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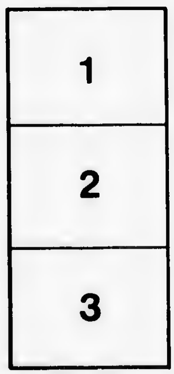
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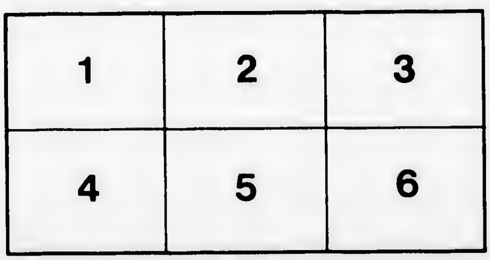
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G. W. DAWSON, PHOTO., 28TH AUG. 1881. IVES PROCESS. GEO. E. DESBARATS. MONTREAL

VIEW LOOKING DOWN BOW-PASS, FROM GEOLOGICAL SURVEY CAMP

GEOLOGICAL AND NATURAL HISTORY SURVEY OF CANADA.
ALFRED R. C. SELWYN, C.M.G., LL.D., F.R.S., DIRECTOR.

REPORT

ON THE

GEOLOGICAL STRUCTURE

OF A PORTION OF THE

ROCKY MOUNTAINS,

ACCOMPANIED BY A SECTION MEASURED NEAR THE 51ST PARALLEL.

BY

R. G. McCONNELL, B.A.

PUBLISHED BY AUTHORITY OF PARLIAMENT.

MONTREAL:
DAWSON BROTHERS.
1887.

ALFRED R

SIR,—I
Rocky Mo
of the pas

OTTAWA, 3

ALFRED R. C. SELWYN, C.M.G., LL.D., F.R.S.,
Director of the Geological and Natural History Survey of Canada.

SIR,—I beg to present herewith my report on an exploration in the Rocky Mountains, accompanied by a section measured in the vicinity of the passes followed by the Canadian Pacific Railway.

I have the honor to be,
Sir,
Your obedient servant,
R. G. McCONNELL.

OTTAWA, 30th April, 1887.

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REPORT

ON THE

GEOLOGICAL FEATURES

OF A PORTION OF

THE ROCKY MOUNTAINS,

ACCOMPANIED BY A SECTION MEASURED NEAR THE 51ST PARALLEL.

The field season of 1886 was occupied in measuring a general section across the Rocky Mountains proper, or that division of the Cordilleran system included between the eastern outcrop of the palæozoic rocks, and the Columbia valley, and in working out, as far as time permitted, the remarkable structural features of the range. The belt of country selected for this purpose, follows the line of the Canadian Pacific railway along the Bow and Wapta (Kicking Horse) Valleys, from Banff westward to Golden City on the Columbia. East of Banff it leaves the railway and follows the Devil's Lake valley eastward to its gap* This portion of the range was examined in part by Dr. Hector, in 1858-59, and is also included in Dr. Dawson's exploration of the southern portion of the Canadian Rocky Mountains, and a description of its more prominent characteristics will be found in his report. (See Annual Report 1885, part B.)

Geographical position of section.

Previous exploration.

The section accompanying the present report is, as far as possible, a natural one, but the winding character of the route traversed, combined with the imperfect topography and ever varying strikes, rendered a certain amount of generalization unavoidable. A line measured at right angles to the strike of the beds, if followed for any distance, would soon diverge widely from the direction of the valley and lead into practically inaccessible regions, and it was therefore found necessary, in many cases, to jog the section for some distance along the strike, and to continue it on the opposite side of the pass. Also in

Character of section.

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* The "Gap" is a local term used to designate the point at which any considerable valley leaves the mountains.

places where the exposures along the main line were defective or absent, the interval was filled by neighbouring parallel sections. The general section is in reality, therefore, a combination of a number of shorter ones, selected in the vicinity of the valleys followed, and measured at right angles to the local strikes. They are, however, connected along the strike in such a manner as to give as perfect a representation as possible of all the beds met with in the range.

In regard to the completeness of the work, it may be stated that while much still remains to be done in the way of filling in local details, yet the general features of the section, as presented, are believed to be fairly accurate, and will not be much modified by future investigations. In a mountainous and mostly wooded region like the one examined, where the possession of any geological fact implies a long and laborious climb of from 2000 to 6000 feet, the construction of a section showing all the structural minutiæ, becomes an arduous undertaking, and would require a much longer time than the four months or so at my disposal.

Shorter sections illustrative of special points.

In addition to the principal section a number of shorter parallel sections were also measured. These serve to illustrate special points in the structure of the range, and also show the rapid change in the character of a fault or fold when traced along the strike.

Section D–C was sketched along the northern side of the valley of the south fork of Ghost River, about two miles south of the Devil's Lake valley. It shows the Cretaceous shales faulted under the Cambrian rocks at the eastern edge of the mountains, while the same beds, or beds belonging to the same group, overlie the palæozoic series a few miles farther west.

Section E–F is drawn along the northern side of the Bow, through the Fairholme mountains, and traverses a few miles farther south the same ranges, as those shown in the principal section east of the Cascade trough.

Section G shows a Cretaceous outlier which occurs east of the same fault as that seen on the principal section, but about three miles farther north.

Sections H and K illustrate the folding of the Cretaceous beds of the Cascade trough. They were measured eighteen and twenty-three miles respectively, S.E. of the corresponding point in the general section.

Section M–S starts near the summit of Johnson Creek, and crosses the Castle Mountain range and the Bow River anticlinal, while section O–N is drawn across the same anticlinal, about eight miles farther north.

Topography.

A general description of the Bow and Hector (Kicking Horse) Passes is given in Dr. Dawson's report (see Annual Report 1885, p. 124 *et seq.*) and the following notes may be considered as merely supplementary to his sketch, and will only refer in detail to places which were not visited by him. **General description of pass.**

The Fairholme Mountains comprise a group of high ridges and mountains, bounded on the east by the foot-hills, on the north by the Devil's Lake valley, and on the south and west by the Bow. On the east, they rise abruptly from the foot-hills to heights of from 2000 to 4000 feet, and face plain-wards as a massive escarpment broken by a number of deep valleys. The receding summits of the different segments are either flat-topped or crowned by ruined cliffs, due to the unequal denudation of the dolomitic limestone capping them. **Fairholm Mountains.**

The western part of the group consists of ridges running parallel, or nearly so, to the Cascade trough, some of which extend, without interruption, northward from the Bow to the Devil's Lake valley. On the south, the cross section cut by the Bow, is about seven miles wide, and shows the triangular ends of such ridges throughout, but going north the group widens out rapidly towards the east, and while the western part of the section seen along the Devil's Lake valley, corresponds in a general way with that on the Bow, the eastern part shows massive square-built mountains of a totally different character, and due to an entirely different set of geological conditions.

