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CAMBRIAN GEOLOGY AND PALEONTOLOGY

No. 7.—PRE-CAMBRIAN ROCKS OF THE BOW RIVER VALLEY, ALBERTA, CANADA

WITH THREE PLATES

BY

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By CHARLES D. WALCOTT

(With Three Plates)

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INTRODUCTION

During the summer of 1909 I continued my study of 1907[1] on the Cambrian formations of the main range of the Rocky Mountains on the line of Bow Valley, in Alberta, with the view of discovering a base to the Fairview formation of the Lower Cambrian, and, if possible, of finding fossils in the shales and sandstones beneath that formation in the Bow Valley. When measuring the Cambrian sandstone on the northeast slopes of Mount Fairview and Saddle Mountain, about 2.5 miles southwest of Laggan, a fine quartz conglomerate about 100 feet in thickness was found, and below it a gentle, forest-

[1] Smithsonian Miscellaneous Collections, vol. 53, No. 5, 1908, Cambrian Sections of the Cordilleran Area, pp. 204–217.

covered débris slope without rock outcrops. Knowing that there were shales and sandstones in the Bow Valley to the northwest, I went up on the slopes of Mount Saint Piran, and from there examined with a strong field-glass the valley and mountains to the northeast. I could see that the Fairview sandstone formed a cliff on Mount Hector and Fort Mountain above slopes that were evidently clear of débris, and that there was a marked change in the character of the rock where the cliff and slope met. A week was next spent at Fort Mountain and vicinity, and, with the information secured there as to the presence of a massive bedded conglomerate at the base of the Fairview formation, a trip was made along the southwest side of Bow Valley in search of contacts between the basal conglomerate and the shales beneath. It was found that the lower slopes and bottom of Bow Valley from Hector Lake to the vicinity of Cascade Station, on the Canadian Pacific Railway, were underlain by pre-Cambrian shales and sandstone formations, to which the names Hector and Corral Creek are applied in this paper. These rocks were formerly referred to the Bow River group of the Cambrian by Mr. R. G. McConnell.[2]

TOPOGRAPHY OF BOW VALLEY

The Bow Valley heads at Bow Pass, and for the first 10 miles of its course it appears to be deeply excavated in the limestones and sandstones of the Cambrian formations. Southeast of Bow Peak the floor of the valley attains a width of two miles; it is joined from the west by the flat of Hector Lake, and from this point the valley is broadly U-shaped in profile, with high mountain fronts on either side. This is illustrated by figure 1, plate 45. This profile is continued to the southeast for about 35 miles to where the ridges of the Sawback Range and the mass of Pilot Mountain on the north, and of Mount Bourgeau on the south, crowd the sides of the valley toward the river; from here to Banff it is deep and narrow. The valley is evidently one of pre-glacial origin that has been widened and shaped by the passage of a great glacier into which lateral glaciers flowed from the side canyons. Rounded hills and ridges of gravel and clay record glacial deposits and subsequent stream erosion.

I find in my field note-book the following: "The view from Fairview Mountain, 3,000 feet above Lake Louise, is a most extended

[2] Annual Rept., Geol. and Nat. Hist. Survey Canada, for 1886, Part D, p. 15 D, 1887.

Fig. 1. PANORAMIC VIEW LOOKING ACROSS THE BOW VALLEY FROM

is view shows on the left Mount Aberdeen and the Victoria Glacier, Mounts Whyte and St. Piran, and to
(Photograph b

