A GEOLOGICAL TOUR OF THE ROOSEVELT CAMPOBELLO INTERNATIONAL PARK

by
Donald B. Allen, Ph.D
Department of Geology, Colby College

Edited by Harold L. Bailey, Naturalist, RCIP

The Roosevelt Campobello International Park has a complex geological history displayed in the craggy cliffs and ledges, thick sand and gravel deposits, and fascinating peat deposits and beaches. This brochure will explain many of the features you will encounter at points of interest as you tour the Park.

Friar's Head

Studies show that apparent changes in sea level may be caused by raising and lowering of land masses and by actual changes in the amount of water in the oceans. As time passes, and as sea levels rise with respect to a land mass, a coast is submerged or *drowned*. Bays are produced as the ocean rises and fills valleys eroded by older streams and glaciers. The remnant ridges flanking these drowned valleys are called headlands.

The bays, headlands, and islands in the panorama from the Friar's Head observation deck are beautiful examples of a submerged coast, and have had a profound impact on the aesthetic character and cultural history of the region. No doubt the Roosevelt family greatly appreciated the magnificent vistas of the region as they sailed the numerous bays and inlets and walked along the headlands and beaches.

Con Robinson's Point

A visit to Con Robinson's Point and Raccoon Beach might prompt you to ask why the material of the beach varies in size from large boulders to fine sand in short distances along the beach. Why are the rocks rounded? Why are the layered rocks rust colored, and yet appear polished and smooth, with scratches that are not parallel to the layers? The rocks and beach of Con Robinson's Point and Raccoon Beach provide clues to solve these mini-mysteries.

Descend the stairs from the picnic area to the beach (Fig. 2).

As you face the ocean, notice the difference in beach material to the right and left. To the right, silt and sand with occasional cobbles change into coarser sand, cobbles, and small boulders seaward and along the beach to the south. (Cobbles are naturally rounded stones larger than pebbles, but smaller than boulders.) To the left, sand and silt change immediately to coarse cobbles and boulders. Coarse, heavy sediments (cobbles and boulders) are found in high wave energy areas because the lighter pebbles, sand, and silt have been removed by strong waves and currents. Finer, lighter sediments (sand and silt) are found in lower wave energy areas where the strength of the waves and currents are not sufficient to carry off these materials. In low wave energy areas, fine sediments may also be mixed with a variety of coarser materials.

From the bottom of the stairs, as you face the ocean, walk to the left, across the cobbles and boulders to a low outcrop of rusty rocks (Fig. 3).

The rusty, polished rocks are dense, layered sedimentary rocks of the *Quoddy Formation*. Close inspection of the layers will reveal light and dark grey bands of siltstones, shales, and fine sandstones.

The shale layers, or *beds*, appear to be darker and finer grained, and are characteristically more rusty appearing with tiny rust spots around numerous squares or cubes. The rust is called *limonite*, and is the result of oxidation of the mineral pyrite (fool's gold).

Originally the siltstones and sandstones were soft, loose sediment that accumulated on the floor of an ancient sea. Mud, silt, and sand were carried by currents along the bottom of the sea until the particles were too heavy for the currents to transport. As they settled out and accumulated in layers (Fig. 4), the more coarse, heavier particles settled first, followed by finer, less dense sediment. Some layers show patterns of light and dark particles that were produced by the turbulent currents as they moved along. The currents moving along the sea floor are called *turbidity currents*, and the sediments they deposit are called *turbidites*. Heat, pressure, and folding in the earth's crust changed the horizontal, soft sediment layers into sedimentary rocks that are presently tilted into an almost vertical position.

The Quoddy Formation probably represents deep water deposits of a gradually shallowing basin on the sea floor in Silurian time, about 400 million years ago.