Wherever the beds are tilted to any considerable angle, so as to expose the upturned edges of the different limestone and shaly formations, their unequal resistance to denudation is marked by the formation of deep valleys running lengthwise with the chain, separated by high limestone ridges, which are very persistent and are cut only by the more important lines of drainage. The projecting crests of these ridges are usually narrow and worn into a series of jagged peaks of a nearly uniform height, united by thin, zigzag knife-edges, on which it is often difficult to obtain a footing. In most cases, as in the Cascade Mountain range, such ridges possess a single serrated crest only, but in others, as the Sawback Range, several such lines are present. The appearance of one of these compound crested ranges, viewed from one of the higher peaks, is wild in the extreme, and is characterized by the sharply angular and pointed shapes of the profiles, and the entire absence of rounded outlines. On the other hand, wherever the beds are horizontal, or nearly so, the ridge system no longer prevails, and the four or five thousand feet of rock, rising above the base-level **Ridges formed by tilted beds.** **Character of mountains where beds are horizontal.**

of erosion in the valleys, is cut into irregular-shaped, steep-sided blocks, terminating in blunt or flat summits, or covered with broken cliffs. Mountains of the first description are the prevailing feature in the eastern ranges, while towards the summit they become largely replaced by those of the second. In the Fairholme Mountains examples of both kinds are present. The western part, as previously stated, consists of parallel ridges, while near the gaps of the Devil's Lake valley and the south fork of Ghost River, good illustrations of the broad-based and cliff-bounded type of mountains, resulting from the wear of heavily bedded limestone lying in a horizontal position, may be seen.

Large basin.

Another feature of this group worth noticing, is the existence, near its centre, of a considerable basin, shut in on all sides, except towards the north, by high limestone cliffs, and rising at one point into a high, flat-topped plateau, which forms the drainage centre of the district. To the east, the south fork of Ghost River, originating in a small lake lying immediately east of the plateau just mentioned, has cut an almost direct way out of the mountains. On the west, the Grotto Mountain range is broken through by a stream flowing to the Bow, and smaller streams starting here flow north and south between the ranges. This system of valleys ramifies in all directions, and affords easy access to every part of the group. Some of its members are of large size, and one ceases to wonder at the proportions of valleys occupied by large, swift streams like the Bow, and to seek for causes other than river erosion to explain their existence, when it is seen that this agent alone, —or with possibly some glacial assistance,—has been able, in the case of a small intermittent stream, only a few miles in length, such as the south fork of Ghost River, to cut out through hard limestone rocks a valley 3000 to 4000 feet in depth, and with a breadth of bottom in places of over a mile. Most of the valleys in this district, especially in their lower parts, are wide and filled with shingle, beneath which the water flows, and except in exceptionally heavy floods, no water appears on the surface. In the latter part of summer the circuit of the group might be made without crossing a single running stream, although on all the higher peaks patches of snow exist throughout the year. The small streams flowing from these, as soon as they reach the main valley, sink in the gravel and disappear.

System of valleys.

Shingle in valleys.

Streams dry up in autumn.

Height of mountains.

The mountains of the Fairholme group seldom exceed 9000 feet in height, and range from that down to 7000 feet. The highest peaks occur near the north-west corner in the neighbourhood of Mount Peechee. Towards the Bow the ranges decrease in height. One of the most prominent peaks, seen from the south, is situated about four miles north-west of Lac des Arcs, or the Bow Lake, and is interesting geologically on account of its anticlinal structure, a rare

Anticlinal mountain.

occurrence in the region. The Lower Banff limestone, here composed of a series of massive limestone beds, bends sharply over its summit, and descending the western slope with many undulations, is faulted off near the base of the mountain. The troughs of the secondary folds are filled with reddish weathering shales, and the whole section at first sight has the appearance of a series of alternating bands of shale and limestone. Devil's Lake Valley.

The Fairholme Mountains are terminated on the north by the Devil's Lake valley, a wide, steep-sided, streamless depression now partially occupied by the Devil's Lake. This valley extends from the cascade trough east to the foot-hills, and joins Ghost River a mile or so from the mountains. Some barometer observations taken by Dr. Dawson in 1883, but which have only recently been worked out, show that this valley has a westerly inclination, and that the surface of Ghost River, at the point where it flows past the gap of the Devil's Lake valley on its way to the Bow, is considerably higher than the surface of the lake. This fact would seem to indicate that at some former period, Ghost River, after leaving the mountains, re-entered them again by this valley and joined the Bow at Banff. Its change of course, like that of most streams in the country which have suffered similar diversions, is probably due to a damming of its channel during the glacial period, and the necessity thus imposed upon it of seeking a discharge in a different direction.* Westerly inclination of Devil's Lake Valley.

The Palliser Range is situated north of the Devil's Lake valley, and is simply a continuation of the subordinate ranges of the Farnholme group, and is of like character. It is almost cut in two by the valley of Ghost River, which enters the mountains a few miles north of the Devil's Lake valley, and runs parallel to it for some distance, until it meets a band of soft shales, along which it is deflected to the north. Among the more conspicuous peaks of this range, are the Devil's Head, which presents a vertical tower-like face towards the plains, but slopes gradually to the west, and a conical peak rising from a ridge about three miles north of the western portion of Devil's Lake, which is as yet nameless. Palliser Range. Ghost River Valley. Devil's Head.

West of the Fairholme and Palliser mountains, is a wide straight valley, running in a north-westerly direction. It is followed by the Bow for about sixteen miles, and by tributaries of this stream for a much longer distance, and also by a number of other smaller streams in its further extension north and south. This great valley owes its origin to the relatively soft character of the Cretaceous shales by which it is underlaid. It has been called the Cascade trough by Dr. Wide valley. Cascade trough.

* For a complete description of the Devil's Lake and valley, see Annual Report 1885, p. 111 B-113 B.

Dawson, and is fully described in his report (see p. 126 B-134 B of Annual Report 1885). West of the Bow it is bounded by the Mount Rundle range, and farther north by Cascade Mountain, both belonging to the single crested type of longitudinal ridges.

Cascade Mountain.

The Bow Valley leaves this basin at Banff, and turning in a westerly direction breaks through a second system of parallel ridges, almost at right angles. Cascade Mountain, the most easterly of these, rises to a height of 9730 feet above the sea, or 5200 above the surface of the valley. Its outline as viewed from the Bow is roughly triangular, and the inclination of its curved western face is almost identical with that of the limestone beds of which it is formed. Its western face is banded by steep cliffs, marking the points at which the massive beds of the upper and Lower Banff limestone come to the surface, while the alternating shaly bands are worn to easier slopes.

Mount Rundle.

Mount Rundle, south of the Bow, is a continuation of the same range, and possesses similar characteristics.

Forty-mile Creek.

The range west of Cascade Mountain is unnamed, but may for convenience be called the Vermilion Lake range, from the name of a lake lying between it and the Bow. It is separated from Cascade Mountain by Forty-mile Creek, a swift mountain stream, about fifty feet broad. This stream has a somewhat tortuous course. Traced up from its mouth, it first runs for some distance along the western base of Cascade Mountain, from which it cuts off a spur, then bending to the west it breaks through the Vermilion Lake range to the next valley, along which the main stream continues to its source, while a tributary which it receives from the west interlocks with a branch from Johnson Creek, and forms a rough but practicable pass across the Sawback Range. South of the Bow the Spray River repeats in an opposite direction the course of Forty-mile Creek.

Vermilion Lake range.

The Vermilion Lake range is surmounted by two prominent notched ridges, rising about 4,000 feet above the valley, and separated by a narrow valley due to the more rapid weathering of a band of shales which separates the two peak-forming limestone bands. Terrace Mountain, the segment of this range south of the Bow, is somewhat narrower, and is terminated by a single crest.

Hot springs.

Around the north-eastern base of this mountain are situated a number of hot springs, which are reported to possess remarkable medicinal properties, and have already attracted large numbers of health-seekers. The country around has been reserved for a national park, and during the past summer a number of good hotels have been erected, and roads connecting the springs with the railway station and with all the objects of interest in the neighbourhood have been surveyed and partly built.

Temperature of water.

The water in the principal spring has a temperature of 111° F. in summer, but is said to rise to 119° in winter. The lower temperature in summer may be caused by the water being affected to some extent by the surface drainage, which is more active at that season. It has a regular flow, and is forced up in large quantities through an aperture several inches in diameter. It is highly charged with mineral matter, and has deposited thick beds of calcareous tufa in the vicinity.