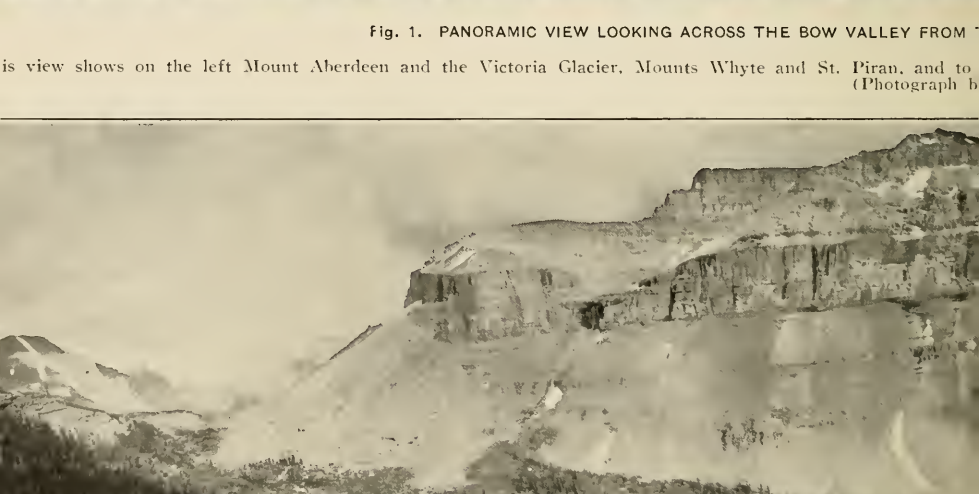


Fig. 2. VIEW OF FORT MOUNTAIN FROM THE WEST SIDE OF CO

e high, massive Cambrian limestone cliffs of the upper half of the mountain and the broken sandstone cliffs bel
by C. D.

V HILLS ABOUT 2 MILES NORTHEAST OF LAGGAN, ALBERTA, CANADA

t of the center Mounts Bosworth and Daly, also in the foreground the broad, almost flat, bottom of the valley. Walcott, 1909.)

REEK, 4.5 MILES NORTHEAST OF LAGGAN, ALBERTA, CANADA

rast strongly with the rounded hills and slopes of pre-Cambrian rocks shown by figure 1, plate 46. (Photograph , 1909.)

Fig. 1. PANORAMIC VIEW LOOKING ACROSS THE BOW VALLEY FROM THE OW HILLS ABOUT 2 MILES NORTHEAST OF LAGGAN, ALBERTA, CANADA

The view shows on the left Mount Aberdeen and the Victoria Glacier, Mounts Whyte and St. Piran, and to the right of the center Mounts Bosworth and Daly, also in the foreground the broad, almost flat, bottom of the valley. (Photograph by C. D. Walcott, 1909.)

Fig. 2. VIEW OF FORT MOUNTAIN FROM THE WEST SIDE OF [illegible] CREEK 4.5 MILES NORTHEAST OF LAGGAN, ALBERTA CANADA

The high massive Cambrian limestone cliffs at the [illegible] contrast strongly with the rounded hills and slopes of pre-Cambrian rocks [illegible] plate 46. (Photograph 1909.)

and beautiful one. To the north and far below lies the broad valley of the Bow, which stretches to the southeast toward Banff and northwest to the beautiful Hector Lake. Rising above the valley on the northeast rugged mountains extend in massive ridges and high peaks from Mount Hector to Mount Richardson, and southeastward to the great wall of Castle Mountain and the serrated Sawback Range. Farther to the southeast are the high points of the Bourgeau Range west of Banff, and beginning with Mount Temple and arching to the south and southwest there is a superb panorama of high mountains, glaciers, and crested walls, such as is rarely seen in any land. As a study in glaciation and topographic forms it is unexcelled, and is well worth a journey across the continent to see."

Panoramic photographs taken from high on the mountains on both sides of the valley show that the valley has been excavated on the northeast slope of a broad, broken anticlinal arch. The general average height of the peaks and ridges as they are massed against the horizon indicates a base-leveling of the region prior to the period of uplift and erosion that has developed the present topography.

The topographic forms resulting from the erosion of the Cambrian rocks are well shown on all the higher mountains adjoining the valley—Mounts Temple, Aberdeen, Victoria, and Hector. Fort (fig. 2, pl. 45) and Castle mountains are capped by high, precipitous cliffs of limestone underlain by alternating slopes of shale and broken cliffs of sandstone for 2,000 feet or more down to the low cliff formed by the Fairview sandstone or its basal conglomerate. Below this cliff the pre-Cambrian shales and sandstones form smooth slopes and irregular, rounded hills and ridges with bands of gray, purple, and greenish shales. These are well shown southeast of Mount Hector and the ridges south of Mount Richardson and Fort Mountain (fig. 2, pl. 46). The contrast of topographic form between the Cambrian and pre-Cambrian rocks is finely illustrated by Fort Mountain (fig. 2, pl. 45) and the area just south of it (fig. 2, pl. 46), and it first led me to suspect the presence of pre-Cambrian rocks in this area.

