf of North America, and also adjacent deeper-water regions of the continental slope and the continental rise. These elements are also collectively known as the *Appalachian Miogeocline*. The region takes its name from Humber Arm in western Newfoundland. The Dunnage Zone represents rocks that formed within the ancient Iapetus Ocean and its associated basins, originally located thousands of kilometres from this ancient continental shelf. … The aspiring Geopark contains rock assemblages that represent these contrasting environments, which are now juxtaposed vertically by the tectonic forces that destroyed the Iapetus Ocean. All of these diverse elements are now assembled into an inclined "stack" in which packages of rocks are separated by important fault zones known as *thrust faults,* because the rocks in the higher packages have been *thrusted* over those below. In this way, thick sections of oceanic crust (known as *ophiolites*) sit at the top of the pile, forming the spectacular mountains of western Newfoundland. At the very bottom of the pile, the shallow-water sedimentary rocks of the innermost continental shelf and coastal regions are disrupted by thrust faults and tight folds. In the intervening parts of the pile, the outer regions of the continental shelf and deeper-water marine environments are represented by diverse sedimentary and volcanic rocks. The aspiring Geopark thus preserves a wide range of geological environments, developed over thousands of kilometres, but now contained within one relatively small area.

Each of these geological packages – the continental shelf, the deeper basin and the oceanic realm – tells a detailed story of events that can now be reconstructed. These events are linked intimately in time and space, over some 200 million years, but are recorded separately, just as three historians might relate the events of the past from their different perspectives. This collective narrative describes the birth of the Iapetus Ocean, its growth and maturity, and its slow collapse into the disarray of orogeny. The geopark region is widely considered to represent the most complete and well-documented record of ancient tectonic processes, and has also contributed much to our understanding of modern continental shelves and adjacent basins. Furthermore, the spectacular sections of oceanic crust preserved in the mountains of western Newfoundland were amongst the first of their kind to be recognized, and are amongst the most complete and best-preserved ophiolite sequences anywhere in the world. The recognition of these key relationships in western Newfoundland was a pivotal step in the Earth Sciences Revolution that developed from the then-controversial concepts of continental drift and plate tectonics. … The region is broadly termed the Humber Arm Allochthon (Fig. 1.5) and broadly corresponds to the outline of our aspiring Geopark.

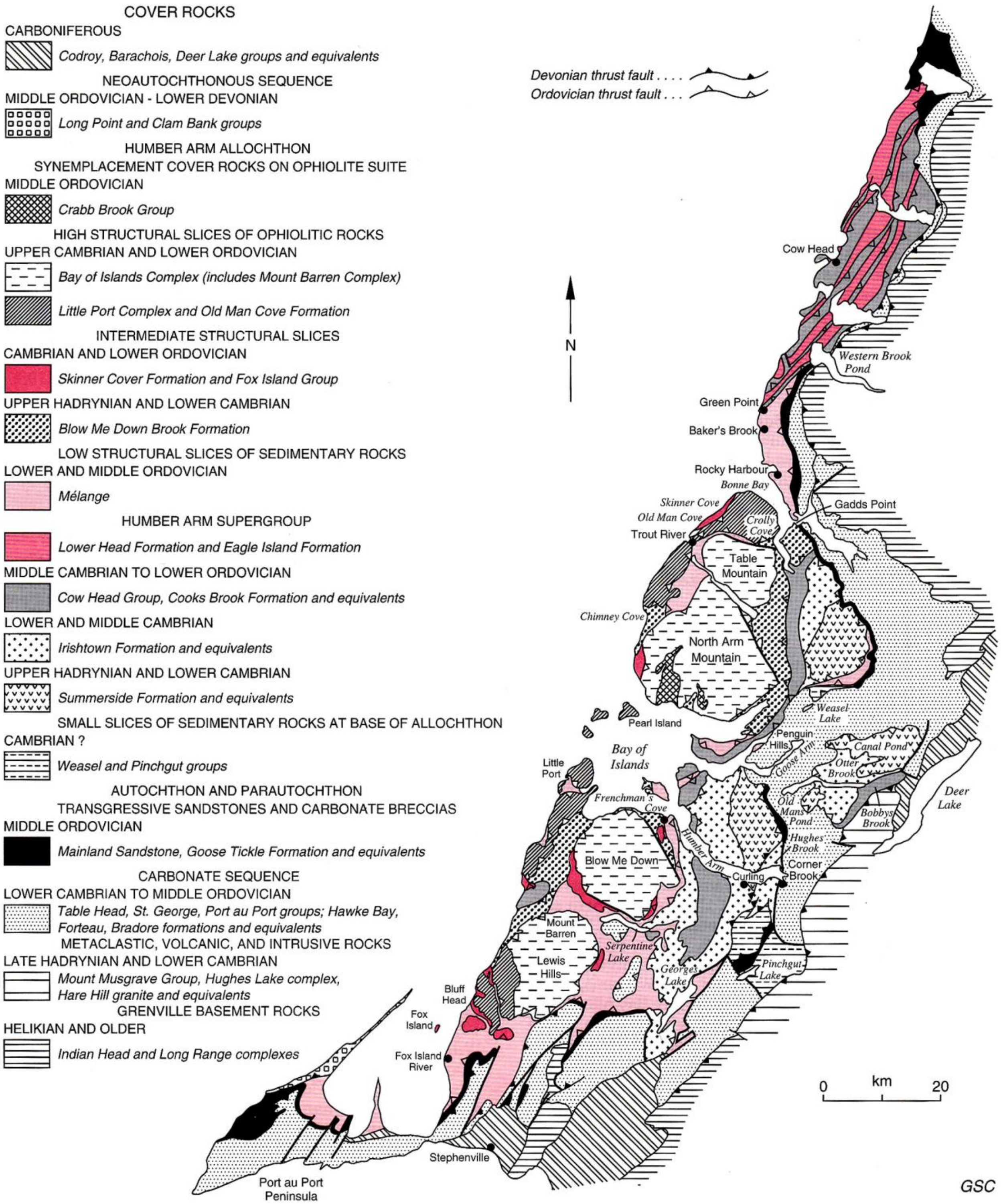


Figure 1.5. General geology of the Humber Arm Allochthon, modified after Williams and Cawood (1989). For more detail the reader is referred to GSC Map 1678A – Geology of the Humber Arm Allochthon.

A Summary of Geological Relationships and Features in the Aspiring Geopark

The Humber Zone has two divisions in which the structural styles and metamorphic grades contrast sharply. The western or *external* division shows moderate deformation, low-grade regional metamorphism, and its stratigraphic sections are preserved or easily restored. The eastern or *internal* division shows intense deformation, its regional metamorphism is medium to high grade, and the original stratigraphic and structural relationships are poorly known. The contacts between external and internal divisions of the Humber Zone are important structural zones where they are not hidden by younger cover rocks. The external Humber Zone is dominated by shallow-water sedimentary rocks, mostly carbonates, but the youngest components are deep-water clastic sedimentary rocks. The original rock types in the internal Humber Zone also include many carbonates, but clastic sedimentary rocks are more abundant, and these include argillaceous sedimentary rocks typical of deep water environments, and their metamorphic derivatives. …

… The nature of the original sedimentary rocks changes progressively from lowest to higher structural slices, showing increasing abundance of clastic sedimentary and volcanic rocks, and increasing deformation and metamorphism. The contorted marine shales, sandstones, and melanges of the allochthons contrast sharply with the underlying mildly deformed carbonate sequence. …

The uppermost parts of the Humber Arm allochthon do not belong to the Humber Zone, but rather to the Dunnage Zone, because they largely consist of material from the mantle, the oceanic crust and rocks developed on the deep ocean floor. Allochthons occur throughout the Appalachian – Caledonian Orogenic Belt, but very few contain well-preserved mantle/oceanic crust sequences, and none are exposed as well as those of Newfoundland. In addition to the sections of oceanic crust and subjacent mantle, the metamorphic rocks that result from the emplacement of the hot ultramafic mantle rocks are also well-preserved beneath the main ophiolites. The ophiolites are collectively known as the Bay of Islands Complex, and all form spectacular mountain regions.

The Bay of Islands Complex occurs in four separate massifs (Fig. 1.6). The two northernmost massifs, Table Mountain and North Arm Mountain, are separated by a fault at Trout River Pond, but were once continuous. The Blow-Me-Down massif was probably also part of this large ophiolite sheet, based on similarities in geological units and structural style; it is now separated from the northern massifs by the Bay of Islands, excavated by recent glaciation. The Lewis Hills massif has an internal structure that contrasts with that of the northern massifs, and may thus have been emplaced separately.

The Bay of Islands Complex contains a complete suite of rock units characteristic of ophiolites, including ultramafic rocks, gabbros, sheeted dykes, mafic pillow lavas and deep-ocean sedimentary rocks. In conjunction with direct drilling in the ocean basins, studies of these rocks have led to many of our insights about the nature and composition of the oceanic crust. Metamorphosed equivalents of these rocks are welded to the base of ultramafic units, and record the conditions of emplacement. The most complete sections are preserved in the Blow-Me-Down and North Arm Mountain massifs, where the various layers of the oceanic crust are disposed in gentle synclinal structures that have northeast-trending axes (Fig. 1.6).

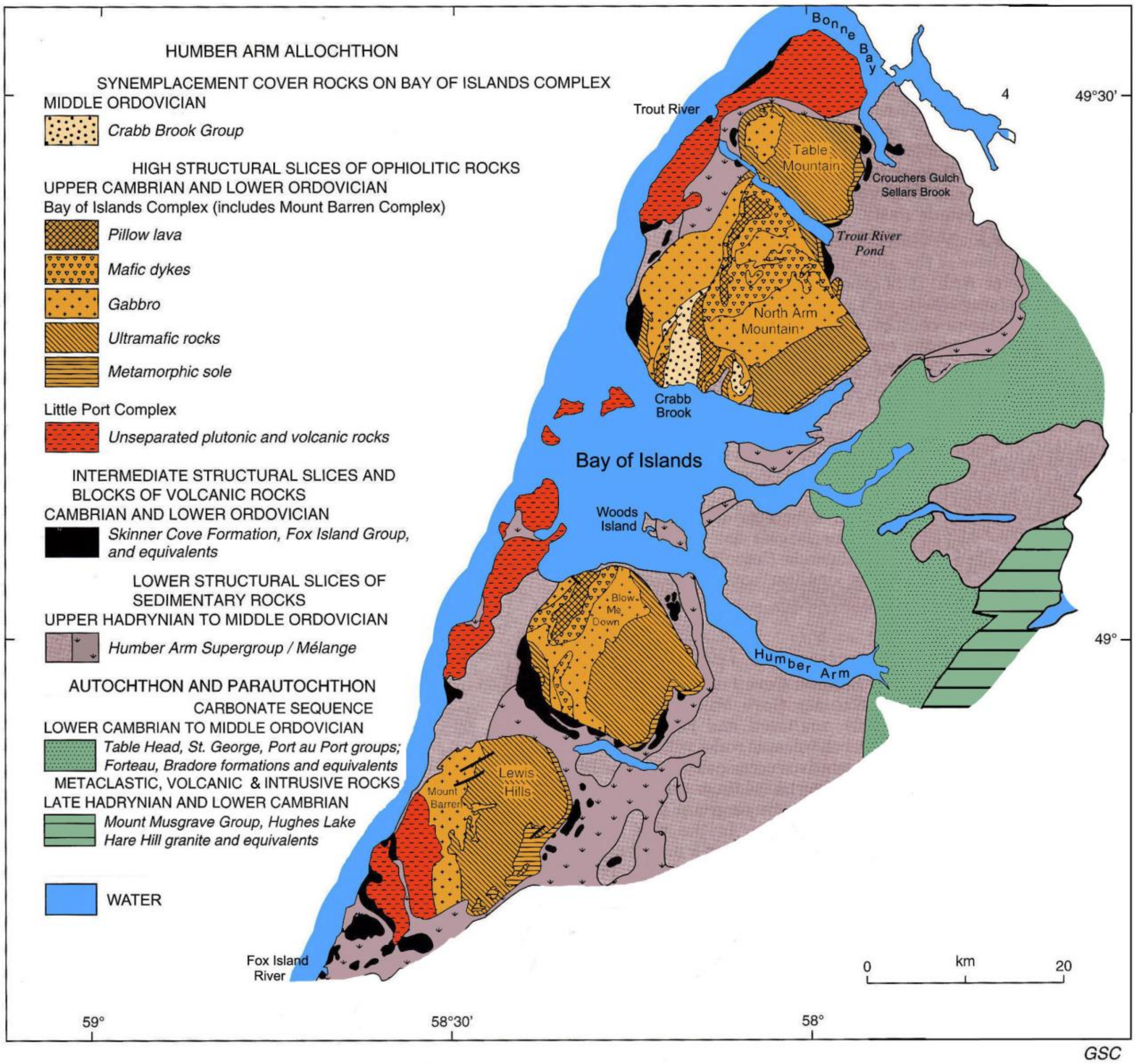


Figure 1.6 Distribution of discrete volcanic blocks and slices within the Humber Arm Allochthon and internal lithic units of the Bay of Islands Complex.

The Bay of Islands Complex is the best exposed and most extensively studied ophiolite complex in Newfoundland, and one of the best-known and most-studied global examples. Although the rocks were originally interpreted as equivalent to those of mid-ocean ridge environments, geochemical data now indicate that pillow lavas in the Bay of Islands Complex include island arc tholeiites, and ultramafic rocks show evidence of derivation from magmas of boninitic affinity. These features suggest that they developed within island arcs in Iapetus, and/or in smaller back-arc basins associated with island arc volcanism. The emplacement of the ophiolite suites is the ultimate consequence of the attempted subduction of continental crust when the North American continental shelf impinged on east-dipping subduction zone(s) within the Iapetus Ocean. Due to its buoyancy, the North American crust rebounded isostatically, uplifting the oceanic crust that had been thrusted above it during the collision. This understanding of the mechanism of ophiolite formation and preservation also developed from studies in Newfoundland.

Structural stacking within the Humber Arm allochthon indicates that the highest volcanic and ophiolitic slices are the farthest-travelled. The progressive transport of these rocks across the continental shelf is recorded by the presence of ophiolitic detritus (notably chromite grains) in allochthonous and autochthonous Lower Ordovician sandstones, and by the local presence of volcanic and ophiolitic blocks in basal melanges now contained within thrust faults. The allochthons were assembled progressively from east to west, and then uplifted and transported across the continental shelf by gravity sliding. The final movements and positioning of the assembled allochthons was probably a late (Silurian or Devonian) event, but they were essentially completely constructed by mid-Ordovician times.

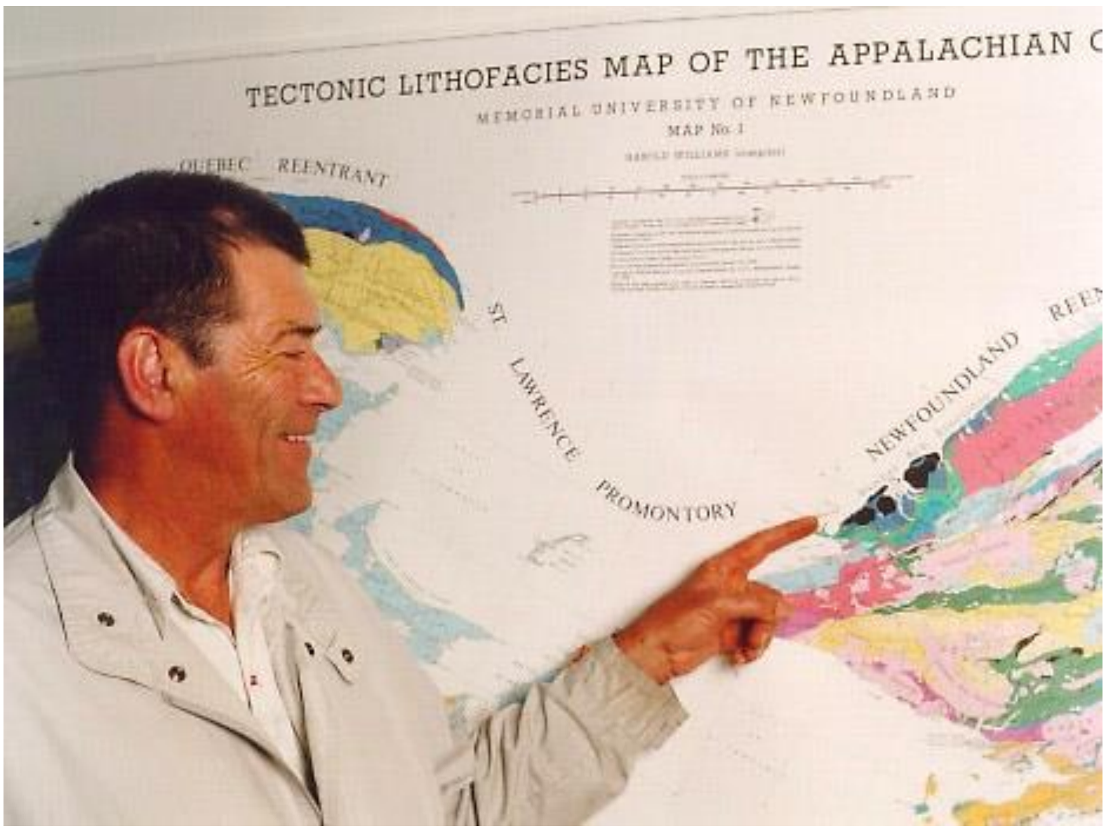
Evidence for plate tectonics

Early geologists recognized that there were many parallels between the geology of the Appalachians – notably Newfoundland – and that of the British Isles. However, in the absence of concepts that could link two areas on opposite sides of an ocean, these were viewed as coincidental. Early advocates of continental drift suggested the Atlantic might have opened between Europe and North America, and further explored these correlations, but they encountered the same objections – how could there possibly be a link?

The recognition of sea floor spreading in the 1960s changed these viewpoints, and more detailed studies of Newfoundland, Ireland and England showed that these similarities were even stronger than previously thought. These results added to the growing evidence for the controversial idea of continental drift. Because the Appalachian – Caledonian Orogen was the best-known of all ancient mountain belts, a strong case could be made for its former continuity, despite gaps of thousands of kilometres.

If an ocean can grow from a small rift zone to a vast expanse, and the size of the Earth remains finite, it follows that oceans must also be destroyed by some processes. For example, the continued opening of the Atlantic is now balanced by the continued destruction of oceanic crust in the Pacific and parts of the Indian Ocean. If this is so, there must have been many former oceans in the history of Planet Earth. Newfoundland contains the largest remnant of the mostly vanished Iapetus Ocean, the precursor to the modern Atlantic. Not only does the geology of Newfoundland provide vital evidence for the reality of recent seafloor spreading and continental drift, it also preserves the long history of an ancient ocean basin of similar magnitude to the Atlantic. The geological history of Newfoundland provides a classic example of a *Wilson Cycle* in which an ocean basin is initiated, grows wide, and is then consumed by the process of subduction as continents converge around it to collide. The terminal collisions are then followed by rifting that leads to the formation of new oceans – and thus to the start of another Wilson cycle. We now know that many such cycles occurred over billions of years, and several former supercontinents are now also defined. All of this began from a new understanding of the geology of Newfoundland, which was a key element in J. Tuzo Wilson's classic 1966 paper entitled *Did the Atlantic close and then reopen?* The Wilson Cycle was named for Tuzo, and many regard his paper as one of the most important in 20th century geoscience. Tuzo drew upon many sources, but a key component was a 1964 paper by his former student, Harold (Hank) Williams, which carefully outlined the symmetrical nature of the Appalachian Orogen in Newfoundland. A colleague of Hank and Tuzo, Robert Stevens, would later write a concise but influential paper that explained how continental shelves, deeper ocean basins, and parts of the Earth's mantle were all brought together in western Newfoundland. The same models are now applied in many ancient orogenic belts around the world.

The aspiring Geopark preserves virtually all the elements of the Appalachian Wilson Cycle, from the dykes and flood basalts that heralded the birth of the Iapetus, to sedimentary rocks that accumulated in narrow rift basins, to the growth and development of its wide continental shelves, and then the events that progressively led to its destruction through the collision of continents. In addition, it is a place where we can find surviving remnants of the Iapetus Ocean and related basins, and actually stand on the Mohorovicic discontinuity (the Moho) that separates the crust and the mantle. Not far away, in Notre Dame Bay, we can even find dykes of basaltic composition that were emplaced in the Jurassic Period, as part of the first stages in the development of the modern Atlantic.

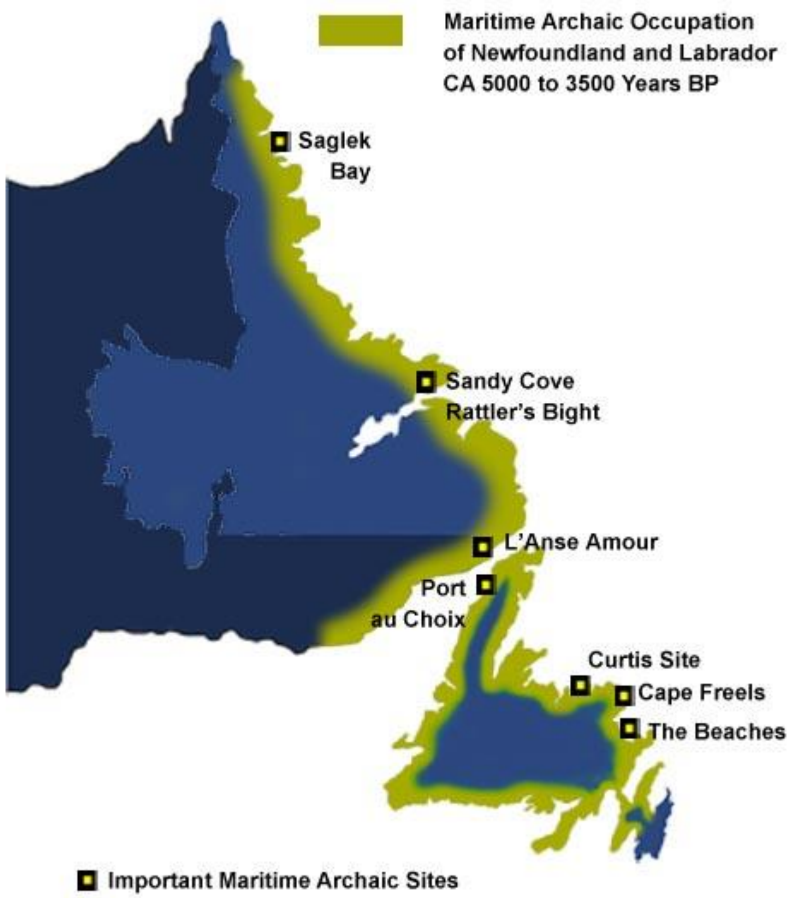


Harold "Hank" Williams points to the Bay of Islands Ophiolite Complex
on his renowned Tectonic Lithofacies Map of the Appalachian Orogen

Tuzo Wilson's name is inextricably linked with the development of the theories of plate tectonics, but he was a geophysicist, who depended on the field skills and observations of geologists to build his theories. The renowned Newfoundland Geologist Harold "Hank" Williams was Tuzo's most famous student, and it was his maps and papers that helped to define the first Wilson Cycle to be recognized. As a musician, Hank could not resist referring to the movement of tectonic plates and the opening and closing of oceans as the "Harry Hibbs Effect", after well-known Newfoundland singer and accordion player Harry Hibbs.