A number of other springs occur close by, among which may be mentioned one which rises and forms a small shallow pool in the bottom of a cave. The cave is about thirty feet deep, and is reached by an opening in the roof. The water rises through quicksands, and its ascending force is just about sufficient to prevent a man from sinking through the yielding floor. It escapes through an opening in the side of the cave, and issuing shortly after from a hill-side, is collected into a second pool, which, on account of its moderate temperature, has become a favorite resort for bathers. Spring in bottom of cave.

The springs are closely connected with a great fault which runs along the eastern base of Terrace Mountain, with a displacement of over 5000 feet. There is no evidence of either recent or ancient volcanic activity in the neighborhood, and the warm condition of the water is undoubtedly dependent on the depth from which it is derived. Springs connected with fault.

West of Terrace Mountain and the Vermilion Lake range, and separated from these by deep valleys, is the Sawback Range, the westernmost of the great series of tilted limestone ridges which constitute the dominant scenic feature in the eastern part of the chain. It is between two and three miles wide, and is composed of about 11,000 feet of strata, dipping at angles of 65° and over, and varying in hardness from quartzite and crystalline limestone down to soft shale. Every degree of relative hardness is now distinctly marked by the unequal denudation which different beds have undergone. The softer bands have sunk into deep, irregular furrows, while the more resisting beds thrust themselves up in long lines of sharp-pointed peaks. The massive beds of the Lower Banff limestone are especially noticable in this connection, and form the most persistent line of peaks in the range. At the western edge of the valley separating the Vermilion Lake range from the Sawback Range, but standing somewhat apart from the latter, is a remarkable looking group of peaks, built of upright beds and terminating in thin wedge-like summits. They are arranged in a line parallel with the main range, and the sharp outline of the most southerly member of the group forms a striking object viewed from the Bow Valley. Sawback Range. Effect of denudation. Remarkable looking line of peaks.

The Hole-in-the-wall is a name given to a cavity in the steeply sloping beds which form the western face of the Sawback Range. It is about 1500 feet above the surface of the valley, and was reported to be Hole-in-the-wall.

inaccessible, but no difficulty was experienced in scaling the steep, rocky slope leading up to it. It is, however, hardly worth the trouble of the climb, as walls and roof are bare and no stalactites or other objects of interest are to be seen. This cave has a roughly circular aperture, estimated to be about sixty feet in diameter, but going back the floor rises rapidly, and cuts off further progress at a distance of about 130 feet. It has probably been excavated by waters, descending between the almost vertical limestone beds, making an exit here.

The continuation of the Sawback Range south of the Bow was not examined.

Direction of the Bow Lakes.

After breaking through the Sawback Range, the Bow Valley bends again to the north-west, and then runs almost straight to its source in the Bow Lakes. Its course is at first somewhat oblique to the general strike of the ranges, but afterwards becomes coincident with it, in consequence of a change in the direction of the latter.

The Sawback Range is bounded on the west by a deep valley leading from the Bow to the Red Deer, and, like most of the longer longitudinal valleys, followed in different parts of its course by a number of different streams.

Johnson Creek.

Near the Bow it is occupied by Johnson Creek, a swift, rocky, mountain stream, about seventy-five feet wide near its mouth, and having a total length of about sixteen miles. The entrance to the valley is blocked by a high ridge, crossing it in a diagonal direction from Castle Mountain to the Sawback Range, through which Johnson Creek has cut a deep, narrow passage to the Bow. Beyond this ridge the valley opens out, and is generally wooded for some miles, though showing small prairie patches near the stream. Approaching the summit, the trees gradually thin out and finally disappear near the base of the last steep ascent, and the surface becomes covered with grass and low shrubs.

Beauty of valley.

The appearance of this part of the valley in early summer is singularly beautiful, and is surpassed by few places in the mountains. Its green and partly wooded floor is bounded on the west by the massive face of Castle Mountain, which here rises in sheer cliffs, broken at intervals by ledges and *cirques*, supporting thick fields of ice, and contrasts strangely with the aerial peaks of the Sawback Range which look down into the valley from the east. The effect of the picture on the observer is also strengthened by the frequent sound of falling avalanches echoing along the valley.

Baker Creek.

On the farther side of the summit a rapid descent is made along a branch of Baker Creek. A few miles further on, this is joined by a stream coming in the opposite direction, and the two, after uniting, bend to the south and force a passage through the Castle Mountain range.

Castle Mountain Range.

Castle Mountain range is built of nearly horizontal limestones, and is a cliff-bordered, oblong block, between two and three miles wide and about thirteen miles long. Its narrow ends are further split by deep valleys, of which the eastern one holds a couple of small lakes. The *massif* of this range, viewed from the Bow, is particularly imposing, owing to the long, wall-like, unbroken front which it presents in that direction. It rises to a height of 4500 feet above the Bow.

Pilot Mountain, south of the Bow, is situated in the strike of Castle Mountain range, and has a height of 5000 feet above the valley. It culminates in a narrow, flat summit, about half a mile long, and forms the end of a rugged range extending from Healy's Creek to Red Earth Creek. It supports a small glacier on its northern slope, the first of any size met with in ascending the pass. **Pilot Mountain**

The watershed range, across the Bow from Castle Mountain, is less regular, and its front has been dissected by numerous glacier-fed streams into short transverse ridges. The higher limestone peaks are here situated some distance back in the range, and are flanked by lower quartzite elevations. To this range belong the loftiest peaks seen along the pass, amongst them being Mt. Lefroy, which carries its snow-clad summit up to a height of 11,658 feet, and a host of others, little if at all inferior. **Watershed range.**

The valleys between the transverse ridges, referred to above, are usually occupied for some distance from their summits by glaciers, and often enclose small but beautifully clear lakes. Emerald Lake, one of the most accessible of these, is situated about two miles west of Laggan. It is about a mile long and half a mile wide, and is closely hemmed in on both sides by steep quartzite cliffs. It is fed by a small stream, which issues about a mile farther up the valley from the front of a glacier. **Valleys occupied by glaciers and lakes.**

A few miles beyond Laggan the railway leaves the Bow and follows a wide valley, which here leads through the watershed range, and connects the eastern and western drainage systems. This valley is followed in its eastern part by Noore's Creek, flowing into the Bow, and in its western part by the Wapta (Kicking Horse) River, a tributary of the Columbia. **Transverse valley.**

The Wapta River finds its immediate source in a lake of the same name, but is joined and largely increased, a short distance from its origin, by two streams issuing from the glaciers of the Waputtehk Mountains. Its descent is at first headlong, and in less than five miles it falls over 1100 feet. Beyond this it becomes, for some miles, less rapid, and flows by several winding channels through a wide gravelly bottom. A mile and a half below Field its bed contracts again, and for some distance the stream is constantly interrupted by falls and rapids. A number of short cañons occur in this part of its course, and in one place the **Wapta River.**

Natural bridge. river is spanned by a natural bridge. In the next few miles it is joined by a couple of large tributaries from the north, and also by the Otter-tail Creek from the south, and becomes swollen to a full-sized river. Farther down it is joined by the Beaver-foot, and then, after falling over a precipice about forty feet high, it bends sharply to the north-west, and cuts a channel obliquely through the Beaver-foot Range to the Columbia. **Length of the Wapta.** The length of the Wapta, between Wapta Lake and the Columbia, is a little over forty miles, and in this distance it has a fall of 2650 feet.