BASAL CAMBRIAN ROCKS

The conglomerate at the base of the Fairview formation is massive bedded and usually formed of small quartz pebbles in a coarse sandstone matrix. At Fort Mountain it is over 300 feet thick and extends northwest and southeast for a long distance. The white quartz pebbles here vary from 2 mm. to 10 cm. in diameter (average 10-15 mm.), and are mixed near the base of the conglomerate with rounded

and angular pebbles (fragments) of the dark siliceous shales of the subjacent Hector formation; also of the siliceous and hard greenish shale that occurs from 520-640 feet below, and the reddish and chocolate-colored, arenaceous shale 640 feet or more below the base of the Cambrian.

Two and one-half miles north of Fort Mountain, at the east foot of Ptarmigan Peak, the basal conglomerate is only 170 feet thick, while on Mount Temple, 8 miles southeast of Fort Mountain, it is represented by a few thin layers of fine conglomerate interbedded in a massive-bedded, fine-grained sandstone.

On the north slope of Vermilion Pass, east of Boom Mountain, 11 miles southeast of Mount Temple, the conglomerate occurs in massive beds that form a series 200 feet and more in thickness.

The variation in thickness of the basal Cambrian conglomerate seems to indicate that the pre-Cambrian surface over which it was deposited was broadly irregular.

UNCONFORMITY BETWEEN THE CAMBRIAN AND THE PRE-CAMBRIAN ROCKS

Viewed in a restricted way, much of the pre-Cambrian surface was regular and the Cambrian rocks appear to be conformable to the subjacent pre-Cambrian strata. All about the sides of the valley the strata of the two formations, Fairview of the Cambrian and Hector of the Algonkian, dip away at about the same angle, but, when we apply the test of the varying thickness of the basal Cambrian conglomerate and the difference in the character of the upper beds of the Algonkian in different places, we at once become aware that the pre-Cambrian surface is more or less irregular, and that when the Cambrian sea transgressed over the area now included in the Bow Valley it found a broadly irregular surface with low hills and broad level spaces covered with a deep mantle of disintegrated rock. It washed out the muds and carried them away and deposited the sand and pebbles of its advancing beaches over and around the irregularities of the pre-Cambrian surface.

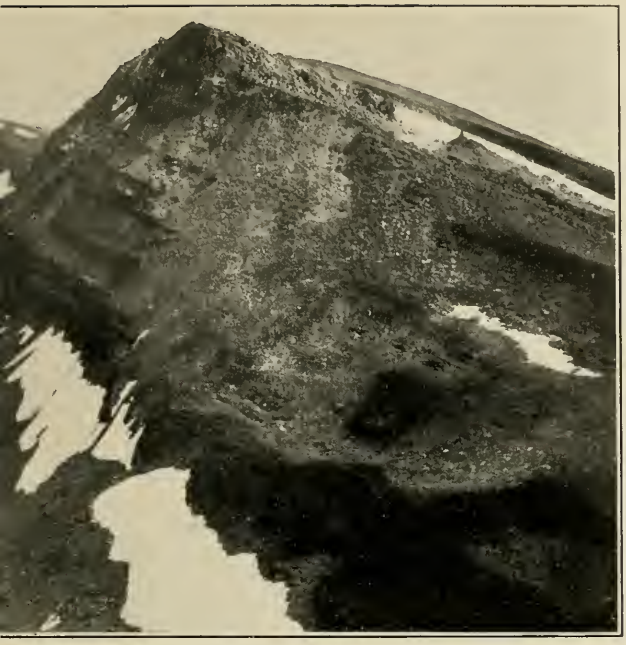
The unconformity is well shown at Fort Mountain, where the basal Cambrian is formed of massive layers 4-10 feet thick, which usually rest directly on the Hector shale (pre-Cambrian). In places, however, slight hollows in the shale are filled with thin layers of a more or less ferruginous sandstone that was deposited by gentle currents prior to the deposition of the massive conglomerate layers. The lower 10-20 feet of this conglomerate contains rounded and

Fig. 1. VIEW FROM THE NORTH OF THE RIDGE SOUTHEAST OF THE LOW
NORTHEAST OF LAG

The upper edge of the snow banks about half way down the slope of th
the pre-Cambrian arenaceous shales of the Hecto

Fig. 2. PANORAMIC VIEW FROM THE SOUTH SLOPE OF FORT MOUNTAIN LOOKING TO THE SO

e lower dark cliff in the mountain on the left is formed by the basal conglomerate of the Cambrian. Below, t
sandstones of the Corral Creek formation overlain by the shales of the Hector formation. In the distance on
909.)