1.2 History and Cartography

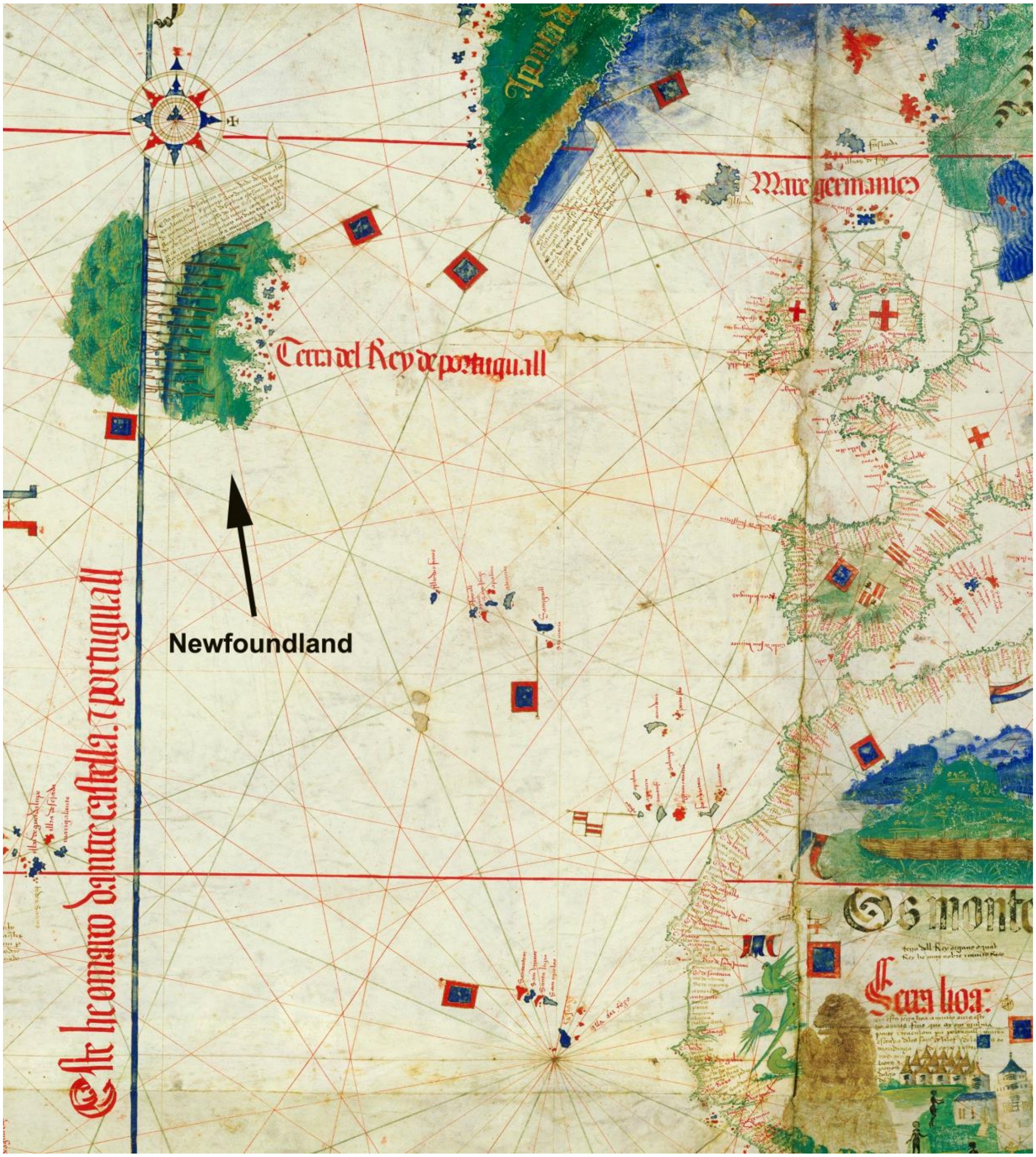
The discoveries and maps of geologist Harold "Hank" Williams are part of a long history of exploration and cartography in Western Newfoundland that began with the Maritime Archaic native people of eastern Canada who explored and settled the coast approximately 5,000 years ago. After their disappearance 3,000 years ago, they were followed by Paleo and Dorset Eskimos, then Algonkian-speaking Beothuck and Mi'kmaq aboriginal peoples.



European exploration of Western Newfoundland began in approximately 1000 AD, when according to the Greenland Saga, Leif Eriksson set sail from Greenland in search of lands recently sighted by Bjarni Herjólfsson. After discovering and naming Helluland (stone-slab land) and Markland (wood land), he discovered and established an encampment at Vinland (wine land), which in the 1960s was discovered by Norwegians Helge and Anne Stine Ingstad at L'Anse aux Meadows on the tip of Newfoundland's Great Northern Peninsula. From Vinland, Leif's brother Thorvald and other Greenland explorers sailed west into the Gulf of St Lawrence and east along the Atlantic coast of Newfoundland. The 16th century Skálholt Map created in Iceland with available documentary evidence on Norse discoveries clearly shows Newfoundland's Great Northern Peninsula, possibly as far south as the Humber Arm Allochthon.

16th century Skálholt Map

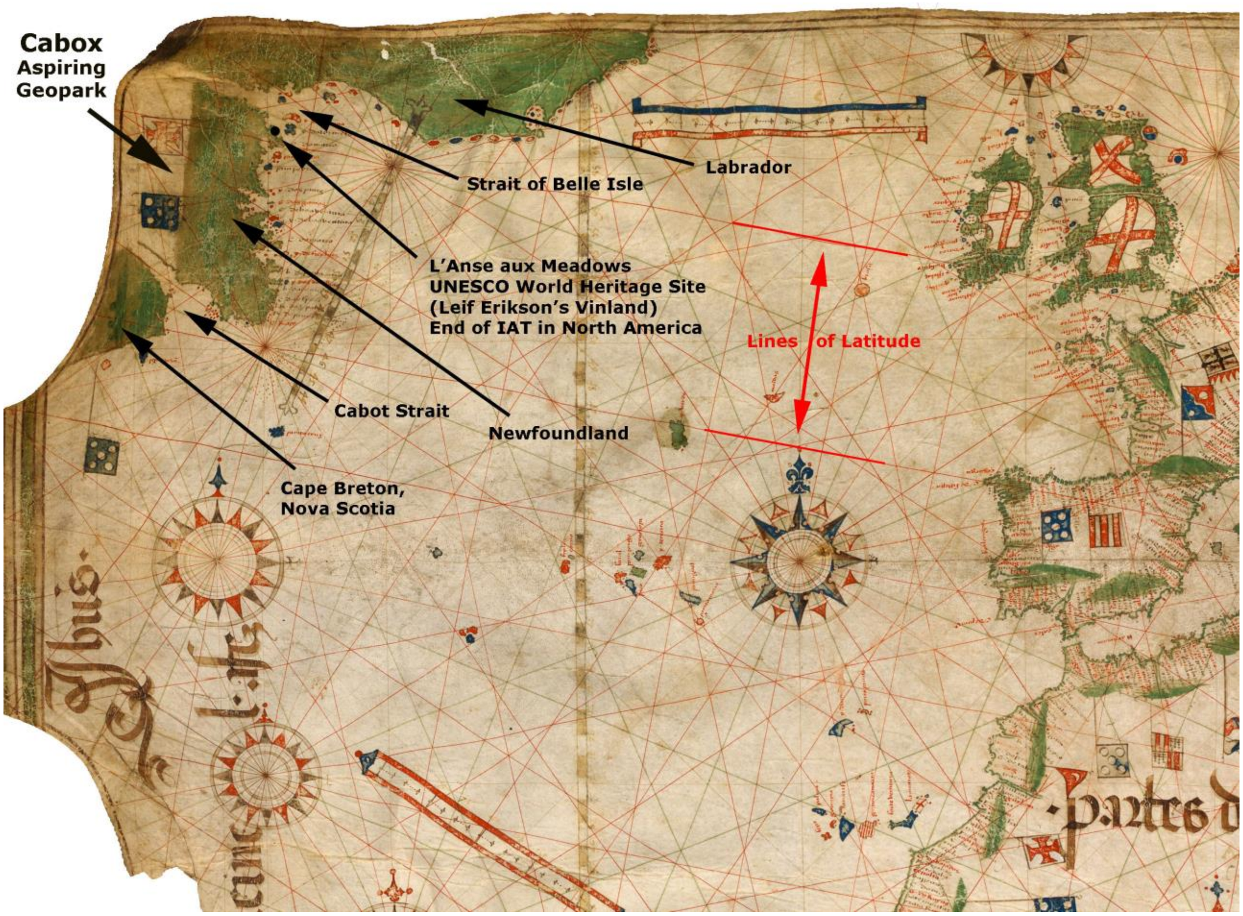
The Norse exploration and settlement of Newfoundland was short-lived, and nearly five hundred years passed before European explorers returned. In 1497, Venetian Giovanni Caboto re-discovered Newfoundland under the commission of King Henry VII of England, while looking for a northeast route to Asia. He was followed in 1501 by Gaspar Corte Real and his brother Miguel, who were exploring what was considered Portuguese possessions in the North Atlantic, as established by the Treaty of Tordesillas with Spain in 1494. The Cantino Planisphere of 1502 places Newfoundland on the eastern (Portuguese) side of the Tordesillas meridian located 270 leagues west of the Cape Verde Islands.



Cantino Planisphere, 1502

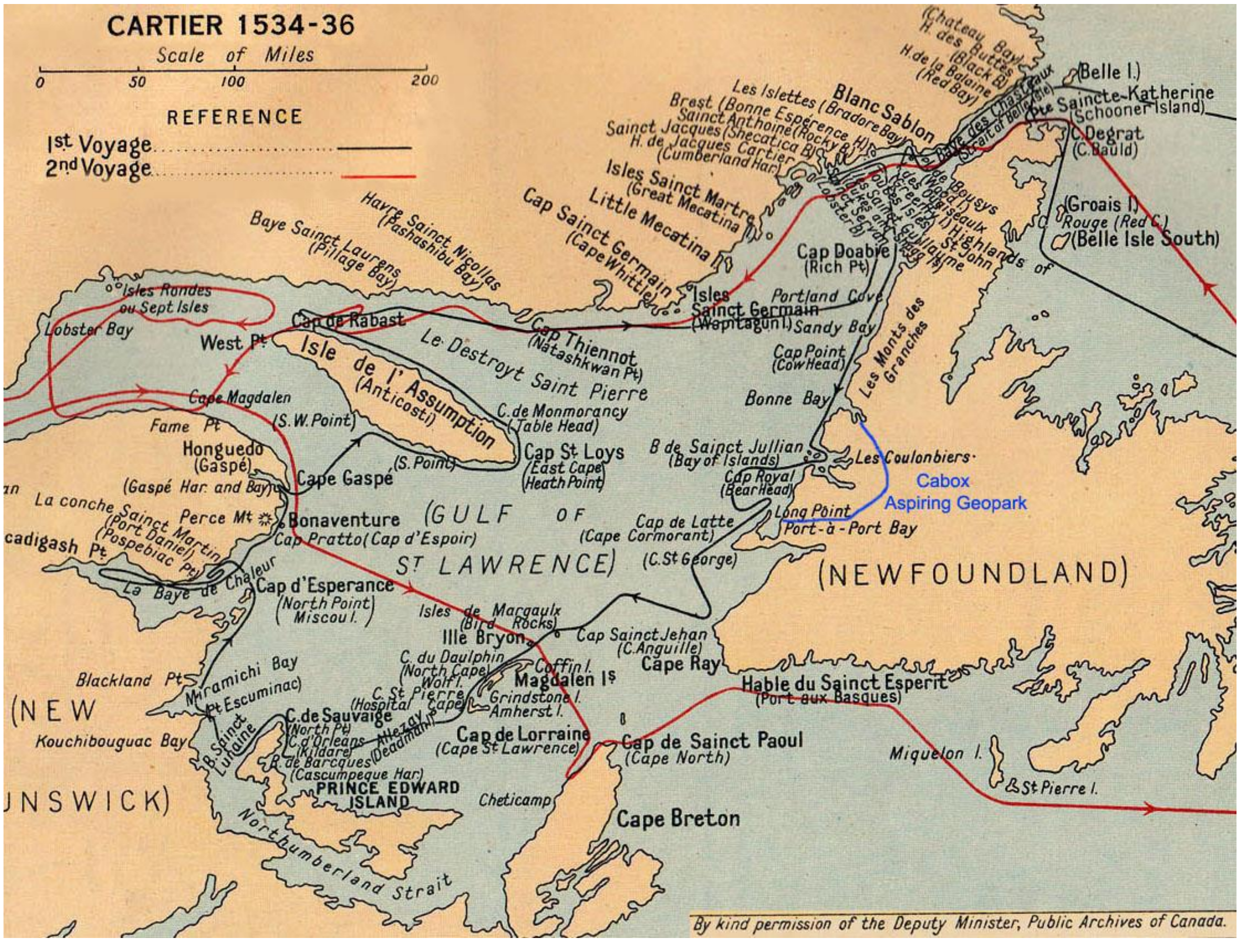
The Pedro Reinel Map of 1504 - created with knowledge derived from the 1501 Corte Real voyage - shows both the Strait of Belle Isle between Labrador and Newfoundland and the Cabot Strait between Newfoundland and Cape Breton, Nova Scotia. It also anticipates the Gulf of St Lawrence and Newfoundland as an island, and is the earliest known nautical chart with a scale of latitudes and wind rose with a fleur-de-lys.

Gaspar Corte Real may have been the first European since the Norse to see the collection of capes and peaks surrounding the Bay of Islands Mountains, when in 1501 after discovering the Cabot Strait, he sent his brother Miguel and two of three caravels home to the Azores before heading north along Newfoundland's west coast to the previously discovered Strait of Belle Isle.



Both Gaspar Corte Real (d.1501) and his brother Miguel (d.1502) were lost at sea, the latter in search of his brother. It was not until 1534-35 when French Explorer Jacques Cartier – who had earlier sailed with Portuguese mariners – entered the Strait of Belle Isle and explored Western Newfoundland (including the Bay of Islands Ophiolite Complex) to the Cabot Strait, eventually proving Newfoundland to be one or more islands. Cartier would go on to explore the St Lawrence River as far as Hochelaga (Montreal) and his discoveries would form the foundation of Canada and the French Shore of Newfoundland, the latter in existence until 1904.

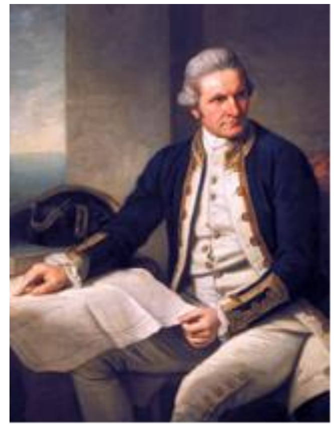
Gaspar Corte Real 1450-1501



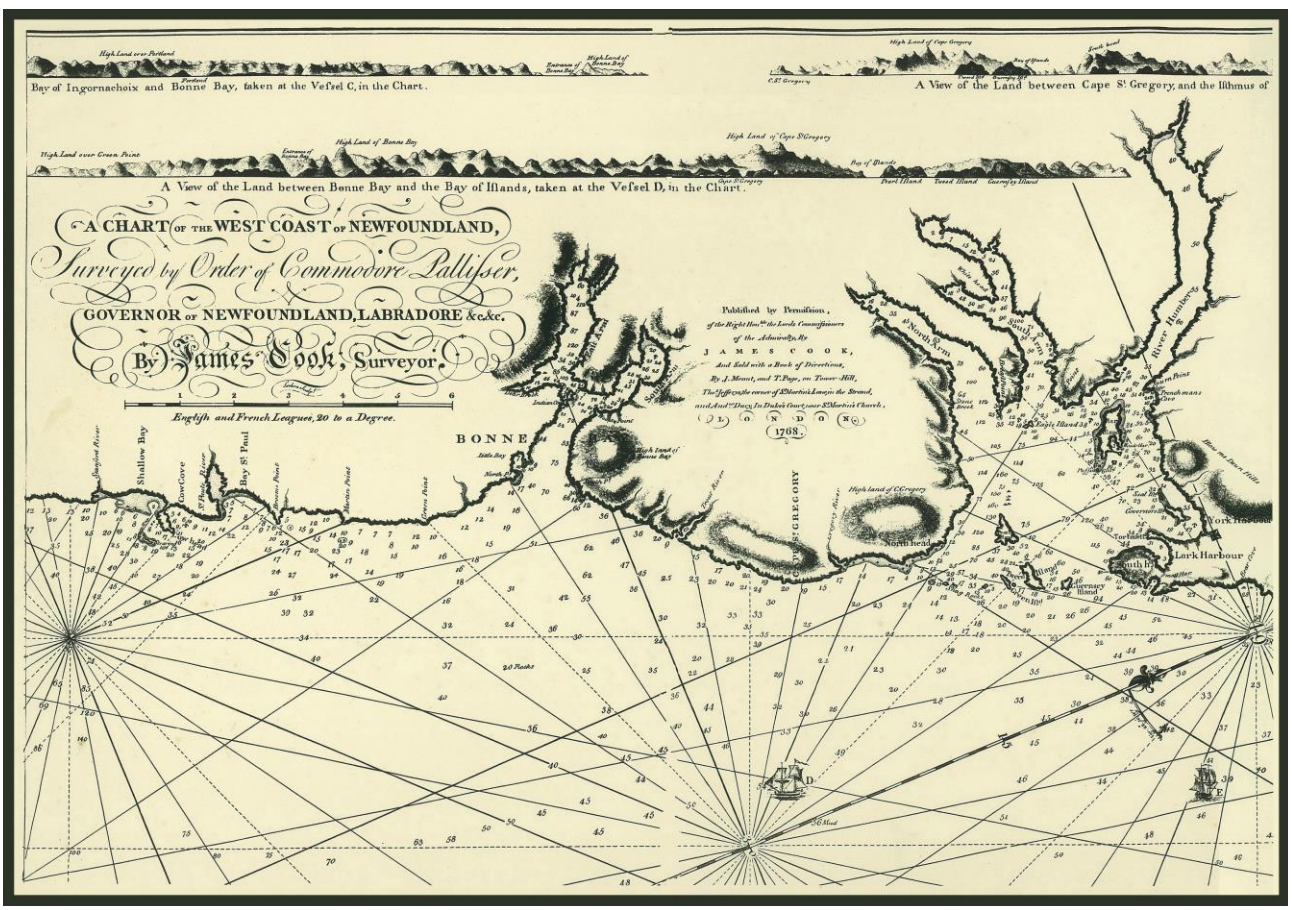
Cartier was also the first recorded European to view the Bay of Islands Ophiolite Complex, when in June 1534 after having 'hove to' the wind during a storm off Newfoundland's Great Northern Peninsula, sighted land again at Bay of Islands. Before long Basques fishermen and whalers were plying the waters of the Gulf of St Lawrence and the highest point of the many peaks surrounding the bay – and on the island of Newfoundland in general – became known as "Cabox", a phonetic plural of the Portuguese and Spanish "cabo", or cape.

Jacques Cartier 1491-1557

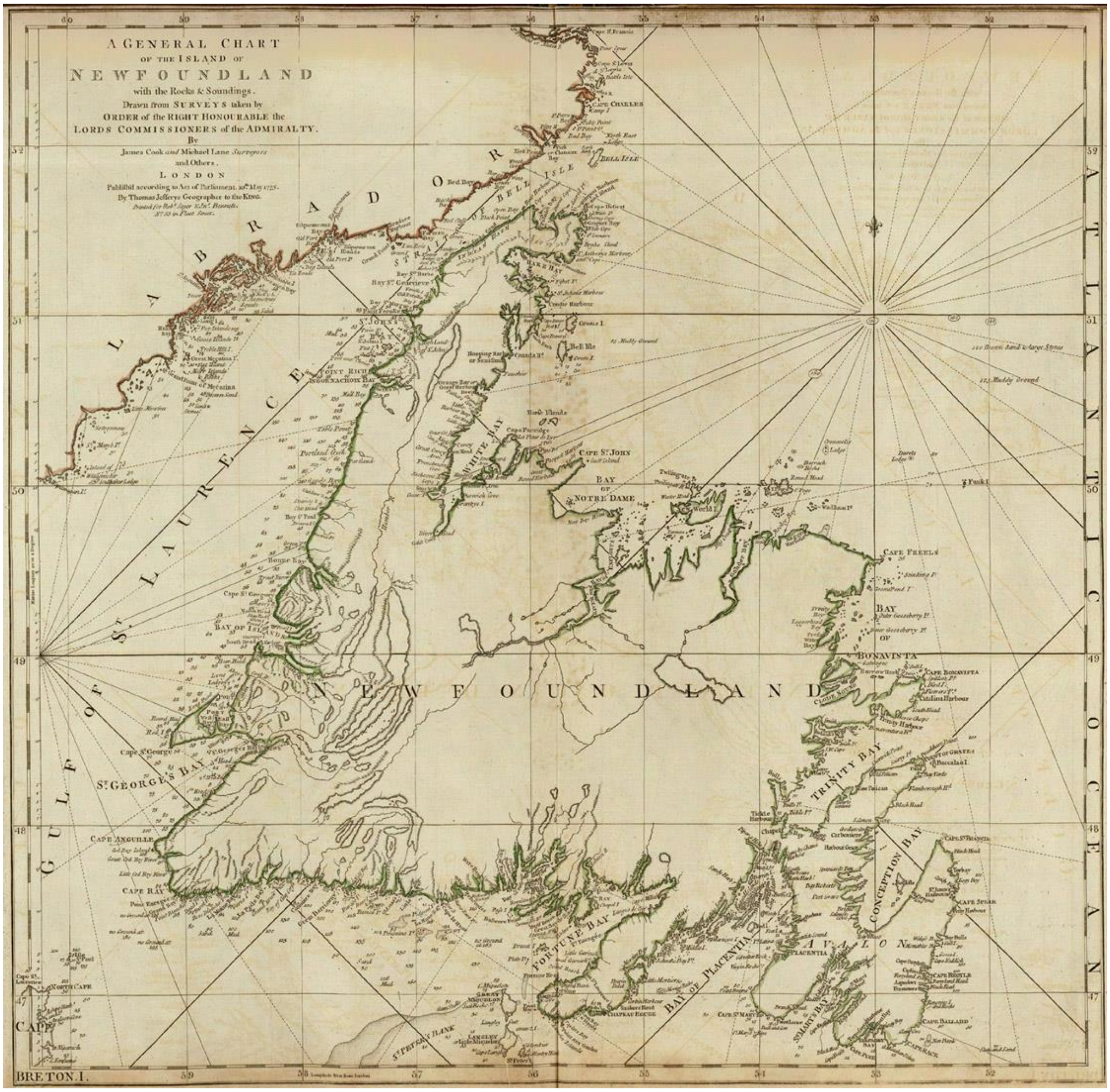
By the 18th century, the island's west coast was part of the French Shore of Newfoundland, having been first established under the Treaty of Utrecht in 1713, then realigned under the Treaty of Paris in 1783. In 1763 after the Seven Years War (French and Indian War in North America), the British Admiralty employed navigator and cartographer James Cook – who participated in the sieges of Louisbourg and Quebec - to survey the north, south and west coasts of Newfoundland, a vast relatively uncharted region of strategic and commercial interest to both England and France.



Cook accepted the 5 year project with characteristic determination and produced the first large-scale, highly detailed and accurate maps of eastern Canada, the first to use hydrographic surveys and geometric triangulation to determine land outlines. In 1767 during his last year in Western Newfoundland, Cook explored and charted the Bay of Islands and Bonne Bay, areas included in Cabox Aspiring Geopark. The following year he departed on his first voyage to the Pacific, having been recruited by the British Admiralty and Royal Society because of his unprecedented accomplishments in Newfoundland.



