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Although the prominent, resistant rocks of the Rockies are of Paleozoic age, it was Mesozoic tectonic forces that created the distinctive thrust faults and folds that are largely responsible for the modern grandeur of these mountains. This aerial view is of the "Big Bowl" on Mount Inflexible, Kananaskis Country, Alberta. MARILYN GARNETT / AIRSCAPES.CA.

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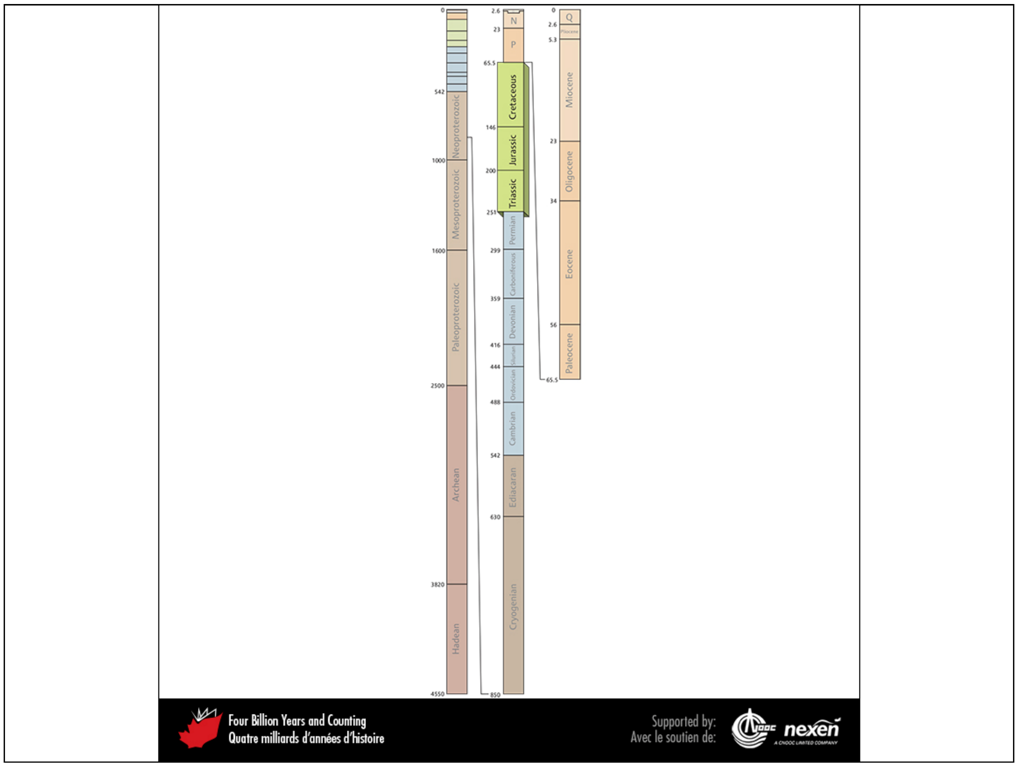
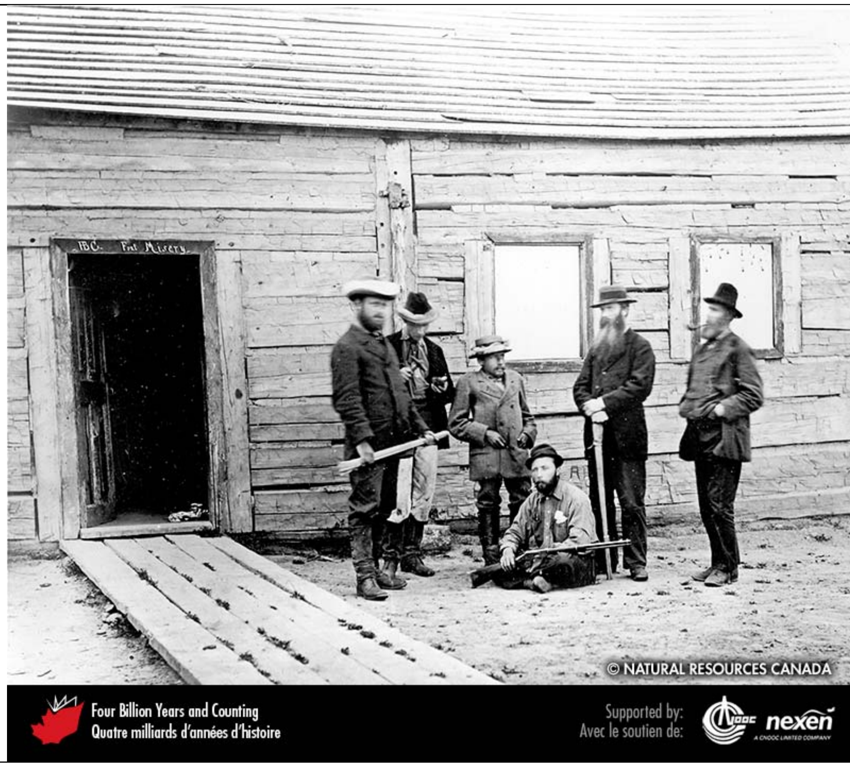


Geologic time scale, showing the interval covered in this chapter. Numbers indicate millions of years ago. P = Paleogene (Paleocene to Oligocene), N = Neogene (Miocene and Pliocene), and Q = Quaternary.



George Mercer Dawson (third from the left) during his International Boundary Commission days. REPRODUCED WITH THE PERMISSION OF NATURAL RESOURCES CANADA 2013, COURTESY OF THE GEOLOGICAL SURVEY OF CANADA .

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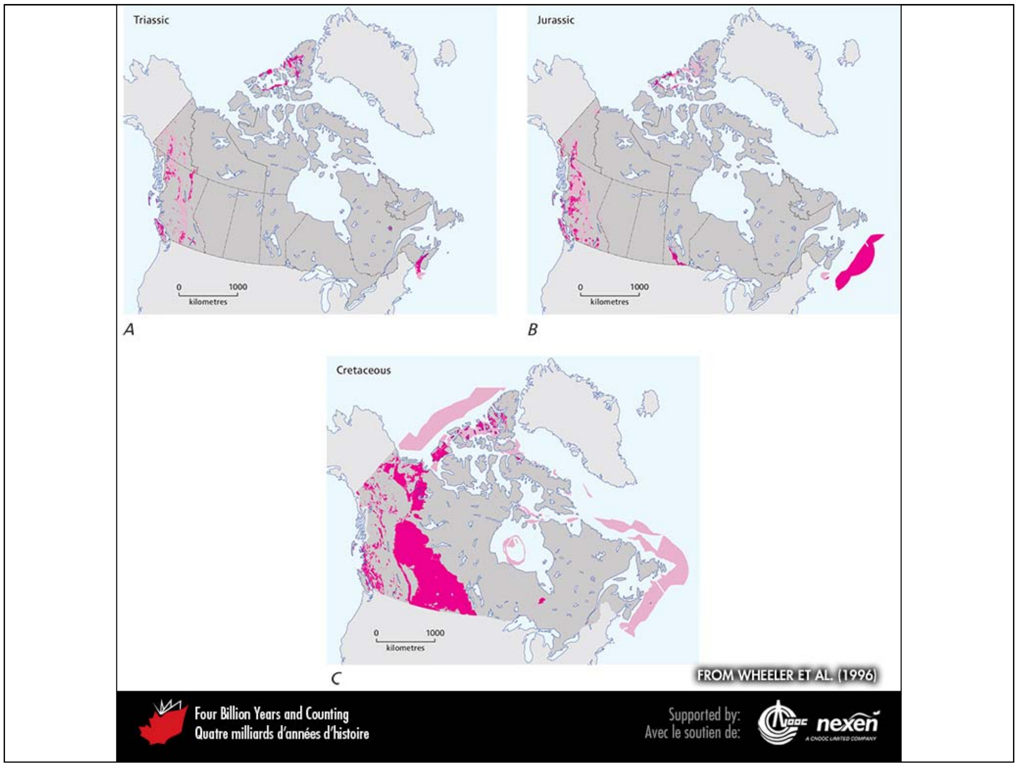
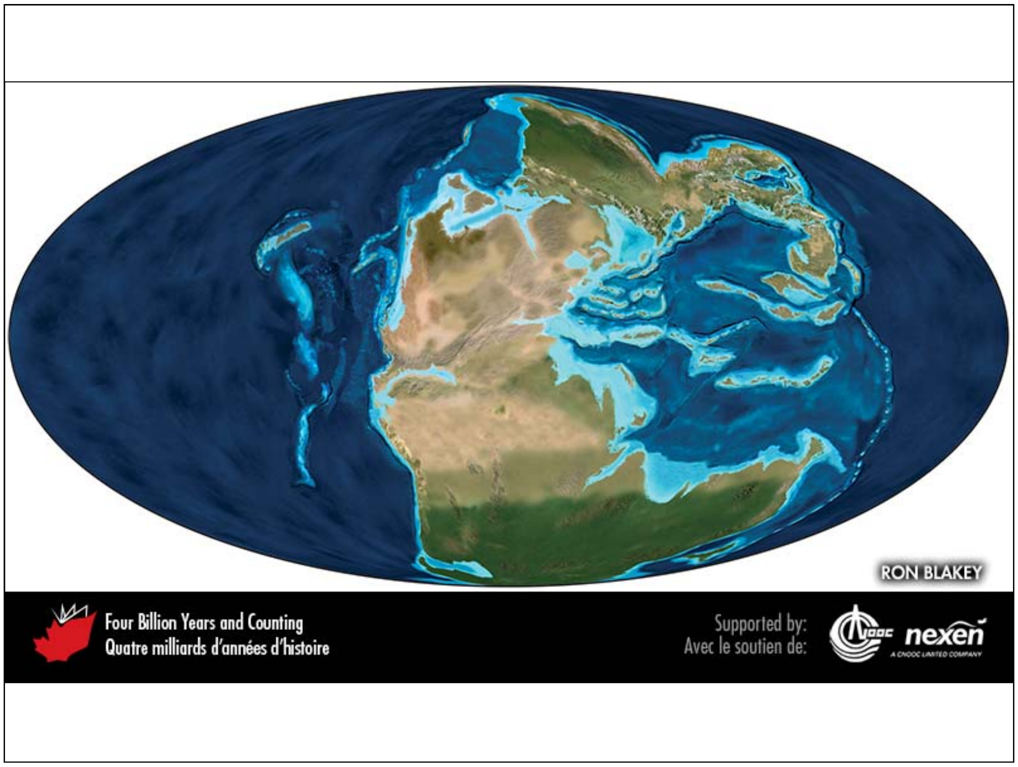


General extent of Triassic (*A*), Jurassic (*B*), and Cretaceous (*C*) rocks at the surface (beneath glacial deposits), onshore and offshore. The lighter shaded areas denote either uncertainty or areas where rocks of the particular age have been confirmed but are intimately associated with rocks of other ages and the scale of the map doesn't allow us to show them separately. ADAPTED FROM WHEELER ET AL. (1996).