OF PTARMIGAN LAKE AND NORTHEAST OF FORT MOUNTAIN, 6 MILES
BERTA, CANADA

marks the line of contact of the Cambrian basal conglomerate with
tion. (Photograph by C. D. Walcott, 1909.)

AST AND SOUTH FROM A POINT 4 MILES NORTHEAST OF LAGGAN, ALBERTA, CANADA

e is formed of the arenaceous shales of the Hector formation. The rounded hills in the foreground are forme
ht are the high peaks of the Bow Range on the southwest side of the Bow Valley. (Photograph by C. D. Wal

Fig. 1. VIEW FROM THE NORTH OF THE RIDGE SOUTHEAST OF THE LOWER END OF PTARMIGAN LAKE AND NORTHEAST OF FORT MOUNTAIN, 6 MILES NORTHEAST OF LAGGAN, ALBERTA, CANADA

The upper edge of the snow banks about half way down the slope of the ridge marks the line of contact of the Cambrian basal conglomerate with the pre-Cambrian arenaceous shales of the Hector formation. (Photograph by C. D. Walcott, 1909.)

Fig. 2. PANORAMIC VIEW FROM THE SOUTH SLOPE OF FORT MOUNTAIN LOOKING TO THE NORTHEAST AND SOUTH FROM A POINT 4 MILES NORTHEAST OF LAGGAN, ALBERTA, CANADA

The lower dark cliff in the mountain on the left is formed by the basal conglomerate of the Cambrian [illegible] is formed of the arenaceous shales of the Hector formation. The [illegible] of the sandstones of the Corral Creek formation overlain by the shales of the Hector formation. In the [illegible] are the high peaks of the Bow Range on the [illegible] Bow Valley. (Photograph by C. D. Walcott, 1909.)

angular fragments of the subjacent pre-Cambrian formations (fig. 1, pl. 46). The Cambrian sea was evidently transgressing across the dark siliceous shales of the pre-Cambrian land and reducing them to rolled pebbles, angular fragments, and mud. The mud gave origin to small lentiles of shale similar in character to the shale below the unconformity, while lentiles of sandstone of greenish tint indicate that fine material was being derived from still older pre-Cambrian formations than the shale.

On the southwest side of the Bow Valley the Fairview formation extends well down on the wooded slopes, but I know of no exposure showing the contact of its basal conglomerate with the underlying Hector shale north of Mount Temple. East of Mount Bosworth the contact of the Cambrian and pre-Cambrian appears to be in the valley just north of Stephen on the Continental Divide.

Of greater importance is the evidence that the sediments of the two periods were deposited under different physical conditions. The Cambrian sandstones are composed of clean, well-washed grains, and the Cambrian calcareous and argillaceous shales were deposited as muds offshore along with the remains of an abundant marine life. The Hector shales of the pre-Cambrian are siliceous and without traces of life; the sandstones are impure and dirty, with the quartz grains a dead milky white, or glassy and iron stained. The sediments forming them were evidently deposited in relatively quiet muddy waters, and I think in fresh or brackish waters.[3]

I do not compare the limestone formations, as they are 2,000 feet or more above the plane of unconformity in the Cambrian, and below the Hector-Corral Creek series in the Algonkian.

PRE-CAMBRIAN ROCKS

The distribution of the pre-Cambrian rocks in the Bow Valley is outlined on the accompanying map (pl. 47). They extend throughout the bottom and lower slopes of the valley from Bow Peak to Cascade, on the Canadian Pacific Railway, about 7 miles west of Banff. East of Mount Hector and in the Mount Richardson-Ptarmigan Peak mass they rise in high hills both east and west of Pipestone River, and continue eastward across Corral and Baker creeks before passing beneath the Cambrian, on the south slopes of Castle Mountain.

[3] This view will be presented more fully in a paper on "The Abrupt Appearance of the Cambrian Fauna in North America" that I have prepared for presentation at the meeting of the International Geological Congress at Stockholm in August, 1910.