James Cook Chart of Western Newfoundland showing Bonne Bay (center) and Bay of Islands (right)



General Chart of Newfoundland by James Cook and Michael Lane, 1775

An important objective of the planned Cabox Global Geopark is to recognize and honour the contributions of explorers and cartographers of Western Newfoundland and Eastern Canada, from Norse adventurers to European explorers and Canadian geologists, including James Cook and Harold "Hank" Williams. In 2017, the International Appalachian Trail (IAT) and Cabox Aspiring Geopark plan to celebrate the 250th Anniversary of James Cook charting the west coast of Newfoundland, including the Bay of Islands and Humber Valley. The IAT Cleveland Way National Trail in Yorkshire, England passes near Cook's birthplace and homeport of Whitby, while the nearby IAT Wolds Way National Trail begins at the original Humber River. Cook's naming of Newfoundland's Humber River and Humber Arm is the nomenclature source of the "Humber Zone" of the Canadian Appalachians and "Humber Arm Allochthon" in Western Newfoundland. He also named the islands of the "Bay of Islands Ophiolite Complex".

1.3 Partners and Supporters

While the primary proponent of Cabox Aspiring Geopark is the International Appalachian Trail Newfoundland & Labrador (IATNL), other partners and supporters include the Western Destination Management Organization, Corner Brook Pulp and Paper Limited, Provincial Department of Natural Resources, Provincial Department of Environment and Conservation, Grenfell Campus of Memorial University, Corner Brook Campus of the College of the North Atlantic, and 15 towns in the Bay of Islands, Humber Valley and Bonne Bay.

Numerous council meetings have been held at town halls over the past three years, with one general meeting per year held at MUN's Grenfell Campus in Corner Brook.


Second of three Cabox Aspiring Geopark meetings held at Grenfell Campus of Memorial University, February 2015

1.4 Steering Committee

In March 2016, a Geopark steering committee was formed that includes representatives from the four Aspiring Geopark regions: Bay of Islands South, Bay of Islands North, Humber Valley, and Bonne Bay West. It includes nine mayors and representatives from the private tourism sector, participating museums and government departments.

If a Geopark is established, the steering committee will become a board of directors of an incorporated not for profit organization with clearly defined management structure and responsibilities.

1.5 Geopark Engagement

The International Appalachian Trail Newfoundland & Labrador (IATNL) – primary propopent of Cabox Aspiring Geopark – first became familiar with the Global Geopark Network in June 2009, when Chairperson Paul Wylezol and Finance Director Kevin Noseworthy joined an International Appalachian Trail (IAT) delegation to the United Kingdom, invited by the British Geological Survey (BGS) to explore expansion of the IAT into the related Caledonian Mountains of Western Europe. While in Scotland, Paul and Kevin visited Lochaber Geopark where they met with Scottish Environment Minister Roseanna Cunningham.

(L-R) IATNL's Kevin Noseworthy, Scottish Environment Minister Roseanna Cunningham, IATNL's Paul Wylezol and BGS Host Hugh Barron, who presented at the first Cabox Aspiring Geopark meeting in Corner Brook, NL, June 2014

Later in Northern Ireland, Paul and Kevin enjoyed a tour of the Causeway Coast and Mourne Mountains with Geological Survey of Northern Ireland (GSNI) Geologist and Vice Coordinator of the European Geopark Network Patrick McKeever, now UNESCO Chief of Section at the Global Earth Observation Section, responsible for the Global Geoparks Network.

(L-R) IATNL Chairperson Paul Wylezol, GSNI Geologist Garth Earls, Vice Coordinator of the European Geopark Network Patrick McKeever, IAT Maine Representative Earl Raymond and IATNL Finance Director Kevin Noseworthy on the now IAT Ulster Way in Northern Ireland

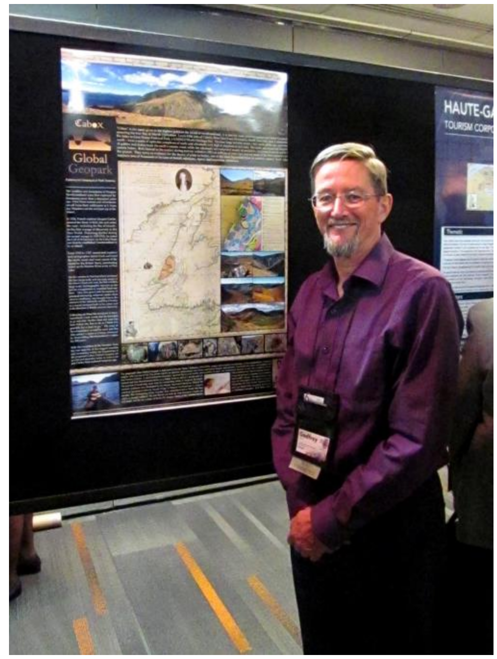
After leaving Ireland and Northern Ireland, Paul and Kevin toured GeoMôn and Fforest Fawr GeoParks in Wales. In the years since, the International Appalachian Trail has expanded to 15 countries and now crosses approximately 15 UNESCO Global Geoparks and Aspiring Geoparks.

In May 2014, the IATNL launched its own bid for a Global Geopark and began holding meetings with community stakeholders. After consultation with towns in the Bay of Islands and western Bonne Bay, it was decided to promote the Bay of Islands Ophiolite Complex (from Lewis Hills to Tablelands) and the region's rich maritime and cartographic heritage, including the exploration and surveys of Royal Navy Captain James Cook and Newfoundland geologist Harold "Hank" Williams.

In August 2014, IAT Chairperson Paul Wylezol presented a triptych of posters at the 4th Conjugate Margins Conference in St. John's, NL: one outlining the history and development of the International Appalachian Trail, another identifying Geoparks along the IAT route across the North Atlantic Ocean, and a third introducing plans to establish "Cabox" Global Geopark in Western Newfoundland.

Paul Wylezol at the 4th Conjugate Margins Conference

In September 2014, Paul also presented the Cabox poster at the 6th International UNESCO Conference on Global Geoparks in Saint John, New Brunswick, where he met Canadian National Committee for Geopark Chairperson Godfrey Nowlan, Stonehammer Geopark Executive Director and Event Manager Gail Bremner and the rest of the Canadian Geopark delegation. Paul also had the opportunity to meet and discuss Global Geoparks with a wide variety of representatives from Europe and around the world.



Canadian National Committee for Geopark Chairperson Godfrey Nowlan at Cabox Poster

Canadian Delegation at the 6th International UNESCO Conference on Global Geoparks, September 2014

A month later in October 2014, the South West Coast Path National Trail hosted the IAT Annual General Meeting in Plymouth, England. In addition to a presentation by Melanie Border, Coordinator of English Riviera Geopark and Chair of the UK Global Geoparks Forum, the week-long event included a day tour of English Riviera Geopark, host of the 7th International Conference on Global Geoparks in September 2016.

UK Global Geoparks Forum Chair Melanie Border giving a Presentation on English Riviera Geopark at 2014 IAT AGM

Also in October 2014, the IATNL sponsored Cabox Aspiring Geopark joined the European Union's Interreg Northern Periphery and Arctic Programme's ***Drifting Apart*** project. (Note above header.) Its goal is to "unearth and strengthen the understanding, appreciation and enjoyment of the fascinating and interconnected geological heritage of the Northern Periphery and Arctic region, and its many links to natural, built and cultural heritage. The project will support the development of new and aspiring Global Geoparks, promote innovative products and services for economic prosperity across the Northern Periphery Region and continue to build a strong network of Northern Periphery Global Geoparks."

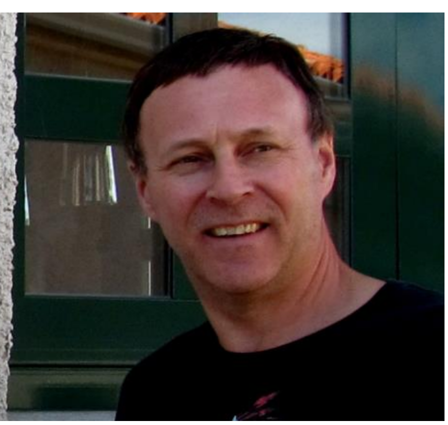
Partner countries include Ireland / Northern Ireland, Scotland, Norway, Iceland, Russia and Canada. Canadian partners include New Brunswick’s Stonehammer Geopark and Cabox Aspiring Geopark.

DRIFTINGAPART

Northern Periphery and Arctic Programme 2014–2020

EUROPEAN UNION
Investing in your future
European Regional Development Fund

During March and April 2015, IAT Chairperson Paul Wylezol toured Portugal's Naturtejo Geopark and Spain's Villuercas-Ibores-Jara Geopark while in the region for the official Launch of IAT Portugal. The event was sponsored by IAT partner Naturtejo Geopark and was attended by Canadian Consul David Marion and over 1000 participants from across the country.



In September 2015, IAT and Cabox Chairperson Paul Wylezol attended the European Geoparks Conference in Oulu, Finland, where he gave a presentation entitled *International Appalachian Trail Partners with European Geoparks*. The well-attended presentation was co-sponsored by IAT partner Naturtejo Geopark of Portugal.

IAT Chairperson Paul Wylezol giving a presentation at the 2015 European Geoparks Conference in Oulu, Finland

Paul is also registered to attend the 7th International Conference on Global Geoparks at English Riviera Geopark in September 2016.

2.0 GeoSites

GeoSites in **Cabox Aspiring Geopark** are divided into three broad categories - Geological, Ecological and Anthropomorphic - providing a complete cross-section of the region's natural and cultural heritage. We use the term Geosite Groups to describe the broad categories.

2.1 Geological GeoSites

Geological GeoSites within Cabox will be divided into five broad geological categories:

A. Ancient Continental Slope
B. Transported Continental Margin
C. Bay of Islands Ophiolite Complex
D. Little Port Island Arc Complex
E. Carboniferous Cover Rocks

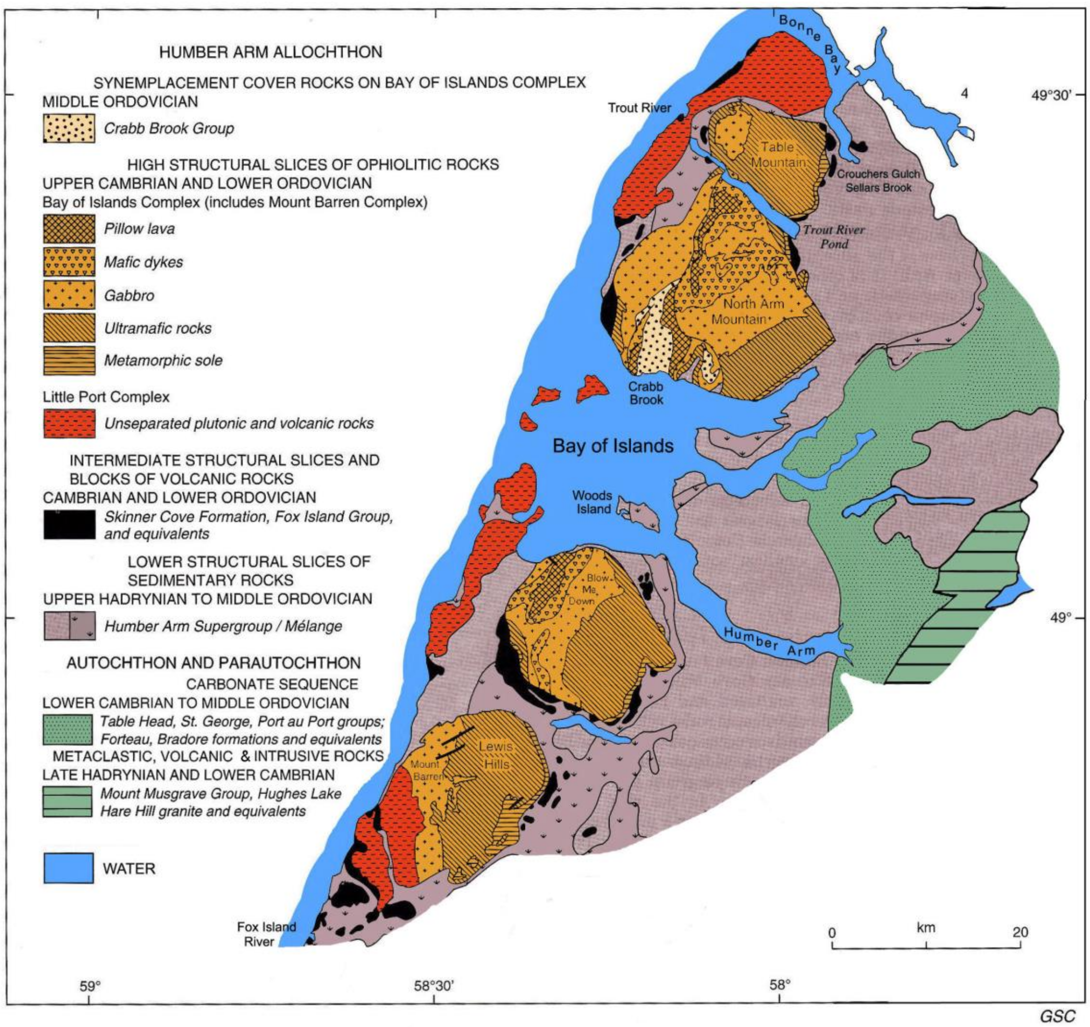
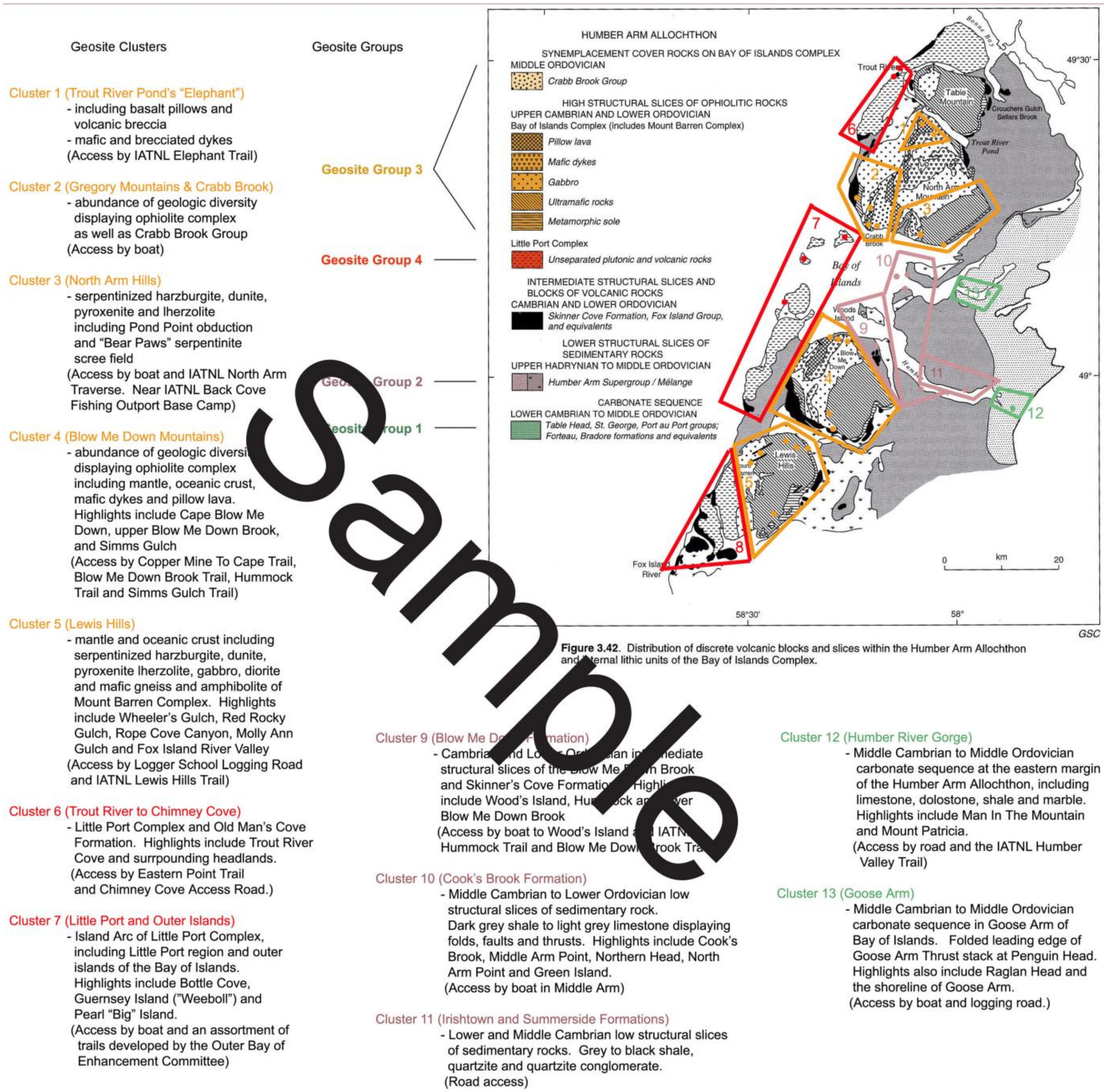


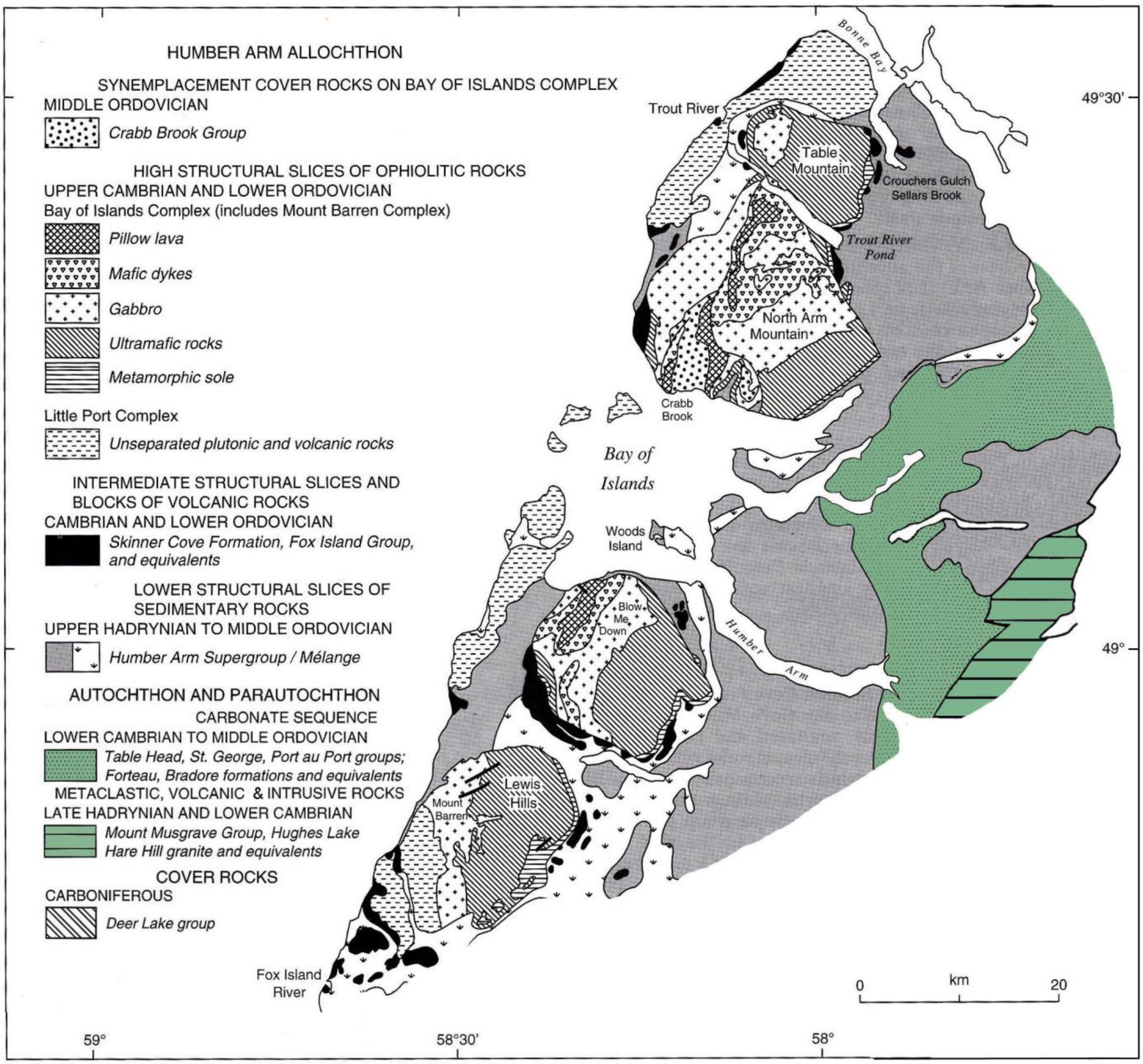
Figure 2.1 Distribution of discrete volcanic blocks and slices within the Humber Arm Allochthon and internal lithic units of the Bay of Islands Complex.

There is no shortage of individual discrete geosites within these broad categorical divisions, but apart from a few samples from each of the three groups, the selection will await more detailed evaluation and must be governed by access and other logistical constraints. Eventual *clusters* of geosites within a geographically proximate area will lend themselves to easy sequential visits that illustrate the geological stories that they portray. The best-known individual geosites are currently within the confines of Gros Morne National Park, which contains just a fraction of the Humber Arm Allochthon. However equivalent and additional localities occur to the south around the Bay of Islands and Humber Valley, and elsewhere in the region.



2.1. A Ancient Continental Slope

GeoSite Group A, or GeoType A, is the ***Ancient Continental Shelf of North America***. This is present in the east central part of planned Geopark (e.g., Humber River Gorge and Goose Arm of the Bay of Islands) and parts of Gros Morne National Park. The Port-au-Port Peninsula, located southwest of the present Park proposal, contains little-disturbed sedimentary rocks and superb original relationships, but most other areas are structurally complex.



GSC

Figure 2.1.A Distribution of discrete volcanic blocks and slices within the Humber Arm Allochthon and internal lithic units of the Bay of Islands Complex.

Rock types are Precambrian to middle Ordovician and of sedimentary origin. They include clastic sequences of the early rift zone, overlain by a thick and diverse carbonate section including rich fossil assemblages, which is overlain at the top by deep-water clastic sequences derived from tectonically transported sequences represented by Site Groups B and C. They record the initiation

of the Iapetus Ocean and the development of its continental shelf sequence. Variations in rock assemblages (facies) within this sequence record changes in global sea level and climates. The uppermost part of the sequence records the drowning of the continental shelf in deep water as it foundered, due to loading by approaching thrust sheets, including ophiolites.

