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THE GEOLOGIC HISTORY OF THE PERCE AREA

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QUEBEC DEPARTMENT OF NATURAL RESOURCES
Honorable Paul-E. Allard, Minister

THE GEOLOGIC HISTORY
of the
PERCÉ AREA

by
H.W. McGerrigle

MINES BRANCH
Geological Services

Québec
1968

P.G. 2



Percé panorama from the Pic de l'Aurore (Peak-of-Dawn). Percé Rock points to Cape Barré and two of Les Trois Soeurs (Three Sisters); Cape Mont Joli is near Percé Rock and Cape Canon is to the right (under the large white house). Bonaventure island in the background. (Photo by Québec Tourist Branch.)

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The reader will find in Popular Geology Series No. 1 an introductory section on "Gaspé Peninsula and Geologic History" which outlines some of the main ideas and laws of geology as a science, particularly as these apply to the peninsula. This publication is a road-log that pin-points many geologic features to be seen along or near Route 6.

FOREWORD

The Geological Services of the Quebec Department of Natural Resources are preparing a series of non-technical pamphlets on the geology and geologic history of many parts of the Province. This series is intended to introduce to residents of the Province and to tourists some of the fundamentals of the long geologic history through which particular areas, and the Province as a whole, have passed before the present landscape or scenery was produced. Great lengths of time and great changes as time moved on are the essence of geologic history.

The description of each area is accompanied by a generalized geologic map of the area and by photographs of the main features of both the land forms and the geology.

The photographs in this pamphlet are by the Geological Services of the Quebec Department of Natural Resources unless specifically acknowledged.

PAUL-E. GRENIER,
Director of Geological Services.

Quebec 1968

Cover photograph is a view of Percé Rock and part of Percé village from the south (Surprise hill).

The Geologic History of the Percé Area

The geologic history of the Percé area begins well back in geologic time. Neither Percé nor any part of Gaspé peninsula can lay claim to "the oldest rocks in the world", as some enthusiasts have stated. However, its oldest rocks have the quite respectable age of about 540,000,000 years (these are the Cambrian rocks of the **Geologic Time Table** and of the **Geologic Map of the Percé Area** that accompany this outline). The Cambrian rocks are exposed in a band 500 to 2,000 feet wide that extends from the big bend on Murphy Creek at the northern end of the Percé hills eastward along the Murphy valley for 1½ miles and thence southeastward 3½ miles through the hamlet of Cannes-de-Roches and to where the Cambrian is covered by the Bonaventure Formation of Carboniferous age. The rocks of this oldest band are probably mainly Upper Cambrian in age, judging from fossils present in them. However, near the western end of the band, in a railroad cut, fossils that represent an age close to the Lower and Middle Cambrian boundary have been found — and this brings us roughly to the figure of 540,000,000 years.

Fossils in themselves (and these are the actual remains or the traces of existence of prehistoric animals or plants) do not give the dates of rocks in terms of years, but they do give relative dates — that is, they tell us whether we are dealing with rocks of Cambrian, Devonian, Cretaceous, Pliocene, or whatever, age. The dates of rocks in terms of years are given by radioactive dating — this is another and a complicated subject but, roughly, it involves the rate of break-down or transformation of radioactive minerals into a special kind of lead.

The rock divisions 1, 2, and 3 of the geologic map (corresponding respectively to Cambrian, Ordovician, and Silurian) are not easily distinguished from one another and their presence and arrangement were determined only after very careful study and mapping of the rocks themselves and study of the relatively few fossils found in them. In general, all three divisions consist of gray limestones and limey shales. However, the Cambrian-Ordovician boundary is marked by a quartz-pebble conglomerate. The succession of limestones and limey shales, with relatively rare rocks of other types (sandstone, conglomerate), as well as a scattering of fossils, indicates that the muds and sands which were the original materials of the Cambrian-Ordovician-Silurian sequence of rocks were deposited on a sea floor in relatively quiet waters.

Formations 4, 5, and 6 are Devonian in age. Formation 4 is given the local name of "Mont Joli beds" but can be correlated with the St. Alban Formation of the Forillon peninsula on the north side of Gaspé bay. Likewise Formation 5 (which is referred to locally as the "Murailles beds" or the "Percé Rock beds") correlates with the Grande Grève Formation of the Forillon. Formation 6 (the Gaspé Sandstones) is represented at Percé only by a small mass at the seaward foot of the Pic de l'Aurore (Peak-of-Dawn), but is very common along the mid-length of Gaspé peninsula and forms the shore cliffs between Malbaie bay and Gaspé bay to the north of Percé.