Ridges on western slope of mountains. The western slope of the Rocky Mountains, like the eastern, is characterized by a system of longitudinal and approximately parallel ridges. The ridges here, however, are mostly formed of beds either lying flat or dipping at low angles, and as a consequence are usually broader, and are also separated by wider intervals than is the case to the east. The Bow or watershed range has been already referred to in connection with a previous description. It is built of heavily-bedded limestone, and has been carved by a complex drainage system into a series of high, massive-looking mountains, of which Mount Stephen forms a good example. The central parts of this range are covered throughout the year by extensive snow-fields which send tongues of ice down all the principal valleys. **Snow-fields.**

Otter-tail Range. West of the Bow Range is the wide valley of the Otter-tail, and across this the Otter-tail Range. The latter is crowned by a number of high, impressive-looking peaks, some of which rise over 6000 feet above the valley. It is continued north-west across the Wapta by Mount Hunter and the Van Horne Mountains. **Mount Hunter.** Mount Hunter is terminated by a narrow, deeply-notched edge, and resembles the ranges in the eastern part of the chain in being formed of highly tilted limestone beds. The line of ranges just mentioned is bounded on the west by a long, straight valley, followed in the upper part by the Beaver-foot River, and farther down by the Wapta, and west of this comes the **Beaver-foot Range.** Beaver-foot Ran[illegible] most westerly range of the chain. The Beaver-foot Range has [illegible] width of above five miles, but slopes upwards into a single zigzag line of sharp limestone peaks. The higher summits of this range exceed 5000 feet in height.

Elevations of stations. Elevations of the stations along the Canadian Pacific Railway, in the Rocky Mountains:

The Gap	4198
Canmore	4253
Duthil	4342
Banff	4531
Silver City	4624
Eldon	4782
Laggan	5005
Stephen	5296

Hector	5177
Field	4026
Ottertail	3664
Leanchoil	3557
Palliser	3250
Golden City	2539

DESCRIPTION OF FORMATIONS.

The various formations occurring along the Bow and Wapta Valleys, have been divided, chiefly on lithological grounds, into seven groups, and as none of these can be correlated exactly with those found in the southern part of the range, as described in the various United-States reports, it has been found necessary to introduce some new terms. The following table exhibits the scheme adopted, as well as the equivalents in the ordinary classification, so far as the fossil evidence at hand admits:

Classification of formations.

Mesozoic, 5000 ft. (min)	Cretaceous	Kootanie Group to Benton	Dark shales, with some sandstones, quartzites and conglomerates.
Palæozoic = 29,650 ft.	Carboniferous passing downwards into Devonian	Upper Banff shales	Reddish-weathering and usually calcareous shales, and quartzites.
		Upper Banff limestone	Moderately crystalline, greyish limestone, often cherty and crinoidal.
		Lower Banff shales	Calcareous shales and shaly limestone.
		Lower Banff limestone	Bluish compact limestone.
	Devonian	Intermediate limestone	Brownish, irregularly hardened dolomites, and greyish, crystalline dolomites, with some sandstones and quartzites.
	Silurian	Halysites beds	Greyish dolomites and quartzites
	Cambro-Silurian	Graptolitic shales	Dark fissile shales.
		Upper part of Castle Mountain group	Mostly shaly limestones, and calcareous dolomitic argillites.
	Cambrian	Lower part of Castle Mountain group	Massive dolomites with some shaly limestone, the latter sometimes schistose.
		Bow River group	Argillites, usually dark-coloured but sometimes greenish and purplish, with quartzites and conglom'tes.

The Cretaceous.

Cretaceous.

The Cretaceous is essentially a clastic formation, and contains beds ranging through every degree of coarseness, from fine-grained fissile shales to heavy conglomerates.

Transverse ridges.

The most favorable localities for examining it are found in that portion of the Cascade trough extending from the Bow to the Kananaskis. Here, the western part of the valley is crossed transversely by a series of short ridges, the summits and steep eastern slopes of which are almost bare, and show connected sections several thousand feet in extent. Only the middle portion of the formation is, however, seen in these sections, as the lower beds are faulted off on the western side of the trough, and are concealed, and probably faulted also, on the eastern side, while the upper beds have been removed by denudation. The beds remaining do not measure over 5000 feet at the most.

Only middle portion of formation seen.

Rocks in lower part of series.

The lower part of the series consists mainly of beds and bands of flaggy sandstone, alternating with dark shales. The shales are usually somewhat arenaceous, and pass gradually, by the addition of more sandy material, into pure sandstone. They are also occasionally carbonaceous, and in a number of places enclose coal-seams, some of which are workable. The sandstone occurs, characteristically, in somewhat thick beds, and is usually coarse-grained and soft, but harder quartzitic beds are not altogether absent. It weathers to a dull red colour. The bands of sandstone are little persistent, and if traced along their strike for any distance are found to break up into subordinate beds, separated by thin shaly partings, or to pass altogether into shales. The upper part of the section contains some conglomerate, in addition to the shales and sandstone. This occurs in massive beds, measuring up to 150 feet in thickness, and is composed of rounded siliceous pebbles, with some shaly and calcareous grains, imbedded in a hard siliceous matrix. The pebbles are usually small, seldom exceeding an inch in diameter, and the rock passes insensibly into sandstone. The section here is more arenaceous than is usually the case, and there is reason to believe that it occupies a comparatively high position in the series, and that the lower part contains a greater proportion of shales. The Cascade River section, a few miles further north, which is undoubtedly lower, shows no conglomerate, and the sandstones are also of less importance, and in nearly every case where beds of Cretaceous age overlie the Banff limestone in an undisturbed condition, showing that the base of the formation is present, they consist almost entirely of dark shales.

Conglomerate in upper part.

In addition to the Cretaceous of the Cascade trough, outliers of this age occur in a number of places along the eastern side of the two principal faults traversing the Fairholme and Palliser ranges, and are often found occupying the summits of the longitudinal passes, the lower parts of the valley having been worn down to the lower beds by denudation. These outliers are all small, and the beds exposed consist of a few hundred feet of black shale, passing downwards into quartzites. No Cretaceous has been found west of the Cascade basin. The resemblance, however, between it and the upper shales of the Banff Series, which underlie them, is so close that it becomes impossible in many places to separate them without fossil evidence, and it is possible that the upper parts of some of the shaly bands which have been referred to the latter may be of this age.

Cretaceous outliers.

No Cretaceous west of Cascade Basin.

The following fossils were collected near the base of a small Cretaceous outlier situated three miles north of the east end of Devil's Lake:—*Oxytoma mucronata*, *Trigonia intermedia*, *Trigonoarca tumida*; all three characteristic of the Queen Charlotte Island series, and species of *Terebratula*, *Ostrea*, *Camptonectes*, *Lima*, *Cyprina*, *Ammonites* and *Belemnites*.

Fossils in Cretaceous.

A small collection, obtained from the shales faulted under the Cambrian limestones at the gap of the south fork of Ghost River, includes amongst others, such Benton species as *Scaphites ventricosus*, and possibly *S. Warreni*, and an *Inoceramus* like *I. undabundus*.

The Banff Limestone.

The Cretaceous is underlaid by the Banff limestone of Lower Carboniferous or Upper Devonian age, and, notwithstanding the complete absence of all the intervening formations, no unconformity was anywhere detected between them, except where faulting is known to have occurred. The apparent conformity is perfect, even in the clearest sections, and the difficulty in drawing an exact line between the two series is further increased by the close lithological resemblance which the upper part of the Banff limestone bears to the lower beds of the Cretaceous.

Banff limestone

Apparent conformity.

The Banff limestone series has a total thickness of about 5100 feet, and is divisible into a lower and upper limestone, and into lower and upper shales.