Geosites in Group A include:

GeoSite 1A1 - Lower Humber River Gorge, just east of the city of Corner Brook

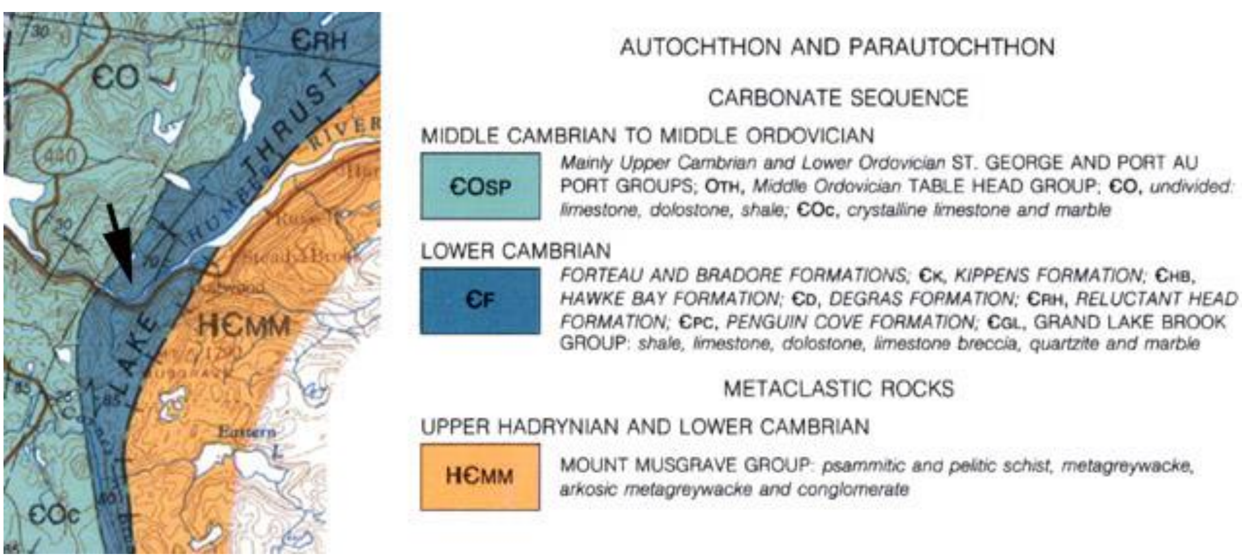
Authority: Crown Land within Corner Brook city limits

Access: By road (Trans-Canada Highway) and trail (International Appalachian Trail's Humber Valley Trail). There is a nearby serviced campground and numerous accommodations providers, including hotels, B&B's and rental cabins.

Features: The final stretch of the Humber River before it enters Humber Arm - both named by surveyor and explorer James Cook in 1767 and the source nomenclature of the Humber Zone of the Canadian Appalachians and Humber Arm Allochthon, renowned for providing evidence for the scientific theory of plate tectonics - winds through a glacier-carved valley of the most westerly section of the Western Newfoundland Autochthon. Rock types include limestone, dolostone, shale, quartzite and marble. The Humber is a world famous salmon river, and a designated viewing area of the “Man in the Mountain” is a popular tourist attraction. The IAT Humber Valley Trail provides spectacular views of the Humber Valley and Humber Arm, including the Blow Me Down Ophiolite of Group C. The Valley is especially scenic in autumn, when fall colors attract Sunday drivers and everyday hikers.

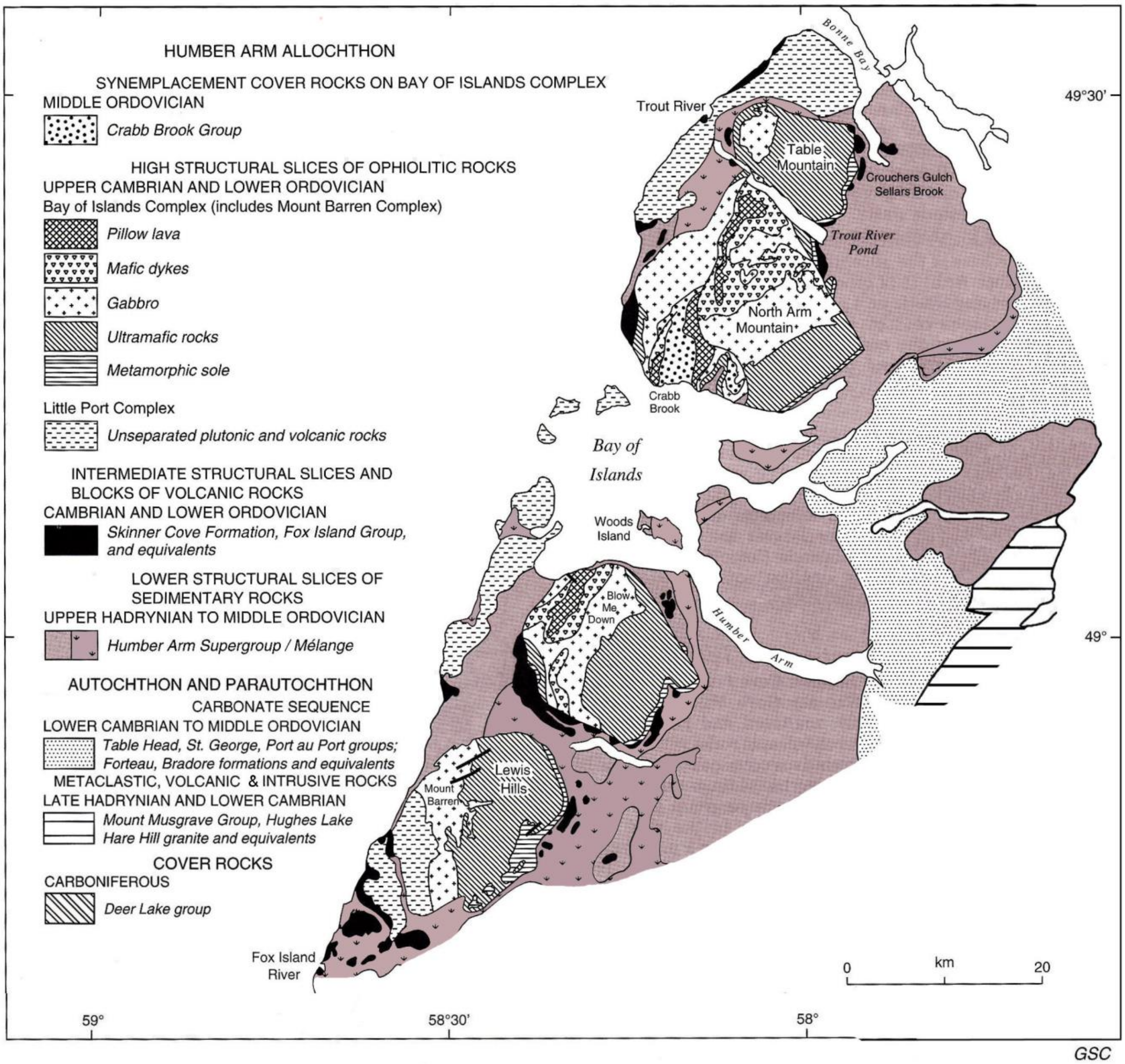
Geological Period: Late Precambrian to Middle Ordovician.

Interpretation: The official Man in the Mountain viewing area off the Trans-Canada Highway at the entrance to Route 440 (Humber Arm North) is the planned location of a large interpretive signage kiosk for both GeoSite Group A and the entire Cabox Geopark. The IAT Humber Valley Trail also provides a trail map of the area, identifying local features.



2.1. B Transported Continental Margin

GeoSite Group B, or GeoType B, is the ***Transported Continental Margin of North America***. This is the most widespread Geosite Group within the planned Geopark, covering large areas that surround ophiolite massifs of the Bay of Islands Igneous Complex, as well as areas immediately west and north of Corner Brook. Individual geosites of this type are well-defined in Gros Morne National Park, most notably in the Green Point – Cow Head area, which includes the international stratotype for the Cambrian-Ordovician boundary. The shores of the Bay of Islands are proposed as the most likely concentrations of individual geosites in this category.



GSC

Figure 2.1.B Distribution of discrete volcanic blocks and slices within the Humber Arm Allochthon and internal lithic units of the Bay of Islands Complex.

Rock types are late Precambrian to middle Ordovician and of sedimentary and volcanic origin, with the former dominant. The sedimentary rocks are extremely diverse, including intermediate-depth and deep-water carbonates, carbonate turbidites and spectacular sedimentary breccias developed on the ancient continental slope. Clastic rocks are equally diverse, ranging from black shales and radiolarian cherts to channel conglomerates that contain clasts of Precambrian basement and shallow-water assemblages akin to GeoSite Group A. Minor mafic volcanic rocks also exist. From a stratigraphic perspective, these rocks preserve a record of the outer shelf region that can be correlated with that of the continental shelf in GeoSite Group A. In both cases, the youngest sedimentary rocks are deep-water clastic sequences that contain ophiolitic detritus.

Site Group B records the development of the outer continental shelf, and allows the reconstruction of its anatomy and sedimentology. As in the case of Site Group A, variations in rock assemblages within this sequence record changes in global sea level and climates. The uppermost part of the sequence records the drowning of the outer continental shelf in deep water as it foundered, due to loading by approaching thrust sheets, including ophiolites. This transition occurs earlier than is seen in the shallow-water realm, and its progress can be traced progressively. The complex structure of the rocks in Site Group B records the events associated with the attempted subduction of North America beneath island arcs developed in the Iapetus Ocean. Thrust faults are common, and large-scale fold structures are defined.

Geosites in Group B include:

GeoSite 1B1 – Middle Arm Point

Authority: Provincial Crown Land

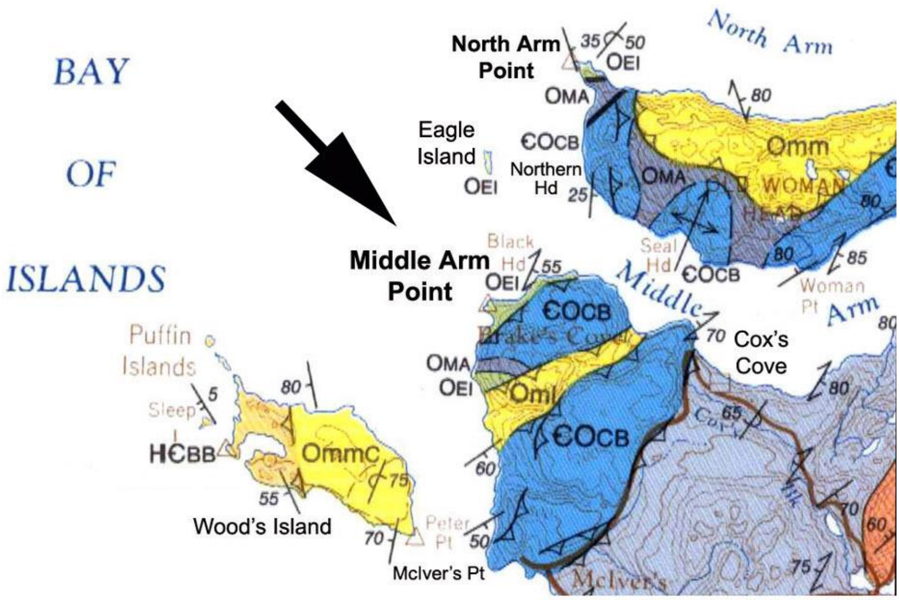
Access: Boat tours by *True North Charter and Tours* and *Four Seasons Tours* of Cox's Cove provide easy and relatively inexpensive access to this roadless maritime site.

Features: Identified as "Back Point" by James Cook in his map of 1768, Middle Arm Point is located between Humber Arm and Middle Arm in the Bay of Islands. Close to the fishing and hunting grounds of the outer Bay of Islands, it was home to Groswater and Dorset Palaeoeskimos, followed by the more recent Beothuck Indians. It is the most westerly section of the transported continental margin in the Bay of Islands and witness to spectacular sunsets across the Gulf of St. Lawrence. For hundreds of years, fishermen passed the near vertical sedimentary layers and sinuous folds of this windswept headland, on their way to seasonal fishing outposts in North Arm. Rock types include grey and green sandstone, dark grey shale to light grey platy limestone, thick limestone breccia, conglomerate and minor chert. Wildlife includes bald eagles and whales.

View of Middle Arm Point

Geological Period: Late Precambrian to Middle Ordovician

Interpretation: Plans call for interpretative boat tours to educate the public and tourists on the natural and cultural history of this scenic coastline. An interpretive panel and campsite will be constructed near the automated navigation light and helicopter landing pad. This GeoSite will also be featured in the EU Drifting Apart project.



INTERMEDIATE STRUCTURAL SLICES

UPPER HADRYNIAN AND LOWER CAMBRIAN

HЄBB	*BLOW ME DOWN BROOK FORMATION and equivalents: grey to pink and red arkosic sandstone, conglomerate, red and grey argillite, local red and green volcanic breccia and pillow lava at base*

MIDDLE ORDOVICIAN

Omm	*Grey to black scaly shale with mainly sedimentary blocks of intermediate and low structural slices. Locally occurs between intermediate and low structural slices;* **OmmC**, *COMPANION MÉLANGE*

LOW STRUCTURAL SLICES OF SEDIMENTARY ROCKS

LOWER AND MIDDLE ORDOVICIAN

OLH	*LOWER HEAD FORMATION;* **OEI**, *EAGLE ISLAND FORMATION: grey and green sandstone, conglomerate and shale, coarsening upward*

LOWER ORDOVICIAN

OMA	*MIDDLE ARM POINT FORMATION of the* CURLING GROUP: *thin bedded black and green shale with dolomitic siltstone and minor limestone*

MIDDLE CAMBRIAN TO LOWER ORDOVICIAN

ЄOSB ЄOGP	*SHALLOW BAY AND GREEN POINT FORMATIONS of the* COW HEAD GROUP; **ЄOCB**, *COOKS BROOK FORMATION of the* CURLING GROUP; **ЄOM**, *McKenzies formation of the* Bonne Bay group; **ЄOBB**, *Bobbys Brook formation of* Old Mans Pond group: *thin bedded alternating dark grey shale and light grey platy limestone, thick limestone breccia units, minor chert*

LOWER AND MIDDLE CAMBRIAN

ЄI	*IRISHTOWN FORMATION of the* CURLING GROUP; **ЄB**, *Barters formation of the* Bonne Bay group; **ЄOB**, *Otter Brook formation of* Old Mans Pond group: *grey to black shale with thick white quartzite and conglomerate units*

UPPER HADRYNIAN AND LOWER CAMBRIAN

HЄS	*SUMMERSIDE FORMATION of the* CURLING GROUP; **HЄM**, *Mitchells formation of the* Bonne Bay group; **HЄCP** *Canal Pond formation of* Old Mans Pond group: *greywacke, quartzite, quartz pebble conglomerate, grey, green and purple shale*

MIDDLE ORDOVICIAN

Oml	*Grey to black and red scaly shale with mainly sedimentary blocks derived from low structural slices and top of autochthon. Occurs between autochthon and low structural slices;* **OmlR**, *Rocky Harbour mélange and equivalents;* **Om**, mélange *undivided*

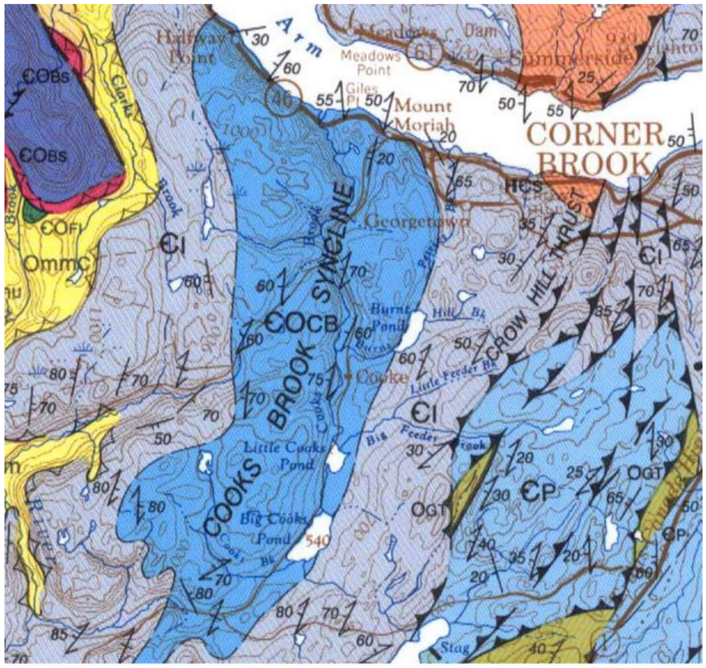
GeoSite 1B2 – Cooks Brook Formation (at Cooks Brook)

Authority: Provincial Crown Lands

Access: By road on Route 450, Cooks Brook and the surrounding Cooks Brook Formation is easily accessible by road and just a short distance from the city of Corner Brook. The International Appalachian Trail is developing a new 10km (6 mile) hilltop trail from Cooks Brook to the community of Benoit's Cove. It will provide terrific views of much of Group B - the transported continental margin - including Cooks Brook, Irishtown and Summerside Formations.

Features: The Cooks Brook and Middle Arm Point formations, situated in Bay of Islands, consist mainly of deep-water carbonates and shales ranging in age from middle Cambrian to early Ordovician. Previous studies have shown that these rocks were deposited as a "base-of-slope sediment apron", downslope from a carbonate platform.[1] Both the Irishtown and Cooks Brook Formations contain clasts of Early Cambrian limestone, while the Cooks Brook also contains indigenous Middle Cambrian fossils in its lower part and Tremadocian graptolites at the top. Rock types include thin bedded shales and platy limestones with prominent limestone breccia units.[2]

A striking feature of the Cook's Brook Formation is its geographic location as a forested foothill of the barren Blow Me Down Ophiolite. The brook itself is an Atlantic salmon river in its original natural state, with plans for a walking trail along its banks.



HIGH STRUCTURAL SLICES OF OPHIOLITIC ROCKS

UPPER CAMBRIAN AND LOWER ORDOVICIAN

BAY OF ISLANDS COMPLEX (ЄOBs - ЄOBv)

ЄOBh	*Serpentinized harzburgite, dunite, pyroxenite and lherzolite; feldspathic rocks of "critical zone" at top*
ЄOBs	*Greenschist, amphibolite, minor quartz-mica schist of metamorphic sole*

INTERMEDIATE STRUCTURAL SLICES

CAMBRIAN AND LOWER ORDOVICIAN

ЄOSC	*SKINNER COVE FORMATION;* **ЄOFI**, FOX ISLAND GROUP; **ЄOCR**, *Crouchers formation: black, green, purple and red pillow lava, pink trachyte, interlayered volcanic breccia, minor red siltstone, sandstone and limestone*

MIDDLE ORDOVICIAN

Omm	*Grey to black scaly shale with mainly sedimentary blocks of intermediate and low structural slices. Locally occurs between intermediate and low structural slices;* **Ommc**, *COMPANION MÉLANGE*

LOW STRUCTURAL SLICES OF SEDIMENTARY ROCKS

MIDDLE CAMBRIAN TO LOWER ORDOVICIAN

ЄOSB ЄOGP	*SHALLOW BAY AND GREEN POINT FORMATIONS of the* COW HEAD GROUP; **ЄOCB**, *COOKS BROOK FORMATION of the* CURLING GROUP; **ЄOM**, *McKenzies formation of the* Bonne Bay group; **ЄOBB**, *Bobbys Brook formation of* Old Mans Pond group: *thin bedded alternating dark grey shale and light grey platy limestone, thick limestone breccia units, minor chert*

LOWER AND MIDDLE CAMBRIAN

ЄI	*IRISHTOWN FORMATION of the* CURLING GROUP; **ЄB**, *Barters formation of the* Bonne Bay group; **ЄOB**, *Otter Brook formation of* Old Mans Pond group: *grey to black shale with thick white quartzite and conglomerate units*

UPPER HADRYNIAN AND LOWER CAMBRIAN

HЄS	*SUMMERSIDE FORMATION of the* CURLING GROUP; **HЄM**, *Mitchells formation of the* Bonne Bay group; **HЄCP** *Canal Pond formation of* Old Mans Pond group: *greywacke, quartzite, quartz pebble conglomerate, grey, green and purple shale*

AUTOCHTHON AND PARAUTOCHTHON

TRANSGRESSIVE SANDSTONES AND CARBONATE BRECCIAS

MIDDLE ORDOVICIAN

OMS	*MAINLAND SANDSTONE;* **OGT**, *GOOSE TICKLE FORMATION and equivalents;* **OCC** *CAPE CORMORANT FORMATION: grey shale and turbiditic sandstone, minor crossbedded pink sandstone, limestone breccia*

Cook’s Brook Formation at lower left, with Blow Me Down Ophiolite in background

Geological Period: Upper Middle Cambrian to Lower Ordovician.

Interpretation: Plans call for interpretative panels to be constructed at Cook’s Brook, location of local swimming and fishing areas. The site will also serve as a gateway to the Blow Me Down Ophiolite, Little Port Complex and Intermediate Structural Slices of the Humber Arm / Bay of Islands South region.

.

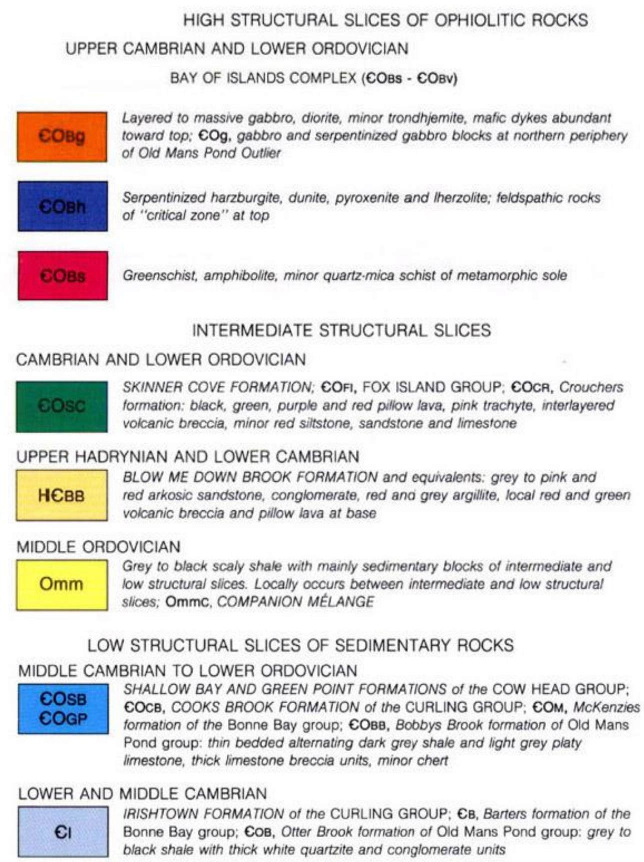
GeoSite 1B3 – Blow Me Down Brook Formation at Frenchman's Cove

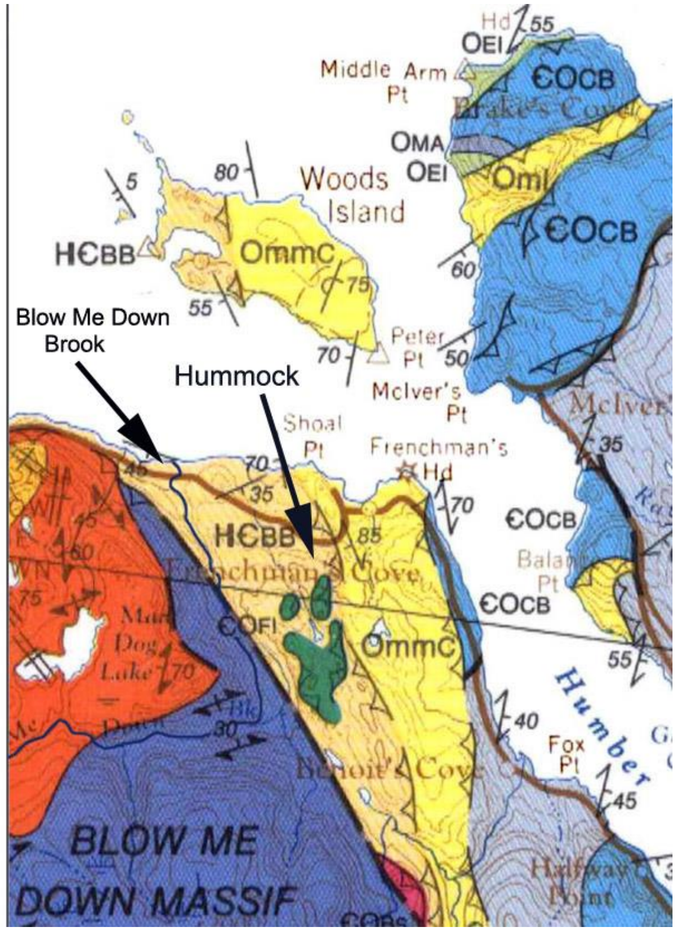
View of the Hummock (right) and Blow Me Down Mountains near Frenchman's Cove

Authority: Provincial Crown Lands

Access: The IATNL Hummock Trail off Route 450 connects the community of Frenchman's Cove to the Blow Me Down Ophiolite via the Hummock, an intermediate structural slice of the transported continental margin within the Blow Me Down Brook Formation.