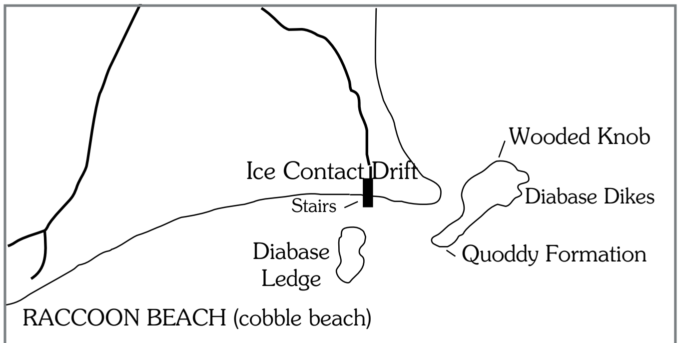


Fig. 2 - Con Robinson's Point

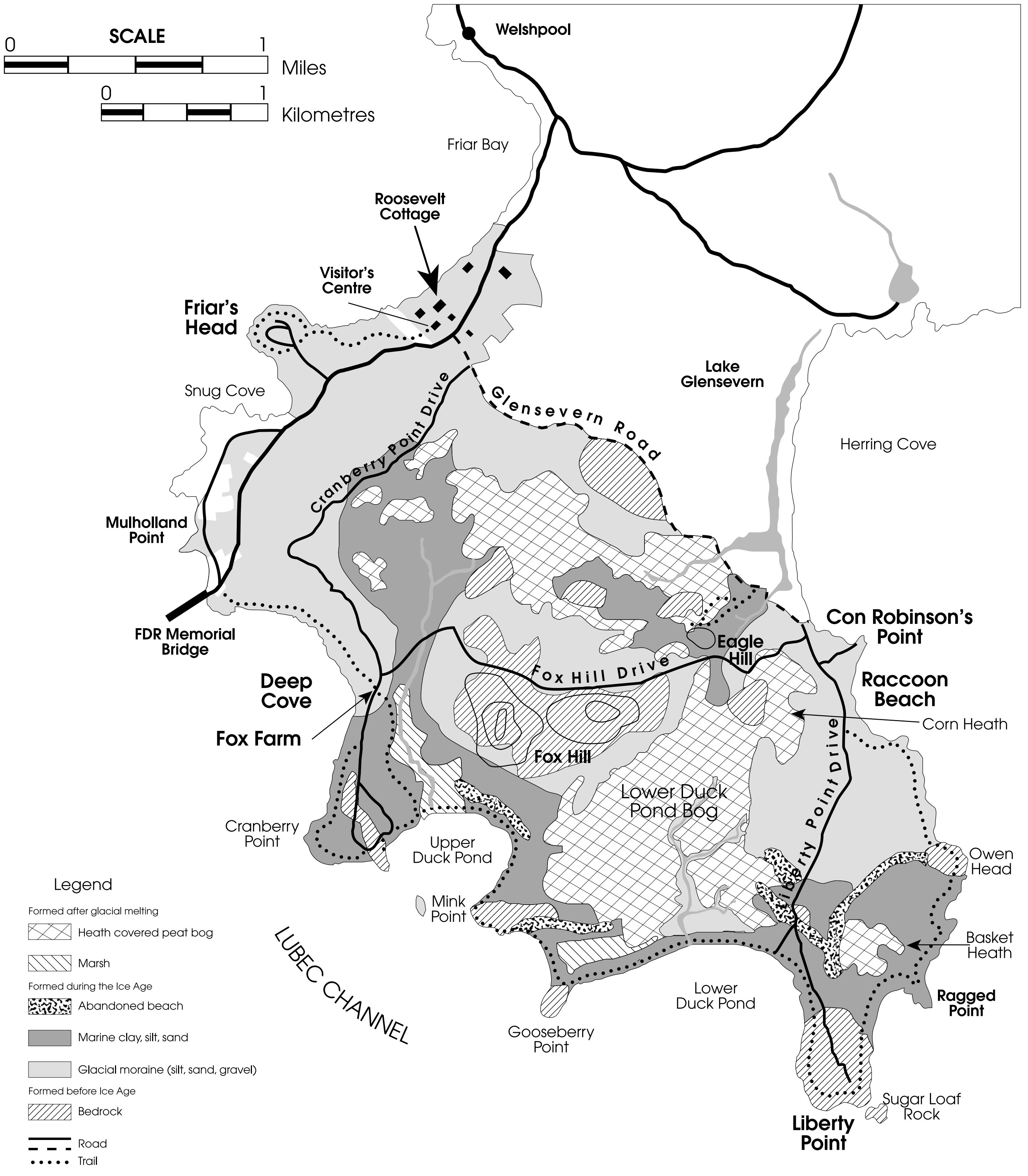


Fig. 1

Roosevelt Campobello International Park

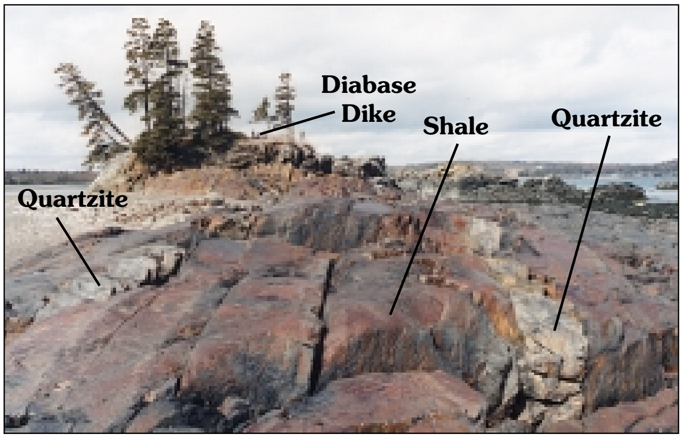


Fig. 3 - Quoddy Formation

The evidence of past glaciation, perhaps as recently as 12,000 - 14,000 years ago, is well-exposed at Con Robinson's Point. Here the tops of the exposed rusty-colored outcrops were smoothed and polished by the scouring action of glacial ice–grinding sand, cobbles, and boulders over the rocks as it passed by, somewhat like giant sandpaper. The scratches and grooves are evidence that larger rocks and boulders in the glacial sandpaper marred the polished surface, showing the direction of ice movement. Thickness estimates of up to twelve hundred metres of ice resting on the rocks in this area create an impressive image of the dynamic forces grinding away at the land's surface.

Turn and face away from the ocean, toward the bank and the stairs from the parking area.

Remnants of the glacial sandpaper are to be found in the high bank from Raccoon Point to Con Robinson's Point, and to the north along Herring Cove Beach. These remnants are an accumulation of glacial sediment called *ice contact drift*, formed when the prominent layers of sand and gravel were left behind when the glacier melted. As erosion of the bank progresses, new sand and gravel are released to the beach and are subjected to movement by the sea.

Glacial deposits of sand and gravel play an important role in shaping our impressions of the Park. Their textural and color differences present a striking contrast to the hard, polished surfaces of the Quoddy Formation and igneous rocks (rocks formed from molten materials). The great diversity of colors, textures, and shapes displayed by the rocks in the ice contact drift deposit and beach sediments is silent testimony to glacial processes that worked across great distances and over numerous rock types.

Raccoon Beach