Paleogeography of what was to become North America and adjacent regions in the Triassic, 245 million years ago. Land is shown in brown, with shading showing topography. The lighter blue areas represent possible coastal or nearshore areas, darker blue represents deeper ocean waters, and black indicates trenches. Aspects of modern geography are shown for orientation.



Global paleogeography 245 million years ago, during the Triassic. Colours as for previous figure.

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Triassic clastic rocks in the Kamenka stone quarry in the Bow Valley, just outside Banff National Park of Canada, Alberta. This quarry produces the commercial stone known as Rundlestone (Chapter 14). DIXON EDWARDS.

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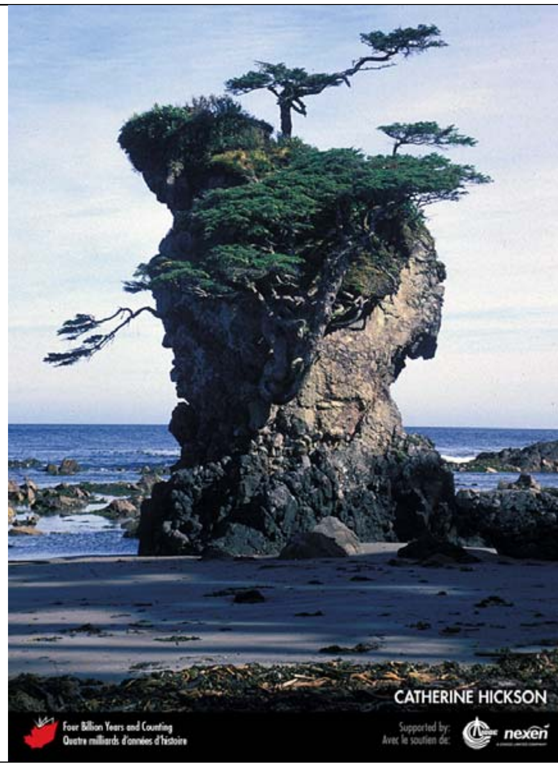

The “Flower Pot”, at the northwest corner of Graham Island, Haida Gwaii, is composed of Wrangellian Triassic-Jurassic volcanic rocks. CATHERINE HICKSON.

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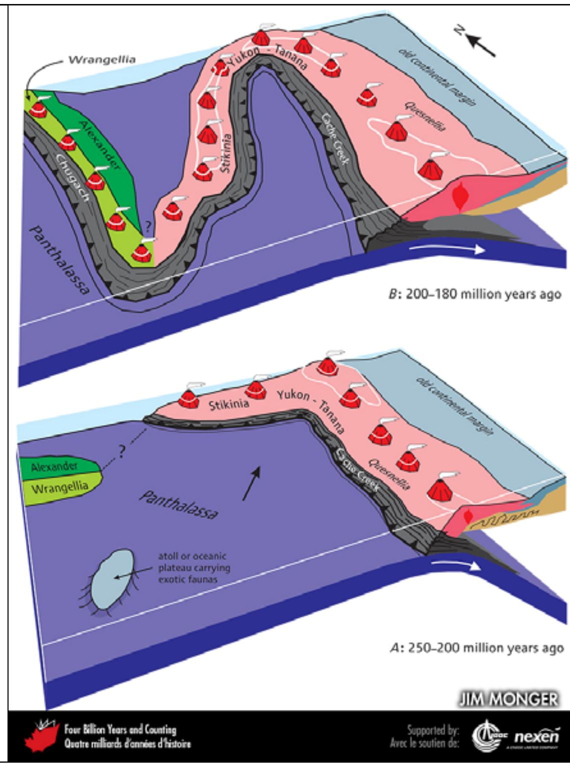
Late Triassic volcanic breccia containing a basalt pillow in a road cut on the Trans-Canada Highway near the west end of Kamloops Lake, British Columbia. Such rocks are typical remnants of the magmatic arcs of Quesnellia. The breccias formed when volcanic material slid down the flank of a submarine volcano. JIM MONGER.



The possible disposition of terranes on the Cordilleran margin during the Triassic (*A*) and early Jurassic (*B*), showing how the Cache Creek Terrane might have ended up sandwiched between Quesnellia and Stikinia. The Chugach Terrane is an accretionary wedge that accrued as oceanic crust of Panthalassa subducted beneath Wrangellia. The white lines represent sea level.

At Five Islands Provincial Park, Nova Scotia, the cliffs to the right expose red lake and sand-flat deposits, white fluvial deposits and, at the top, North Mountain Basalt, all of late Triassic age. At left the basalt is now at beach level due to faulting. ANDREW MACRAE.

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Late Triassic scene in the Fundy Basin, about 220 million years ago. A family of the mammal-like reptile *Hypsognathus* browse among the ferns, hidden from the predatory crocodile-like amphibian *Metoposaurus*. In the background, a dinosaur like rauisuchid drinks from a channel in the braided-stream network. The animals in this scene are based on fossil finds around the Bay of Fundy in Nova Scotia. The plants, dominated by ferns, the horsetail *Neocalamites* (to the left of the *Metoposaurus*), and gymnosperm araucarian trees (such as the large tree shading the *Hypsognathus* family), are drawn from the general flora known from the time. PAINTING BY JUDI PENNANEN, COURTESY OF THE ATLANTIC GEOSCIENCE SOCIETY.

Wasson Bluff, near Parrsboro, Nova Scotia. The rocks are: dark grey-brown, latest Triassic North Mountain Basalt at the right; light lacustrine limestone, lower middle; red eolian sandstone, left; and brown paleotalus ("fossil" scree) composed of basalt boulders, upper centre. All the sedimentary rocks are probably of earliest Jurassic age. ROB FENSOME.

Side view of the skull of the tuatara-like reptile *Clevosaurus*, from early Jurassic deposits at Wasson Bluff, near Parrsboro, Nova Scotia. HEINZ WIELE, COURTESY OF THE ATLANTIC GEOSCIENCE SOCIETY; SPECIMEN COURTESY OF THE FUNDY GEOLOGICAL MUSEUM.

A lava tube and dyke in volcanic rocks that are equivalent to the latest Triassic North Mountain Basalt, Seven Days Work Cliff, Grand Manan Island, New Brunswick. GREGORY MCHONE.

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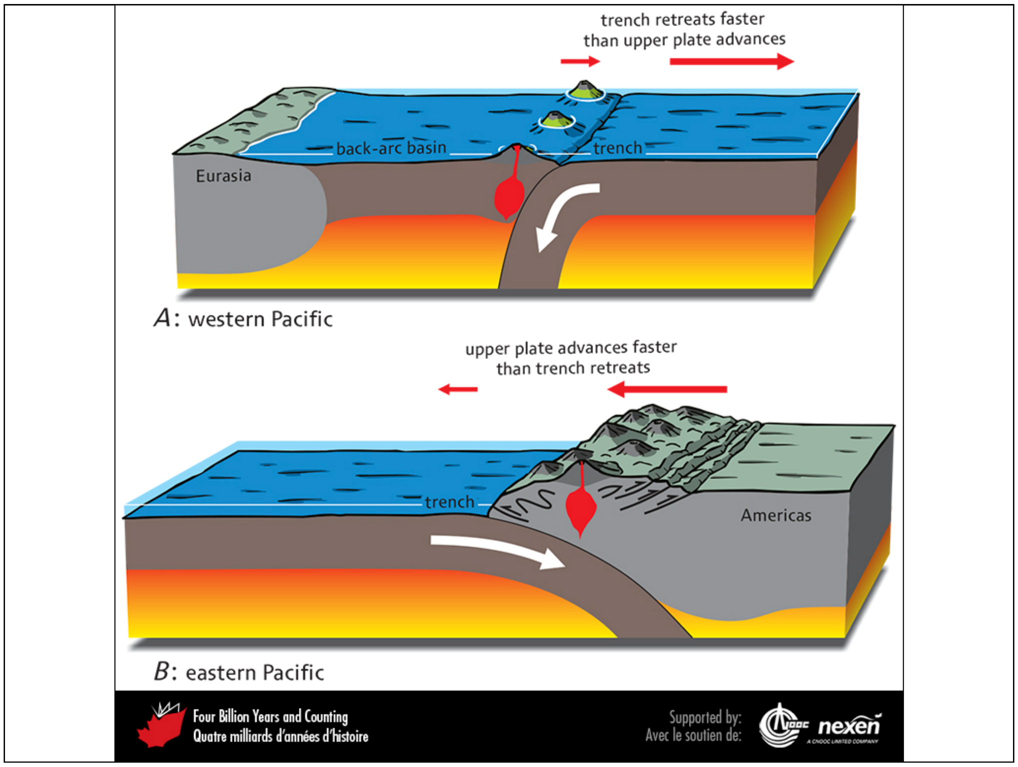
CHAPTER 9
Part 2 of 4



Comparison between aspects of plate convergence in the modern western Pacific Ocean (*A*) and the present-day eastern Pacific Ocean (*B*).

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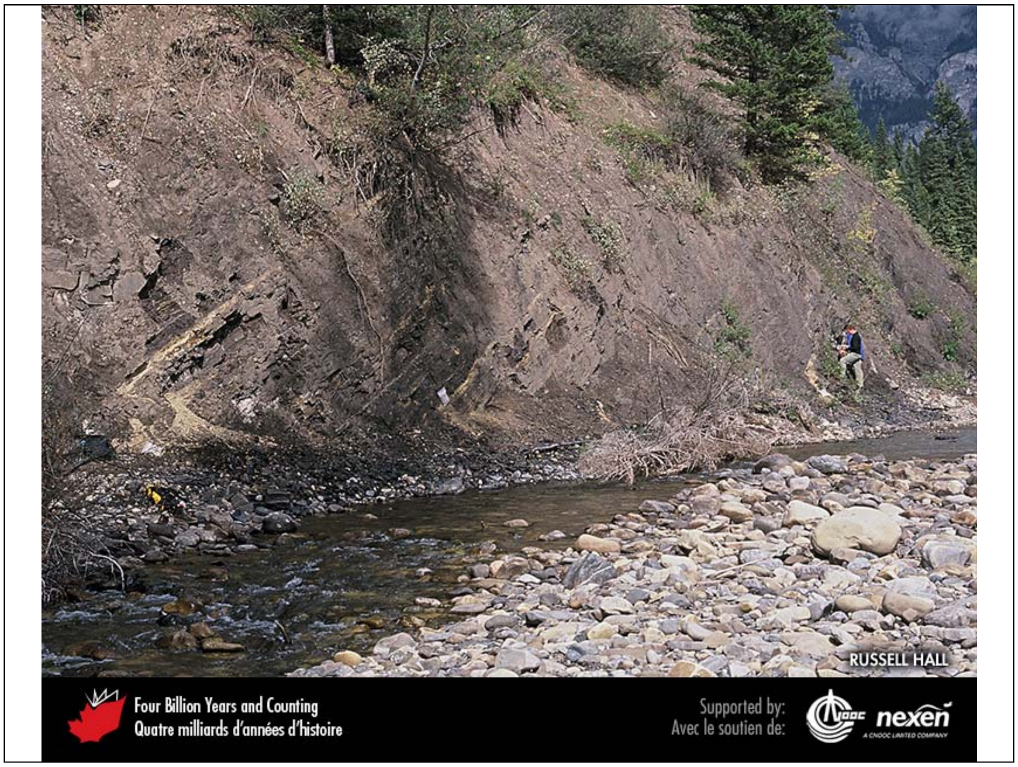

Early Jurassic rocks from the Bighorn Creek area, southwestern Alberta. Thin, light-coloured volcanic ash layers are interbedded with brown-weathering shales. These ash beds record the approach of Quesnellian magmatic arcs to the old continental margin. RUSSELL HALL.