At the south end of Fort Mountain the descending section beneath the Cambrian conglomerate is as follows, as measured on the east side of Corral Creek Canyon, 4 miles northeast of Laggan:

CAMBRIAN CONGLOMERATE

Unconformity

ALGONKIAN

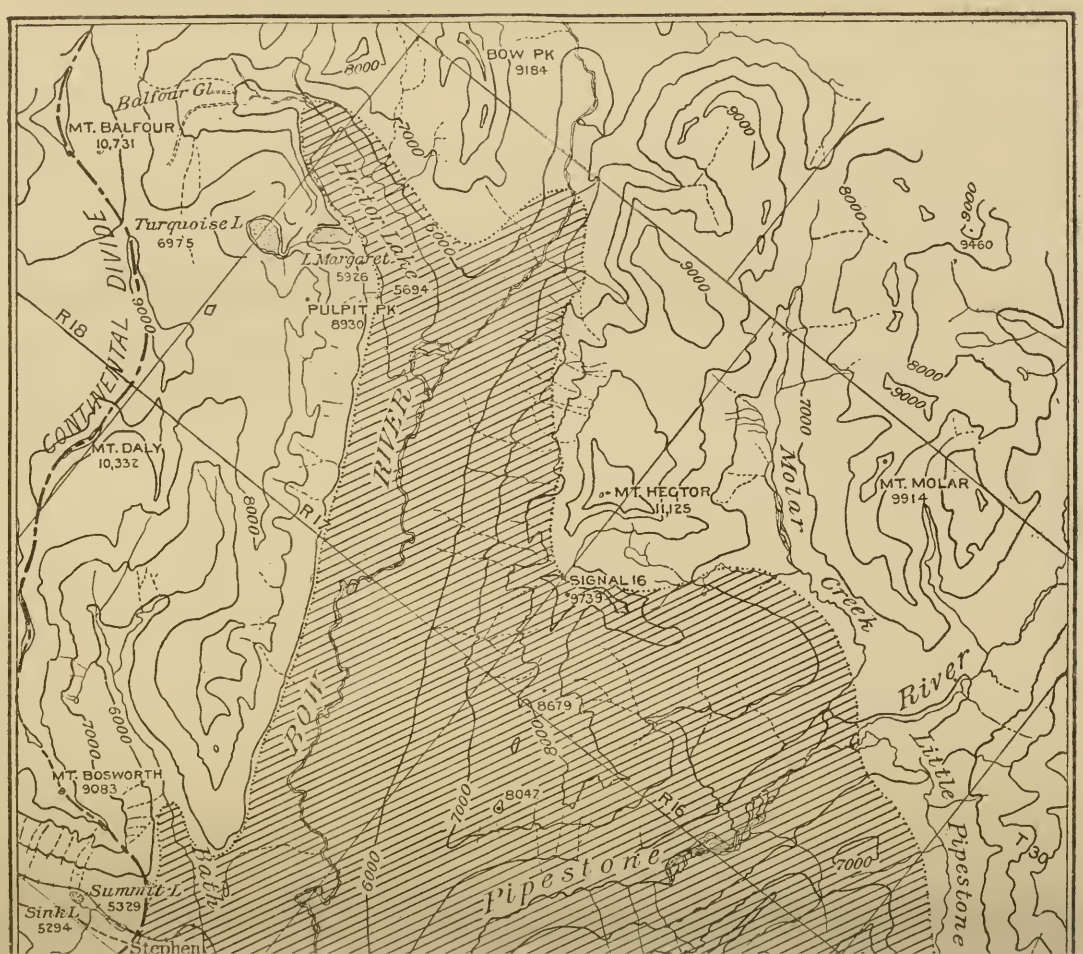
HECTOR FORMATION:

	Feet
1. Dark-gray to black, finely arenaceous (siliceous) shale breaking down on weathered slopes, or sometimes forming low ragged cliffs beneath conglomerate. Upper surface slightly eroded..	520
2. Greenish, finely arenaceous shale, with bands of reddish-colored shale. At 110 feet down a layer of fine interformational conglomerate occurs, with a finely arenaceous, greenish-colored matrix that includes thin layers of pinkish, compact limestone that weathers more rapidly than the matrix.....	120
3. Purple-colored, finely arenaceous or siliceous shale.....	140
4. Greenish-colored, finely arenaceous or siliceous shale.....	40
5. Massive-bedded conglomerate. Matrix a coarse sandstone, with quartz pebbles and fragments of gray pinkish limestone..... This is evidently a deposit made from material brought down by a river reaching back into the hills of that epoch. The presence of the limestone is very important, as it indicates limestones below any exposures of the pre-Cambrian rocks of the Bow Valley. In places the matrix is coarse-grained and in others a fine-grained sandstone. The limestone fragments are small and those of sandstone usually larger, some being 12 inches across.	27
6. Reddish purple, arenaceous, siliceous shale, with greenish bands. This shale is widely distributed and often folded and broken in exposures along the valley.	455