Thickness of Banff series.

The upper shales vary in thickness from 500 to 1500 feet, but are usually in the neighborhood of 700 feet, and where this is much exceeded, as at the mouth of Johnson Creek, there is reason to suspect that some of the Cretaceous beds are included with them. They exhibit great diversity in structure, and pass, according to the amount of arenaceous

Upper Banff shale.

matter present, from finely fissile shales, through flaggy and ordinary sandstone, into hard quartzite. The quartzites, where present, occupy the lower part of the division, and are overlain by the shales, and the two sets of beds in this position can occasionally be traced from one end of a range to the other. In other cases, however, this regularity is wanting, and shales constantly pass into quartzites, and *vice versa*. These shales are often calcareous or dolomitic, and in places are represented by an impure limestone, and they always contain sufficient iron to give them a reddish color when weathered. They are found on the western slopes of most of the ranges in the eastern part of the chain, and also in the bottoms of most of the longitudinal valleys of the same district, as from their relative softness they are one of the valley-making formations of this part of the range, an office which they fill in common with the Cretaceous shales. The Upper Banff shales are underlain by about 3000 feet of limestone, which may be called the Upper Banff limestone, in order to distinguish it from the lower limestones of the same series. This usually occurs as a greyish purely calcareous and well crystallized rock, but is also found under a number of other forms. It is often dolomitic, and hard, bluish, compact beds are not uncommon, nor are shales and sandstones altogether absent. Its most characteristic features, however, are the abundance of crinoidal remains which it everywhere shows, (some of the beds being wholly composed of the broken stems of Crinoids,) and the cherty concretions which are distributed through it, either irregularly or arranged in lines along the bedding. These concretions are especially abundant in Pilot Mountain and along the western side of the Sawback Range, and in both these places are often united into thin, irregular beds. They also become more numerous towards the top of the limestone, and are occasionally continued on into the shales.

Position of shales. — **Upper Banff limestone.** — **Character of limestone.** — **Crinoidal remains and cherty concretions.**

Below these limestones come from 500 to 700 feet of shales and shaly limestone, constituting the Lower Banff shales. The shales are dark colored, but usually weather red, and are somewhat arenaceous, and pass into flaggy sandstone. They are also nearly always calcareous, and in places the series is represented altogether by impure, shaly limestones. At a point about two miles up a small creek, which joins the Bow from the north a short distance above the Bow River gap, this group is underlain by from fifteen to twenty feet of coal-black fissile shales, which rest directly on the massive limestone beds of the underlying formation, and are interesting on account of their fossiliferous character. A number of specimens of a *Clymenia*, besides other fossils, were collected here. At one point these black shales bend around a large and well-rounded limestone boulder, belonging apparently to the Castle Mountain group, and looking exactly like an eratic of the glacial drift.

Lower Banff shales. — **Black fissile shales.** — **Rounded boulder.**

The lowest division of the Banff limestone consists of from 600 to 800 feet of heavily-bedded bluish and fairly compact limestone. In composition it is mostly calcareous, but it also contains a certain amount of dolomitic matter distributed in an irregular manner through the beds, and evidently collected together by concretionary action. The dolomite is not visible on a fresh fracture, but, owing to its superior durability, it projects from weathered surfaces, over which it often forms a rough reticulation. This limestone differs from the Upper Banff limestone in being darker, more compact, and in the smaller number of crinoidal fragments and cherty concretions which it contains, although neither of these are altogether absent. It is very evenly bedded, and weathers into bold cliffs, such as are seen in Tower Mountain on Devil's Lake, in Cascade Mountain, and in a number of other places.

Lower Banff limestone.

The Banff limestone is the principal constituent of all the longitudinal ranges east of Castle Mountain. It is found in the western part of Pilot Mountain, and forms the principal mass of the Vermilion Lake range and of Cascade Mountain. East of the Cascade trough, it is found in the Grotto Mountain range and all along the Devil's Lake, but is replaced, soon after passing the end of this lake to the east, by the Intermediate limestone and the limestones of the Castle Mountain group. It ends abruptly against a fault east of Castle Mountain, and although it reaches that point from the east with undiminished volume and shows no signs of thinning out, is not seen again all the rest of the way across the range, and seems to have been entirely swept away by the tremendous denudation to which the whole chain, but especially the western part, has been subjected.

Distribution of Banff limestone.

The fossils of the Banff limestone show both Devonian and Carboniferous forms, and include a *Rhynchonella* like *Rocky Montana*, another like *R. metallica*, *Atrypa reticularis*, and a *Spirifera* like *S. Whitneyi*; also species of *Athyris*, *Productus*, *Lichas*, *Eridophyllum* and *Diphyphyllum*. A large number of other species have been obtained, but these have not yet been studied.

Fossils.

The uppe shales of this series have yielded some *Aviculopectens* and *Lingulæ*.

The Intermediate Limestone.

The Intermediate limestone underlies the Banff limestone conformably, and passage beds partaking of the lithological character of both groups occur at the junction of the formations. It is mainly composed of a great series of brownish dolomitic limestones, and has a thickness of about 1500 feet. The typical dolomites of this formation are dark-brownish in colour, are finely crystalline, and

Intermediate limestone.

Thickness of intermediate limestone.

Character of intermediate limestone.

are often irregularly hardened by concretionary action. They have, in many places, a blotched appearance, due to small cavities becoming filled with calcspar, are cherty, and are characterized throughout by an abundance of corals. In some sections a light-greyish variety is not infrequent. It is more coarsely crystalline than the dark variety, and is unfossiliferous. In addition to the dolomites, beds and bands of sandstone, quartzite, and calcareous limestone, are found all through the series. A light-yellowish siliceous band, varying in thickness from 100 to 400 feet, occurs near its base, on the south fork of Ghost River and along the eastern part of Devil's Lake valley, and is also found at the entrance to the White Man's Pass.

Siliceous band.

Section near gap of Bow.

A good section across this series was obtained in the first range, near the gap of the Bow. Here it dips to the west, at an angle of 40°, and is enclosed between the Castle Mountain and Banff limestones. The former, at this point, is terminated above by some shaly, non-dolomitic limestone, overlying which, is about forty feet of reddish and bright yellowish, weathering sandstones and quartzites, forming the base of the intermediate formation. Above these come several hundred feet of brownish-weathering, irregularly hardened, magnesian limestone, holding chert and corals, succeeded by light-coloured, regularly bedded, crystalline dolomites. The latter grade upwards into a series of alternating beds of the two last varieties, associated with some beds of quartzite. Then comes a small band, consisting of soft greenish crumbling argillaceous sandstone, and hard, yellowish-weathering quartzites, overlying which are twenty feet of greyish, limestone. This limestone is succeeded by magnesian limestones and quartzites, above which come about fifty feet of heavily bedded, brownish weathering dolomites, forming the top of the series, and underlying the bluish massive beds of the Banff limestone. This section affords a fair general illustration of the relative lithological importance of the different members of the series, but could not be even approximately duplicated half a mile away, owing to differences in local detail.

Distribution of intermediate limestone.