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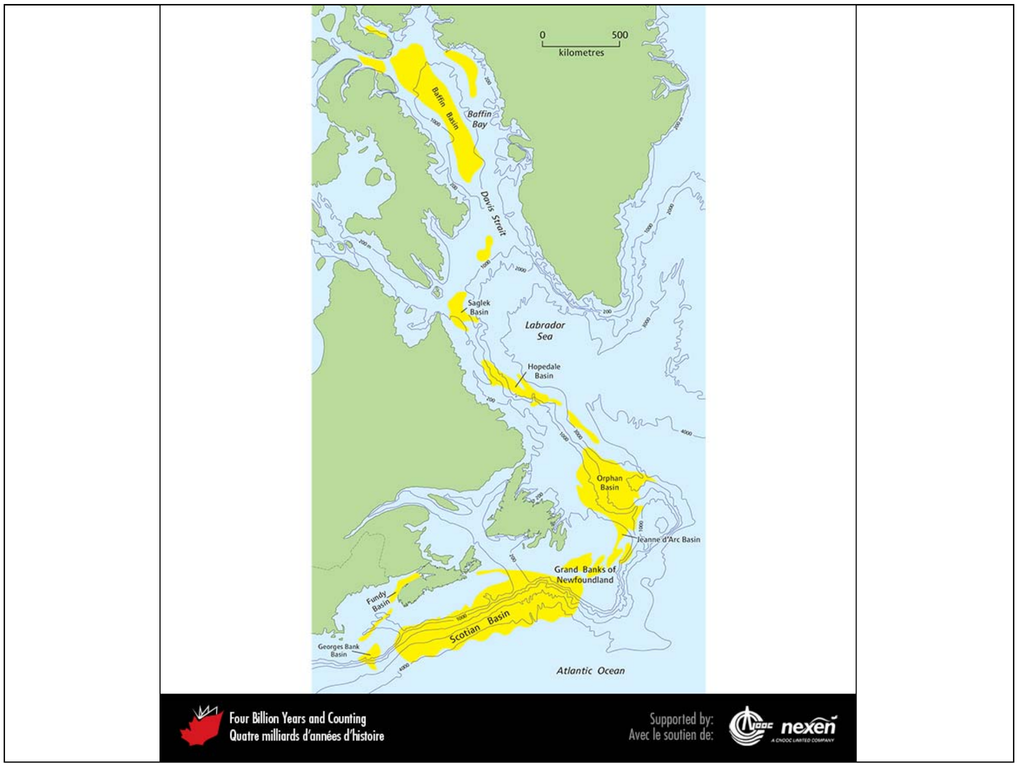

Mesozoic-Cenozoic sedimentary basins of offshore eastern Canada. Depths are in metres. ADAPTED FROM VARIOUS SOURCES.

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Fossil sponges in a drill core of Jurassic carbonate reef rocks from the Demascota G-32 well in the Scotian Basin off Nova Scotia. LESLIE ELIUK.

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Paleogeography of what was to become North America and adjacent regions in the Jurassic, 170 million years ago. Land is shown in brown, with shading showing topography. The lighter blue areas represent possible coastal or nearshore areas, darker blue represents deeper ocean waters, and black indicates trenches. Aspects of modern geography are shown for orientation.

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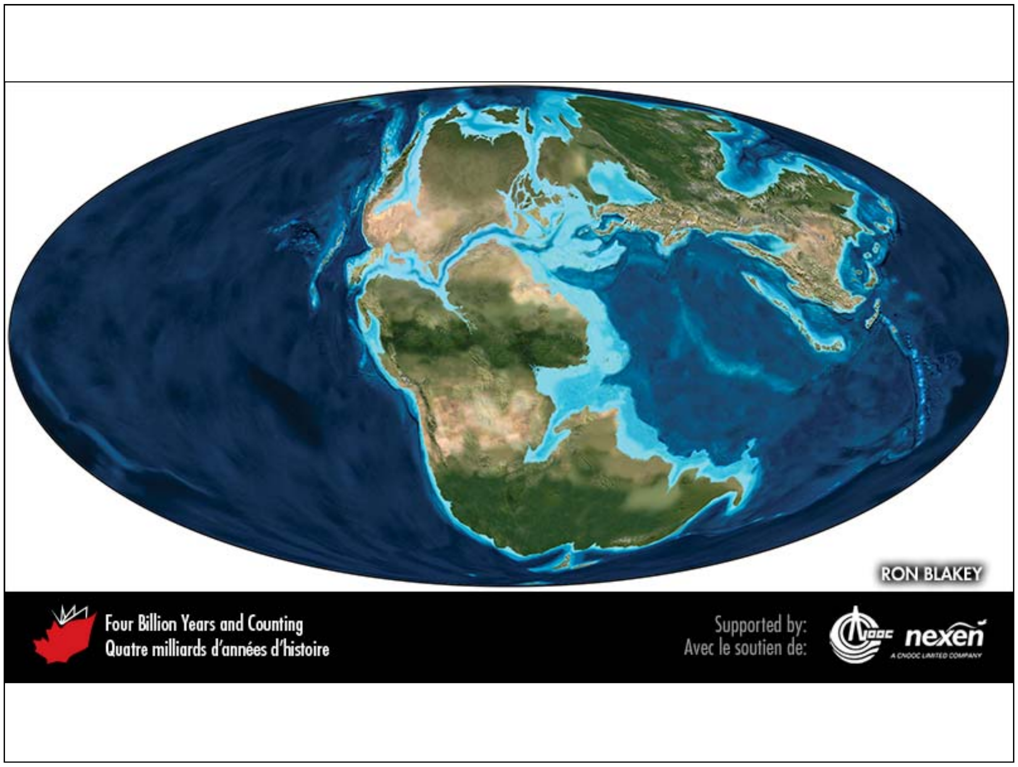

Global paleogeography 170 million years ago, during the middle Jurassic. Colours as for previous figure.

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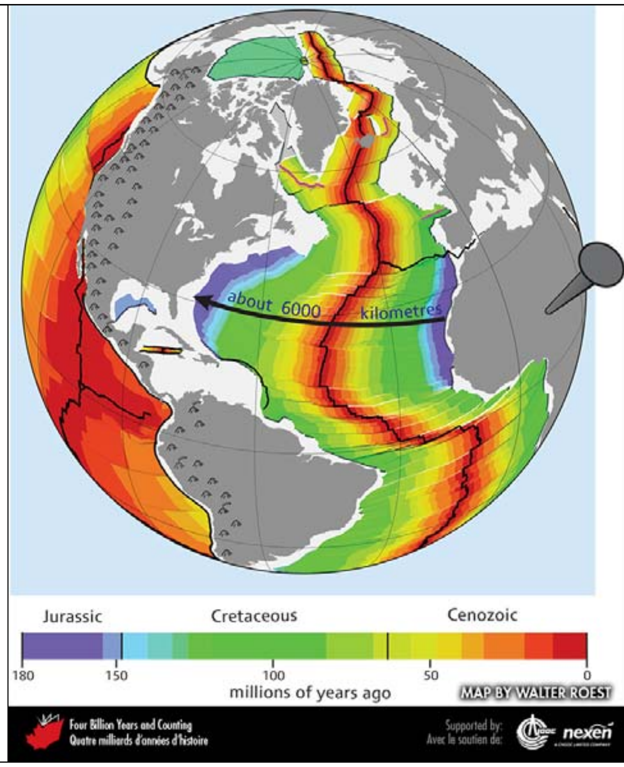
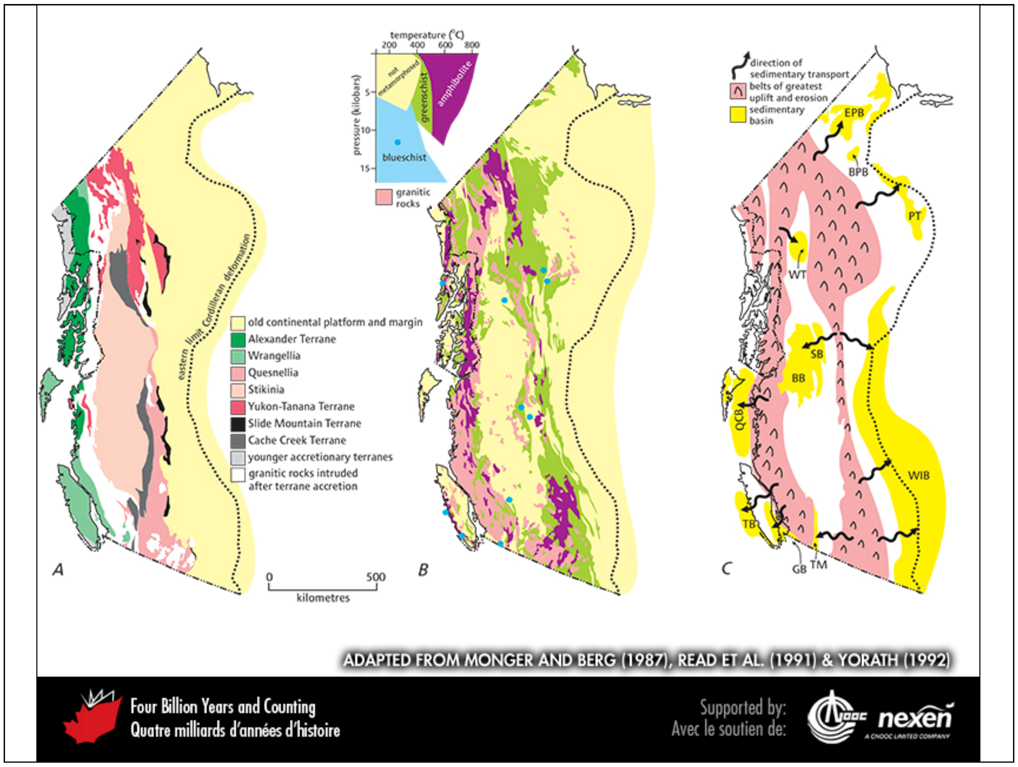


The Atlantic Ocean and bordering continents showing how, over the past 180 million years, this ocean has grown to be over 6,000 kilometres across. The darker grey areas represent modern land, the lighter grey areas represent submerged continental margins underlain by continental crust, and the coloured areas represent oceanic crust of various ages, as indicated in the legend. The black lines represent, in part, plate boundaries. ADAPTED IN PART FROM A GRAPHIC BY WALTER ROEST.