The main point to keep in mind in connection with the rocks so far mentioned is that all of them were deposited in the sea as muds, silts or sands and that all except the Gaspé Sandstones were deposited in quiet waters — that is, below the influence of waves but still in relatively shallow waters. This implies that the bottom of the sea must have been sinking more or less steadily to accommodate the sediments being spread over its floor, because the total thickness of Cambrian to Devonian sedimentary rocks here is several thousand feet. Such a thickness is not exceptional. In many mountain ranges throughout the world sequences of sedimentary rocks several miles thick were formed under similar conditions and have been raised many thousands of feet above present sea-level.



Plate I — Mount Ste. Anne from the southeast showing Carboniferous Bonaventure Formation dipping (slanting) gently to the north.



Plate II — Looking north from about mid-length of the west side of Percé Rock. Part of Percé village in the center with Cape Mont Joli in the left foreground and Mount Blanc (rounded) in the left background. Cape Barré and part of Les Trois Sœurs, with the Pic de l'Aurore behind them.

The youngest sedimentary rocks in the Percé area are those that make up the Bonaventure Formation of Carboniferous age (Formation 7). This is the formation that caps Mount Ste. Anne (about 1,100 feet above sea-level) and, to the north, Mount Blanc (1,200 feet above the sea), and Pic de l'Aurore (640 feet above the sea). It also is exposed at sea-level between Cape White Head (Cap Blanc) and the South Beach of Percé. Also, it is the only bedrock to be seen on Bonaventure island except for a little Grande Grève (Formation 5) at the northern tip of the island. The Bonaventure Formation may be seen also at various places along the shore to the west of Percé as far as Nouvelle bay, west of Carleton.

The Bonaventure Formation, wherever it occurs, is characterized by flat to gentle dips (Plates I, VI). This means that it has remained relatively undisturbed since it was deposited. The only exceptions to this undisturbed condition are local and are related to faults (Plate XV). The origin of the formation is not quite clear. However, it obviously was formed in a depression closely corresponding with the outline of the present Chaleurs bay, because it is common along both the Gaspé and the New Brunswick shores of the bay — but, as fossils of life that lived in marine waters are unknown from Bonaventure rocks, it is possible that the Chaleurs depression was blocked off from the sea in Bonaventure time. The only fossils found in this Formation are plant fragments some of which are of the trunks of trees (Plate X). These fossils (found a few miles north of Percé), plus the relation of the Bonaventure to the underlying Devonian, are enough to indicate its Carboniferous age but are not enough to show whether it is Lower or Upper Carboniferous. Middle Carboniferous is the obvious compromise, and hence an age of 310,000,000 years is suggested as the general age of the Bonaventure Formation. This means that the time interval between the youngest Devonian formation at Percé and the Bonaventure Formation was something like 60,000,000 years.

The question may well be asked why the Bonaventure Formation does not rest everywhere on the next oldest formation. A part of the answer is that during the 60,000,000 years referred to above all the other rocks (Cambrian, Ordovician, Silurian, Devonian) were folded at least once, raised



Plate III — Unconformity (indicated by dashes) between overlying, younger Carboniferous rocks (dipping gently to the north) and the older Ordovician rocks (dipping steeply to the south). Neither color nor black-and-white show this unconformity clearly because the Ordovician just under the contact with the Carboniferous is stained by iron-bearing solutions that have seeped down from the red Carboniferous rocks. North flank of Cape Blanc (White Head), in the sea-cliff below the Cote de la Surprise Belvedere. Mount Ste. Anne in background.

above the seas in which they were deposited, and then subjected to erosion before the Bonaventure muds, sands, and gravels were spread across them and, later, hardened into rock. The band of Cambrian rocks mentioned above actually marks the crest of an anticline (upfold) and upturned Ordovician and Silurian rocks appear in succession outward from this crest. The steeply dipping Devonian rocks of Percé Rock and the Murailles are on the northern limb of this major fold (Percé anticline). The southern limb is represented only near the axis of the fold — the rest is covered by the Bonaventure Formation.

Stated in another way. — Because the flat to very gently folded Bonaventure Formation lies across the upturned edges of the older (Cambrian to Devonian) sharply folded formations it follows that a period of folding and mountain-building ("Acadian orogeny") intervened between the deposition of the Devonian rocks in Gaspé peninsula and the

deposition of the Carboniferous Bonaventure rocks. This was the orogeny that folded most of the rocks of Gaspé peninsula and raised this whole region above sea-level. Since that time, or for about the last 350,000,000 years the Gaspé region as a whole has remained above sea-level and has been subjected to the wearing-down forces of weathering and erosion. In all of that time the only geologic events that can be dated with any confidence in the Gaspé Peninsula region are:

1. The deposition of the Carboniferous Bonaventure Formation about 310,000,000 years ago.
2. Glaciation during the last million years.
3. A post-glacial, Recent rise in the land with respect to sea-level of a few hundred feet. This rise, which may still be going on, is merely the rebound from loading, and consequent depression, of much of northern North America by ice during the Glacial or Ice Age of the last million years.