Features: The Blow Me Down Brook Formation is a siliciclastic unit in the Humber Arm allochthon of western Newfoundland that was deposited on the ancient North American continental slope and rise during the early stages of the development of the Iapetus Ocean. This unit consists primarily of sand-rich turbidites that appear to be barren of body fossils. The shales, however, contain trace fossil assemblages dominated by the ichnogenus Oldhamia and also include Planolites, Gordia, and other indistinguishable simple forms. Oldhamia is considered as an index fossil for the Early Cambrian. Oldhamia traces have been found in the Blow Me Down Brook Formation at 27 localities along the length of the allochthon and occur beneath each of the four ophiolitic massifs. Together, the assemblages from this unit contain five Oldhamia ichnospecies including O. radiata, O. antiqua, O. smithi, O. flabellata, and the newly reported O. curvata. Different ichnospecies are dominant in the Oldhamia assemblages at the 27 localities and these differences appear to be systematic. In the northernmost localities of the Blow Me Down Brook Formation simple radial forms predominate, including O radiata and O. smithi, whereas in the southernmost localities dendritic forms such as O. flabellata are common. This north to south distribution from radial to dendritic forms may represent an evolutionary trend of feeding optimization.[3]






View of the Blow Me Down Brook Formation and Intermediate Structural Slices at Hummock (left)

Geological Period: Upper Lower Cambrian to Lower Ordovician.

Interpretation: Plans call for interpretative panels to be constructed along the IATNL Hummock Trail, beginning on the Frenchman's Head Trail at Frenchman's Cove. Plans also call for interpretive panels and a signage kiosk at the parking lot to Blow Me Down Brook Trail.

Views of Blow Me Down Brook & Woods Island (above), part of the Blow Me Down Brook Formation

2.1. C Bay of Islands Ophiolite Complex

GeoSite Group C includes the Bay of Islands Complex Ophiolite Massifs. These are the most obvious and spectacular natural features in the Aspiring Geopark, forming high upland plateau areas and dissected mountainous terrain. There are four such massifs, as outlined in Section 1.1, located north and south of the Bay of Islands. The Tablelands Ophiolite, in Gros Morne National Park, contains a number of defined geosites, including the Moho, but numerous potential sites exist in the other massifs. The Blow-Me-Down and North Arm Mountain massifs contain the most complete ophiolite sequences, but many are remote and only accessible by boat and/or hiking trails, including the International Appalachian Trail.

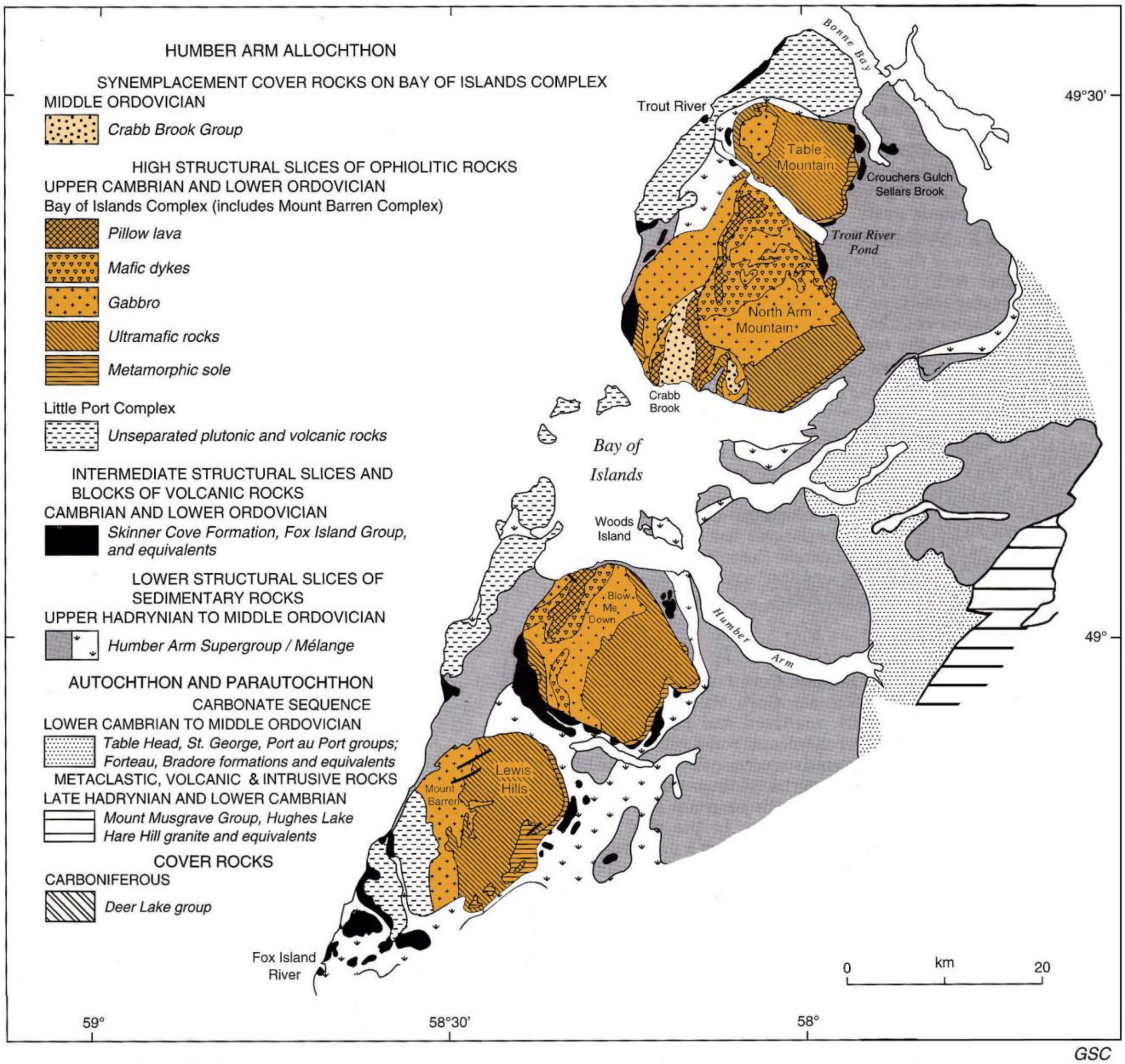
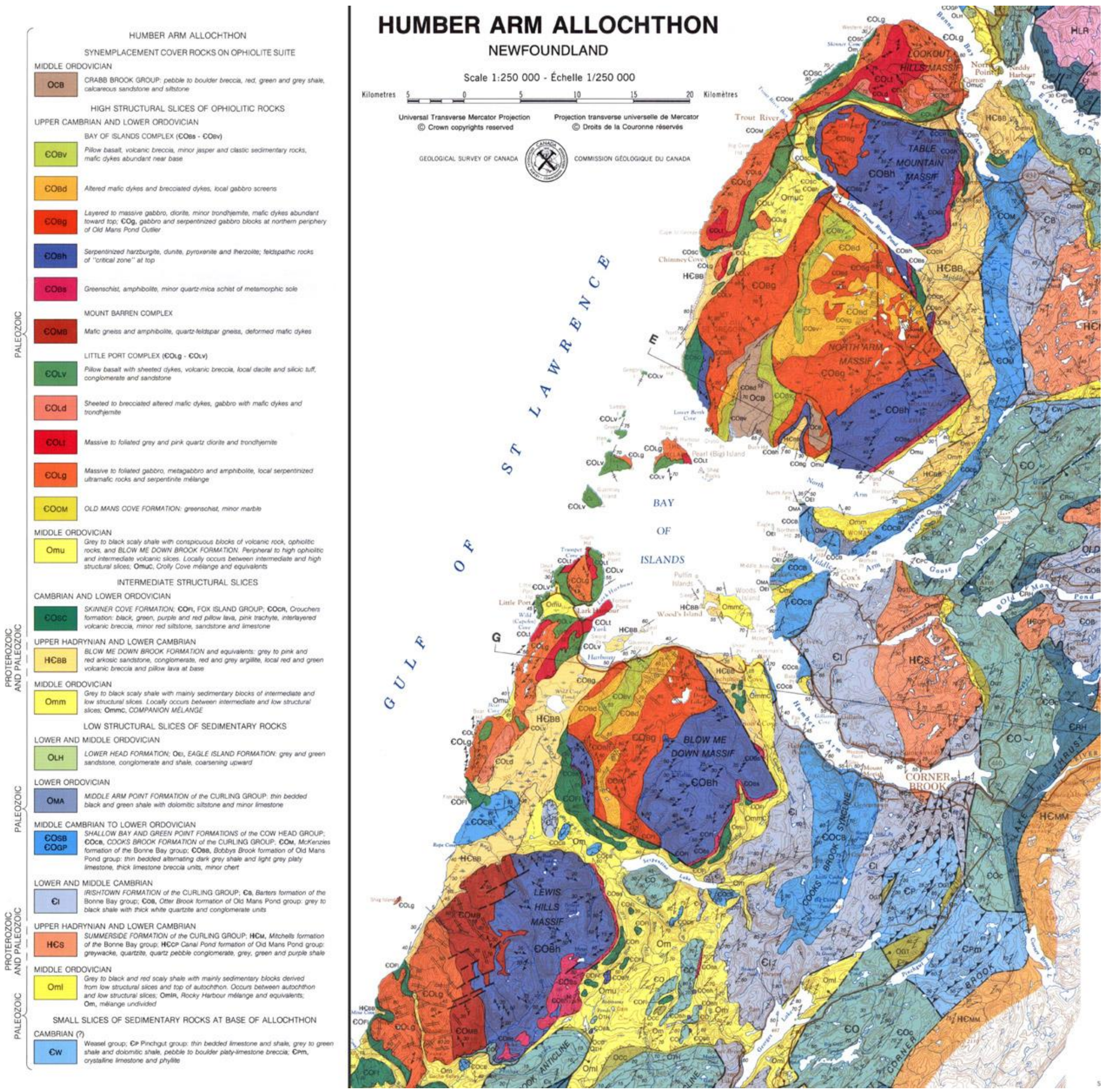


Figure 2.1.C Distribution of discrete volcanic blocks and slices within the Humber Arm Allochthon and internal lithic units of the Bay of Islands Complex.

Rock types are Cambrian to Ordovician and largely of igneous origin, but include some sedimentary rocks associated with the ancient ocean floor. From lowest to highest topographically and structurally, the massifs consist of ultramafic rocks (harzburgite and dunite), layered to massive gabbro, sheeted diabase dyke complexes and pillow basalts erupted on the sea floor. Felsic rocks representing differentiates of mafic magmas and/or partial melts of oceanic crust are also preserved in some slices. Metamorphic rocks preserved in some areas record the conditions of emplacement of these complexes above the rocks of Site Group B.

GeoSite Group C represents sections of oceanic crust, likely developed within arcs and back arc basins in the ancient Iapetus Ocean. These have been tectonically transported across the largely sedimentary rocks of GeoSite Groups A and B. The rocks of Group C provide insight into the nature and structure of the oceanic crust, and are some of the best-known and best-preserved ophiolite suites in the geological record.



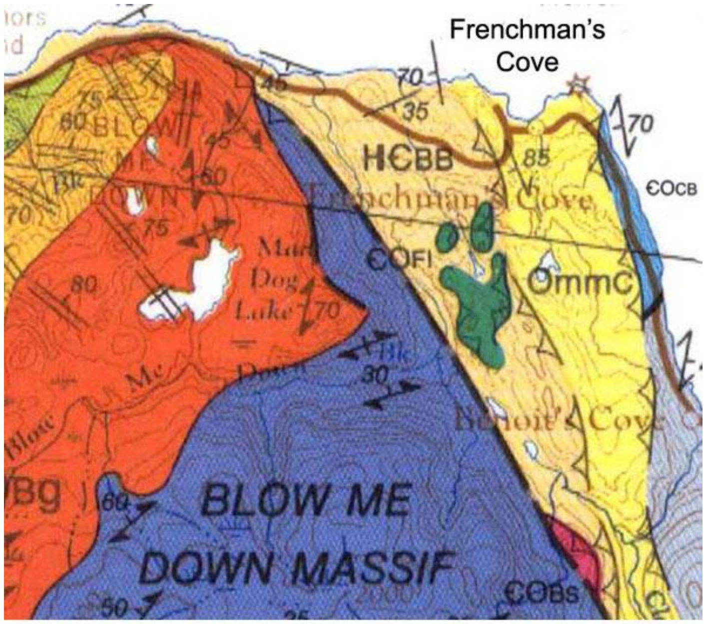
Geosites in Group C include:

<u>GeoSite 1C1 – Upper Blow Me Down Brook Valley, Blow Me Down Ophiolite Massif</u>

Authority: Provincial Crown Land

Access: Half-day to full-day hike on Blow Me Down Brook Trail or IAT Hummock Trail.

Features: The Upper Blow Me Down Brook courses through a 4 kilometer forked glacier-carved valley at the convergence between the ultramafic section of the Blow Me Down Ophiolite Massif and the oceanic crust, sheeted dykes and pillow lava to the west. On the west crest of the valley is light grey gabbro, in stark contrast to the rust-colored peridotite on the eastern flank. Both minerals mix at the bottom of the valley. At the upper end of the western fork of the valley is 250ft Blow Me Down Brook Waterfalls, which cascades over oceanic crust into the ultramafic valley below. At the base of the falls is a large 150ft diameter pool ideal for a refreshing mid-summer swim.



HIGH STRUCTURAL SLICES OF OPHIOLITIC ROCKS

UPPER CAMBRIAN AND LOWER ORDOVICIAN

BAY OF ISLANDS COMPLEX (**ЄOBs - ЄOBv**)

ЄOBv	*Pillow basalt, volcanic breccia, minor jasper and clastic sedimentary rocks, mafic dykes abundant near base*
ЄOBd	*Altered mafic dykes and brecciated dykes, local gabbro screens*
ЄOBg	*Layered to massive gabbro, diorite, minor trondhjemite, mafic dykes abundant toward top;* **ЄOg**, *gabbro and serpentinized gabbro blocks at northern periphery of Old Mans Pond Outlier*
ЄOBh	*Serpentinized harzburgite, dunite, pyroxenite and lherzolite; feldspathic rocks of "critical zone" at top*
ЄOBs	*Greenschist, amphibolite, minor quartz-mica schist of metamorphic sole*

INTERMEDIATE STRUCTURAL SLICES

CAMBRIAN AND LOWER ORDOVICIAN

ЄOsc	*SKINNER COVE FORMATION;* **ЄOFI**, FOX ISLAND GROUP; **ЄOCR**, *Crouchers formation: black, green, purple and red pillow lava, pink trachyte, interlayered volcanic breccia, minor red siltstone, sandstone and limestone*

UPPER HADRYNIAN AND LOWER CAMBRIAN

HЄBB	*BLOW ME DOWN BROOK FORMATION and equivalents: grey to pink and red arkosic sandstone, conglomerate, red and grey argillite, local red and green volcanic breccia and pillow lava at base*

MIDDLE ORDOVICIAN

Omm	*Grey to black scaly shale with mainly sedimentary blocks of intermediate and low structural slices. Locally occurs between intermediate and low structural slices;* **Ommc**, *COMPANION MÉLANGE*

LOW STRUCTURAL SLICES OF SEDIMENTARY ROCKS

MIDDLE CAMBRIAN TO LOWER ORDOVICIAN

ЄOSB ЄOGP	*SHALLOW BAY AND GREEN POINT FORMATIONS of the* COW HEAD GROUP; **ЄOCB**, *COOKS BROOK FORMATION of the* CURLING GROUP; **ЄOM**, *McKenzies formation of the* Bonne Bay group; **ЄOBB**, *Bobbys Brook formation of* Old Mans Pond group: *thin bedded alternating dark grey shale and light grey platy limestone, thick limestone breccia units, minor chert*

LOWER AND MIDDLE CAMBRIAN

ЄI	*IRISHTOWN FORMATION of the* CURLING GROUP; **ЄB**, *Barters formation of the* Bonne Bay group; **ЄOB**, *Otter Brook formation of* Old Mans Pond group: *grey to black shale with thick white quartzite and conglomerate units*

Geological Period: Upper Cambrian to Lower Ordovician

Interpretation: Signage and interpretive panels explaining the area's geology will be erected along the Blow Me Down Brook Trail and IAT Hummock Trail.

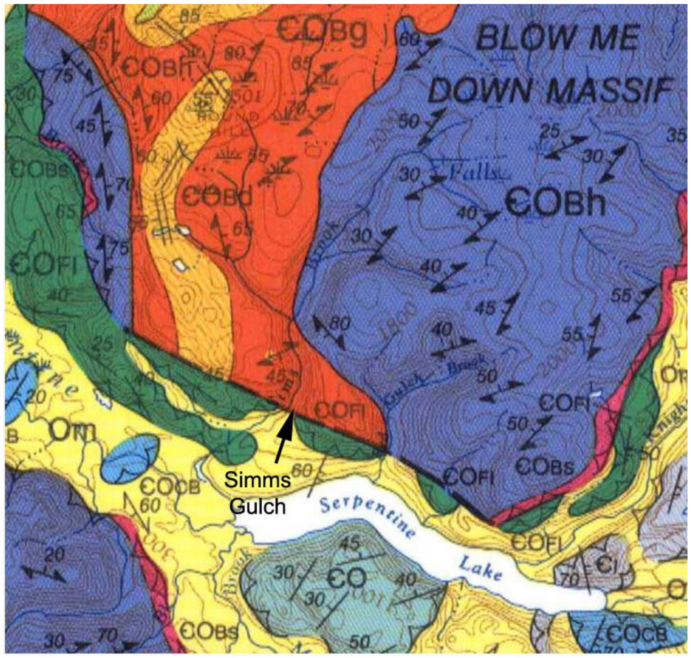
GeoSite 1C2 – Simms Gulch, Blow Me Down Ophiolite Massif


View of Simms Gulch, where mantle meets oceanic crust (top)

Authority: Provincial Crown Land

Access: By 1.5 hour drive on gravel logging road from the town of Mount Moriah on Route 450. From the end of the road, hikers must wade or paddle across the western end of Serpentine Lake, then take the IAT Blow Me Down Mountain Trail to the entrance to Simms Gulch. This is a full day adventure.

Features: It could be said that Simms Gulch is the southern bookend to the Blow Me Down Brook Valley on the north side of the Blow Me Down Ophiolite Massif. Both are forked glacier-carved valleys at the convergence between oceanic crust and ultramafic mantle. Distinguishing 5km long Simms Gulch is its broad base and "stone glacier" overlying underground streams flowing beneath rocks and boulders that have eroded from the surrounding 2,000ft cliffs and steep slopes. At its entrance is a large intermediate structural slice of the Fox Island Group that serves as a tectonic gateway to the hidden gorge.



HIGH STRUCTURAL SLICES OF OPHIOLITIC ROCKS

UPPER CAMBRIAN AND LOWER ORDOVICIAN

BAY OF ISLANDS COMPLEX (**ЄOBS - ЄOBV**)

ЄOBd	*Altered mafic dykes and brecciated dykes, local gabbro screens*
ЄOBg	*Layered to massive gabbro, diorite, minor trondhjemite, mafic dykes abundant toward top;* **ЄOg,** *gabbro and serpentinized gabbro blocks at northern periphery of Old Mans Pond Outlier*
ЄOBh	*Serpentinized harzburgite, dunite, pyroxenite and lherzolite; feldspathic rocks of "critical zone" at top*
ЄOBs	*Greenschist, amphibolite, minor quartz-mica schist of metamorphic sole*

LITTLE PORT COMPLEX (**ЄOLg - ЄOLV**)

ЄOOM	*OLD MANS COVE FORMATION: greenschist, minor marble*

MIDDLE ORDOVICIAN

Omu	*Grey to black scaly shale with conspicuous blocks of volcanic rock, ophiolitic rocks, and BLOW ME DOWN BROOK FORMATION. Peripheral to high ophiolitic and intermediate volcanic slices. Locally occurs between intermediate and high structural slices;* **OmuC**, *Crolly Cove mélange and equivalents*

INTERMEDIATE STRUCTURAL SLICES

CAMBRIAN AND LOWER ORDOVICIAN

ЄOSC	*SKINNER COVE FORMATION;* **ЄOFI,** FOX ISLAND GROUP; **ЄOCR,** *Crouchers formation: black, green, purple and red pillow lava, pink trachyte, interlayered volcanic breccia, minor red siltstone, sandstone and limestone*

LOW STRUCTURAL SLICES OF SEDIMENTARY ROCKS

MIDDLE CAMBRIAN TO LOWER ORDOVICIAN

ЄOSB ЄOGP	*SHALLOW BAY AND GREEN POINT FORMATIONS of the* COW HEAD GROUP; **ЄOCB,** *COOKS BROOK FORMATION of the* CURLING GROUP; **ЄOM,** *McKenzies formation of the* Bonne Bay group; **ЄOBB,** *Bobbys Brook formation of* Old Mans Pond group: *thin bedded alternating dark grey shale and light grey platy limestone, thick limestone breccia units, minor chert*

AUTOCHTHON AND PARAUTOCHTHON

CARBONATE SEQUENCE

MIDDLE CAMBRIAN TO MIDDLE ORDOVICIAN

ЄOSP	*Mainly Upper Cambrian and Lower Ordovician* ST. GEORGE AND PORT AU PORT GROUPS; **OTH,** *Middle Ordovician* TABLE HEAD GROUP; **ЄO,** *undivided: limestone, dolostone, shale;* **ЄOc,** *crystalline limestone and marble*

British Geological Survey's Hugh Barron entering Simms Gulch

Geological Period: Upper Cambrian to Lower Ordovician

Interpretation: Signage and interpretive panels explaining the area's geology will be erected along the IAT Blow Me Down Mountain Trail.