Late Jurassic deltaic sedimentary rocks of the Bowser Basin, southeast of Taft Creek, Skeena Mountains, British Columbia. These rocks were folded during the Cordilleran collisions of the Cretaceous. MARGOT MCMECHAN.



The effects of Mesozoic and early Cenozoic collisions in the Canadian Cordillera and the adjoining part of southeastern Alaska. *A.* The distribution of terranes in the Canadian Cordillera (see Chapter 8). *B.* The distribution and nature (see inset graph) of Mesozoic metamorphic rocks and granitic intrusive igneous rocks produced by Mesozoic collisions, showing their grouping mainly in two largely separate belts. The eastern belt underlies the Columbia, Omineca, and Cassiar mountains of the eastern Cordillera, and the western belt underlies the Coast Mountains. Note how the eastern belt corresponds to the boundary between the inner terranes (including Quesnellia, Stikinia, and Yukon-Tanana) with the old continental margin, and the western belt to the boundary between the inner terranes and the outer terranes (Wrangellia and Alexander). Yellow shading on map represents areas of non-metamorphosed to weakly metamorphosed rocks. *C.* Location of areas of long-term uplift and long-term subsidence: the uplift coincides with areas of metamorphism in *B*, where once deeply buried rocks are now at the surface; and the subsidence is recorded by sedimentary basins. The sedimentary basins include: Bonnet Plume Basin (BPB), Bowser Basin (BB), Eagle Plains Basin (EP B), Georgia Basin (GB), Peel Trough (PT), Queen Charlotte Basin (QCB), Sustut Basin (SB), Tofino Basin (TB), Tyaughton-Methow Basin (TM), Western Interior Basin (WIB), and Whitehorse Trough (WT). *A* IS ADAPTED FROM MONGER AND BERG (1987), COURTESY OF THE US GEOLOGICAL SURVEY; *B* IS FROM READ ET AL. (1991); *C* IS ADAPTED FROM YORATH (1992).

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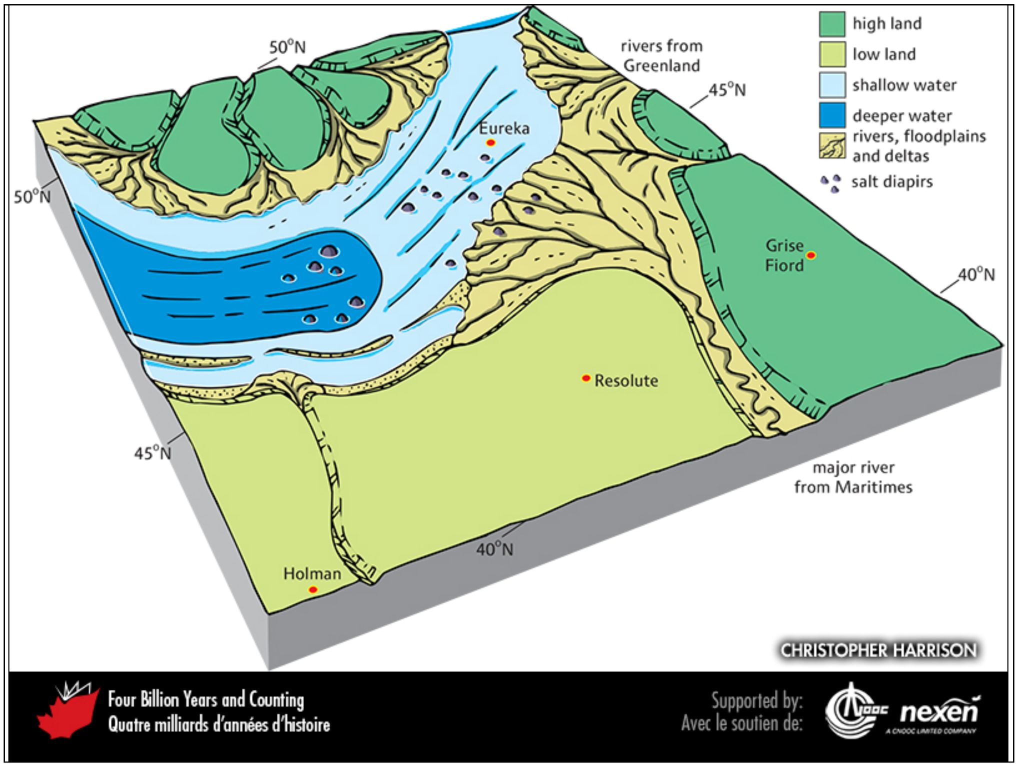

Paleogeography of what was to become the Canadian Arctic in the middle late Triassic to early Jurassic, 215 to 195 million years ago. The approximate locations of Holman, Resolute, Grise Fiord, and Eureka are included to provide a guide for orientation, as well as paleolatitudes. The main feature was the Sverdrup Basin, now dominated by clastic deposition, especially from large deltas.

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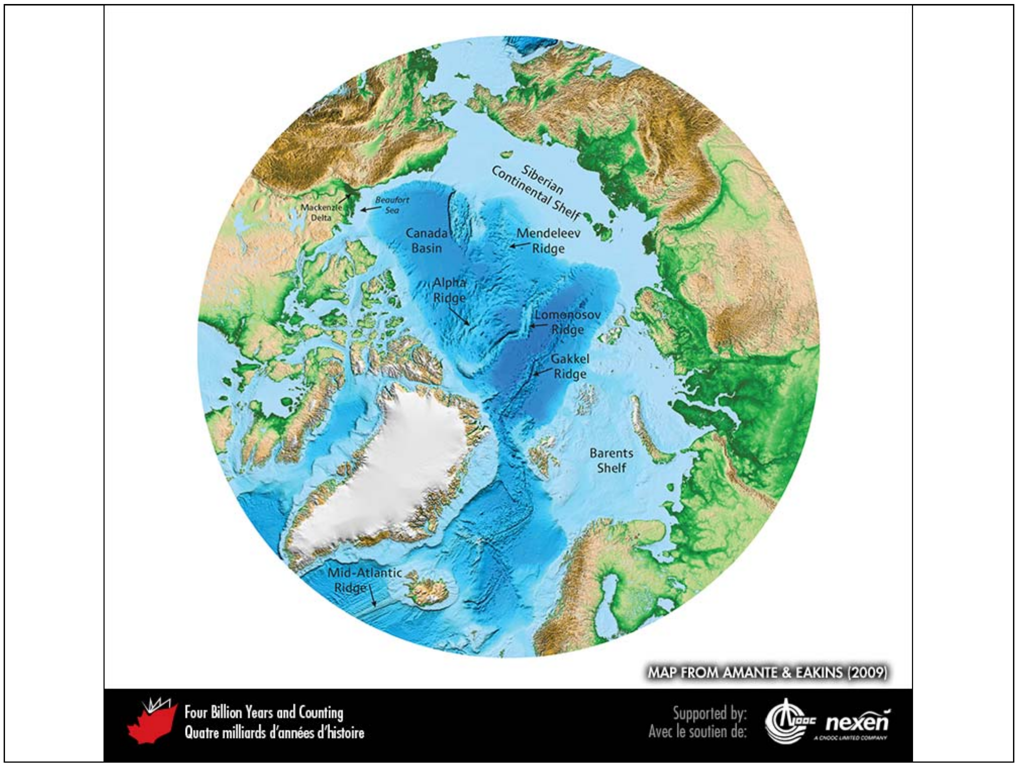
Sea cliffs west of Smith Creek, northwest Ellesmere Island, Nunavut, expose early Triassic light-coloured sandstone and siltstone of shallow marine origin, overlain by dark mudstone of deeper marine origin. ASHTON EMBRY.

Aerial view of cliffs and hoodoos developed in early Cretaceous deltaic sandstone, Ellef Ringnes Island, Nunavut. CAROL EVENCHICK.



Modern bathymetry of the Arctic Ocean and topography of its borderlands. MAP FROM AMANTE AND EAKINS (2009).

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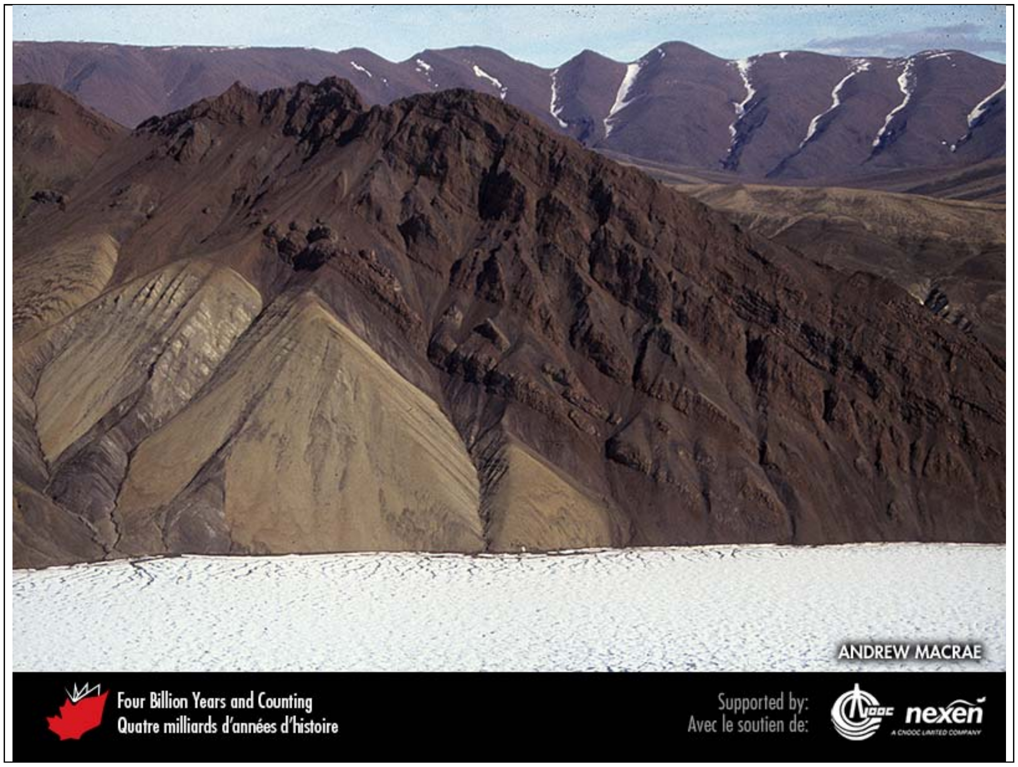

Tilted brown Cretaceous lava flows and pyroclastic rocks overlie lighter-coloured Cretaceous sediments, Kanguk Peninsula, Axel Heiberg Island, Nunavut. ANDREW MACRAE.