The Intermediate limestone is first met with at the gap of the Bow, and runs from that point, in an undulating manner, towards the Devil's Lake valley, which it crosses about two miles east of Devil's Lake. In this exposure there is a general width of about three-quarters of a mile, but this is greatly increased in places in consequence of the beds flattening out and forming a capping to the series of short transverse ridges existing between the streams issuing from the mountains. A second band occurs near the western end of Lac des Arcs, and runs as far north as Bow Mountain, where it is concealed by an anticlinal fold in the Banff limestone. A short band also crosses Devil's Lake, about two miles east of its western end, and extends a couple of miles each way. It is next met with along the western edge of the Cascade trough, overlying the Cretaceous shales, and forming the lower part of the cliff portion of Mount Rundle and Cascade Mountain. Still going west, the limestones of this group are found in the eastern slopes of Terrace Mountain and the Vermilion Lake range, and further west form the central portion of the Sawback Range. They make their last appearance in Pilot Mountain, where their volume is as great as at the gap of the Bow, and in the ridge extending from Castle Mountain to Johnson Creek. Beyond this point they disappear as completely and as suddenly as the Banff limestone. Sudden disappearance.

The fossils of the Intermediate limestone are usually badly preserved and consist mainly of almost structureless corals. Fossils.

Halysites Beds.

The only formation common to the eastern and western part of the Rocky Mountains, along the Bow and Wapta Valleys, is the Castle Mountain group, which is of Cambrian age, and will be described farther on. This group is overlaid, in the eastern ranges, by the Intermediate limestone just referred to, and in the west is continued upwards by the Graptolitic shales and the Halysites beds. Halysites beds.

The Halysites beds consist of about 1300 feet of dolomites and quartzites. This is, however, a minimum estimate of the total volume of the formation, as the upper part in this region has been removed by denudation. The quartzites occupy the lower part of the series, are usually light coloured, and occur in even, massive beds, which break into large rectangular fragments on exposure. The great angular blocks of quartzite which strew the valleys of the lower part of the Wapta, and of Horse Creek and Fifteen-mile Creek (both of which flow into the Columbia south of Golden City), are derived from these beds. The quartzites are somewhat dolomitic in places, and often pass gradually into the overlying dolomites. Thickness. Character of quartzites.

The dolomites are very evenly bedded, and vary in colour from light grey to bluish, and in texture from a compact to a moderately crystalline condition. They contain little iron, and the darker varieties weather to a dull, neutral grey. The lighter coloured varieties seem to be more ferruginous, and often show pale yellowish surfaces. This series of dolomites differs from those of the Intermediate limestone, to which it is most closely related, in being more evenly bedded, less ferruginous, and in the presence of its characteristic fossil *Halysites catenulatus*, which occurs in great abundance in some of the beds. Character of dolomites.

Distribution of Halysites beds.

The Halysites beds appear to have a very limited distribution, and have as yet only been found in disconnected strips along the central and more elevated parts of the Beaver-foot Range and its continuations. They are most available for study in the cañon of the lower part of the Wapta, where they form part of a closely appressed overturned synclinal, and descend below the level of the valley. Going south along the range, they gradually flatten out, and opposite Palliser, were only found in the summits of the higher peaks. The beds of this series have never been found in contact with the Intermediate limestone, and the lower position assigned them is entirely on the evidence of fossils.

The fossils of this formation consist of *Halysites catenulatus*, *Favosites,* a coral like *Zaphrentis,* and some badly preserved brachiopods.

The Graptolitic Shales.

Graptolitic shales.

The Graptolitic shales occupy an intermediate position between the Halysites beds and the Castle Mountain group, into both of which they appear to graduate. They have a thickness of about 1500 feet in the Beaver-foot Range, south of Palliser, but thin out considerably going north towards the Wapta cañon. They consist, as a rule, of hard black or nearly black shales are very fissile and separate easily into regular slate-like laminæ, but sections are also found showing much disturbance. The two arms of the overturned synclinal of the Beaver-foot Range, previously referred to in connection with the Halysites beds, differ markedly in this respect in the Wapta section. The upper and overturned limb is regularly and evenly bedded, and is rich in graptolites, while the lower one has been greatly crushed and corrugated and all traces of fossils obliterated. In some sections the shales alternate with small beds of limestone, and near the top are occasionally associated with quartzites and dolomites.

Thickness.

Character.

Overturned synclinal.

Graptolitic shales not found in eastern part of mountains.

The Graptolitic shales, like the Halysites beds, which they accompany, have not been detected in the eastern part of the mountains, and are at present only known from the ranges adjoining the Columbia on the east. They are found on both sides of the Beaver-foot Range, and good and easily accessible sections, close to the railway, may be found in the bed of a small stream which joins the Wapta from the north, about half way between Palliser and Golden City. Most of the graptolites mentioned in the sequel were collected at this point.

The fossils obtained from this formation consist entirely of graptolites, and the collection made has been submitted for examination to Professor Lapworth, who contributes the following notes in regard to it:—

Fossils.

"There are few species in this collection, but the forms are generally fairly well preserved, and the fauna represented is a distinctly typical one. The following are the species I have identified:—

(*a*) Family Dichograptidæ.

(1) *Didymograptus*, sp. nov., allied to *Didymograptus enodus*, Lapworth, from the Llandeilo beds of Aberiddy Bay, South Wales. (See Quart. Journ. Geol. Society, 1875, plate 35, figs. 1a 1b.)

(*b*) Family Glossograptidæ.

(2) *Glossograptus ciliatus*, Emmons.
(3) " *spinulosus*, Hall sp.

(*c*) Family Diplograptidæ.

(4) *Cryptograptus tricornis*, Carr. sp.
(=*C. marcidus*, Hall sp.)
(4) *Diplograptus angustifolius*, Hall.
(6) " *rugosus*, Emmons.
(7) *Climacograptus cœlatus*, Lapworth.

There are also a few other forms, doubtful species of *Phyllograptus* or *Lasiograptus*, etc.

"The fact that these graptolites have been obtained from the distant region of the Rocky Mountains gives them an especial interest, as few graptolites have hitherto been noticed from that region. The only notice of graptolites from the Western States known to me is that given by Dr. Chas. White in Vol. IV. (Palæontology) of the Report of the Geological Survey of the 100th Meridian. Four forms are described by him (*loc. cit.* pp. 9-10 *et seq.*) as having been obtained from some beds of partially metamorphosed shale, five miles north of Belmons, Nevada. No fossils were found associated with them that might assist in the determination of their exact age, and they were provisionally referred to the geological date of the Utica slate of New York State.

"These graptolites from the Kicking Horse (Wapta) Pass under notice may also be referred to the age of the Utica slate, or at any rate to the Trenton-Utica fauna of the United States and Canada. The association of forms is just such as occurs in the Llandeilo (lower and middle) of Britain, and some of the forms are common to both sides of the Atlantic. The geological range and geographical localities of the forms enumerated above are shown in the table on the following page.

"It is curious that none of the family of the Dicranograptidæ (*Dicranograptus* and *Dicellograptus*) are represented in this little collection. It is just possible that it may, therefore, be somewhat older than the typical Norman's Kill beds, where the Dicranograptidæ are exceedingly abundant. Neither have we any of the peculiar genera of the Leptograptidæ (*Cœnograptus* and *Leptograptus*, etc.) so prevalent in the Norman's Kill horizon everywhere. Thus it is by no means unlikely, judging from the evidence at present at our disposal, that the fauna of the shales of the Kicking Horse (Wapta) Pass come from strata answering broadly to the British Lower Llandeilo. They are distinctly newer than the Point Levis beds, and belong to the second Ordovician fauna, but in all probability to the oldest zones of that fauna.

"Table showing distribution (geographical) of the graptolitic species of the Kicking Horse (Wapta) Pass, B. C."