THE SCENERY OF THE PERCÉ AREA

What has been said so far in this history is intended to stress the fact that the scenery or landscape of the Percé area is the product of a series of events through many millions of years. Recognition of the great lengths of time involved, and of the great changes that take place as time moves on, is essential to any real understanding of geology and of scenery.

The most notable feature of the Percé area is Percé Rock (le Rocher Percé), the island-peninsula from which the village and the area take their names (Cover and Plate I). In a sense the Rock may be regarded as a sea-stack (although of rather exceptional size) because it is a relatively high remnant of rock that once reached out from the shore but was isolated



Plate IV — The Grande Coupe valley (middle of photo) separates Ordovician rocks (cliff in foreground) from the Pic de l'Aurare sea-cliff and its content of Ordovician, Devonian, and Carboniferous rocks.



Plate V — The head of the Grande Coupe is cut in Carboniferous (Bonaventure) rocks and serves as a base for part of Route 6.

by wave action. Actually, of course, a true sea-stack does form the seaward end of the Rock. This resulted when the arch connecting it to the main part of the Rock collapsed June 17, 1845. Now only one arch remains, and should last a few hundred years. If this seems a little less than optimistic please remember that four arches were apparently seen here by sailors in the 1600's. The arches resulted from the erosive action of waves along planes of weakness (fractures or joints) in the rock.

Percé Rock, plus the rear sea-stack, is roughly 1,550 feet long, 300 feet wide at its widest, and 288 feet high at its highest point (at the prow, or inner end); it is 215 feet high above the hole, and the sea-stack at its outer end is 154 feet high. The Rock is made up of silty limestones in layers 1 inch to 3 inches thick, many of which contain abundant fossils — mostly brachiopods and trilobites. (Please bear in mind that along steep cliffs such as characterize the sides of Percé Rock there is always the danger of rock falls — so choose where you stop to look for fossils with care). The rock layers when formed in the sea from mud and silt about 375 millions of years ago were horizontal, or nearly so; now, however, they are almost vertical or almost standing on end (Plate XI) as the result of mountain-building Earth forces toward the end of Devonian time. These rocks are correlated by means of fossils with the Grande Grève Formation, which has its type area at Grande Grève on the southern side of Forillon peninsula some 16 miles directly to the north, and which is widely represented in the interior of Gaspé peninsula. Similar rock, also nearly vertical, forms the Murailles (= walls = sea cliffs) north of North Beach, and which rise to the high Pic de l'Aurore (Peak-of-Dawn) (Plates II; IV); at the peak, however, and down on its south shoulder the limestones are covered unconformably by the Carboniferous Bonaventure conglomerate. (The peak actually is mainly Grande Grève but there are local, small remnants of the conglomerate.)

The accompanying map shows that the Grande Grève Formation is present northwest of Percé in the Portage River valley. The rocks here and at the Murailles and in Percé Rock were originally all part of one band, but it has been broken by faulting and cut down by erosion so that between Portage



Plate VI - The Carboniferous Bonaventure Formation on the east side of Bonaventure island. Red conglomerate at sea-level overlain by red sandstone. Note pits and furrows formed by solution. (Photo by Province of Québec Film Bureau.)



Plate VII — Solution pits and furrows in the Carboniferous Bonaventure Formation in the walls of the "Amphitheatre" on the Falle Road.



Plate VIII — Looking east to "La Crevasse" from Falle Road.



Plate IX — "La Crevasse" in Carboniferous Bonaventure conglomerate.

river and the Murailles it is masked or covered by the Bonaventure Formation. There is no doubt, also, that this formation extended seaward at least as far as Bonaventure island, because it outcrops on the northern tip of the island and almost directly in line ("on strike") with Percé Rock.

The cape (Mont Joli) that separates the North and South beaches seems to have about the same general structure



Plate X — Fossil tree trunk in Carboniferous rock. Loose block on beach north of the old Cannes-de-Roches wharf.



Plate XI — Southwest side of Percé Rock from 500 feet north of the hole showing vertical to steep southwest dip (slant) of the rock layers (Devonian age). The sea-stack at the outer end of the Rock is to the right in the photo. Bonaventure island in the background.



Plate XII — The alternating silty to sandy and shaly (darker) layers of Cape Mont Joli dip steeply southwest. Devonian rocks. Local offsets of layers mark minor faults.