Much of the Raccoon Beach is made up of cobbles, a marvelous assortment of rocks betraying many periods of geologic history. Some are pink, green, or gray granites formed from hot molten rock deep within the earth's crust. Others are brick red, flinty stones with a probable origin at some distant volcano. Still others are flat and shiny, with mica flakes glistening in the sunlight, revealing a history of great heat and pressure before being caught up by passing glaciers and streams to be brought to a temporary pause on this beach.

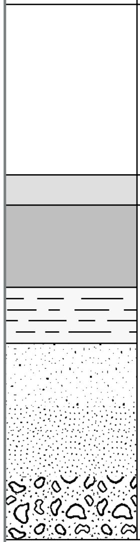
Igneous rocks composed predominantly of minerals of approximately equal hardness (quartz and feldspars), with lesser amounts of dark softer minerals (micas and hornblende), assumed a more or less spherical shape when subjected to prolonged abrasion by the glacier and the ocean. Rocks with greater proportions of micas develop a rounded, tabular shape. In areas where rounded, spherical rocks predominate, smooth cobbles clattering and rattling around in the surf swash are a spellbinding part of the experience that many visitors will recall for years to come. In areas where tabular rocks predominate, a more or less shingle-like arrangement, representing an orientation of least resistance to the wave action can be observed.

The smooth, wet cobbles have had their beginnings in far different places and circumstances. They are transient materials, being altered by present processes and destined to be parts of future rocks. Cobbles are the stuff of coarse sedimentary rocks called *conglomerates*. Similar accumulations of rounded cobbles bonded together with sand, silt, clay, and natural cements have been recorded in ancient rocks, implying that another beach went through the same processes in some past time. Perhaps some of the cobbles on Raccoon Beach were once larger stones tumbling around on an ancient beach, to be brought here by the processes of erosion and deposition to become smaller and smoother, and to eventually become part of a future conglomerate.