GeoSite 1C3 – Northern End of Lewis Hills Massif

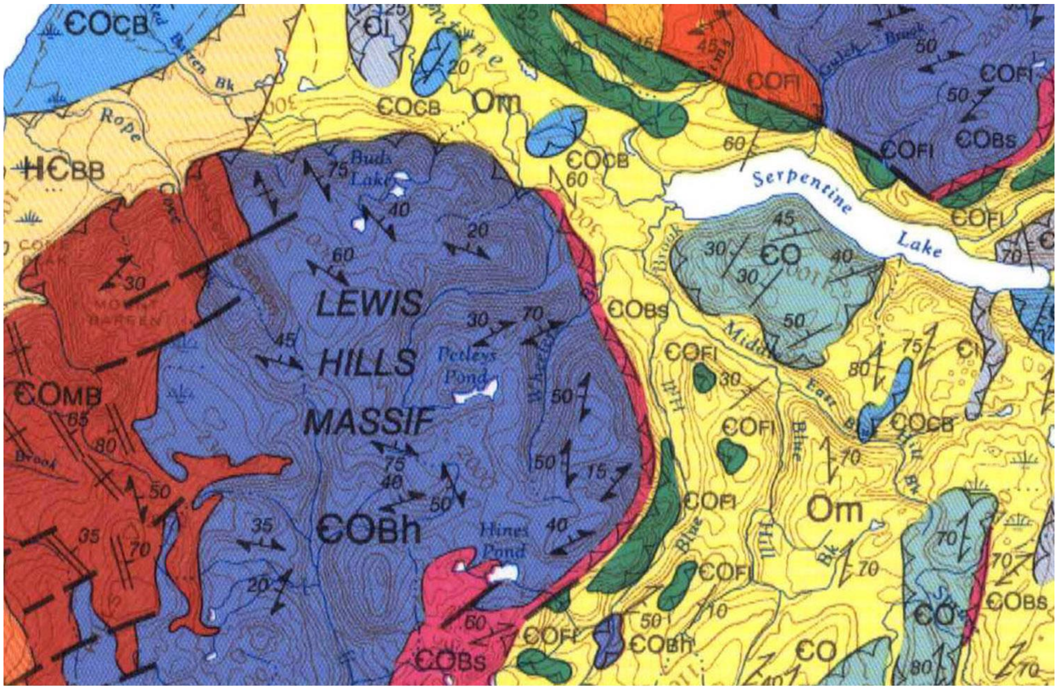
View through Red Rocky Gulch, with Serpentine Lake and Blow Me Down Mountains in background

Authority: Provincial Crown Lands

Access: By 1.5 hour drive on gravel logging road from the town of Mount Moriah on Route 450. From near the end of the road, hikers walk approximately 1 hour on the IAT Lewis Hills Trail to the base of the Lewis Hills. This is a full day adventure.

Features: The northern end of the Lewis Hills Massif is defined by three northeast facing glacier-carved valleys (known locally as gulches) that are carved through high structural slices of ophiolitic rock, including serpentinized harzburgite, dunite, pyroxenite, and lherzolite, with feldspathic rocks on top. Across the entrance to the gulches is a long sliver of greenschist, amphibolite, and minor quartz-mica schist of metamorphic sole.

The valley floors are strewn with boulders of varying sizes and the entire region is generally devoid of vegetation because of the high ph of the rocks. The 1650ft pyramid shaped peak between Wheeler's and Red Rocky Gulches provides a spectacular 360 view of the area, and is easily climbed in under an hour. It provides looping day hike combinations up, around and down the gulches.



HIGH STRUCTURAL SLICES OF OPHIOLITIC ROCKS

UPPER CAMBRIAN AND LOWER ORDOVICIAN

BAY OF ISLANDS COMPLEX (**ЄOBs - ЄOBv**)

ЄOBh	*Serpentinized harzburgite, dunite, pyroxenite and lherzolite; feldspathic rocks of "critical zone" at top*
ЄOBs	*Greenschist, amphibolite, minor quartz-mica schist of metamorphic sole*

MOUNT BARREN COMPLEX

ЄOMB	*Mafic gneiss and amphibolite, quartz-feldspar gneiss, deformed mafic dykes*
ЄOOM	*OLD MANS COVE FORMATION: greenschist, minor marble*

MIDDLE ORDOVICIAN

Omu	*Grey to black scaly shale with conspicuous blocks of volcanic rock, ophiolitic rocks, and BLOW ME DOWN BROOK FORMATION. Peripheral to high ophiolitic and intermediate volcanic slices. Locally occurs between intermediate and high structural slices;* **OmuC**, *Crolly Cove mélange and equivalents*

INTERMEDIATE STRUCTURAL SLICES

CAMBRIAN AND LOWER ORDOVICIAN

ЄOSC	*SKINNER COVE FORMATION;* **ЄOFI,** FOX ISLAND GROUP; **ЄOCR,** *Crouchers formation: black, green, purple and red pillow lava, pink trachyte, interlayered volcanic breccia, minor red siltstone, sandstone and limestone*

Geological Period: Upper Cambrian to Lower Ordovician

Interpretation: Signage and interpretive panels explaining the area's geology will be erected at the trailheads to the IAT Lewis Hills Trail, as well as along the trail itself.

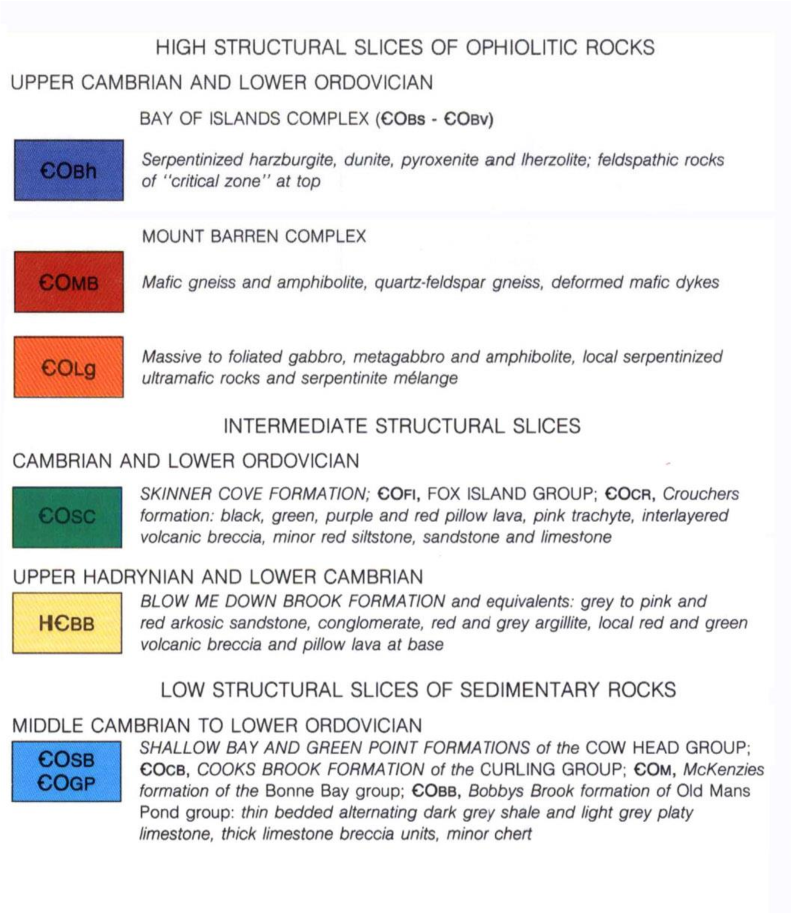
View out Wheeler's Gulch, with Serpentine Lake and Blow Me Down Mountains in background

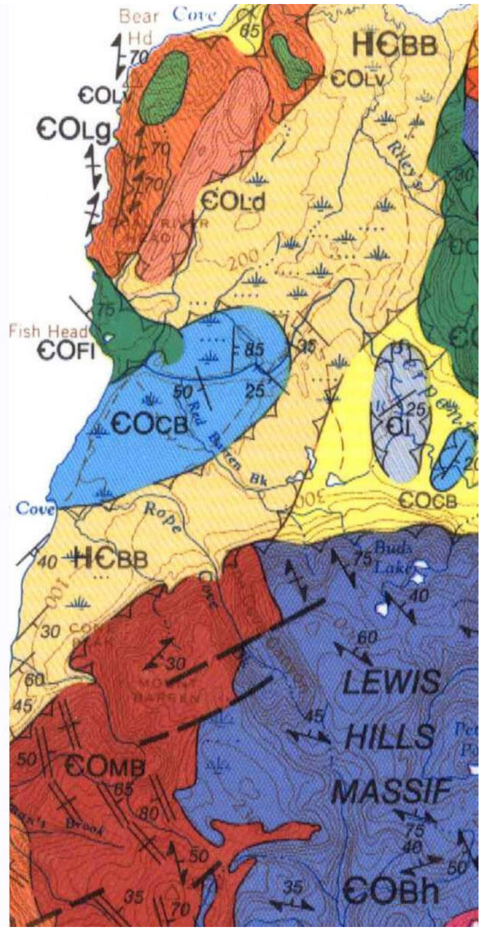
GeoSite 1C4 – Rope Cove Canyon, Lewis Hills

Authority: Provincial Crown Lands

Access: Rope Cove Canyon is one of the most remote GeoSites in Cabox Aspiring Geopark. It is located on the northwest corner of the Lewis Hills, approximately one day walk from the north or south trailhead of the IAT Lewis Hills Trail. It can also be accessed by snowmobile in late winter or early spring, or by helicopter tour.

Features: Like the gulches on the northeast side of the massif, Rope Cove Canyon is a glacier-carved valley which bisects high structural slices of the Lewis Hills massif, including ultramafic sections of the Bay of Islands Ophiolite Complex and mafic gneiss of the Mount Barren Complex. It "could not be more starkly different from Molly Ann Canyon [GeoSite 1C5, located just 3km to the southwest] - or any other place on earth. Its headwall is serpentine, its eastern wall is gabbroic, and its western wall is apparently a combination of gabbros and basalts. The contact zone between mantle and crust is in plain view from the headwall of Rope Cove: serpentine, gabbro, basalt, a perfect ophiolite sequence. The result is a rainbow of colored cliffs."[4]





Geological Period: Upper Cambrian to Lower Ordovician

Interpretation: Signage and interpretive panels explaining the area's geology will be erected at the trailheads to the IAT Lewis Hills Trail, as well as along the trail itself.

GeoSite 1C5 – Molly Ann Gulch, Lewis Hills

Authority: Provincial Crown Lands

Access: Molly Ann Gulch is one of the most remote GeoSites in Cabox Aspiring Geopark. It is located on the western flank of the Lewis Hills, approximately one day walk from the north or south trailhead of the IAT Lewis Hills Trail. It can also be accessed by snowmobile in late winter or early spring, or by helicopter tour.

Features: Like the other gulches and canyons of the Lewis Hills, Molly Ann Gulch is a glacier-carved valley which bisects high structural slices of the Lewis Hills massif. However unlike the others, it contains no ultramafic mantle, only mafic gneiss and amphibolite, quart-feldspar gneiss, and deformed mafic dykes of the Mount Barren Complex. It is “a downright Rivendell-esque landscape of waterfalls, rivulets, snowfields, and basaltic cliffs, overlooking the ocean.”[5]

Molly Ann Gulch is also distinctive for its lush green landscape - from low grasses and shrubs to stunted coniferous trees - which contrasts sharply from the barren plateaus and slopes of the ultramafic mantle. Its western orientation provides spectacular sunsets over the Gulf of St. Lawrence.

Geological Period: Upper Cambrian to Lower Ordovician

Interpretation: Signage and interpretive panels explaining the area’s geology will be erected at the trailheads to the IAT Lewis Hills Trail, as well as along the trail itself.

Transition plateau between Rope Cove Canyon and Molly Ann Gulch

GeoSite 1C6 – North Arm Mountain

North Arm Mountain (center) with Serpentinite outcrop at left and Stone Brook Canyon at center left

Authority: Provincial Crown Lands

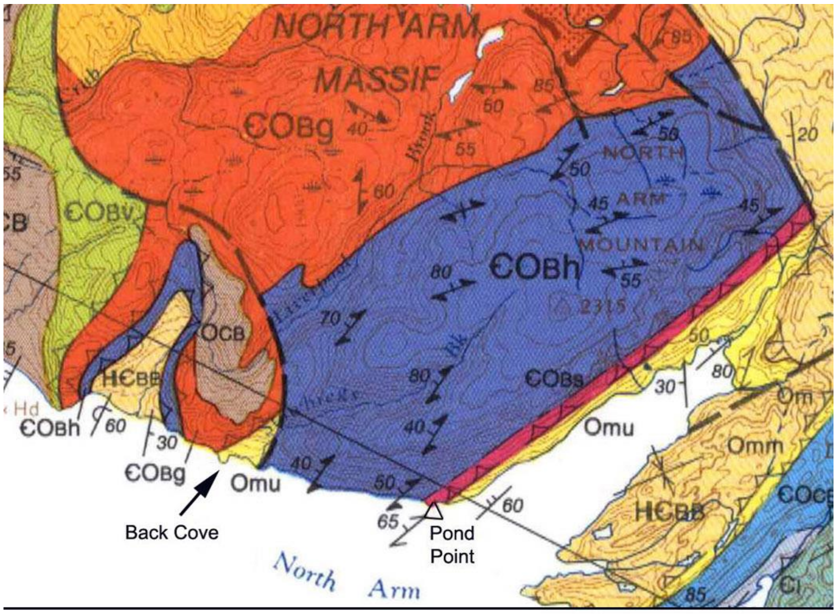
Access: North Arm Mountain is located on the north side of North Arm in the Bay of Islands. It can be accessed by boat (e.g. 45 minutes from the town of Cox's Cove) or by foot on the IAT North Arm Traverse hiking trail. The IAT also has a two-storey hiking base camp at Back Cove near James Cook's Stone Brook (aka Stowbridges Brook), which drains the north side of North Arm Mountain.

Features: The most striking feature of North Arm Mountain is its monolithic size and composition as it rises out of the deep waters of North Arm, Bay of Islands. At Pond Point it can clearly be seen overriding lower structural slices, derived from a period of tectonic thrusting during the closing of the Iapetus Ocean. Composed primarily of rust-colored ultramafic rock such as serpentinized harzburgite, pyroxenite, and lherzolite, it glows at dusk as the sun sets over the Bay of Islands.

On the west side of Stowbridges Brook is possibly the largest outcrop of exposed serpentinite on the Bay of Islands Ophiolite Complex. The "Bear Paws" site is just a short walk above the IATNL base camp at Back Cove, which is also near a good example of beachfront pillow lava.

Geological Period: Upper Cambrian to Lower Ordovician

Interpretation: Signage and interpretive panels explaining the area's geology will be erected at the IAT base camp at Back Cove, as well as along the IAT North Arm Traverse extending from Back Cove to Trout River in Gros Morne National Park.



HUMBER ARM ALLOCHTHON

SYNEMPLACEMENT COVER ROCKS ON OPHIOLITE SUITE

MIDDLE ORDOVICIAN

OCB — CRABB BROOK GROUP: *pebble to boulder breccia, red, green and grey shale, calcareous sandstone and siltstone*

HIGH STRUCTURAL SLICES OF OPHIOLITIC ROCKS

UPPER CAMBRIAN AND LOWER ORDOVICIAN

BAY OF ISLANDS COMPLEX (**€OBs - €OBv**)

€OBv — *Pillow basalt, volcanic breccia, minor jasper and clastic sedimentary rocks, mafic dykes abundant near base*

€OBd — *Altered mafic dykes and brecciated dykes, local gabbro screens*

€OBg — *Layered to massive gabbro, diorite, minor trondhjemite, mafic dykes abundant toward top;* **€Og,** *gabbro and serpentinized gabbro blocks at northern periphery of Old Mans Pond Outlier*

€OBh — *Serpentinized harzburgite, dunite, pyroxenite and lherzolite; feldspathic rocks of "critical zone" at top*

€OBs — *Greenschist, amphibolite, minor quartz-mica schist of metamorphic sole*

MIDDLE ORDOVICIAN

Omu — *Grey to black scaly shale with conspicuous blocks of volcanic rock, ophiolitic rocks, and BLOW ME DOWN BROOK FORMATION. Peripheral to high ophiolitic and intermediate volcanic slices. Locally occurs between intermediate and high structural slices;* **Omuc**, *Crolly Cove mélange and equivalents*

INTERMEDIATE STRUCTURAL SLICES

UPPER HADRYNIAN AND LOWER CAMBRIAN

H€BB — *BLOW ME DOWN BROOK FORMATION and equivalents: grey to pink and red arkosic sandstone, conglomerate, red and grey argillite, local red and green volcanic breccia and pillow lava at base*

High and low structural slices on North Arm Hill

Volcanic Rock at Back Cove

GeoSite 1C7 – The Elephant


View of the Elephant, with Tablelands at background left

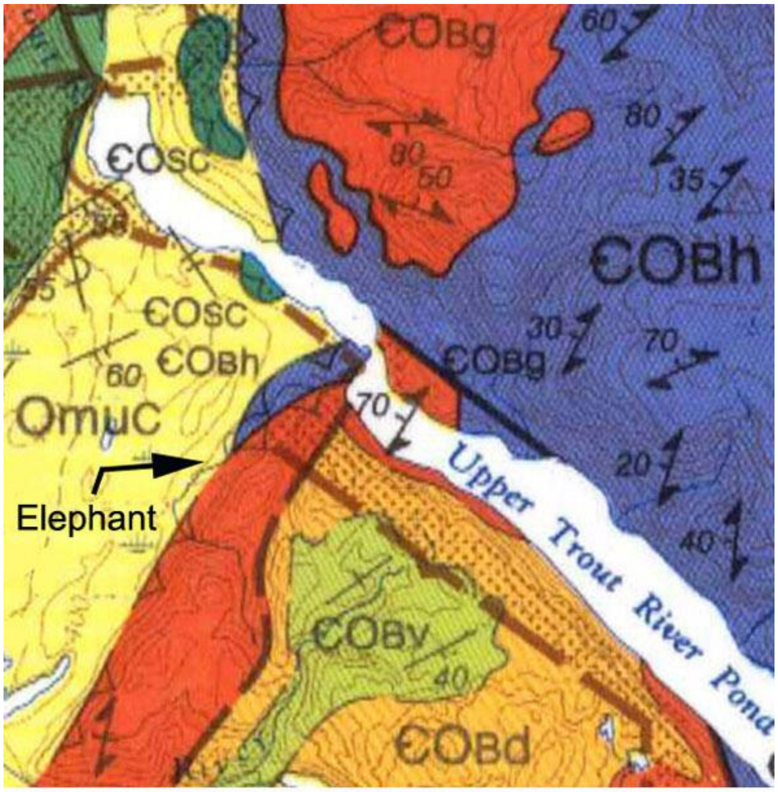
Authority: Provincial Crown Lands and Gros Morne National Park

Access: A 3 km gravel road from the northwest end of Trout River Pond connects to a 3 km ATV trail which in turn connects to the IAT Overfalls Trail extending from the base of the Elephant to the Overfalls waterfall at the southeast end of Trout River Pond. Hikers can take a two-day scenic trek that begins or ends with a boat ride across the pond.

Features: The Elephant is a geographic feature at the northwest corner of Trout River Pond straddling the boundary of Gros Morne National Park. As the name suggests, it resembles an elephant's trunk, head and back. But unlike the nearby Tablelands, it also contains a full ophiolitic suite, from pillow lava and mafic dykes to oceanic crust and earth's mantle.

The base of the Elephant rests on a platform of ultramafic rock such as serpentinized harzburgite and dunite, then rises through layered to massive gabbro, diorite and minor trondhjemite to an upper tier of mafic dykes crowned with pillow basalt, volcanic breccia, minor jasper and clastic sedimentary rock.


View of the Tablelands and Trout River Pond from top of the Elephant



HIGH STRUCTURAL SLICES OF OPHIOLITIC ROCKS

UPPER CAMBRIAN AND LOWER ORDOVICIAN

BAY OF ISLANDS COMPLEX (**€OBs - €OBv**)

€OBv	*Pillow basalt, volcanic breccia, minor jasper and clastic sedimentary rocks, mafic dykes abundant near base*
€OBd	*Altered mafic dykes and brecciated dykes, local gabbro screens*
€OBg	*Layered to massive gabbro, diorite, minor trondhjemite, mafic dykes abundant toward top;* **€Og**, *gabbro and serpentinized gabbro blocks at northern periphery of Old Mans Pond Outlier*
€OBh	*Serpentinized harzburgite, dunite, pyroxenite and lherzolite; feldspathic rocks of "critical zone" at top*
€OBs	*Greenschist, amphibolite, minor quartz-mica schist of metamorphic sole*

LITTLE PORT COMPLEX (**€OLg - €OLv**)

€OOM	*OLD MANS COVE FORMATION: greenschist, minor marble*

MIDDLE ORDOVICIAN

Omu	*Grey to black scaly shale with conspicuous blocks of volcanic rock, ophiolitic rocks, and BLOW ME DOWN BROOK FORMATION. Peripheral to high ophiolitic and intermediate volcanic slices. Locally occurs between intermediate and high structural slices;* **OmuC**, *Crolly Cove mélange and equivalents*

INTERMEDIATE STRUCTURAL SLICES

CAMBRIAN AND LOWER ORDOVICIAN

€Osc	*SKINNER COVE FORMATION;* **€OFI**, FOX ISLAND GROUP; **€OCR**, *Crouchers formation: black, green, purple and red pillow lava, pink trachyte, interlayered volcanic breccia, minor red siltstone, sandstone and limestone*


Climbing the gabbroic lower flank of the Elephant, with Tablelands in Background

Geological Period: Upper Cambrian to Lower Ordovician

Interpretation: Signage and interpretive panels explaining the area's geology will be erected at the Overfalls Trail trailhead at the base of the Elephant, as well as along the trail itself.


View of the ultramafic mantle at Tablelands, with mafic dykes in foreground

2.1. D Little Port Island Arc Complex

GeoSite Group D, or GeoType D, includes the ***Little Port Island Arc Complex*** of unseparated plutonic and volcanic rocks that form narrow northeast-trending coastal slices between Fox Island River and Bonne Bay. The Complex overlies the Humber Arm Supergroup in most places, but between Trout River and Bonne Bay it overlies the Skinner Cove and Old Man Cove formations. It is separated by the Bay of Islands Complex by a wide valley, except at Lewis Hills where deformed gabbros, peridotites and tonalite gneisses of the Mount Barren Complex occur between the Little Port Complex to the west and the Bay of lslands Complex to the east, all part of the Lewis Hills massif. Generally considered an island arc, the only remaining islands of the Complex are found in the outer Bay of Islands, and include Guernsey, Tweed and Pearl Islands.