Plate XIII — Thrust fault (trace indicated by dashed lines and direction of movement by arrow) in the Cape Mont Joli cliffs west of Plate XII. Ordovician rocks to the left have been thrust over the Devonian rocks to the right.

as Percé Rock. However, appearances are not borne out when the rocks of this cape are examined. The northern part is shown by its fossils (mainly corals) to be Lower Devonian whereas the southern part is shown by its fossils to be Upper Ordovician; the Ordovician has been thrust up over the Devonian along a fault that dips about 45° to the south (Plate XIII). Continuing southward, a short beach separates Mont Joli from Cape Canon. At Cape Canon, the rocks (Ordovician) are light blue, thin limestones interbedded with thin, black shales (Plate XIV). In Logan Park on the Cape Canon rise (where a memorial to W. E. Logan, eventually Sir William Logan, Canada's first geologist of consequence, was erected in 1913 by the Thirteenth International Geological Congress), fragments in the "Limekiln conglomerate" carry Ordovician fossils (brachiopods, trilobites).

The Bonaventure, or youngest, formation of the Percé area, is characteristically reddish because of its iron content and so adds considerable color to the scenery. Some of this color has seeped down into older rocks that underlie, or formerly underlay (Percé Rock, e.g.), the Bonaventure.

The Bonaventure represents a most interesting type of sedimentary formation because it is made up in large part of pebbles, cobbles, and boulders up to 2 feet in diameter (as well as angular fragments) of other types of rock most of which have a long history of their own. These rock fragments (Plates VI, IX) include volcanic rocks of various types and some intrusive rocks (granite, e.g.), various types of sedimentary rock (limestone, shale, sandstone, and conglomerate), quartz, jasper, and possibly agate, — evidently this formation is the source of the agate scattered thinly along the Chaleurs beaches from Percé to Carleton, although no one has as yet reported agate in the formation. Sandstones and shales are interbedded with the conglomerate in many places, and in some places they make up the bulk of the formation.

As the sediments that make up the Bonaventure Formation were deposited and built up on an old erosion surface they filled in shallow valleys and spread across low hills. This fact provides a possible reason why the Bonaventure is up to 1,200 or more feet thick under Mount Ste-Anne and Mount

Blanc. This is the thickest known part of the formation in the Chaleurs Bay region. The relatively great thickness here was perhaps the result of the filling in of a valley that had the Pic de l'Aurore (Peak-of-Dawn) and other hills (now eroded away) on its northern side and Ordovician-Silurian hills (formerly called Les Monts Blancs, or White Mountains) on its southern side. (The term Mount Blanc is now popularly applied to the hill with the television mast, ½ mile northwest of Mount Ste-Anne and underlain by the red Bonaventure Formation).

The Bonaventure Formation once extended northwest at least 10 miles from the Percé hills because it forms the flat cap of the conspicuously flat-topped hill at that distance, and which can be seen from the highway on the sand bar at the inner edge of Malbaie bay. It also reached out to sea at least 3 miles, to the outer edge of Bonaventure island. It probably still is connected under water with the island because the island rocks slope gently inland and the mainland rocks slope gently seaward, thus suggesting a gentle basin structure in the rocks under Percé bay; also, the reefs in Percé bay off South Beach are made of Bonaventure rocks.

It has been suggested that many of the cliffs (Plates V, VII, VIII) that mark the lateral limit of the Bonaventure Formation in the Percé hills are the result of faults. However, there is little evidence that this is so, and the cliffs are much more likely to have been produced by the much gentler processes of weathering and erosion. The effects of weathering may be seen in many places in the cliffs themselves and in the large angular blocks that have fallen from the cliff faces. A good example of the effects of weathering is given by **La Crevasse** — the crevice at the top of the cliff near the northwest edge of the Percé mass of Bonaventure rocks (Plates VIII, IX). This is not the result of a "cataclysm of nature" or of a "geologic upheaval" but simply the result of the iron-bearing, calcareous cement and matrix that held the pebbly rock together being dissolved out by waters seeping along a joint. The pebbles were then washed away by waters from rains and melting snow. Frost action would also be effective here. The trend or strike of the La Crevasse joint is roughly parallel to the nearby north-facing cliff and almost at right angles to a smaller crevasse (also a joint) in the same cliff some 200 feet to the east.

Eventually, after several hundred years, these two crevasses should join and the stage will be set for a gigantic block of rock to fall off this north-facing cliff face.

There is very little direct evidence in the Percé area itself of the Ice or Glacial Age through which northern North America passed in the last million years. However, a few valleys have the U-shape characteristic of valley glaciation, e.g. the head of the valley draining to the east between Mount Ste-Anne and Mount Blanc (the mountain with the television mast), and also the upper part of the valley draining eastward along the south side of Mount Ste-Anne. Also, some of the valley heads, as that between Mount Ste-Anne and Mount Blanc, are suggestive of cirques (amphitheatre-like depressions characteristic of the heads of valley glaciers).