Liberty Point

Observation decks at Liberty Point offer two different perspectives of this part of the coastline.

The view from the west observation deck, southwest across the Lubec Channel, includes in the distance a candy-striped lighthouse called West Quoddy Head Light. Walk to the end of the west observation deck.



Grain Size	Description
Shalestone	**Usually darker and finer grain.** **Contains the finer-graned particles which would have settled out last, clay and mud, which eventually hardened to shale.**
Siltstones	**Finer-grained than the sand.**
Sandstones	**Some layers reveal ripples produced by undersea currents.** **As turbidity currents lessened, coarser, heavier particles settled out first, producing a grading of the sandstone layers from the heaviest and largest on the bottom, to the smallest and lightest on the top.**

Fig. 4
Ideal Sequence of Turbidity Current Sediments

IT IS RECOMMENDED THAT VIEWING BE DONE FROM THE OBSERVATION DECK. ATTEMPTING TO REACH THE ROCKS OF THE FINGERS IS NOT RECOMMENDED; POOR FOOTING ON LOOSE SOD AND SLIPPERY ROCKS MAY RESULT IN SERIOUS INJURY.

The ragged outline of Liberty Point, in the immediate foreground, resembles five fingers or knuckles of a hand extending into the ocean, and is an excellent example of how rocks of different origin and composition react differently to the mechanical and chemical weathering agents of the atmosphere and ocean. For reference purposes (Fig. 5), if one faces the lighthouse on West Quoddy Head, and considers the rock ledge underneath the observation deck to be the thumb of the hand, and the rocks just to the right of the platform to be the first finger; then the rocks of the second finger are orange to red in color and those of the third finger have a layered light and dark gray appearance. Each finger of land jutting into the sea has a different color and fabric, and betrays a different aspect of the geologic history of Liberty Point and the Park in general. The fingers are separated by faults that have weakened the rocks to erosion by ice and water.

The massive, dark gray rocks of the prominent cliffs that make up the little finger are called *diabase* and *gabbro*. They are very similar to the rocks directly under the observation platform. Closer examination of these rocks would disclose small, rectangular white crystals of feldspar, with somewhat larger, but less well-shaped dark crystals of a mineral called pyroxene. The two minerals, mixed together in this fine texture, crystallized in a very hot magma far below the earth's surface. This magma was *intruded*, or forced, into fractures in the overlying hard sedimentary rocks.

Attention is easily drawn to the diagonally-layered appearance of the light and dark gray rocks of the third finger. These rock layers are composed of fine clay, silt, and sand, and are not able to withstand erosion by the sea to the same degree as the other rocks. These shales, siltstones, and fine sandstones are part of the Quoddy Formation, seen earlier at Con Robinson's Point. They have been metamorphosed by heat and pressure and tilted into their present position by faulting and folding.

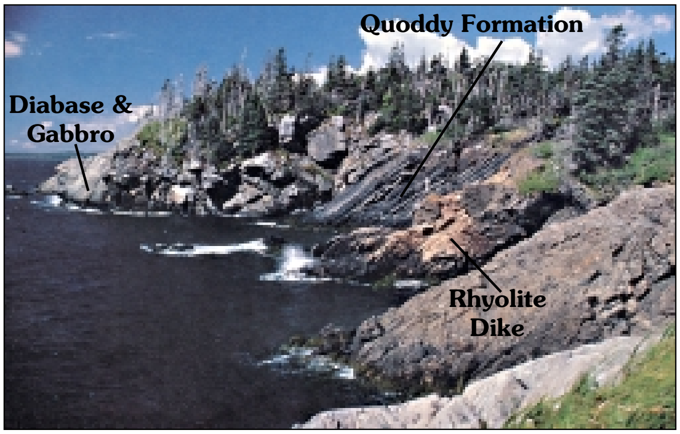


Fig. 5 - Liberty Point

The rocks of the second finger, nearer the observation deck, are also layered, and are interrupted by an orange and brick-red band called a *rhyolite dike*, two to three meters wide. The rhyolite dike cuts across both the bedding structures of the Quoddy Formation and the exposed diabase, making the rhyolite younger than either of the other rock types. This dike also formed when hot molten rock magma was introduced into cracks in the sedimentary layers far below the surface, but with a different composition and cooling history. Small crystals of feldspar and quartz had already begun to form when movement of the magma-containing crystals into a higher part of the earth's crust caused a rapid loss of heat and fluids. The chilling of the magma would not allow the formed crystals to grow any larger, and inhibited additional formation of new crystals. Under these conditions, the iron present, which was uniformly spread throughout the magma, was oxidized to produce the red color.