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Paleogeography of what was to become North America and adjacent regions in the Cretaceous, 130 million years ago. Land is shown in brown, with shading showing topography. The lighter blue areas represent possible coastal or nearshore areas, darker blue represents deeper ocean waters, and black indicates trenches. Aspects of modern geography are shown for orientation.

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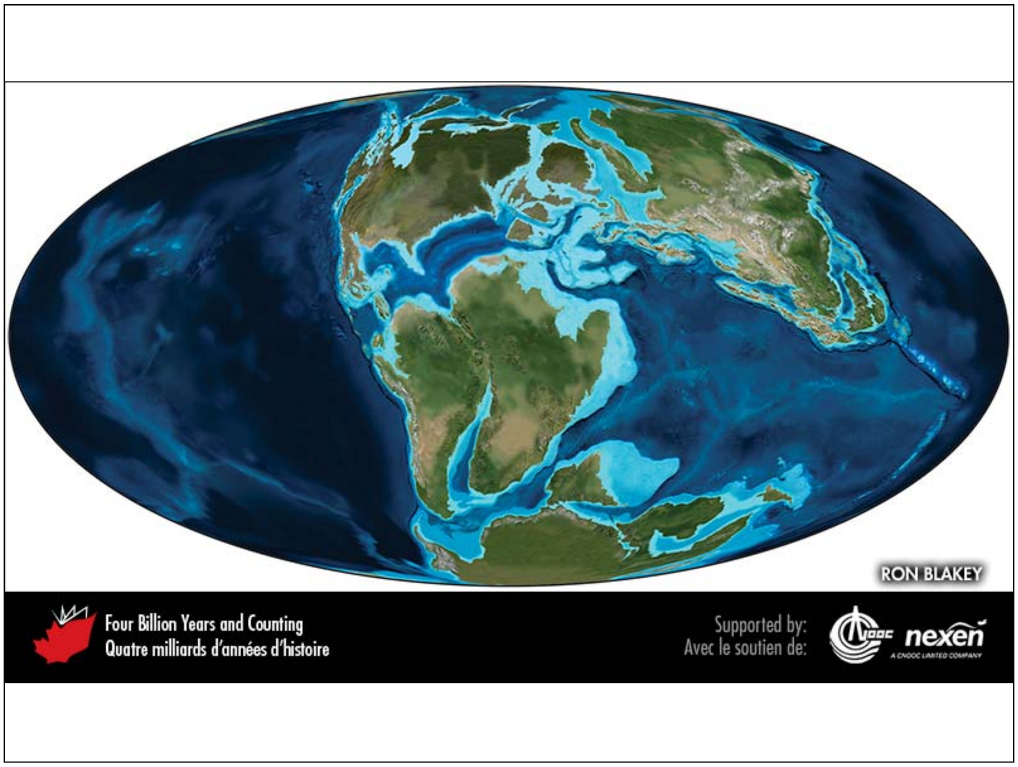

Global paleogeography 130 million years ago, during the early Cretaceous. Colours as for previous figure.

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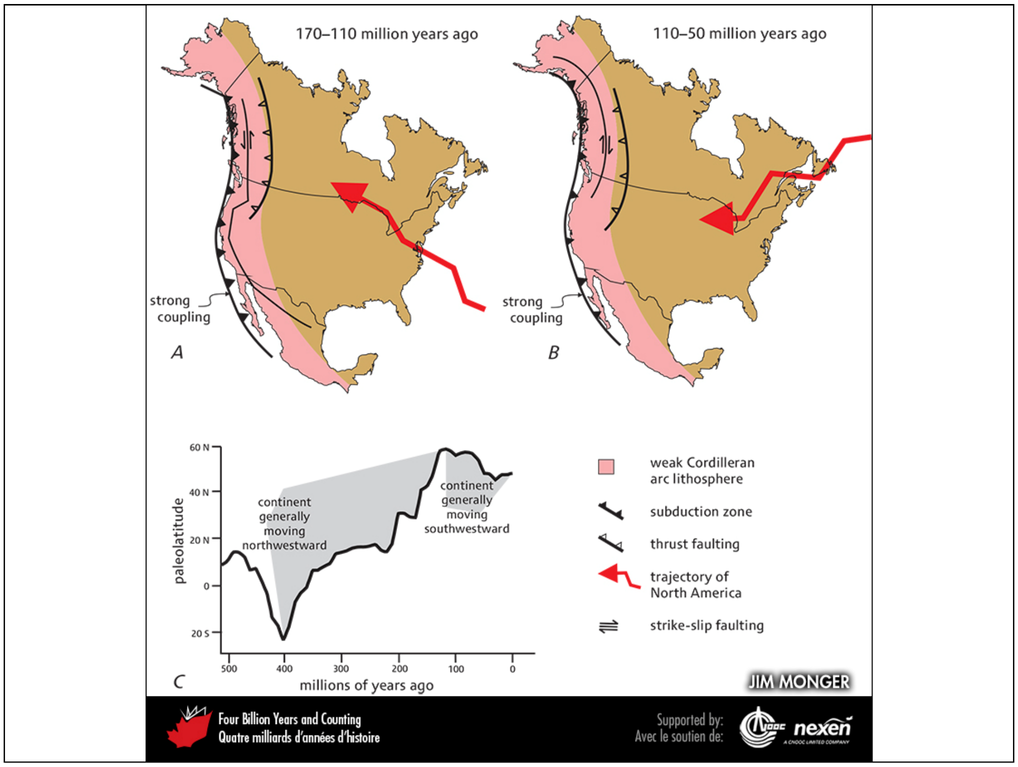

Major structural features of the Cordillera and their relationship to the overall motion of tectonic plates. The fault symbols represent the general situation, not specific faults. The strong compressional force produced by the convergence of the North American Plate on the one side and the plates underlying the Pacific Ocean on the other causes the plates at the boundary to become stuck together (or strongly coupled). As a consequence, the strain was largely taken up by strike-slip faulting within the weak western edge of the North American Plate. From 170 to 110 million years ago, this strike-slip faulting was left lateral, reflecting northward movement of the continent relative to the subduction zone (*A*); from 110 million years ago to the present, faulting has been right-lateral, reflecting southward movement of the continent (*B*). *C* shows paleolatitudes determined from paleomagnetic studies of the continental interior, calculated using the 20- to 30-million year running averages for a point in northwestern Montana (48°N and 115°W).

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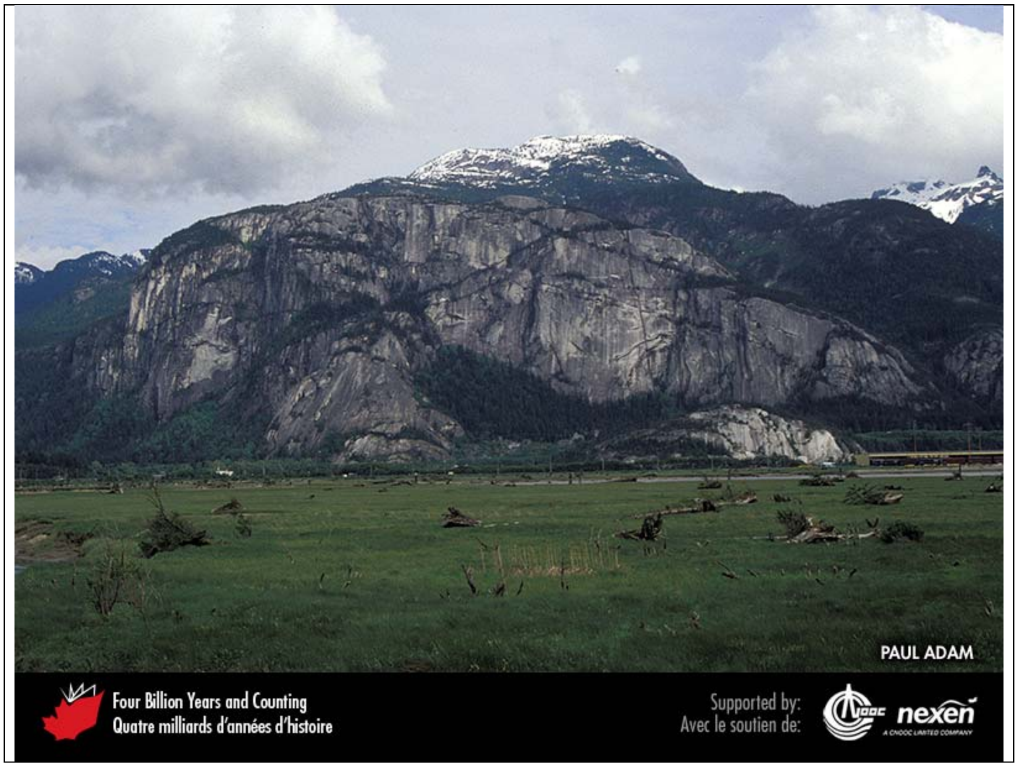
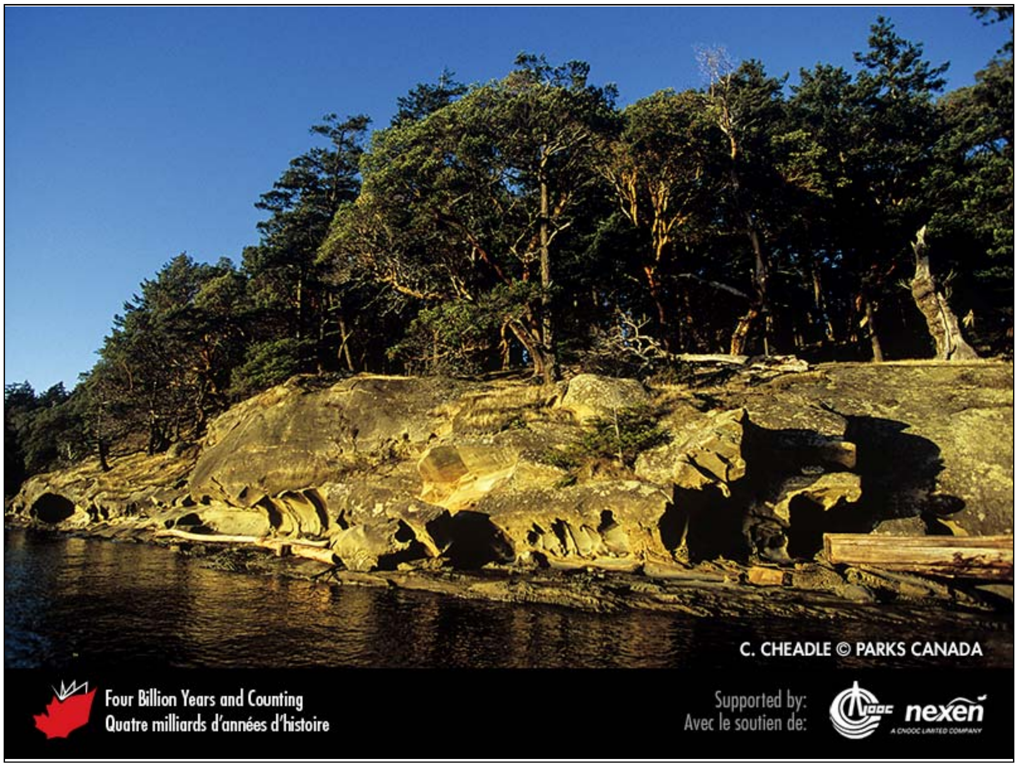


A middle Cretaceous granitic pluton forms the Stawamus Chief (better known as "The Chief"), a rock climbers' mecca, near Squamish, British Columbia. PAUL ADAM.