	America.		Britain.			
	Norman's Kiln, N. Y.	Marsouin River and Griffin Cove, Can.	S. Wales. Lower Llandeilo of Aberiddy Bay.	Shropshire. Llandeilo of Shropshire.	Scotland. Glenkiln shales of S. Scotland.	r—representative forms; not certainly identified with typical species.
1 Didymograptus enodus, *Lapworth* ..	— —	—	•	•	—	
2 Glossograptus ciliatus, *Emmons*	•	•	•	•	•	
3 " spinulosus, *Hall*	•	—	—	—	•	
4 Cryptograptus tricornis, *Carruthers*.	•	•	•	•	•	
5 Diplograptus angustifolius, *Hall* ..	•	•	•r	•r	•r	
6 " rugosus, *Emmons*	•	•	—	•	•	
7 Climacograptus cœlatus, *Lapworth*.	.....	*	•	•	•	

The Castle Mountain Group.

Castle Mountain group.

The Castle Mountain group is the most widely distributed series in this part of the range, and is the only one which is found on both sides of the great break west of the Saw-back Range. In the eastern ranges it is overlaid by the Intermediate limestone, and in the west, along the Columbia, by the Graptolitic shales. It has a known minimum thickness of 7700 feet, but as the whole series was never seen in one section, and none of the horizons could be traced for any distance across the folds, it is highly probable that this estimate is too small, and that its total volume approaches 10,000 feet.

Thickness.

Composition of rocks.

The Castle Mountain group is essentially a limestone formation, and consists of ordinary and magnesian limestonos, together with every gradation between them and calcareous shales and schists. Its mode of stratification, like its composition, and dependent upon it, is very variable, and massive beds of hard limestone are often replaced in the course of a few miles, by cleavable calc-schists and soft shales. The beds are more persistent along the strike than in a transverse direction, and the harder bands project as longitudinal ridges, often of great length, separated by valleys, which mark the position of the softer varieties. Stratification.

Amongst the most important rock species of this formation, are the dolomites of the Castle Mountain range and other places. These occur in heavy beds, often several feet in thickness, and weather into steep, massive-looking cliffs. They are usually compact, or moderately crystalline, in texture, but numerous fragments, observed along the eastern edge of the Otter-tail Range, resemble Archæan limestones in their coarseness. It is possible, however, that these may be derived from veins, as they were not seen *in situ*. The dolomites on a fresh fracture have a greyish or banded appearance, but weathered surfaces are always more or less rusty. The deep ferruginous coloration of irregular patches, which is observable in some of the sections, is probably due to local influences. A variety of this rock, seen near the base of the formation at Emerald Lake, has a peculiar cavernous structure. The cavities are small, are partly refilled, and run in lines parallel with the bedding. Dolomites.

A large proportion of the rocks of the Castle Mountain group, consist of mixtures, in various proportions, of dolomites and limestones. The ribanded limestones, found in the ranges west of the summit, are of this character, and are often regularly and beautifully striped with different colours. In some instances, where this rock is much weathered, the dolomitic layers project, as yellowish ribs, above the greyish calcareous bands. Ribanded limestone.

In the calcareous variety occuring at the gap of the Bow, and along the eastern part of the Devil's Lake valley, the dolomitic and other impurites, have segregated together, and are arranged in irregular broken lines, parallel with the bedding.

In the Wapta Valley, west of Field, the limestones and dolomites are associated with a great series of greenish calc-schists, and greenish and reddish shales and slates. These schistose rocks often show green, glossy surfaces, but are never very highly altered, and hold few secondary minerals. They are usually soft, are highly calcareous, and are traversed by a set of cleavage planes, dipping at a high angle and running parallel to the general direction of the chain. A second set of cleavage planes, striking nearly at right angles to the first, is developed in some localities, but is of less importance. Limestones associated with argillittes. Cleavage.

The greenish variety comes to the surface in the bottoms of the wide longitudinal valleys of the Otter-tail and Beaver-foot, and is replaced in the neighbouring ridges by the more indurated greyish and reddish shales, slates, and limestones.

A series of four specimens from this formation, representing stages in the transition from heavily bedded dolomites to cleaved dolomitic slates and schists, was examined by Mr. F. D. Adams, in order to ascertain if the structural changes are due to original differences in composition, or are simply indicative of varying degrees of mechanical alteration. The results of his examination are given in the following notes:—

Analyses by Mr. Adams.

I. From Mount Stephen.—A bluish-gray dolomite, with indistinct lines of banding.

Insoluble residue	1·069	per cent.
Carbonates	98·931	"
	100·000	

The insoluble, before ignition, was greyish-black in colour. After ignition, it was white, with a faint reddish tinge, and seemed to consist principally of quartz. The dark colour previous to ignition was due to organic matter.

II. From Van Horne Mountains.—A very finely laminated brown dolomitic argillite. Shows lines of bedding transverse to the plane of lamination.

Insoluble residue	82·719	per cent.
Carbonates	17·281	"
	100·000	

The insoluble residue, which, before ignition, was of a faint brownish colour, after ignition was of a light brownish-grey colour. It was found to be composed of silica and alumina, with a small quantity of ferric oxide, lime and magnesia, and is therefore argillaceous matter. The acid solution was found to contain, in addition to lime and magnesia, a little ferric oxide and alumina.

III. From Otter Tail Valley.—A rock composed of more or less lenticular shaped pieces of a bluish dolomite, separated by thin partings of argillaceous matter.

Insoluble residue	42·524	per cent.
Carbonates	57·476	"
	100·000	

"The insoluble, which, before ignition, was of a rather dark bluish-grey colour, and which after ignition was white, was composed of silica, alumina and a little lime. It is therefore also argillaceous matter, but probably contains a small admixture of quartzose material. The acid solution contained, in addition to lime and magnesia, a little alumina and ferric oxide.

"IV. From Mount Hunter.—Resembles No. III., but is of a buff colour, and has a much better developed schistose structure.

Insoluble matter	43·069	per cent.
Carbonates	56·931	"
	100·000	

"The insoluble residue had before ignition a faint, brownish tint, and after ignition was of a light-brown colour. It was very gritty, and probably consisted, for the most part, of quartzose material. The acid solution contained proportionately more lime and less magnesia, than in the case of any of the previous specimens, showing that the rock is an impure magnesian limestone rather than an impure dolomite. The acid solution also contained a little alumina and ferric oxide, as before.

"In determining the amount of insoluble residue present in those rocks the carbonates were removed by means of dilute nitric acid. The small quantities of water and organic matter present in the rocks are here included with the carbonates, which were determined by difference.

"These four specimens are believed to represent, pretty closely, the several series from which they were taken, and their examination was undertaken with a view to ascertaining whether Nos. 2, 3 and 4 could have been produced from No. 1, by simple process of diagenesis. The results given above show that this is not possible, No. 1 being a nearly pure dolomite, while, Nos. 2, 3 and 4, in addition to numerous minor differences, contain on an average more than 50 per cent. of argillaceous or silicious matter. It must, however, be mentioned that No. 1 does contain small beds of rock, similar in composition to Nos. 2, 3 and 4, a small fragment of shaly rock, from one of these beds, was found to be an argillaceous dolomite, resembling, in a general way, No. 2 and 3. No. 5 also forms small beds in a dolomite, equivalent to No. 1." Dolomites and dolomitic shales.

In addition to the rock varieties of this group, already mentioned, a hard limestone conglomerate appears, towards the top of the formation in the Sawback Range and other places, and beds showing a peculiar oolitic structure, are also common in some localities. Mr. Adams furnishes the following description of a specimen of this rock from near Hector Station, Hector Pass. Limestone conglomerate. Oolitic beds.

Description of oolite.