In any event, it is probable that the Percé area shared with the rest of Canada and the northern United States in being overridden by ice during the Pleistocene Glacial Period. Among other things this, also, would have contributed to the development of cliffs toward the borders of the Bonaventure Formation in the Percé hills.

The most recent major geologic event in the region was the rise of the land relative to sea-level that began when the glaciers melted out of the St. Lawrence valley, and that still may be going on. As with glaciation, the records of this rise in the Percé area are not too clear in general. On the north side of Gaspé peninsula, and in some places on the south side, marine terraces (beaches) built of gravel and sand rise step-like from the present shore and provide undoubted evidence of a rise of the land of as much as 400 feet since the last glaciation (four Pleistocene glaciations are known — and we may be living now in just a warmer stage between two glacial stages). One prominent terrace in the Percé area is cut on the rock towards the outer end of Cape Blanc (White Head) where the lighthouse stands; this is 150 feet above the sea. Poorly developed rises that may be marine terraces extend inland from the Cape Blanc rock terrace to a height of about 200 feet. The top of Percé Rock has been planed by the sea (just as were the rocks at Cape Blanc) and this top now averages about 210 feet above the sea except at its



Plate XIV — The Ordovician rocks on the south side of Cape Canon have been crushed, broken, and sheared by folding movements. Note the abundant calcite veins (white) filling fractures in this rock. Mount Ste. Anne in the background.

proW (or inner end) where it is 288 feet. Some land forms above 210 feet also suggest marine terracing.

Mention of "faults" appears here and there in the above outline. Faults are breaks in the Earth's crust that may be miles or only a fraction of an inch in extent and along which the mass of rocks on one side has moved relative to the mass on the other side. The development of, or movement along, faults is the main cause of earthquakes (the major faults in Gaspé peninsula have been inactive for millions of years, so don't be afraid to photograph, or even to stand on them).

One fault already mentioned (Plate XIII) is near the west edge of the Cape Mount Joli outcrop. This is a thrust, which usually results (as in this case) in the pushing of older rocks over younger ones probably in an attempt to fool geologists (and sometimes they do) by seemingly reversing the sequence.

A second fault (Plate XVI) is exposed on the shore just west of Cape Blanc (White Head). This is a normal fault along which nearly horizontal beds of the Bonaventure Formation dropped down and now rest against steeply dipping Silurian limestones.



Plate XV — Carboniferous rocks upended along a fault (to the left of the photo) that dropped the Carboniferous down against Ordovician rocks. Cannes-de-Roches shore.

A third obvious fault (Plate XV) in the Percé area is seen along the shore northwest of Percé, at Cannes-de-Roches. Here, Bonaventure-type rocks that lie flat near the old wharf bend up steeply near the stream west of the wharf and along the shore to Coin-du-Banc (Corner-of-the-Beach). About a mile along the shore east of Cannes-de-Roches gray Ordovician limestones seem to lie on top of the Bonaventure-type rocks, this being the result of thrusting from the south, and the strata are overturned so that they dip at about 60° to the south. The normal dip for the Bonaventure rocks here would be flat or gently to the north. Remains of fossil plants and impressions of fossil trees (Plate X) may be seen in the Bonaventure-type rocks near Coin-du-Banc and eastward to Cannes-de-Roches, and also at the thrust-fault locality on the shore a mile to the east of Cannes-de-Roches.

Also, the contact between the reddish Bonaventure Formation and the gray Ordovician rocks on the inner side of the highway at the Grande Coupe "Belvedere" (resting place and look-out) appears to be a fault.



Some Geologic Terms Relating to This Outline

Anticline and Syncline

The two basic types of folds in the rocks of Earth's crust. Both are canoe-shaped in general. In a syncline (down-fold) the axis of the fold (keel of the canoe) is down, and the strata (layers or beds) on the two sides or limbs of the fold dip towards each other. In an anticline (up-fold) the keel or axis is at the top (the "canoe" is upside down) and the two sides of the fold dip away from each other. Such folds vary in size from small wrinkles to many miles across and hundreds of miles long.

Formation

A mappable succession of rock strata (layers; beds) usually with common characteristics and of the same general age throughout; the usual unit of geologic mapping.

Fossil

The actual remains (usually shells or bones) or the traces of existence (tracks, trails, borings, impressions) of animals or plants that lived in prehistoric time.

Fault

A fracture in the rocks of Earth's crust along which the mass of rocks on one side of the fracture has moved or slipped relative to the mass on the other side. Faults that result from compression are usually of the thrust or push type. Other faults are the result of stretching or settling, where one side of the fault drops down against (or relative to) the other side. Both types range from fractions of an inch to hundreds of miles long. Movement (slipping) along faults is the prime cause of earthquakes. Thrusts are common in regions of strong folding, as along the north side of Gaspé peninsula. Although many faults of various types are known in Gaspé peninsula none are now active.