Cretaceous sandstone of the Georgia Basin, Tumbo Island, Gulf Islands, British Columbia. C. CHEADLE, COPYRIGHT PARKS CANADA.

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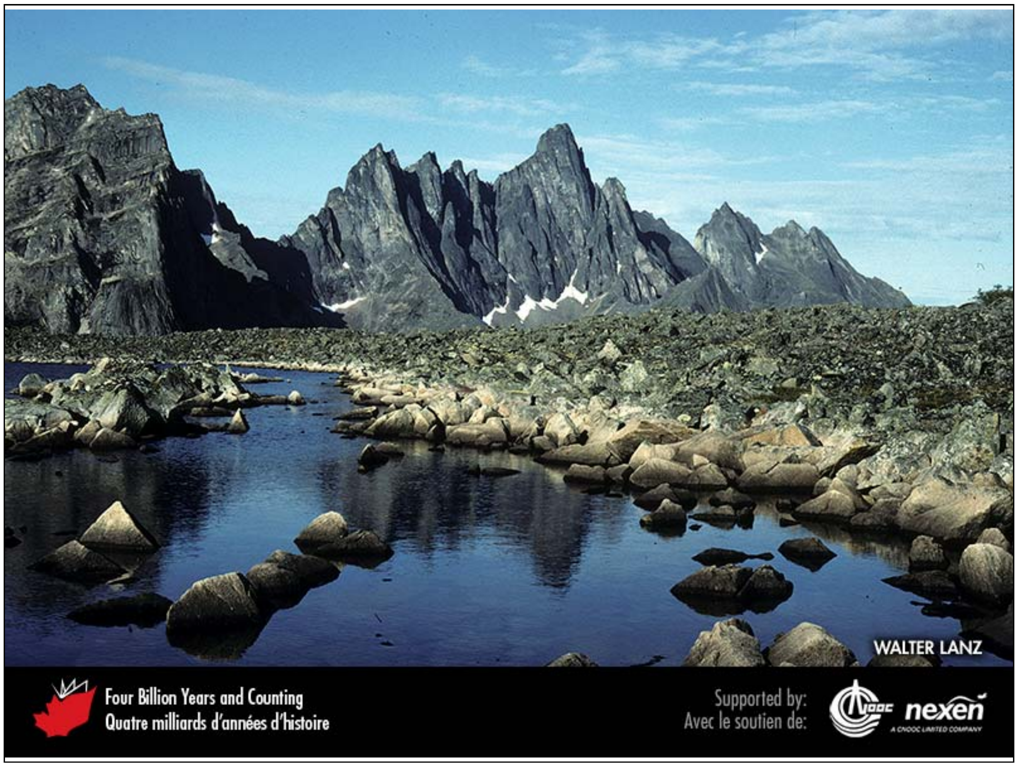

The Tombstone Range, seen from Talus Lake, Yukon, has been eroded from the middle Cretaceous Tombstone Pluton. WALTER LANZ.

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Richard McConnell was the first person to recognize the thrustfaulted and folded structure of the Rocky Mountains. REPRODUCED WITH THE PERMISSION OF NATURAL RESOURCES CANADA 2013, COURTESY OF THE GEOLOGICAL SURVEY OF CANADA.

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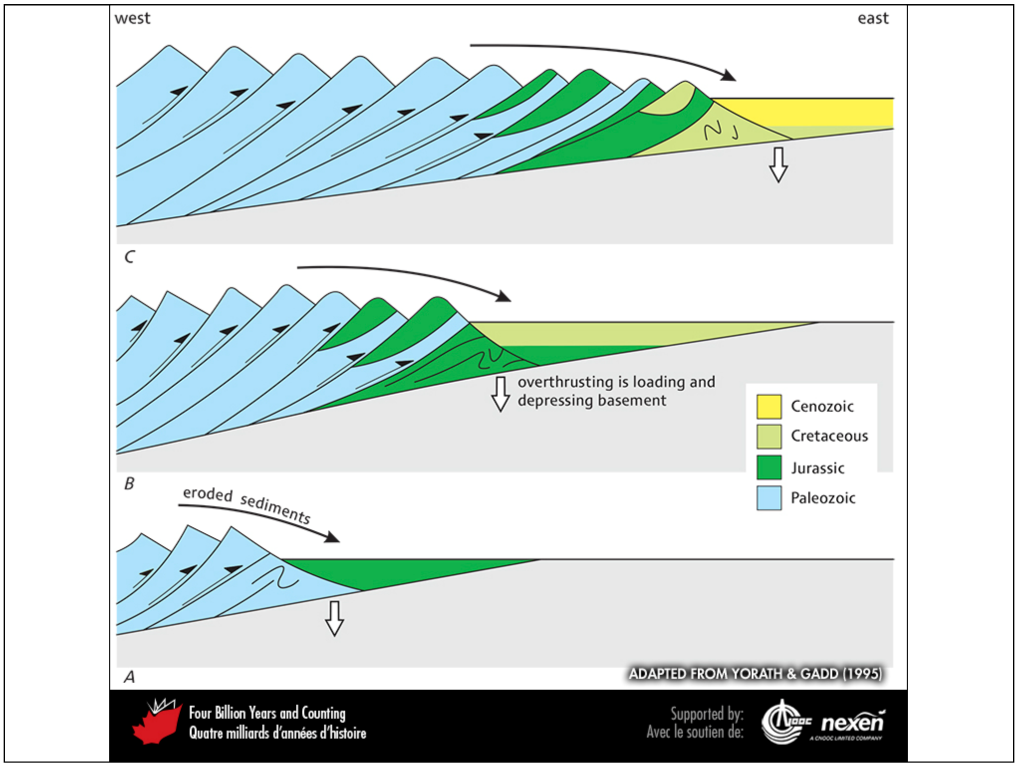
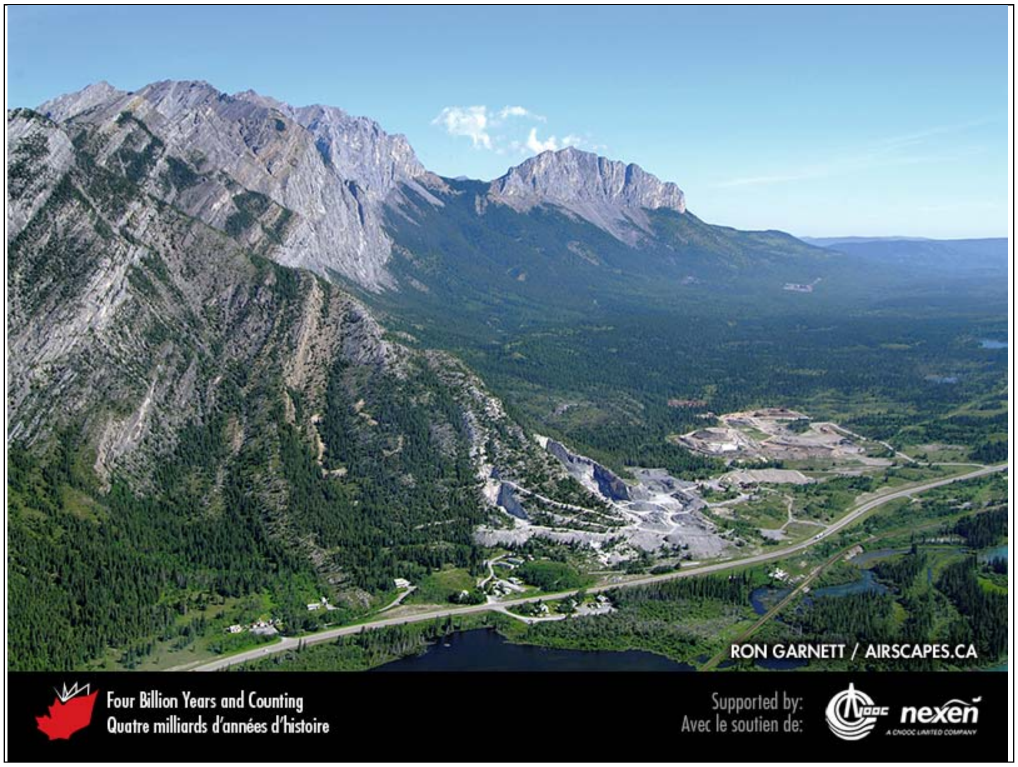


The progressive evolution from Jurassic to Paleocene (*A* to *C*) of the foreland basin in front of the advancing Rocky Mountains. ADAPTED FROM YORATH AND GADD (1995), REPRODUCED WITH PERMISSION OF THE AUTHORS, DUNDURN PRESS, AND NATURAL RESOURCES CANADA.



An aerial view along the Trans-Canada Highway near Exshaw, Alberta. To the left is Door Jamb Mountain and in the right centre Yamnuska (Mount Laurie). The surface trace of the McConnell Thrust is located at the break in the slope on both mountains. This fault places Cambrian carbonate over Cretaceous shale and sandstone (the vegetated areas). RON GARNETT / AIRSCAPES.CA.

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Typical topography of the Rocky Mountain Front Ranges, seen in this view to the northwest from above the Trans- Canada Highway in the Sundance Canyon area, near Banff, Alberta. The landscape reflects the repetition of erosionresistant Paleozoic carbonate strata thrust over more-easily-eroded Mesozoic clastic rocks in the valleys. RAY PRICE.