The view from the east observation deck includes the bluffs of Grand Manan Island, some 3.7 kilometres off shore to the southeast; nearby Sugar Loaf Rock, and the broad sweep of Liberty Cove, leading to the Sunsweep sculpture on Ragged Point (Fig. 1) to the left, or north.

The geology of Grand Manan Island is different from that of Campobello Island. Most notably, the steep cliffs and relatively flat profile are produced by layers of volcanic lava rock, standing as a resistant monument against the ravages of the Atlantic Ocean. Lava flows of this size and type are not present on Campobello Island; consequently, geologists who have studied the geology of the region have concluded that a major break in the earth's crust occupies the strait between the two islands. This break has been named the *Bellisle Fault* on some geologic maps of the area.

Walk to the end of the east observation deck and look at the rocks directly below the platform.

These rocks are slightly different from those under the west deck. The knotty, rough appearance is produced by small clusters of tiny feldspar crystals about two centimeters in diameter. The long term affects of weathering have left these more resistant clusters of crystals standing out in relief, like flattened kernels of popcorn.

When faulting or other earth movements occur, rocks often respond by breaking or pulling apart along parallel planes of weakness called *joints*. Joints are the flat plane surfaces and straight line cracks so evident in the rocks on either side of the observation decks. The rugged cliffs and blocky nature of Liberty Point and Ragged Point are produced by abundant joints with different orientations.

The effects of weathering and erosion can be easily seen on Sugar Loaf Rock (Fig.1). The relentless pounding of the sea and the seasonal alternate freezing and thawing of water, penetrating the cracks and joint surfaces, have sculpted the rock into jagged faces, leaving pieces of sod clinging tenaciously to the polished surfaces of gray rock. Bright patches of golden and yellow lichen add color to the scene and also participate in the chemical decay of the rocks.

Lower Duck Pond

For many people, there is an almost limitless fascination with the endless cycle of change that takes place at the boundary of the sea. The ebb and flow of waves and currents on the land suggest a mighty tug-of-war between a powerfully turbulent medium and a seemingly immovable mass. At stake, of course, is the delicate equilibrium between matter and energy. It is clear that man's attempts to influence the balance of forces that govern the interaction of land and seas are, at best, trivial. Ignoring this fact gives a temporary false sense of confidence in our abilities to direct the course of action in these processes. At times, when the enormous power of the sea is unleashed, we stand in awe at how insignificant our intrusion into this relationship has been. The beaches of the Park permit one to examine some of these boundaries, and perhaps to appreciate more the persistent struggle between sea and land.

Geologists think of beaches as moving deposits at the boundary of land and water called the shoreline. A beach extends from the low-water line to the highest part of the shore washed by waves and tides. The term "coast" encompasses the shoreline and beaches, and often extends inland from the shore for many kilometres. The ability of a beach to adjust to dramatic changes in the forces acting upon it is called *dynamic equilibrium*, and is the key to its existence.

A beach's mobility as a landform is often painfully apparent to the hiker who ventures for any distance along the top of a shingle berm, or attempts to run in the fine, dry sand. The force exerted by each step causes the beach to respond by changing its shape and the arrangement of its particles. Firm resistance to the force is only felt after much of its energy has been absorbed.

In like fashion, a beach responds to seasonal changes of weather patterns and tides. Powerful winter storms and accompanying high tides diminish the size of beaches by expending enormous amounts of wave energy dragging sediment seaward. Large *cusps* and natural seawalls are established at the landward limit of winter wave influence, and are clear testimony of a stormy past. Semiconsolidated bank materials are eroded, undermining the soil and vegetation and causing slumping and tree falls. The calmer weather of spring and summer is marked by gentler waves and currents, and a time of beach rebuilding.