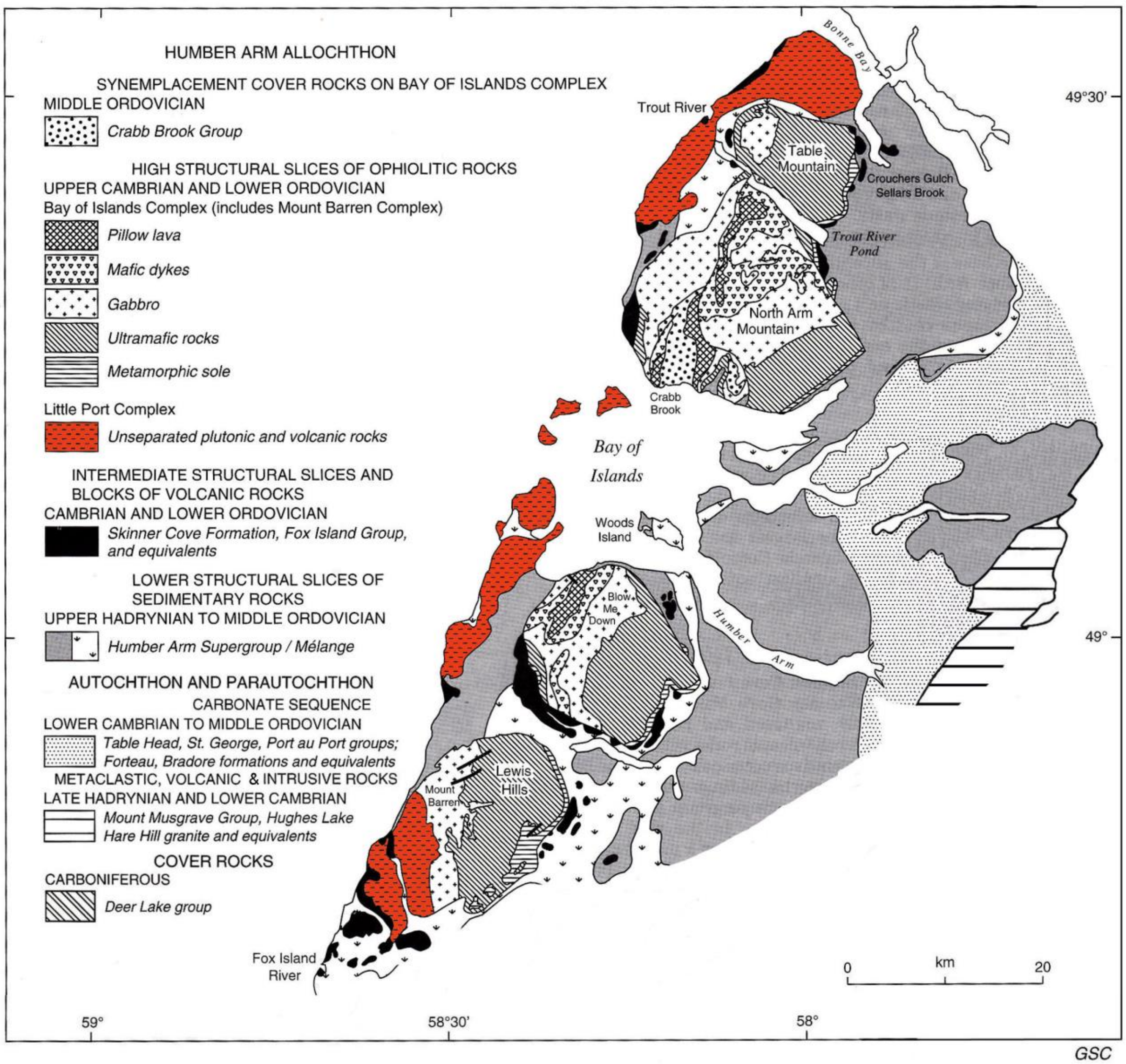
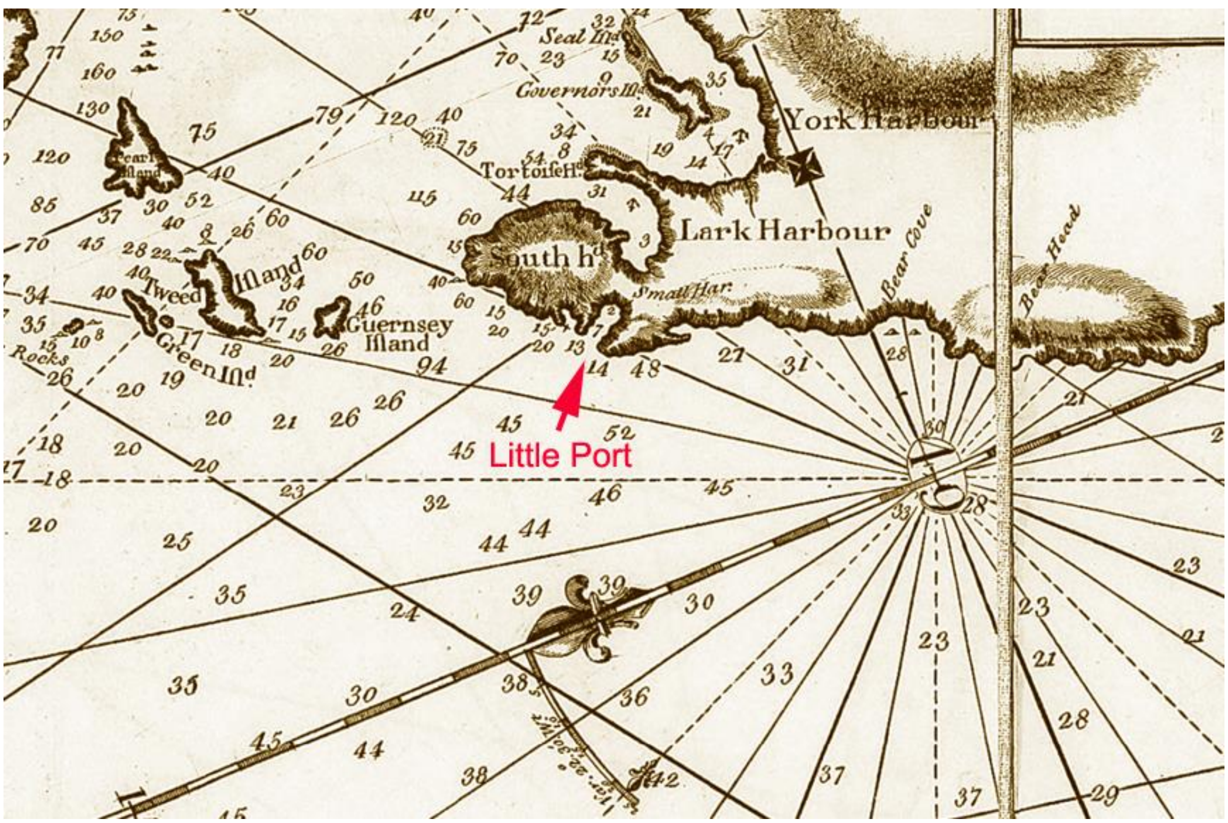


Figure 2.1.D Distribution of discrete volcanic blocks and slices within the Humber Arm Allochthon and internal lithic units of the Bay of Islands Complex.

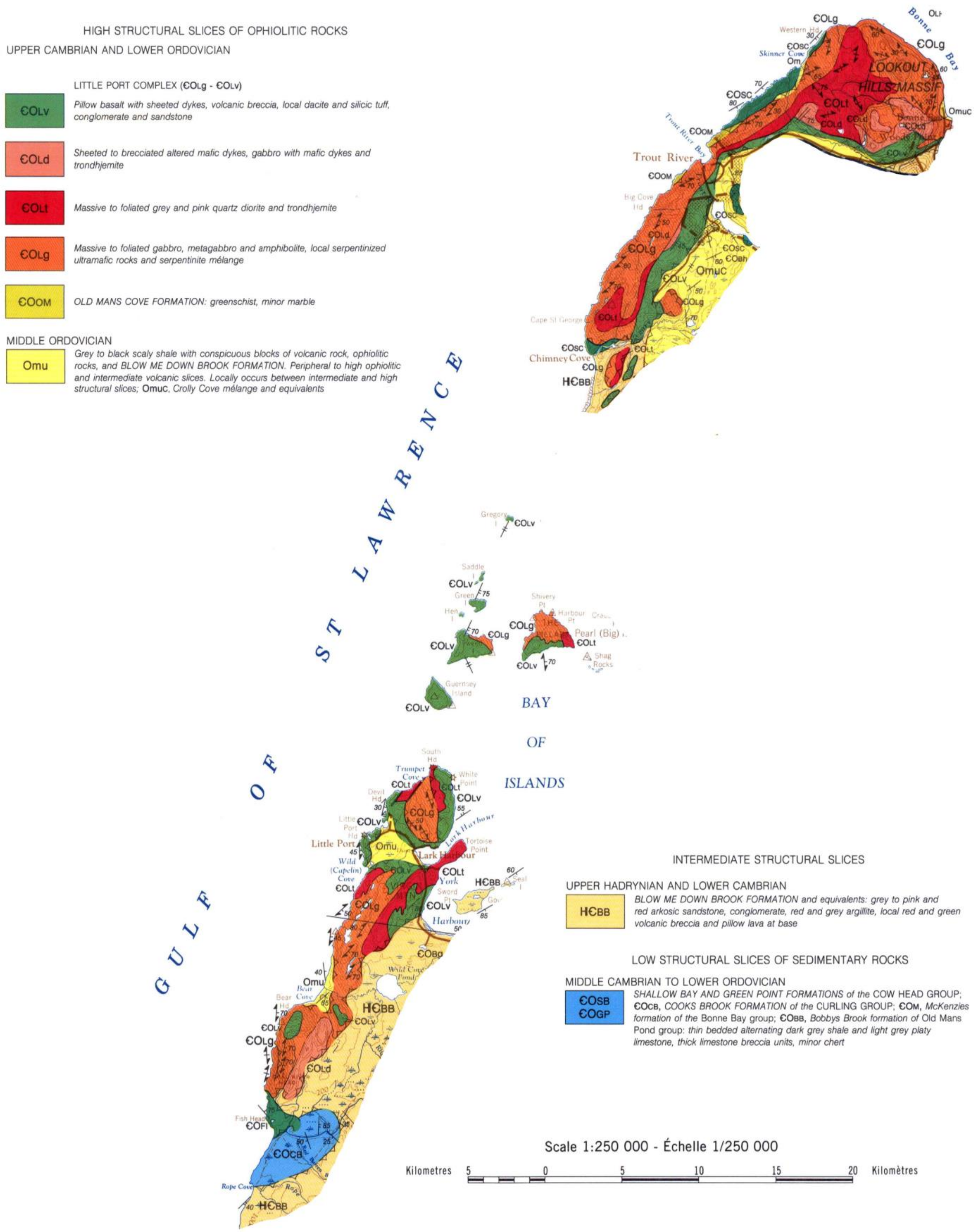
Rock types are late Cambrian to middle Orodvician, with the oldest being foliated layered gabbros, amphibolites and minor peridotites. Quartz diorites or tonalites cut deformed amphibolites and produce intrusion breccia on Big Island of the Bay of Islands. The granitic rocks vary from massive to well-foliated and occur as northeast-trending bodies that parallel the form of the Little Port structural slices. On the south side of the Bay of Islands, the succession of Little Port slices trends northwest and the long dimension of granitic bodies and main foliations in gabbroic rocks all trend in the same northwest direction.

Massive mafic dykes cut foliated gabbros, amphibolites and granitic rocks and the dykes are inseparable from mafic volcanic rocks that are also part of the complex. The dykes trend northeast in most places and form thin sheeted sets that separate deformed plutonic rocks from nearby, relatively un deformed volcanic rocks. The dykes are almost everywhere brecciated Volcanic rocks of the Little Port Complex are mainly green and red mafic pillow lavas and pillow breccias. Porphyritic dacite and grey silicic flows occur within the northern slice between Chimney Cove and Bonne Bay. Volcanic boulder conglomerate and sandstone are included in the complex at Little Port. Locally, the volcanic rocks contain prehnite, pumpellyite and analcime

GeoSite Group D has the components of an ophiolite suite. However, the proportions of its rock types, especially an abundance of tonalite, and intricate internal structures, contrast with the orderly succession and proportions of pristine units in the nearby GeoSite Group C, Bay of Islands Ophiolite Complex. The group records the development of an island arc created by tectonic subduction during the closing of the Iapetus Ocean.



James Cook Map of the Bay of Islands and Little Port, 1768


HIGH STRUCTURAL SLICES OF OPHIOLITIC ROCKS
UPPER CAMBRIAN AND LOWER ORDOVICIAN
LITTLE PORT COMPLEX (ЄOLg - ЄOLv)
ЄOLv
Pillow basalt with sheeted dykes, volcanic breccia, local dacite and silicic tuff, conglomerate and sandstone
ЄOLd
Sheeted to brecciated altered mafic dykes, gabbro with mafic dykes and trondhjemite
ЄOLt
Massive to foliated grey and pink quartz diorite and trondhjemite
ЄOLg
Massive to foliated gabbro, metagabbro and amphibolite, local serpentinized ultramafic rocks and serpentinite mélange
ЄOOM
OLD MANS COVE FORMATION: greenschist, minor marble
MIDDLE ORDOVICIAN
Omu
Grey to black scaly shale with conspicuous blocks of volcanic rock, ophiolitic rocks, and BLOW ME DOWN BROOK FORMATION. Peripheral to high ophiolitic and intermediate volcanic slices. Locally occurs between intermediate and high structural slices; Omuc, Crolly Cove mélange and equivalents
GULF OF ST LAWRENCE
BAY OF ISLANDS
Trout River
LOOKOUT HILLS MASSIF
Bonne Bay
Chimney Cove
Little Port
Lark Harbour
York Harbour
INTERMEDIATE STRUCTURAL SLICES
UPPER HADRYNIAN AND LOWER CAMBRIAN
HЄBB
BLOW ME DOWN BROOK FORMATION and equivalents: grey to pink and red arkosic sandstone, conglomerate, red and grey argillite, local red and green volcanic breccia and pillow lava at base
LOW STRUCTURAL SLICES OF SEDIMENTARY ROCKS
MIDDLE CAMBRIAN TO LOWER ORDOVICIAN
ЄOSB ЄOGP
SHALLOW BAY AND GREEN POINT FORMATIONS of the COW HEAD GROUP; ЄOCB, COOKS BROOK FORMATION of the CURLING GROUP; ЄOM, McKenzies formation of the Bonne Bay group; ЄOBB, Bobbys Brook formation of Old Mans Pond group: thin bedded alternating dark grey shale and light grey platy limestone, thick limestone breccia units, minor chert
Scale 1:250 000 - Échelle 1/250 000
Kilometres 5 0 5 10 15 20 Kilomètres

View of the Bay of Islands section of the Little Port Island Arc Complex

Geosites in Group C include:

<u>Geosite 1D1 – Guernsey Island</u>

Guernsey Island (center) with South Head (background left) and Tweed Island (right)

Authority: Provincial Crown Lands

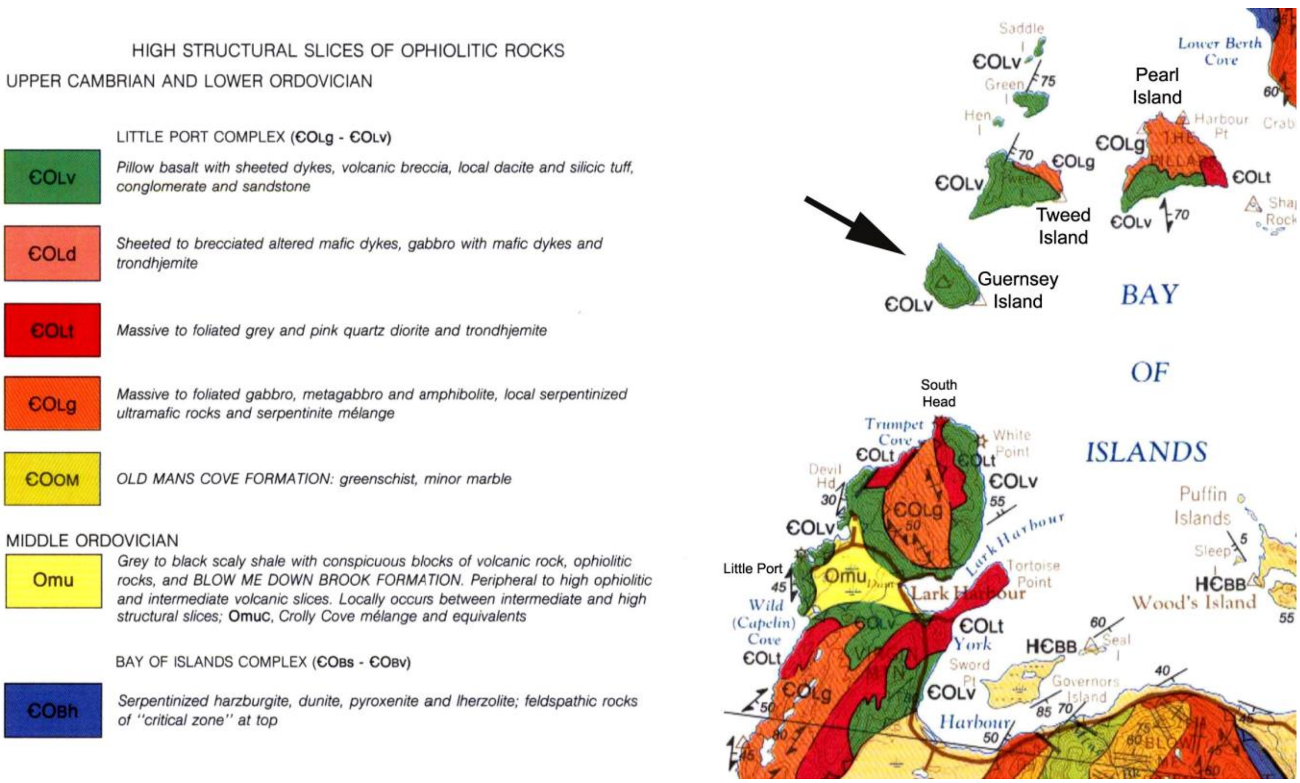
Access: By boat tour from Lark Harbour, York Harbour, Frenchman's Cove or Cox's Cove. Tour companies include True North Charter and Tours out of Cox's Cove.

Features: Guernsey Island, known locally as the Weeball, is one of three large volcanic islands at the entrance to the Bay of Islands. It is composed of pillow basalt, sheeted dykes, volcanic breccia local dacite and silicic tuff. Unlike the other two islands (Pearl and Tweed), it is has no safe anchorage or fishing harbour and is difficult to land on. However under ideal conditions, hikers can access the island from the north end.

Guernsey Island (left) and Tweed Island, with Seal Island in foreground

Geological Period: Upper Cambrian to Lower Ordovician

Interpretation: Signage and interpretive panels will be erected at key viewpoints of Guernsey Island, such as the parking lot of the Copper Mine to Cape Trail in York Harbour.



Geosite 1D2 – Little Port, Bottle Cove and South Head

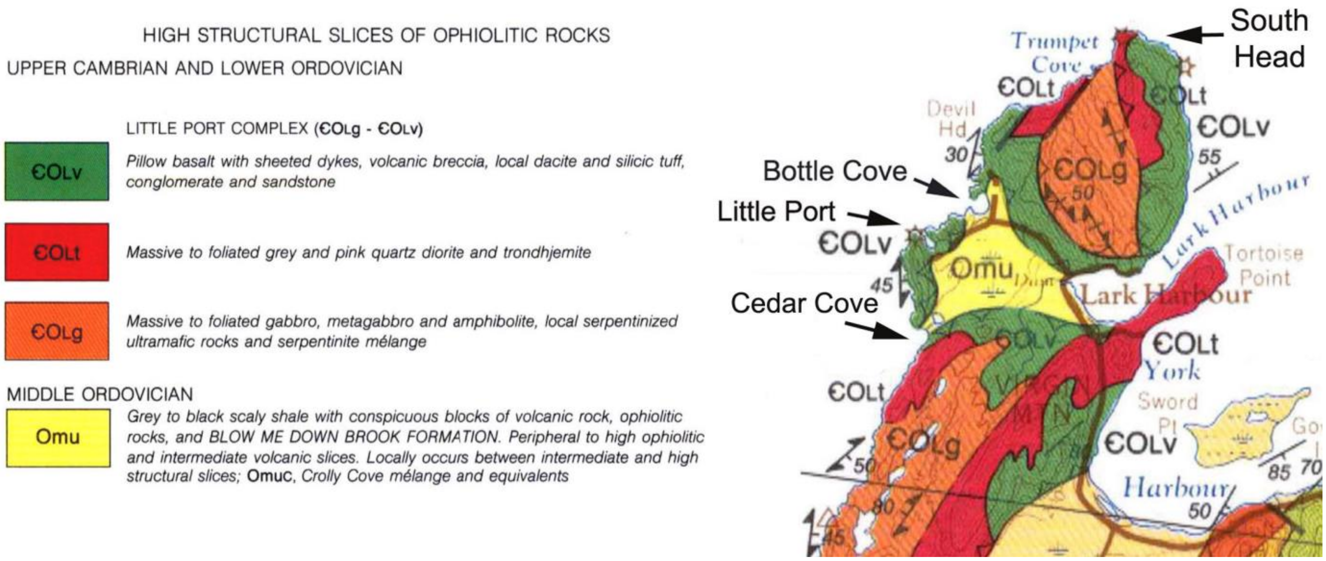
Authority: Provincial Crown Lands

Access: By road on Route 450, then by the Outer Bay of Islands Enhancement Committee's (OBIEC) Bottle Cove Trail.

Features: A popular day park with sandy beach, spectacular sunsets and hiking trails to the surrounding coves, cliffs and headlands. Rock types include pillow basalt with sheeted dykes, volcanic breccia, grey and pink quartz diorite and trondhjemite, massive to foliated gabbro, metagabbro and amphibolite, and serpentinized ultramafic rocks and serpentinite mélange.

Entrance to Bottle Cove

Geological Period: Upper Cambrian to Lower Ordovician



Interpretation: Signage and interpretive panels will be erected at key viewpoints in Cedar Cove, Little Port, Bottle Cove, and on South Head.

Sunset at Bottle Cove

View of wharf and fishing boats at Little Port

View of Guernsey, Tweed and Pearl Islands from OBIEC's South Head Trail

Geosite 1D3 – Greater Green Gardens

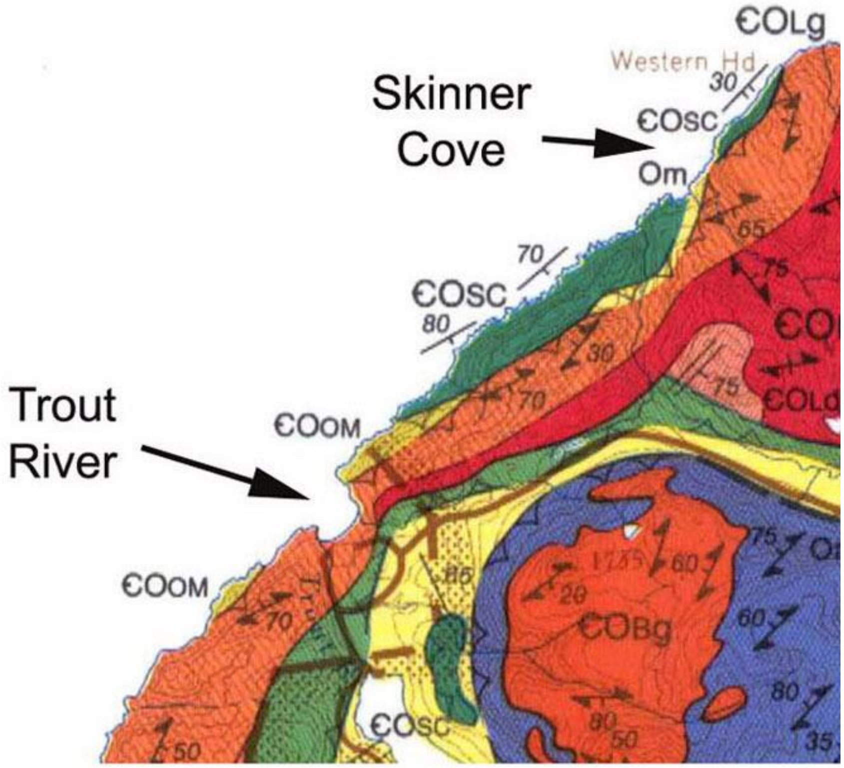

View of beach at Trout River

Authority: Provincial Crown Lands and Gros Morne National Park

Access: By Route 431 to the town of Trout River, then by foot on the Eastern Point Trail

Features: Sandy beach, grassy slopes, seaside cliffs and sea stacks. Rock types include pillow basalt with sheeted dykes, volcanic breccia, local dacite and silicic tuff, massive to foliated gabbro, metagabbro and amphibolite, local serpentinized ultramafic rocks, greenschist and minor marble.