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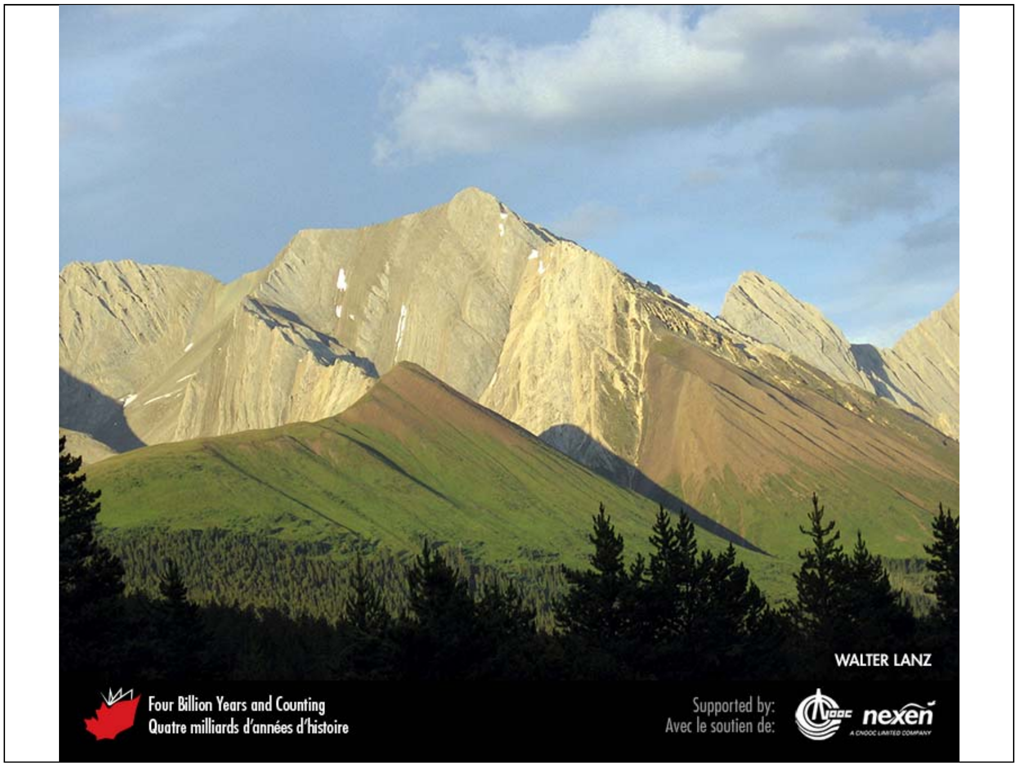
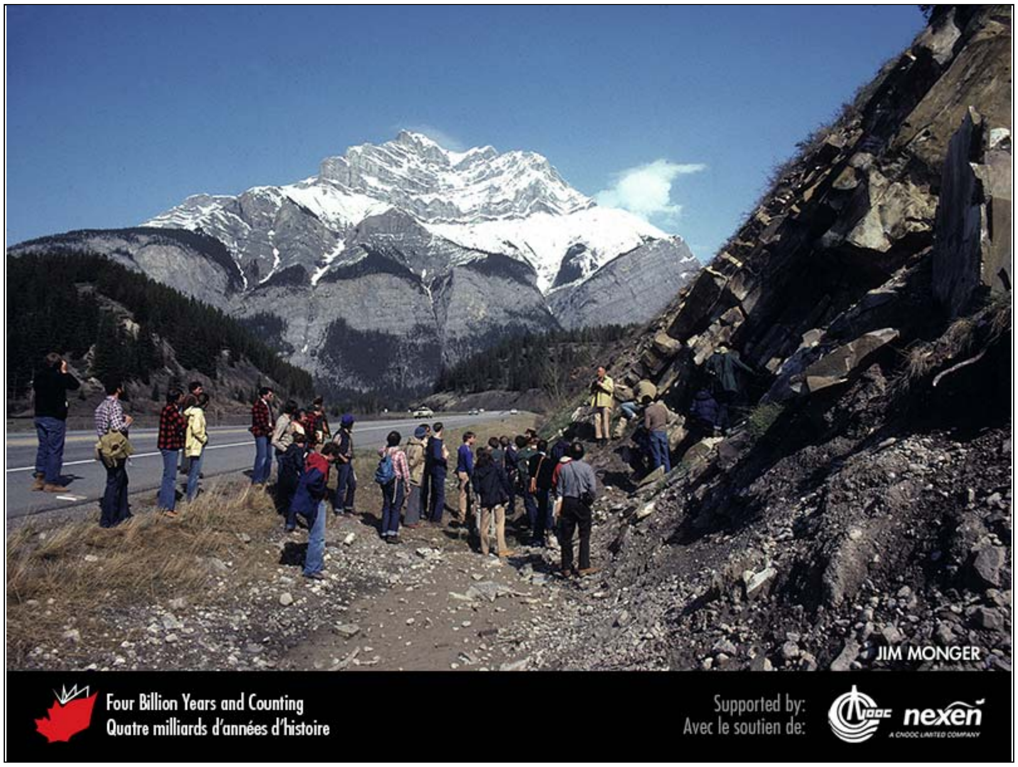


Tilted late Devonian carbonate strata of The Ancient Wall, a mountain in Jasper National Park of Canada, are highlighted by low sunlight. These rocks were moved eastward tens to hundreds of kilometres by thrust faulting during middle Cretaceous to Paleocene times. WALTER LANZ.



Geologists examine tilted Jurassic shale and sandstone on the Trans-Canada Highway east of Banff, Alberta. Cascade Mountain in the background consists of folded Devonian and Carboniferous carbonate strata, which have been thrust over the Jurassic strata. JIM MONGER.

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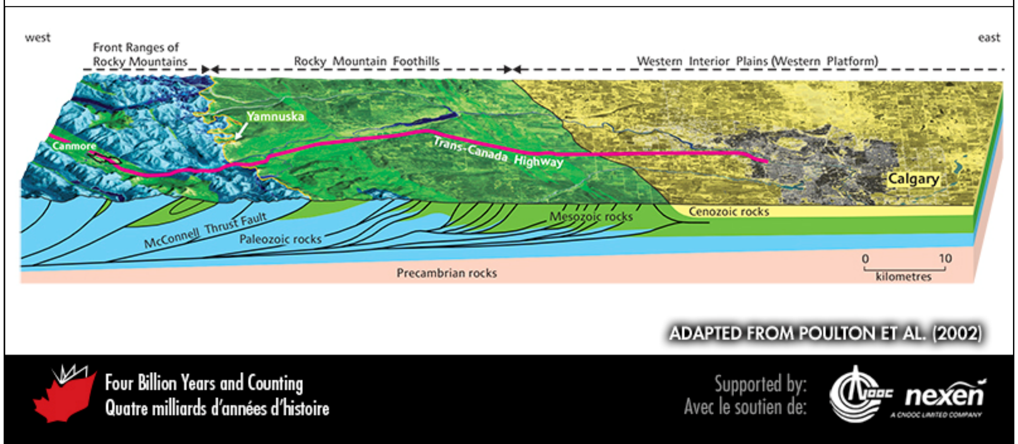

The Rocky Mountain thrust-and-fold belt in southern Alberta, showing a generalized section through the Rocky Mountains and Western Interior Plains around and west of Calgary. The section shows the deformed edge of the former continental margin now underlying the Rocky Mountains, transitioning eastward to relatively undeformed rocks beneath the Plains. Paleozoic rocks (blue) thicken significantly westward; eastward they continue across the Plains beneath a cover of Mesozoic (green) and Cenozoic (yellow) strata. The mountains coincide generally with the area where the harder Paleozoic rocks reach the surface, a region bounded to the east by the McConnell Thrust Fault (orange line). The Foothills, between the Fault and Calgary, are underlain by deformed, but relatively easily eroded, Mesozoic strata. ADAPTED FROM POULTON ET AL. (2002).

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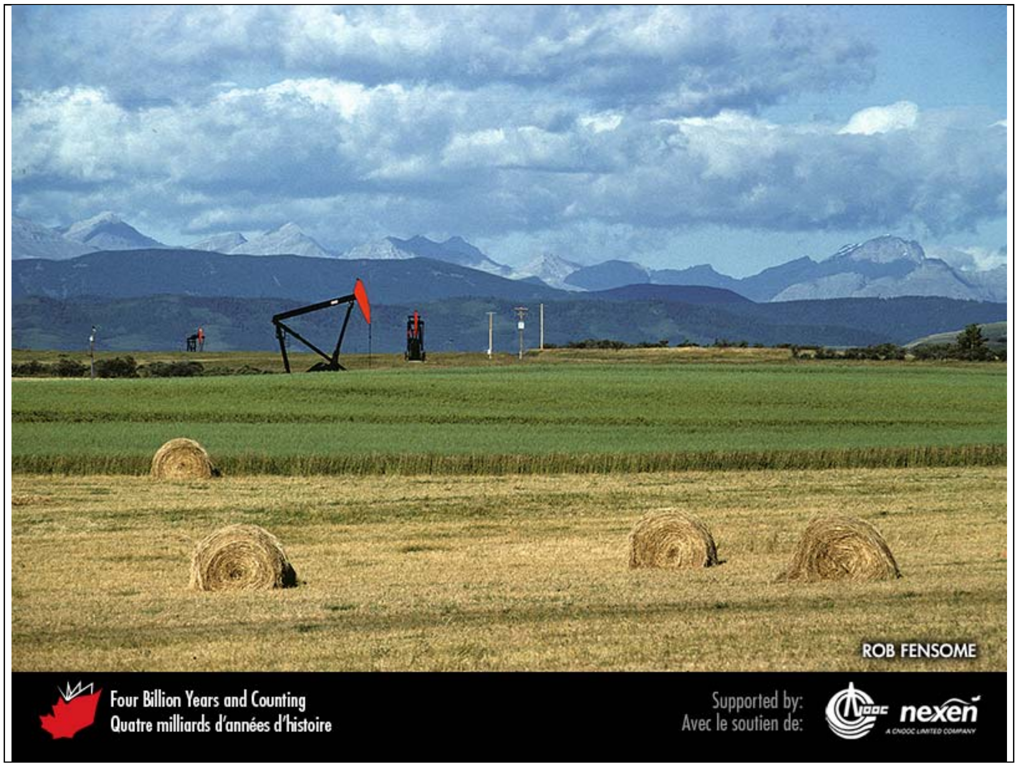

South of Calgary, Alberta, plains and rolling foothills are underlain by less resistant, but still deformed, Mesozoic clastic sediments. On the horizon are distant peaks of the Front Ranges underlain by more resistant Paleozoic carbonates. Also evident are signs of two of Alberta's major industries, petroleum and farming. ROB FENSOME.

The lighter-coloured sandstone in this roadcut at Pink Mountain, British Columbia, represents the channel deposits of a river that flowed in the Western Interior Basin sometime during the middle Cretaceous. DARREL LONG.