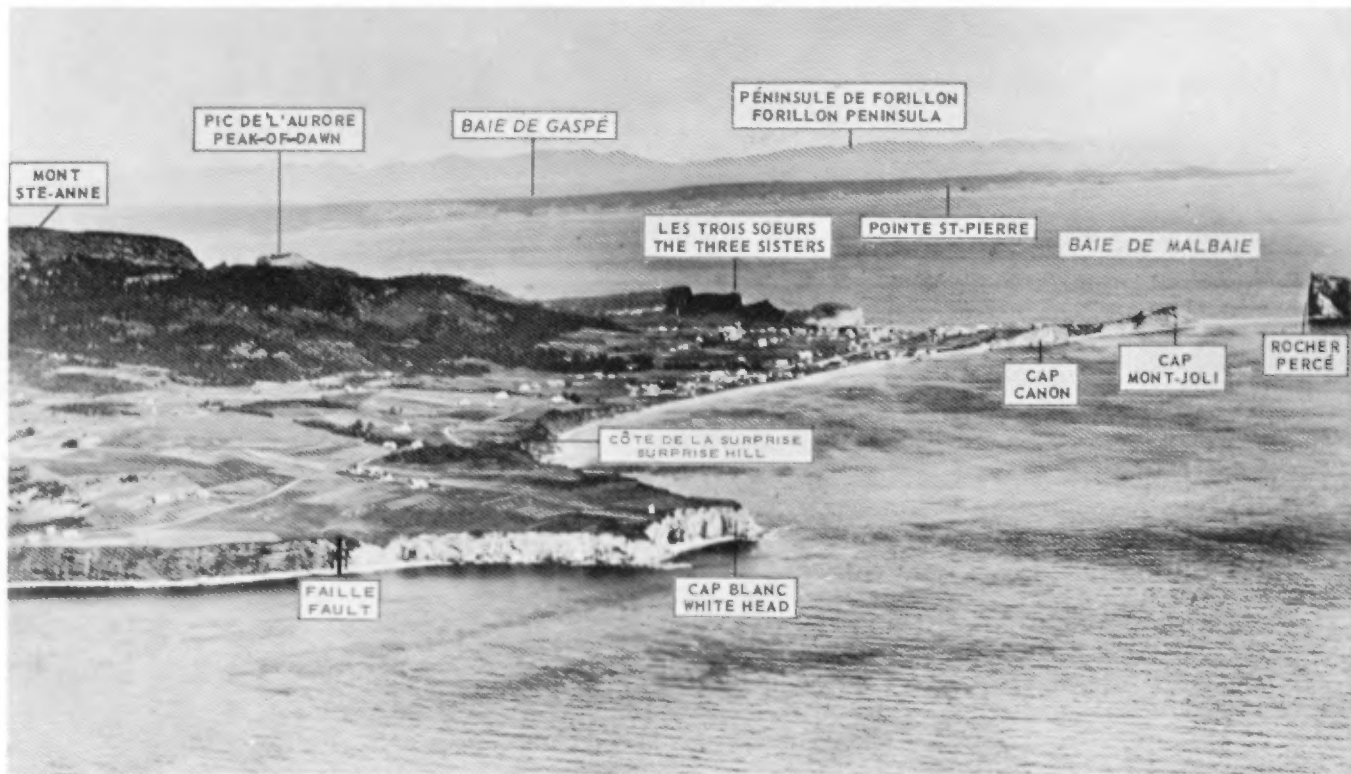


Plate XVI — Panorama of the Percé area. Looking north across Malbaie bay and Gaspé bay to the Forillon peninsula. (Photo La Cie Aérienne Franco-Canadienne for the Québec Department of Roads, 1927).

Joint

A fracture in rocks along which no, or very slight, movement takes place. They may be produced by tension or by compression.

Orogeny

(From the Greek **oros** = mountain and **genesis** = to be born.)

The process of mountain-building through folding and faulting of rocks (mainly sedimentary) in Earth's crust. The Appalachian mountains resulted from three such orogenies, namely, — 1. The **Taconic**, during which Ordovician and older rocks from Gaspé peninsula to the Taconic mountains of western Vermont and Massachusetts and of eastern New York were affected; 2. The **Acadian**, during which Devonian and older rocks from Newfoundland south to Virginia were deformed; and 3. The **Appalachian**, during which Carboniferous and older rocks (and probably Permian rocks) from Virginia to Alabama were folded, and the Carboniferous rocks of Canada's Maritime Provinces were gently warped.