CORRAL CREEK FORMATION:

1. Coarse-grained, light-gray sandstone in massive layers, with some of the layers a fine quartz conglomerate. Estimated... The outcrop of this bed is usually concealed by débris.	120
2. Hard, quartzitic sandstones that break down on exposure to weather. Estimated..... An anticline and general disturbance of the strata at this point breaks the downward continuity of the section.	1,200+

On the west side of Corral Creek Valley and south of the syncline of Cambrian limestones and sandstones of Mount Richardson and Ptarmigan Peak the strata of the Hector and Corral Creek formations are displaced by thrusts and folds, so that the section is broken and imperfect. The same is true of the pre-Cambrian formations south of the base of Fort Mountain.


BOW PK
9184
Balfour Gl.
MT. BALFOUR
10,731
Turquoise L
6975
L. Margaret
5326
5694
PULPIT PK
8930
CONTINENTAL DIVIDE
R18
MT. DALY
10,332
R17
Pulpit
MT. HECTOR
11,125
SIGNAL 16
9739
Water
Creek
MT. MOLAR
9914
River
8679
8047
R16
Pipestone
little Pipestone
R15
MT. BOSWORTH
9083
Summit L.
5329
Sink L.
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Stephen
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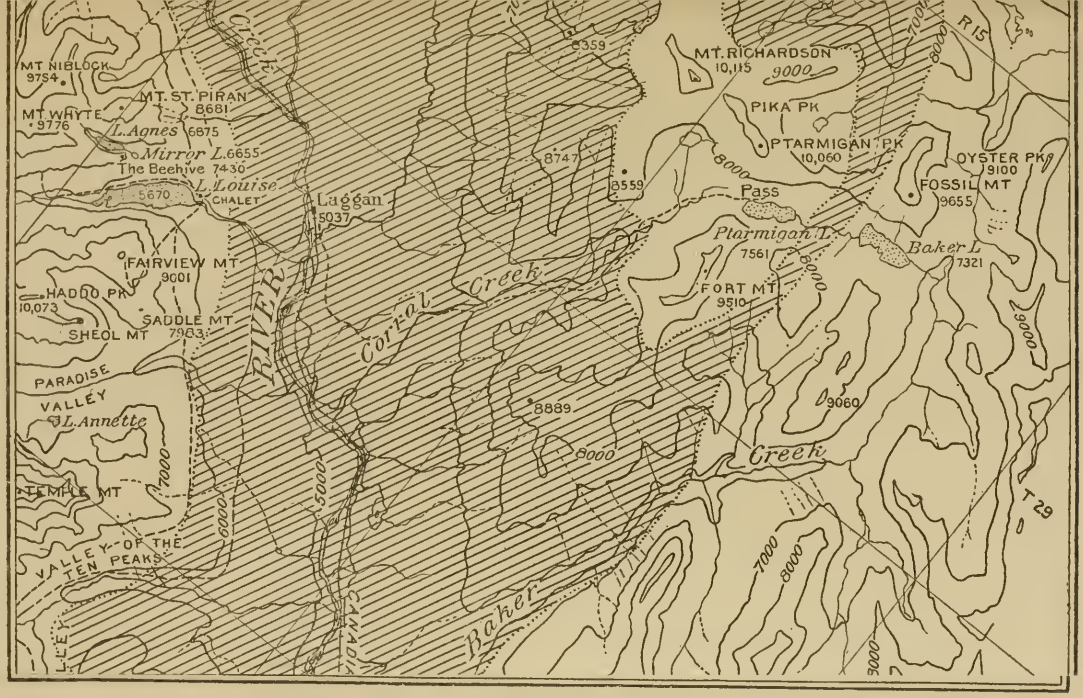
6000