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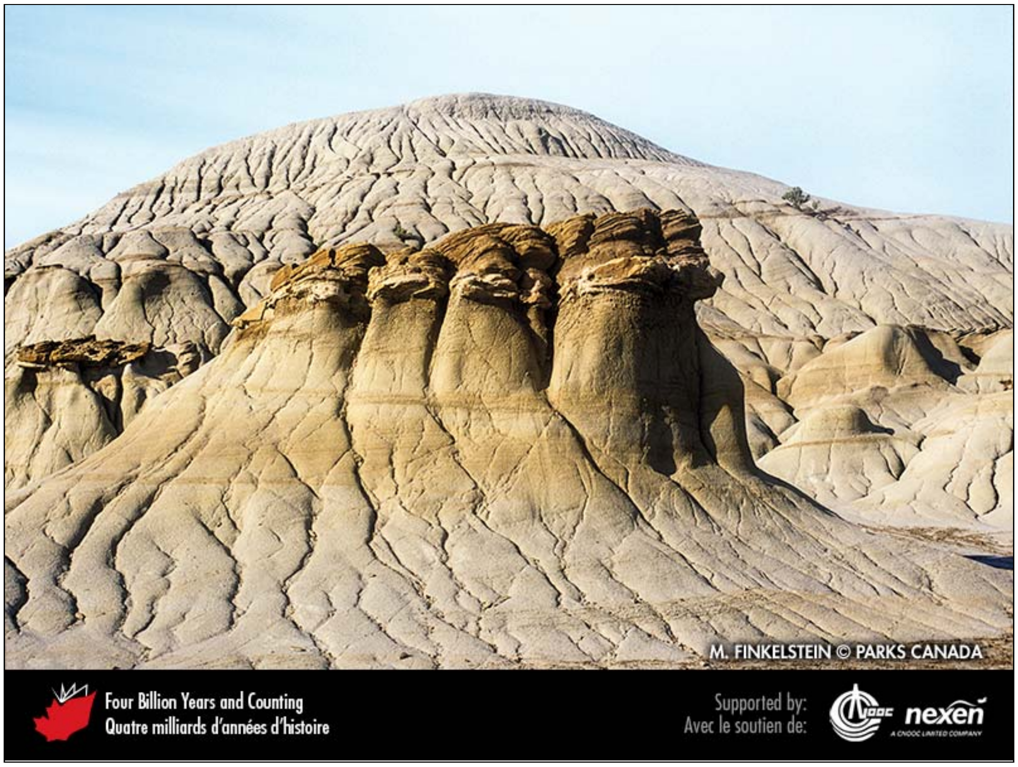
Part 4 of 4

Cretaceous tidal deposits associated with the Bearpaw Sea, near Drumheller, Alberta. The rhythmic layering of the sediment reflects daily tidal cycles. ANDREW MACRAE.

Tilted late Jurassic strata along the Trans-Canada Highway, just east of Banff, Alberta. These rocks were deposited in the Western Interior Basin. They represent a transition from marine to non-marine environments and are part of the first major influx of clastic sediments eroded from the rising Cordillera to the west. JIM MONGER.



Late Cretaceous strata in Dinosaur Provincial Park, Alberta, have been sculpted into interesting shapes by erosion. M. FINKELSTEIN, COPYRIGHT PARKS CANADA.

Paleogeography of what was to become North America and adjacent regions in the late Cretaceous, 85 million years ago. Land is shown in brown, with shading showing topography. The lighter blue areas represent possible coastal or nearshore areas, darker blue represents deeper ocean waters, and black indicates trenches. Aspects of modern geography are shown for orientation.

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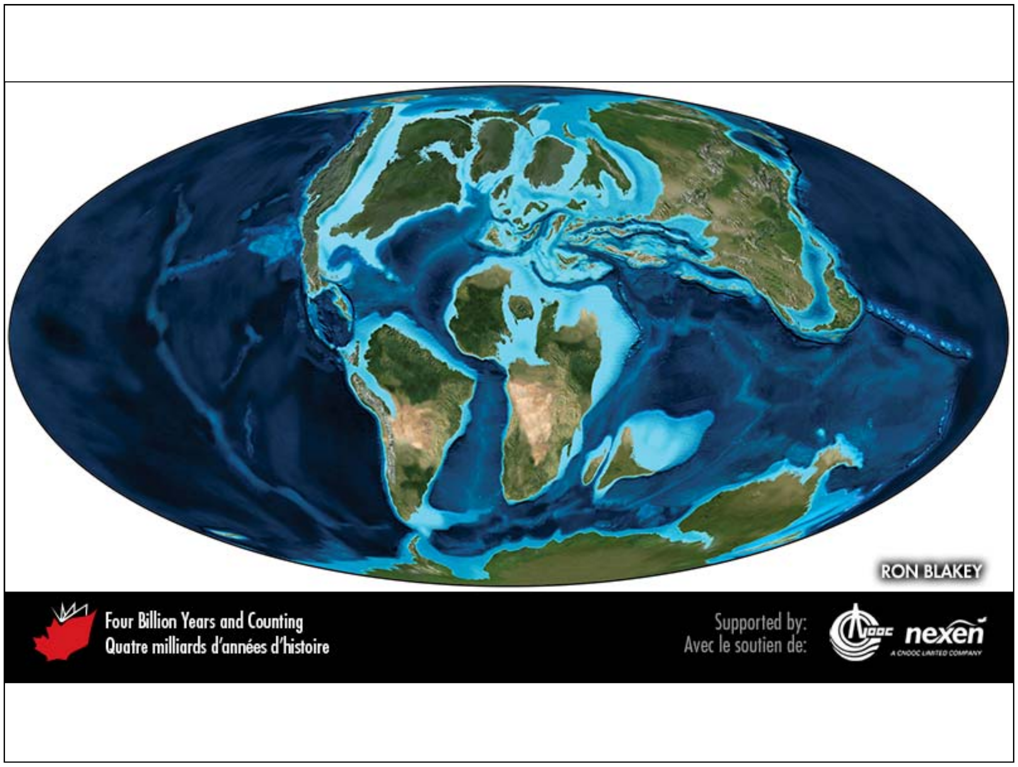

Global paleogeography 85 million years ago, during the late Cretaceous. Colours as for previous figure.

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Small pockets of early Cretaceous deposits, rarely exposed at the surface, occur in the Maritimes. Some of the white fluvial sand and gravel from this quarry, south of Sussex, New Brunswick, is used for sand traps on golf courses. ROB FENSOME.

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Aerial view of Mont Rougemont (the forested area at bottom left), one of the Monteregian Hills of Quebec. ROB FENSOME.

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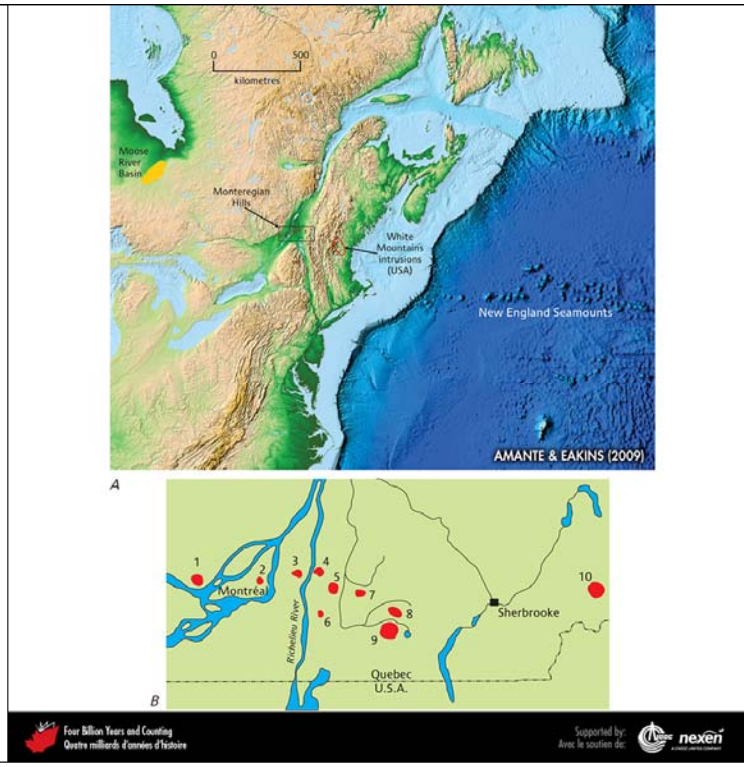

A shows parts of eastern North America and the western North Atlantic including the location of the offshore New England Seamounts, the White Mountain intrusions in New England, the Monteregian Hills in Quebec, and the Moose River Basin in northern Ontario. *B*, represented by the box in *A*, shows the distribution in southern Quebec of the Monteregian Hills: 1 = Oka, 2 = Mount Royal, 3 = Mont Saint-Bruno, 4 = Mont Saint-Hilaire, 5 = Mont Rougemont, 6 = Mont Saint-Grégoire, 7 = Mont Yamaska, 8 = Mont Shefford, 9 = Mont Brome, 10 = Mont Mégantic. ADAPTED FROM VARIOUS SOURCES.

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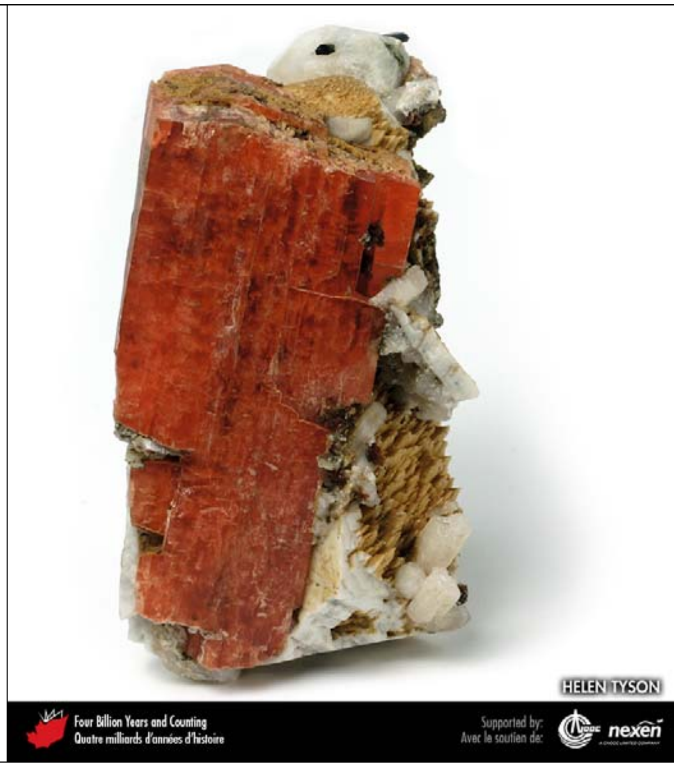

The igneous rocks that form the Monteregian Hills are a source of rare minerals, such as this specimen of orange serandite from Mont Saint-Hilaire, Quebec. HELEN TYSON, FROM THE COLLECTION OF HELEN AND ROD TYSON.

An excavated bone bed in Dinosaur Provincial Park, Alberta. DAVID EBERTH.

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Cretaceous-Tertiary boundary layers at the base of a coal bed, Wood Mountain Creek, south-central Saskatchewan. The thin white layer, which marks the boundary, was originally a layer of glass beads derived from rock that melted during the asteroid impact event but is now weathered to kaolin clay, a white aluminum-rich clay. The overlying rusty-brown to dark grey impact layers (1 to 1.5 centimetres thick) are enriched in iridium and contain shocked quartz (Box 11). ART SWEET.

Ferns proliferated within weeks to months following the asteroid strike at the end of the Cretaceous, much as they do today after a forest fire. This scene is near Halifax, Nova Scotia. ANDREW MACRAE.