Unconformity

Usually a surface of erosion on older rocks and upon which younger rocks have been deposited. The most pronounced unconformity in the Percé area is that at the base of the Bonaventure Formation (Plate III). This formation, Carboniferous in age and essentially flat, lies across the upturned edges of formations ranging from Cambrian to Devonian in age and is made up largely of sediments (muds, sands, gravels, and boulders) derived by erosion from these older formations.

Cement and Matrix

The **matrix** of any rock is the "background" of finer grains in which fossils, pebbles, or relatively large crystals are embedded. The **cement** is a chemical precipitate

(silica, lime, iron) that binds grains together in such sedimentary rocks as sandstones and conglomerates.

SEDIMENTARY ROCKS

Most sedimentary rocks are formed by the consolidation or hardening of sediments (muds, silts, sands, gravels). Sediments, along with chemical material, are produced by the breaking down through weathering and erosion of pre-existing rocks of every kind — including sedimentary rocks. Transportation of most of the rock waste is done by streams, and most sediments eventually reach the seas. Here the selective settling out of the sediments (coarser material near the shore and finer material farther out), and sinking of the sea floor, set the stage for the development of sequences of sedimentary material up to several miles thick. During and after deposition of the sediments packing takes place and chemical material (lime, silica, iron, etc.) works in among the grains of sediment to act as a binder or cement.

The most common of the mechanical sedimentary rocks are:

Shales — consolidated muds; very fine in grain.

Siltstones — consolidated silts; between shales and sandstones in grain size.

Sandstones — consolidated sands; grains readily seen without a lens or a microscope.

Conglomerates — these grade from very small pebble-size to beds (layers) of boulders; the pebbles and boulders are "packed" in sandstone (commonly) or in shale or in limestone.

Among the chemical rocks are limestones, chert (very hard, flinty rock), salt, gypsum, and potash.

The four mechanical types plus limestones make up the great bulk of sedimentary rocks. All of these are common in Gaspé peninsula, and chert is present in the Grande Grève

Formation along Forillon peninsula and as pebbles in some conglomerates.

FOSSILS

Forms of life preserved in sediments (later sedimentary rocks) and mentioned in the text above:

1. **Brachiopods** — Also called "lamp shells" from the general resemblance in shape of the common form living in present day seas to Biblical lamps. However, most fossil brachiopods are not of this type. They all have two shells ("valves"), one closing against the other as in clams (a pelecypod); however, unlike clams, the two shells are not mirror images. Brachiopods were much more common in ancient seas than in the present seas.

2. **Cephalopods** — The octopus, squid, and cuttle-fish belong here. Most of the fossil forms possessed straight or coiled shells, and these are common in rocks of Paleozoic and Mesozoic age.

3. **Graptolites** — Forms of life that lived only in Paleozoic seas. Like many corals, the graptolites were colonial animals; each individual lived in a tiny cup, and the cups were arranged regularly along a slender stem. Most species floated in the sea, attached either to a float or to other colonies, and so they became widely scattered. Most fossils of this class look like black lines with sawtooth edges (a thin film that resembles a pencil mark — hence the name, **graptos lithos** = writing on rock).

4. **Gastropods** — Snails, commonly with a coiled shell.

5. **Trilobites** — A class of crustacean that lived in Paleozoic seas. Related to the lobster and crayfish. The name derives from the fact that the body shield is divided lengthwise into three lobes. Also, most are

divided into a head area (cephalon), body area (thorax), and tail area (pygidium); it is relatively rare to find all three of these parts in one fossil specimen.

The Geologic Time Table given here is very generalized, — a skeleton. However, it gives the larger units of geologic time back to the Precambrian. Although the Precambrian represents much the greater part of geologic time, correlation of the succession of events and of rock units (formations) between regions is very difficult owing to the practical lack of fossils in Precambrian rocks, — some fossils are found but they are too few for correlation purposes. Fossils are common in Cambrian and younger rocks and they permit region to region and even continent to continent correlations of rock units. The fossils present in Eocene or Triassic or Cambrian rocks in China, for example, represent forms of life at least generally similar to those that lived in North America in those periods, and the general succession of life as represented by fossils is strikingly similar throughout the world. In many cases, correlations have been made between Europe and North America on the bases of **identical species**, — particularly species of graptolites, cephalopods, and trilobites, because these were types that could be, and were, widely distributed by ocean currents.

A question that may well be asked is: If age determinations can be made by physical (radioactive) methods in terms of years why bother with the relative ages supplied by biology (fossils)? The answer to this has several parts, some of which are: — (1) Radioactive dating has been developed only recently, and is still being perfected. Also, costs are high and "geochronology" (time-measuring) laboratories are few.