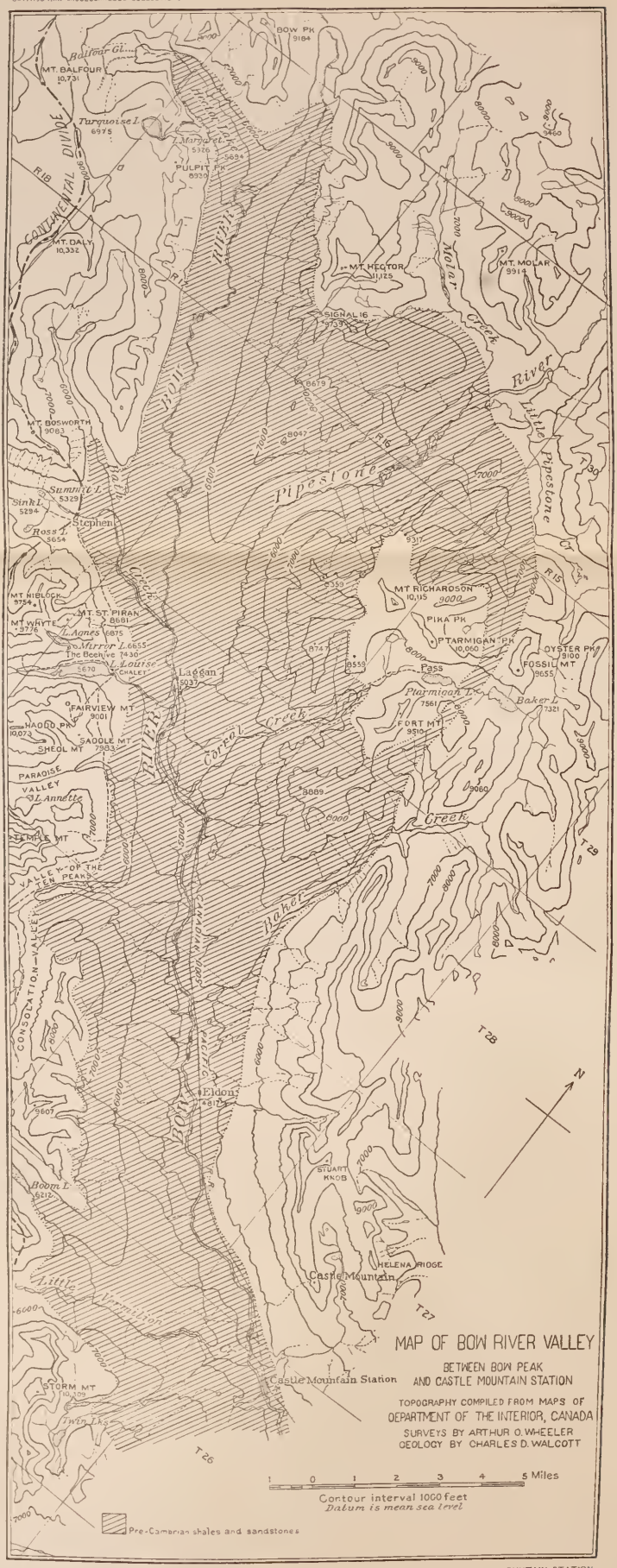


MAP OF THE PORTION OF THE BOW VALLEY EXTENDING FROM BOW PEAK SOUTHEAST TO CASTLE MOUNTAIN STATION, JUST BELOW LITTLE VERMILION CREEK

The boundary lines of the pre-Cambrian formations are put in from reconnaissance observation and are subject to minor modification, especially on the northeast toward Little Pipestone Creek.

Except on the northeast, where the Silurian and Devonian rocks of the Sawback Range come in contact with the Algonkian, the entire area is surrounded by overlying Cambrian rocks.

The extension beyond the map to the southeast is outlined on the north by the slopes a little north of the railroad track as far as the vicinity of Cascade, and on the south by Copper and Pilot mountains. No Algonkian rocks were observed east of Cascade.



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BOW PK

Résumé

HECTOR FORMATION:	Feet	
1. Dark-gray shale	520	
2. Greenish shale, with narrow bands of reddish purple shale	120	
3. Purple shale	140	
4. Greenish shale	40	
5. Conglomerate	27	
6. Purple shale	455	
Total		1,302
CORRAL CREEK FORMATION:		
1. Sandstone (estimated)	120	
2. Sandstones (estimated)	1,200	
Total		1,320
Total section		2,622

At the east base of Ptarmigan Peak, 2.5 miles north of the Fort Mountain section, the Hector shales and conglomerate beneath the basal conglomerate of the Cambrian are essentially the same as on the south end of Fort Mountain, except that the green and purple shales are closer to the Cambrian, owing to the thickness of dark gray shale being less. Opposite the head of Baker Lake the pre-Cambrian shales and subjacent compact, hard sandstones are thrust over the Siluro-Devonian, arenaceous limestones.