High Structural Slice of Ophiolitic Rocks at Trout River Cove



HIGH STRUCTURAL SLICES OF OPHIOLITIC ROCKS

UPPER CAMBRIAN AND LOWER ORDOVICIAN

BAY OF ISLANDS COMPLEX (**ЄOBS - ЄOBV**)

ЄOBg	*Layered to massive gabbro, diorite, minor trondhjemite, mafic dykes abundant toward top;* **ЄOg**, *gabbro and serpentinized gabbro blocks at northern periphery of Old Mans Pond Outlier*
ЄOBh	*Serpentinized harzburgite, dunite, pyroxenite and lherzolite; feldspathic rocks of "critical zone" at top*

LITTLE PORT COMPLEX (**ЄOLg - ЄOLV**)

ЄOLV	*Pillow basalt with sheeted dykes, volcanic breccia, local dacite and silicic tuff, conglomerate and sandstone*
ЄOLt	*Massive to foliated grey and pink quartz diorite and trondhjemite*
ЄOLg	*Massive to foliated gabbro, metagabbro and amphibolite, local serpentinized ultramafic rocks and serpentinite mélange*
ЄOOM	*OLD MANS COVE FORMATION: greenschist, minor marble*

MIDDLE ORDOVICIAN

Omu	*Grey to black scaly shale with conspicuous blocks of volcanic rock, ophiolitic rocks, and BLOW ME DOWN BROOK FORMATION. Peripheral to high ophiolitic and intermediate volcanic slices. Locally occurs between intermediate and high structural slices;* **OmuC**, *Crolly Cove mélange and equivalents*

INTERMEDIATE STRUCTURAL SLICES

CAMBRIAN AND LOWER ORDOVICIAN

ЄOSC	*SKINNER COVE FORMATION;* **ЄOFI**, FOX ISLAND GROUP; **ЄOCR**, *Crouchers formation: black, green, purple and red pillow lava, pink trachyte, interlayered volcanic breccia, minor red siltstone, sandstone and limestone*


View of Skinner Cove Formation at Greater Green Gardens

Geological Period: Upper Cambrian to Lower Ordovician

Interpretation: Signage and interpretive panels will be erected at key viewpoints in Trout River Cove and along the Eastern Point / Greater Green Gardens Trail.


Sheep at Greater Green Gardens

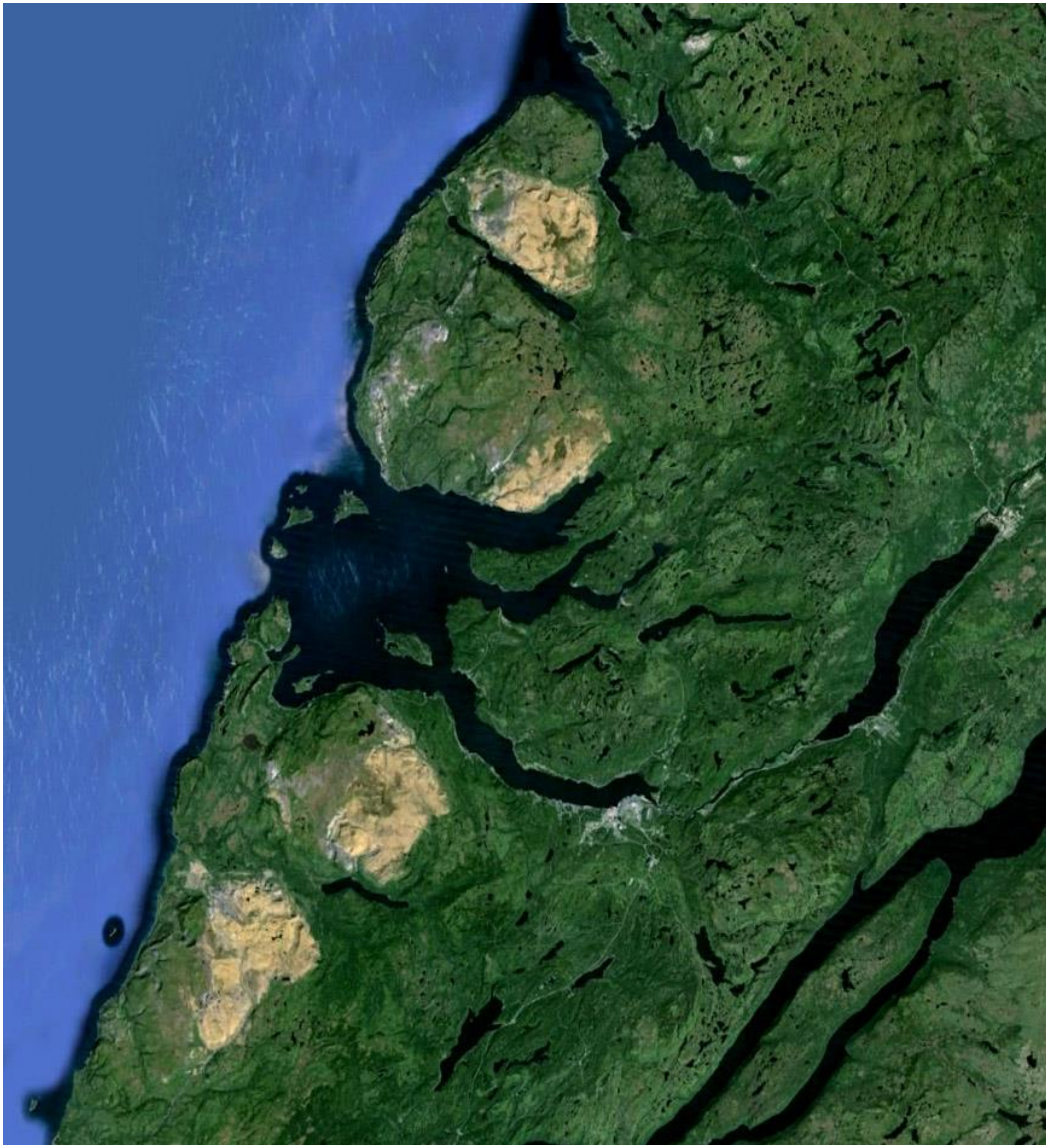
2.2 Ecological Geosites

Ecological GeoSites within Cabox will be divided into seven broad geological categories:

A. Barrens
B. Cirques
C. Wetlands
D. Forests
E. Rivers
F. Lakes
G. Ocean

Over the coming years, a Cabox committee will work with the Provincial Department of Environment and Conservation, Corner Brook Pulp and Paper Ltd, and local post secondary institutions (e.g. Memorial University of Newfoundland's Grenfell Campus and College of the North Atlantic) to identify key representative sites.

View of Serpentine River, between Lewis Hills and Blow Me Down Mountains

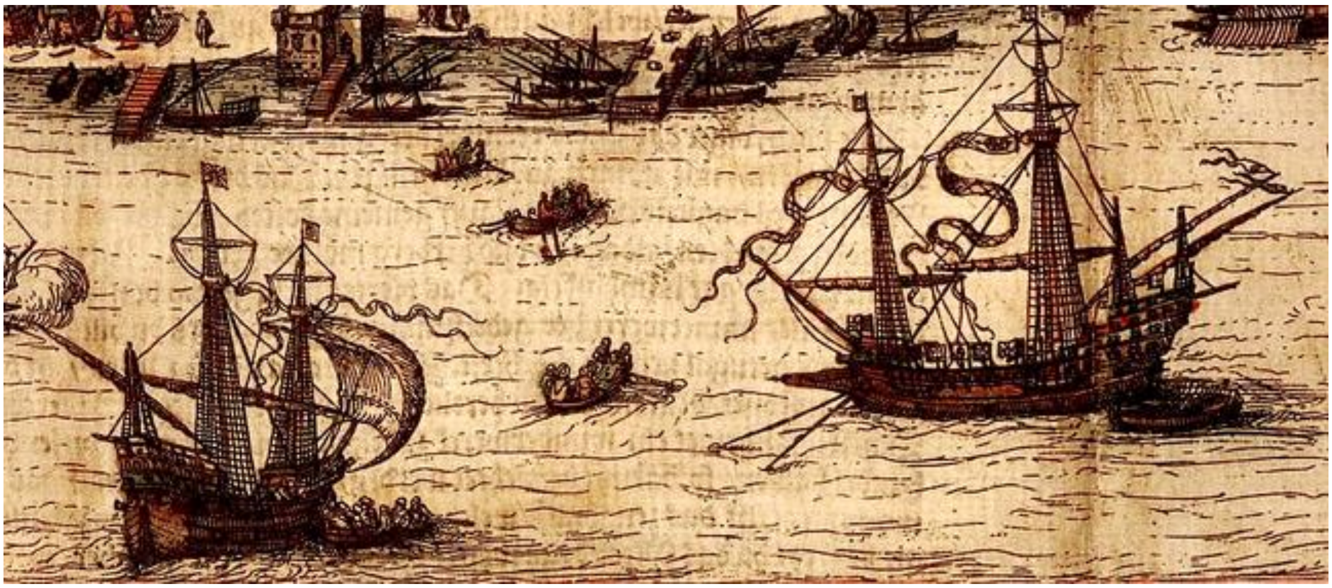


Google View of Cabox Aspiring Geopark

2.3 Cultural (Anthropomorphic) Geosites

The geographic location of Newfoundland's Humber Zone at the eastern margin of the ancient continent of Laurentia positioned it to play an important role in the closing of the Iapetus Ocean and the formation of the Appalachian Orogen. 500 million years later, geological exploration of this region played an important role in the understanding of these processes.

Prior to this geological exploration, geographic exploration of Western Newfoundland played an important role in the European discovery of North America. Beginning with the Norse around 1,000AD, European mariners sailed the rugged coastlines of the Humber Zone looking for new lands and a sea route to Asia. Though preceded by Native Americans and the later Inuit migrants from Asia, they eventually led to the permanent settlement and industrialization of the Bay of Islands and Bonne Bay.



Portuguese vessels c. 1570

Cultural – or Anthropomorphic - GeoSites within Cabox will be divided into several categories, including:

A. Native History
B. European Exploration
C. Settlement and Colonization
D. Industry and Science

Over the coming years, a Cabox committee will identify key cultural sites and install interpretative and directional signage. They will include (in summary form):

GeoSite 3B1 – Jacques Cartier Commemorative Site at McIvers

Jacques Cartier Lookout, McIver's, Bay of Islands

The scenic lookoff from McIvers community trail at Bound Head will commemorate the 1534 visit of French explorer Jacques Cartier on his first voyage of discovery to the New World. Cartier laid the foundation of French Canada and the French Shore of Newfoundland, including the Bay of Islands.

GeoSite 3B2 – James Cook Commemorative Site at Tortoise Head

View of (l-r) Humber Arm, Cape Blow Me Down and York Harbour from Tortoise Head

Tortoise Head in Blow Me Down Provincial Park (between Lark Harbour and York Harbour) has been identified as the Cabox Commemorative Site for renowned English explorer and cartographer James Cook who completed his 5 years of surveying and charting the coasts of Newfoundland in the Bay of Islands in 1767. His work in Newfoundland led the British Admiralty and Royal Society to select him to sail to the Pacific Ocean the following year to witness the transit of Venus and search for the fabled southern continent.

GeoSite 3C1 – Cannon Ball Cliff at Penguin Head

Conflict between Britain and France over fishing rights along the western coast of Newfoundland during the 1700s and 1800s resulted in very slow population growth compared to other regions of the island. Evidence of the conflict can still be seen in the cliff face of Penguin Head in Middle Arm, Bay of Islands. The rock face is still pockmarked from cannon target practise, while the shoreline below has surrendered numerous cannon balls recovered by local fishermen who used them to weigh down their nets. Geologically, the folded leading edge of Goose Arm Thrust stack is located at Penguin Head.

GeoSite 3C2 – Resettled Community of Woods Island

Woods Island is a resettled community at the mouth of Humber Arm. In the late 19th and early 20th centuries it was an important harbour of the Bay of Islands herring fishery and a popular port of call for passing schooners. At its peak, the town had approximately 500 residents, divided between the harbour on the western end and settlement on the eastern end. A combination of factors, including the opening of the Newfoundland railroad, decline of the Bay of Islands herring fishery, advent of cold storage fishing boats and Premier Joey Smallwood's 1960's resettlement plan, led to the community's decline and abandonment. Today the island's sheltered harbour is home to summer cottages and a recreational boat dock, all within easy reach of the community of Frenchman's Cove.

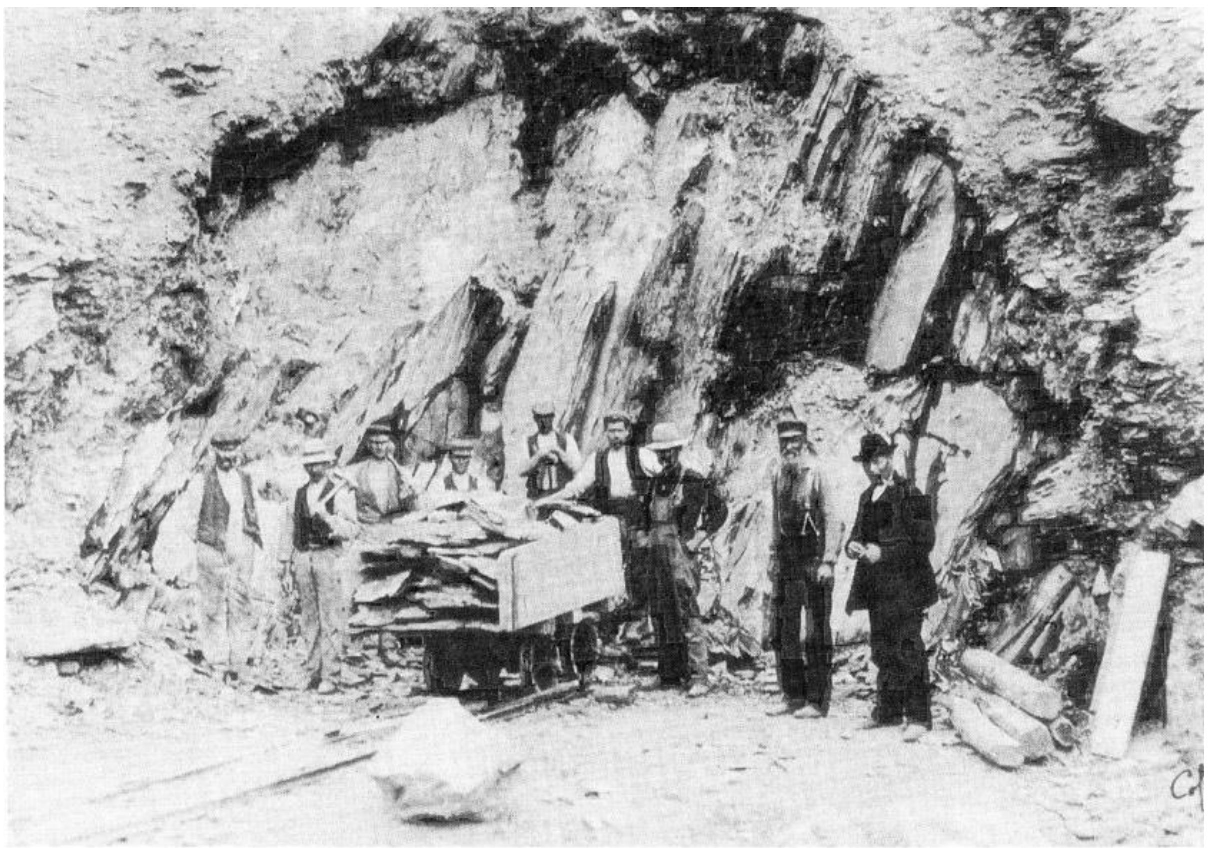
View of Wood's Island Harbour

GeoSite 3C3 – Traditional Summer Outport at Back Cove

Remote seasonal outport and hiking base camp at Back Cove, North Arm

Because of the size and mountainous terrain of the Bay of Islands, much of the outer bay - particularly in North and Middle Arms - are relatively inaccessible by land, apart from the few logging roads constructed by the paper mill in Corner Brook. As a result, the tradition of summer outports close to fishing grounds and winter homes close to woodlands and fur traps continued well into the 20th century, and in some cases continue to this day. At Back Cove in North Arm, the International Appalachian Trail is restoring a two storey fisherman's house into a backcountry hiking and boating base camp at the base of North Arm Ophiolite. The outport was established a century ago by the Park family from Cox's Cove, who spread out along the north shore of the bay from Liverpool Brook. One Park descendant still fishes out of Back Cove today, keeping a Newfoundland tradition alive and adding authenticity to an historic cultural experience.

GeoSite 3D1 – Slate Quarry at Summerside



Welsh slaters standing with cartload of slates in the Summeside slate quarry, c. 1903. Man with pipe on extreme right may be Owen J. Owen.

In the early 1900s, the "Great Strike of Penrhyn" at the Penrhyn Slate Quarry in Wales, UK led to the establishment of an industrial quarry in Summerside, Bay of Islands to extract slate from the Summerside Formation (of the Transported Continental Margin of Laurentia). The strike began on November 22, 1900 and lasted three years. It was the longest labour dispute in British industrial history and cast a shadow of unreliability on the North Welsh slate industry. It precipitated a sharp decline in orders that resulted in the layoff of thousands of workers. The mine at Summerside was short lived however, as it was abandoned after the strike was settled.

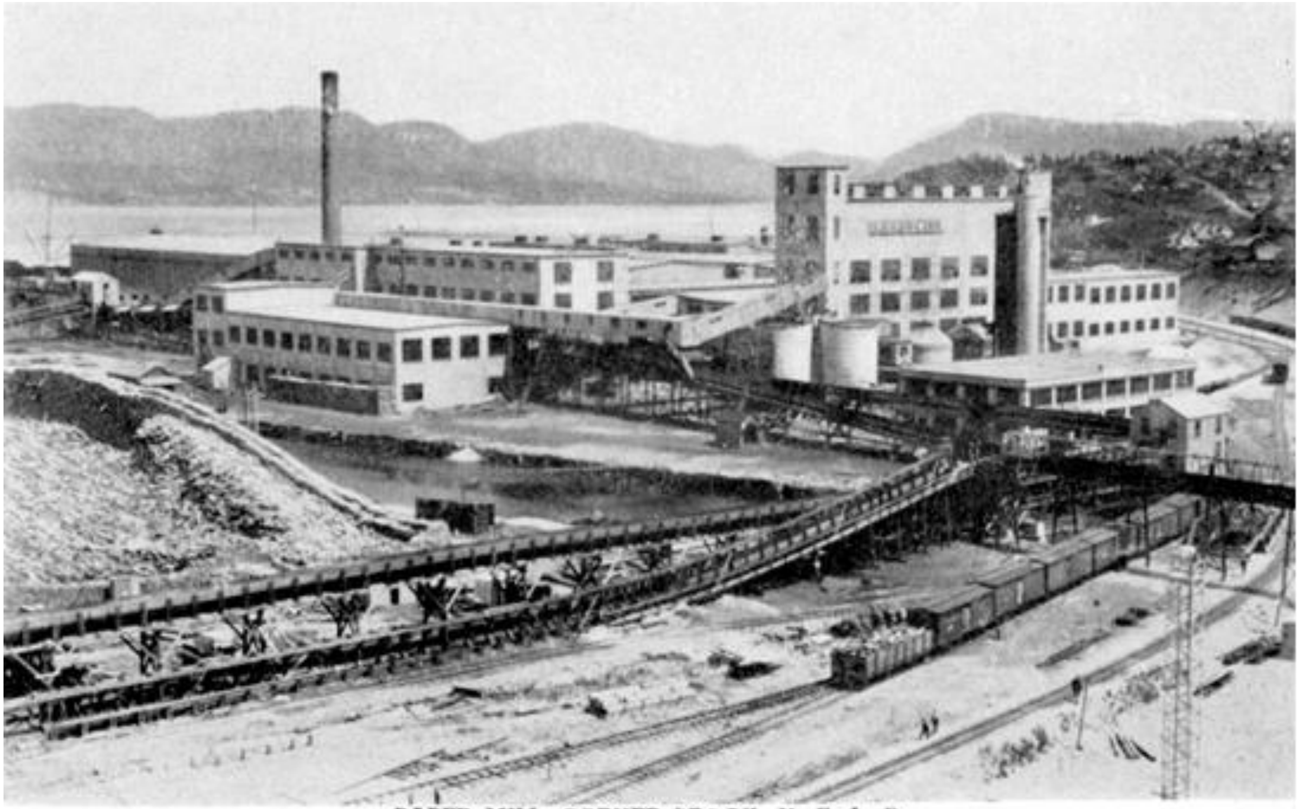
GeoSite 3D2 – Copper Mine at York Harbour

Mural of York Harbour Copper Mine shaft head based on a contemporary photo

Around 1892, a prospector named Daniel J Henderson located an Ophiolitic volcanic-hosted copper deposit about a mile east of the town of York Harbour and some 1,000 feet up the precipitous north side of Blow-Me-Down Mountain in a gully known today as Copper Mine Brook. Mining began in 1897 when four shafts were sunk and a precarious chute and pulley contraption was constructed to transport pork barrels of ore down the cliff to the coast. Improvements were made by deepening the shafts and installing a motor to raise the ore. However the workings were directed away from the ore body, leading to the mistaken conclusion that the bottom of the ore was reached and the vein was exhausted. Further troubles – including financial and labour issues - led to the mines eventual closure in 1913, after a mine collapse claimed the life of a worker. By then the mine had shipped over 15,000 tons of ore to the United States. Today, ruins of the mine workings and some machinery are still visible at the parking area of the Copper Mine To Cape Trail near the bottom of Copper Mine Brook.

Note: Ophiolitic volcanic-hosted environments are found predominantly within the sheeted dyke and overlying pillow lava components of the ophiolite complexes, most of which contain geochemical evidence for a supra-subduction zone setting.

GeoSite 3D3 – Paper Mill at Corner Brook



PAPER MILL, CORNER BROOK, N. F. L. D.

In 1922, the city of Corner Brook was a small but thriving community on the Humber Arm of the Bay of Islands in Western Newfoundland. Sawmilling had been an important activity since the 1860's and the arrival of the railway in 1898 provided a reliable transportation link with the rest of Newfoundland and indeed the world. Newfoundland had vast tracts of forests accessible both by water and the new railway, and with the explosive growth of newspapers in Europe and North America, tremendous demands for new sources of cheap pulp and paper was required. In 1923 construction of the mill in Corner Brook began and it officially opened on August 1925. The mill had a profound effect on western Newfoundland. It created new jobs, pumped millions of dollars into the economy, fostered hundreds of new skills, generated dozens of new services and stimulated the construction of countless projects including housing, schools, recreation, cultural activities and much more.[6]

Corner Brook Pulp and Paper Ltd is a partner in Cabox Aspiring Geopark and special emphasis will be placed on identifying ecological GeoSites that reflect the productive habitat and growth of forest industries that sprang up in and around the Humber Arm Allochton.

[1] Roy, Kaustuv (1989) Conodonts and phosphatic problematica from the Cambro-Ordovician Cooks Brook and Middle Arm Point formations, Bay of Islands, western Newfoundland. Masters thesis, Memorial University of Newfoundland
[2] Williams, Geology of the Appalachian—Caledonian Orogen in Canada and Greenland, p. 103
[3] The distribution and possible biostratigraphic significance of the ichnogenus Oldhamia in the shales of the Blow Me Down Brook Formation, western Newfoundland, by Rosanne M. Lindholm, John F. Casey, Canadian Journal of Earth Sciences, 1990, 27(10): 1270-1287, 10.1139/e90-137
[4] Eastern Alpine Guide, Beyond Ktaadn, 2012, p. 185
[5] Eastern Alpine Guide, Beyond Ktaadn, 2012, p, 185
[6] Virtualmuseum.ca