(2) Relatively few age determinations have been made on sedimentary rocks, and rarely on those that carry fossils.

(3) Radioactive datings up to now have been based for the most part on granitic igneous rocks or on rocks altered by granitic, or other, igneous intrusions; in some cases they have been based on rocks altered by mountain-building forces. Such datings give the age of the intrusions but not necessarily of the intruded rock; or, they give the age of the

GEOLOGIC TIME TABLE
(after Arthur Holmes, 1960)

Era	Period	(numbers in parentheses refer to millions of years)
Cenozoic (70) Age of Mammals, Birds, and Modern Plants	Recent	Post last great glaciation — 10,000 years to Present
	Pleistocene	Ice Age (1) — 1,000,000 years to Present
	Pliocene (10)	
	Miocene (14)	
	Oligocene (15) Eocene (30)	
Mesozoic (155) Age of Reptiles (dinosaurs, etc.)	Cretaceous (65)	Age of reptiles (dinosaurs, e.g.)
	Jurassic (45)	First flowering plants
	Triassic (45)	
Paleozoic (375) Age of Vertebrates and Land Plants ----- ----- Age of Invertebrates and Marine Plants	Permian (45)	Extinction of trilobites and certain corals.
	Carboniferous (80)	Age of Amphibians Age of Plants
	Devonian (50)	Age of Fishes
	Silurian (40)	Corals, brachiopods (now rel. rare), cephalopods.
	Ordovician (60)	Graptolites (now extinct), trilobites, brachiopods, cephalopods.
Cambrian (100)	Fossils common; most invertebrate classes present. Trilobites were the dominant animals.	
Precambrian (4,000 to 600)	Beginning of life. — Single celled forms found as well as algal remains (seaweeds), worm burrows, rare shelled invertebrates, sponge spicules, jelly fish? — All evidences of life are very scarce.	
Pre-Precambrian (?5,000 to 4,000)	Development of the Planet Earth and of its geologic crust.	

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Age of
Man

mountain-building movements and only the minimum age of the rocks involved.

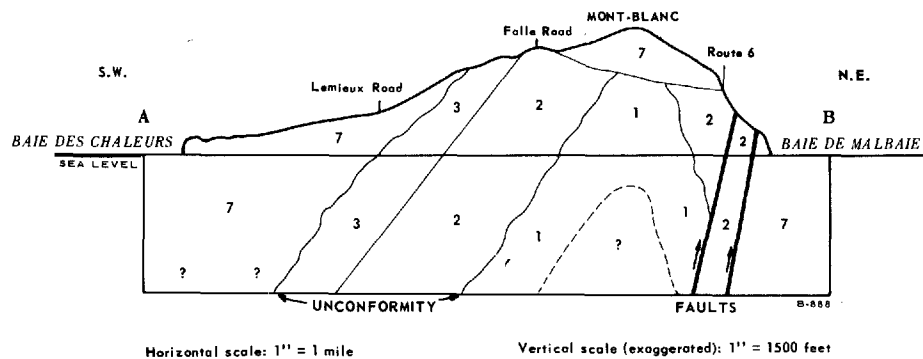
Nevertheless, the fact remains that the radioactive determinations of age (the "absolute ages") that have been made agree very well in general with the relative ages established on the basis of fossils.

Getting back to the Time Table. — The names of the eras are descriptive and reflect the progressive development of life: **Paleozoic** or ancient life, **Mesozoic** or middle life, **Cenozoic** or recent life. The names of the **periods** are based mainly on rock successions in areas where early field studies were made: **Cambrian** from the old name for Wales; **Ordovician** and **Silurian** for ancient Welsh tribes; **Devonian** from Devon in England; **Jurassic** from the Jura mountains, shared by France and Switzerland; **Permian**, from the province of Perm in eastern Russia; **Triassic** from its threefold division in Germany. Two period names are based on a characteristic content; — **Carboniferous** from its coal-bearing (carbon) content in Europe, and **Cretaceous** from its chalk (creta) content in England. And finally **Eocene**, **Miocene**, **Pliocene**, and **Pleistocene** refer to early recent, middle recent, more recent, and most recent, respectively. The youngest term (**Recent**) in the Time Table is not disguised and refers to the present time and back for 10,000 years.









H.W. McGerrigle, 23 nov. 1966

Cross-section along the line A-B (drawn on the accompanying map) to indicate what the structure and succession of the Percé Area rocks would look like if a cut were made across them at right angles to their trend and all the hills and rocks southeast of the cut were removed. The face of such a cut would be a vertical cliff at right angles to the trend of the rock formations. The section is extended below sea-level to make the relationships of the formations more clear.

The dips of the formations in the cross-section (except for the Bonaventure) are steepened to compensate for the exaggerated vertical scale.