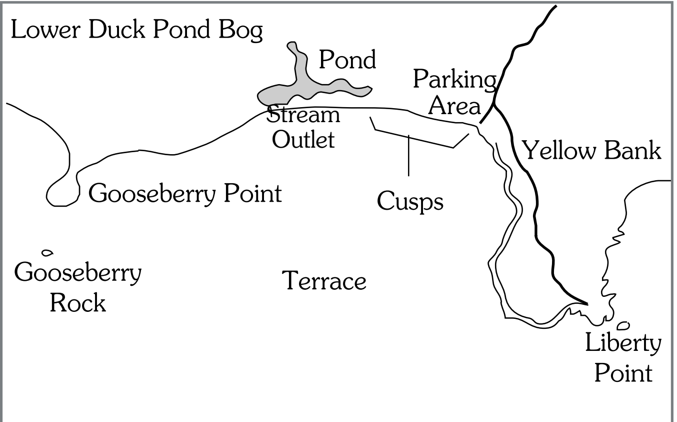


Fig 6 - Liberty Point/Lower Duck Pond Area

Descend from the parking area to the beach.

The walk along the beach from the Lower Duck Pond Parking Area to Gooseberry Point (Fig. 6) can be a very different experience at high tide from the same walk when the tide is down. When the tide is high, walking is restricted to a narrow zone between the waters edge and the top of the gravel seawall. At low tide, the vast expanse of sand and mud flats draws one away from the cobble beach to explore different paths to Gooseberry Point, some of which may be sandy and firm and others sticky or slippery.

As you face the bay, notice the change in the size of beach sediment from the coarse boulders on your left to the smaller cobbles to your right, along the seawall leading to Gooseberry Point. The keen observer will notice that cobble size differs along the beach and seaward. The energy of waves changes seasonally, and is not uniform along the beach; consequently, materials respond to these differences and are coarse (large cobbles) in high energy areas, and fine (small pebbles and sand) in low energy areas. Heavy storm surf leaves very large cobbles and driftwood stranded at the top of the seawall, above the reaches of normal high tide waves.

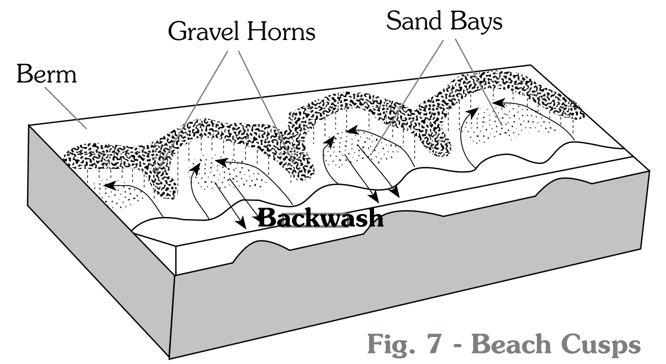


Fig. 7 - Beach Cusps

Evidence of storm surf can often be seen in the crescent or horseshoe-shaped pattern of cobbles called cusps (Fig. 7). Cusps are produced by the interference of waves as they strike the shore, piling up sand, gravel, and cobble in crescent shaped ridges, with the *horns* of the crescent pointing toward the ocean. The troughs between the ridges are filled with finer material. Generally speaking, larger cusps are produced by stronger waves and are located closer to the top of the cobble seawall. Smaller cusps, formed by normal wave action at high tide, are located along the high tide line.

The seawall itself is an interesting feature. Seawalls are constructed by waves during storms or unusually high tides, and generally define the upper limit, or boundary, of wave action during the strongest storms. The top of the seawall is peculiar in that the flat cobbles are arranged somewhat like shingles, with the flattest surfaces slightly inclined either toward or away from the ocean. As long as the seawall remains undisturbed by other than natural processes, it will serve as a buffer between the sea and the Lower Duck Pond bog, inland of the seawall.

The broad, gently sloping *terrace* exposed at low water has, in most years, a well developed *ridge and runnel* (Fig. 8) produced by wave action. The ridge is the low mound of sand that parallels the beach. Between the ridge and the high water line is a trough, or runnel, that serves as a drainage channel as water level changes. The broad, rich carpet of silt and sand forming the terrace is a fascinating place to explore. Evidence of life is everywhere, and it is exhilarating to stand a great distance from the high water mark and survey an area that only hours before was submerged beneath the sea.