The relations of the basal conglomerate and the pre-Cambrian are well shown north of Ptarmigan Peak; also at the north foot of Fort Mountain.

On the northeast ridge of Mount Temple and northwest of the Valley of the Ten Peaks the downward section is as follows:

CAMBRIAN CONGLOMERATE

Unconformity

ALGONKIAN

HECTOR FORMATION:	Feet
1. Hard, steel gray, siliceous shales in thin lamellæ, with interbedded siliceous layers, varying from thin shale to an inch in thickness	145
2. Flaggy, compact, finely arenaceous beds	480
3. Greenish, compact, slaty, siliceous shales, with a few thin layers of hard dove-colored to pinkish limestone. [This is about the same horizon as the interformational conglomerate in No. 2, of the Fort Mountain section.]	255

	Feet
4. Shales similar to those of No. 3, with purple and greenish bands	65
5. Shales similar to those of No. 3, of a dark-purple color	590
6. Massive-bedded conglomerate, with coarse sandstone matrix, pebbles of white quartz, gray and yellowish buff sandstone, green siliceous shale, and rolled fragments of a reddish purple, jaspery, siliceous rock	365
7. Greenish, compact, siliceous, slaty shales	250+
Total	2,150+

Below No. 7 there are more shales and then a series of compact, hard quartzitic sandstones of the Corral Creek formation, as seen south of Fort Mountain. The sandstones are not well exposed in the Mount Temple section.

At Vermilion Pass a gray saponaceous, siliceous shale occurs beneath the basal Cambrian conglomerate, and outcrops of purple-colored shales occur low down on the northeast slope of Boom Mountain.

On Bath Creek, along the line of the Canadian Pacific Railway, west of Laggan, outcrops of tilted and folded, arenaceous, purple shales occur, and at various points in the broad valley of the Bow the shales and sandstones of the Hector? formation may be seen. Usually, however, the floor of the valley is covered with the gravels, sand, and clays of the drift.

CORRELATION OF BOW VALLEY PRE-CAMBRIAN ROCKS WITH THOSE OF NORTHERN MONTANA

The finely arenaceous and siliceous purple, gray, and greenish shales of the Hector formation are of the same general character as those beneath the basal Cambrian conglomerate in Montana,[4] except that the pre-Cambrian shales in Montana are more distinctly arenaceous. The shales and sandstones of this series extend north from the Montana-Alberta international boundary to about 30 miles south of Crow Nest Pass, where they are cut off by faults that bring the Carboniferous and Cretaceous formations against them either by overlap or faulting. It is highly probable that pre-Cambrian rocks will be found not far north of Crow Nest Pass and west of the known Cretaceous and Carboniferous rocks; also in the valley of the Kootanie River, east of the Brisco and Stanford ranges. There

[4] Bull. Geol. Soc. America, vol. 17, 1906, Algonkian Formations of Montana, p. 3, *2a* of section.

is a large and interesting field for exploration in this region and north to the known Cambrian rocks of the Kicking Horse-Bow Valley section. With the data now available there should be little difficulty in mapping the pre-Cambrian, Cambrian, and post-Cambrian rocks.

With our present information the Hector and Corral Creek formations may be correlated in stratigraphic position with the Camp Creek and Kintla-Sheppard series of the Montana Algonkian, which are above the great Siyeh limestone.[5] The Bow Valley section does not extend down to the horizon of any massive pre-Cambrian limestone, but the fragments of limestone in the conglomerates of the Hector formation indicate the presence of subjacent limestones that were so situated as to be eroded by streams or shore waves when the sediments of the Hector formation were being deposited.

RÉSUMÉ

The object of this brief paper is to call attention to the presence in the Bow Valley, Alberta, of unaltered sedimentary strata of pre-Cambrian age. They lie unconformably beneath the Cambrian and are non-fossiliferous, as far as known. The formation names Hector and Corral Creek are proposed for them, and they are correlated with the Camp Creek and Kintla-Sheppard series of arenaceous rocks which lie beneath the Cambrian and above the Siyeh limestone in Montana, southwestern Alberta, and southeastern British Columbia.

[5] Bull. Geol. Soc. America, vol. 17, 1906, p. 18.