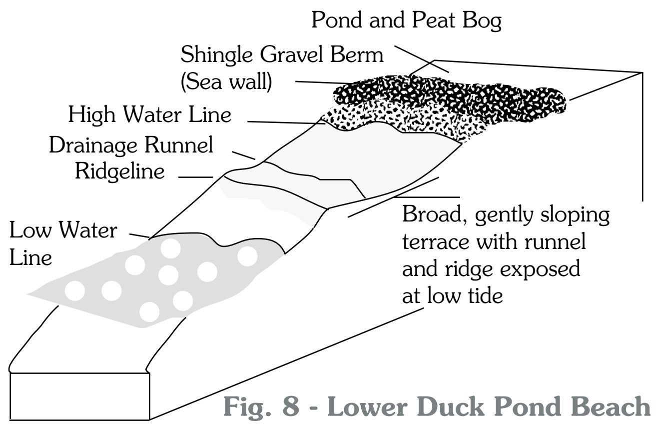


Fig. 8 - Lower Duck Pond Beach

Continue along the beach until you reach the opening, or breach, in the seawall caused by the outlet stream of a small pond entrapped behind the seawall. If the breach is not evident, strong storm tides may have recently pushed cobble and sand into the opening and blocked the outlet stream, resulting in a deeper and larger pond. Water from the pond will be seeping in broad areas or rivulets through the beach some distance down its slope.

Perhaps one of the most interesting features of this beach is the outlet stream from Lower Duck Pond Bog, about half way to Gooseberry Point.

If the tide permits, follow the stream down the slope of the beach toward the ocean.

The stream meanders down the beach face, displaying many of the features of larger rivers and streams of the world as they merge with the sea across broad flats and deltas. At the outlet of the pond, the stream has enough energy to cut a channel through the seawall, peat, and underlying silt. The opening in the seawall exposes pebbles and cobbles resting on a dark brown layer of organic material called *peat*. The peat, a material commonly used in gardening, is resting on sand and sticky, gray silt and clay. The underlying silt and clay prevent water from penetrating deeply into the rocks beneath, and aid in the development of the small pond and bog.

As it moves across the sloping beach, the stream loses volume and energy and begins to drop some of the material it is carrying - larger material first, then smaller material. Note how the stream constantly shifts, forming and destroying many small channels and dividing and joining until it disappears into the porous, permeable sands and silts of the terrace.

Fox Farm - Deep Cove

This walk is best taken at low tide; however, some features can be observed at high tide. Begin your walk at the base of the hill beyond Fox Farm by walking to the beach through the mowed gap in the wild roses.

The flat, shingle-like accumulation of stones at the top of the beach is a seawall, and is covered with beach peas and rugosa roses. The seawall here is small, and not at all impressive compared to the seawall at Lower Duck Pond.

Once on the beach, walk south away from the Customs House and the International Bridge to the area where the bank contains a mixture of sand, silt, and cobbles and rises to about 4.6 metres in height - toward the area where large cobbles and boulders become dominant beach materials. Stop before you reach this more coarse part of the beach. Notice that the mud beneath your feet is a tan to gray, sticky, silty clay with pebbles and sand pressed into the exposed upper surface. Look for areas of mud cracks somewhat resembling an irregular mosaic or quilted pattern. (The tide must be out 7-12 metres for a good view of the pattern.)

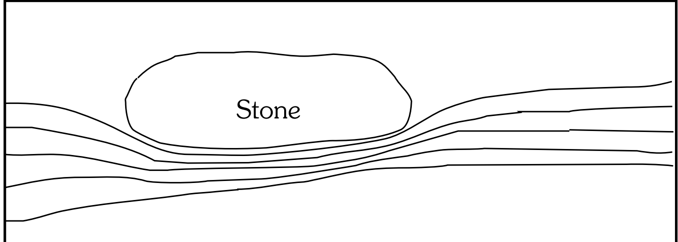


Fig. 9 - Compressed Layers of Clay

The fine silt or mud on the beach beyond Fox Farm is typical of tidal flats where wave energy is very low. The fact that pebbles and sand are pressed into the upper surface is explained by the erosion of sediment from the bank. As the mud is saturated and softened with tidal rise and fall, the weight of the overlying pebbles, sand, and rocks causes them to sink into the mud, compacting the clays beneath them. It is possible to see the compressed layers of silt and clay by trimming the edge of a 25-30 centimetres diameter piece of mud mosaic with a pocket knife. In cross section (Fig. 9), the compressed layers underneath a stone are revealed more clearly.

Modern day examples of sediment formation, such as that found here, provide information about *depositional environments*, past environments in which sediment was deposited. Imagine what this combination of mud and pebbles would look like if it were hardened into a rock. Depending on the relative amounts of mud and pebbles, it might look something like a mortar mix or concrete. In the future, geologists might call this material a conglomerate. The fact that the mud has been depressed beneath each pebble would provide a clue about the direction of gravity acting upon the sediment; in other words, which direction was up at the time of sediment accumulation. Geologists look for any evidence in sedimentary rocks that will provide an understanding of the direction in which forces like gravity were acting. In thick layers of sedimentary rocks, the up direction, or *direction of younging*, once established, can be used to solve other geological problems.

Continue to walk toward Cranberry Point, taking notice that the cobbles and boulders become more numerous and larger in size in that direction.

The largest and most numerous cobbles and boulders are found on the small point of land about half the distance along the beach to the outcrops of dark gray igneous rocks that are part of Cranberry Point. The increased size of sediment (boulders) indicates more wave energy directed at this point, perhaps sheltering the muddy areas to the north by absorbing energy. The currents generated by the rising and falling tides, and the angle at which waves strike the shore transport finer sediment along the shore and toward the sea.

Consider that this fine-to-course gradation in beach materials is present along a beach in our current time period, and assume that the rates of present processes have always been the same throughout time. You can see how it is possible to use similar gradations observed in old sedimentary rocks to reconstruct the environment which existed when the deposits making up those old rocks were being laid down - the patterns of currents and sediment transport and accumulation, and areas of wave energy absorption.

Consider the possibility of a change of depositional environment with time. Suppose, for example, that the tidal mud with pebbles is buried by sediment washed down from the bluff, either by surface water runoff during rains or by sea level rises over a period of time, causing waves to undercut the bank. In the future, after the sediments have been hardened into rocks, a cross section of this part of the beach would show layers of mud overlain by layers of gravel and sand derived from the bank. If the direction of younging has been preserved, the depositional history of the rocks can be reconstructed from the *stratigraphy*, the sequential layers. These stratigraphic principles are applied by geologists to reconstruct the geological history of not only local small beaches, but also large parts of the earth's crust that have experienced change with time.

Conclusion

It is not surprising that FDR enjoyed his time on Campobello and called it his "beloved island". The exceptional quality of landscapes and coastline, and the dynamic processes that have shaped a changing perception of the environment are major attractions of the island. Strolling the beaches, ascending the headlands, or pausing to simply drink in the beauty of the area allows one to appreciate the unfolding geological history of the Park, and to participate with past generations in the heritage that has been preserved here.

Dr. Allen wishes to acknowledge the work of Dr. Malcolm McLeod, whose Master's thesis *The Geology of Campobello Island, Southwestern New Brunswick* served as a valuable initial resource in the preparation of this pamphlet. He also wishes to acknowledge the assistance of Harold Bailey, Park naturalist, and of the Roosevelt Campobello International Park Commission and staff, without whom this document would not have been prepared.

The Season

The Park opens the Saturday following Victoria Day (the Saturday prior to U.S. Memorial Day), and remains open through Canadian Thanksgiving (U.S. Columbus Day). Visiting hours are from 10 a.m. to 6 p.m. A.D.T. (9 a.m. to 5 p.m. E.D.T.) seven days a week. The last tour of the cottage is at 5:45 A.D.T. (4:45 E.D.T.). There is no admission charge. Although the Roosevelt Cottage is closed to inside tours after Canadian Thanksgiving/U.S. Columbus Day, the Park's Visitor Centre remains open through the end of october for the convenience of fall travelers. The Park's Natural Area is open year round.

Roosevelt Campobello International Park Commission website: http://www.fdr.net.

All inquiries should be directed to the Executive Secretary at 459 Route 774, Welshpool, N.B., Canada E5E 1A4 or P.O. Box 129, Lubec, Maine, U.S.A. 04652.

In 1980, the Roosevelt Campobello International Park commission adopted a logo based on President Roosevelt's original design for his match book covers. The letters "FDR" for a sailboat, representative of his favourite pastime. The Commission added a star over the bow and a maple leaf over the stern to signify participation by the United States and Canada in joint operation of the Park, the only one of its kind in the world.