" A sort of oolite, consisting of small, globular concretions of a bluish-black colour, imbedded in a dull, yellowish ground-mass. The concretions are about one millimetre in diameter, and form about half the volume of the rock. When a section of the rock is examined under the microscope, each concretion is seen to be composed of numerous elongated individuals of calcite, radiating from its centre to its circumference. Each concretion thus forms a well defined spherulite, which, between crossed nichols, shows a more or less perfect black cross, whose arms are parallel to the vibration planes of the nichols. They show no concentric structure, but are well defined against the groundmass, which is very fine-grained and contains much argillaceous matter. By transmitted light the concretions are of a very light brownish colour. When separated from the ground-mass and treated with cold, dilute hydrochloric acid, they disolve readily, leaving some flocculent (argillaceous ?) matter, to which their light brownish colour, by transmitted light, is probably due. The acid solution is found to contain much lime, and a small quantity of magnesia, but no ferric oxide. The rock itself, even in fragments, dissolves readily in cold, dilute, hydrochloric acid, but leaves a large amount of insoluble, apparently argillaceous, matter. The acid solution contains much lime, with a smaller amount of magnesia and a little alumina and ferric oxide, showing that the rock is an impure magnesious limestone."

Beds dolomitic below and calcareous above.

Section in Castle Mountain.

The sequence and relative importance of the various members of this group, differ widely in every section, but as a rule, the beds are more dolomitic and more heavily bedded below, and become more shaly and calcareous above. In the Castle Mountain section, the series commences with a thin band of shaly, limestone, above which comes 1500 feet of massive dolomites, forming the steep cliff face of the range. The massive dolomites are overlaid by some yellowish, compact impure dolomites, and these by 300 feet of reddish shales, above which comes several hundred feet of shaly, magnesian limestones, forming the top of the mountain. Mount Stephen shows a section of about 5000 feet, consisting mainly of heavy dolomites, but holding shaly bands at intervals. One of these, occurring at the base of the formation, and another about 2000 feet higher up, are rich in trilobites. In the Sawback Range, the base of the formation is faulted off, but the part present shows several thousand feet of heavy limestones, mainly dolomitic, interstratified with some shaly bands, and passing upwards into more flaggy beds. At the summit of Johnson Creek, the upper part of this section contains some schistose beds closely resembling those of the Otter-tail Valley. At the gap of the Bow, and of Devil's Lake valley, the base is again faulted off, and the limestones and dolomites in sight represent the upper part of the

Schistose beds at summit of Johnson Creek.

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Since the paragraph on the "Fossils" of the Castle Mountain Group was written, five new species of trilobites from the "Primordial" rocks of Mount Stephen have been described by Dr. Carl Rominger, in the Proceedings of the Academy of Natural Sciences of Philadelphia.

Of these, *Ogygia Klotzi*, *O. serrata*, *Embolimus spinosa* and *E. rotundata* are represented in the collection made by Mr. McConnell at Mount Stephen, near Field.

formation. At the former locality, the limestones are associated in one place with some schistose beds. In the Beaver-foot range, the highest beds of the series occur, and consist of impure shales and shaly limestone, passing downwards into more altered beds. The exact position in the series of the schists, shales, and limestones of the Van Horne and Hunter ranges, has not been determined. They are unfossiliferous, and are separated from known horizons by disturbed zones, across which it is impossible to trace individual beds or even a series of beds.

Distribution of Castle Mountain group.

The beds of the Castle Mountain group are found at the gap of the Bow, where they form the outer range, overlooking the plains, and extend from there, in a gradually widening band, north to the Devil's Lake valley and beyond. They are next met with, going west, in the Sawback range, and still further on in the Castle Mountain range. After crossing the Bow River anticlinal, which brings up lower rocks, they are again met with in the watershed range, and then cover all the surface as far as the Columbia, with the exception of the central part of the Beaver-foot range, and a small area in the valley of the Wapta, between Wapta Lake and Field.

The Castle Mountain group extends from the Cambrian up into the Cambro-Silurian, and seems to have approximately the same range as the Pogonip limestone of Clarence King's Middle Nevada section.

Fossils.

A hasty examination of some of the fossils obtained from it enabled Mr. Whiteaves to recognize species belonging to three distinct horizons. Such Lower Cambrian forms as *Paradoxides*, &c., were found near its base, and about 2000 feet higher up such Middle Cambrian genera as *Olenoides* and *Doropyge*, with two species of *Bathyourus*, while the upper beds yielded *Raphistoma rotuliformis* and an *Asaphus*, and are, therefore, probably Cambro-Silurian (*Ordovician*).

Bow River Series.

Bow River group.

The Bow River group forms the basal member of the section in this part of the mountains, and, as developed along the line of railway, consists mainly of a great series of dark-coloured argillites, associated with some sandstones, quartzites and conglomerates. The base is not seen, but the part exposed has an estimated thickness of 10,000 feet.

Thickness.

Argillites.

The argillites are usually dark-greyish in colour, but become greenish and purplish in places, are very impure, and frequently grade into flaggy sandstones, which are often slightly calcareous. The small quantity of lime present is due doubtless, in most cases to a decomposition of the felspathic constituents of the rock. They are hardened and occasionally cleaved, and scales of mica are often developed along divisional planes, but on the whole show comparatively little alteration for beds of this age.

Conglomerates. The conglomerates are described in the following terms by Dr. Dawson (Annual Report, 1885, p. 159 B) :—"The conglomerates above alluded to were seen for the most part in connection with the Cambrian anticlinal of the upper part of the Bow Valley. They are characterized by pebbles of milky or semi-transparent quartz, together with pieces similar in size of fresh-looking, whitish felspar, and the matrix contains abundance of pale mica. These constituents have evidently been derived from some not far distant exposures of coarse granitic or gneissic rock. Fragments are found of dark, lustrous schist. Rocks of the character of those largely developed on Shuswap Lake and in the Gold range would afford such material."

The conglomerates characterize more especially the top of the formation, and occur in thick, massive-looking bands, alternating with quartzites and shales. They are usually firmly cemented into a hard, unyielding rock, but are also met with in a little consolidated and crumbling condition.

Quartzites. The quartzites, like the conglomerates, are mostly found in the upper part of the formation, and sometimes, as in Cathedral Mountain, replace the latter altogether. They are largely developed in the watershed range between Eldon and Laggan, where they rise into high foot-hills in front of the main limestone peaks.

Distribution of Bow River group. The Bow River series occupies the wide longitudinal valley east of the watershed range, and is met with all along the line of railway between Silver City and Stephen. A little east of this latter place it is carried below the surface by a synclinal fold, but appears again about a mile west of Wapta Lake, and then gradually rises in Cathedral Mountain, until it meets the fault, which runs in a north-westerly direction between Mount Stephen and Cathedral Mountain, by which it is brought almost down to the surface of the valley, and is soon afterwards buried by a westerly dip. It is possible that some of the schistose rocks of the Otter-tail and Beaver-foot valleys, which have been referred to the Castle Mountain group, may belong to this series.

Fossils. The only fossils obtained from this formation were collected by Dr. G. M. Dawson at the summit of the Vermilion Pass in 1884, and consist of a couple of trilobitic impressions, one of which has been identified by Prof. C. D. Walcott as *Olenellus Gilberti*, a characteristic Middle Cambrian fossil.

Structural Features.

The Rocky Mountains, in the latitude of the present line of section, are divided by radical differences in structure into two distinct geological provinces, the line of division being nearly coincident with the western base of the Sawback range. The region east of this line has been broken by a number of parallel or nearly parallel longitudinal fractures into a series of oblong orographic blocks, and these tilted and shoved one over the other into the form of a westerly-dipping compound monocline. In the section examined there are seven principal faults, besides some of minor importance, and six well-defined blocks, the latter resting on one another in regular succession from west to east. The thrust producing these crust movements and dislocations came from the west, and must have been highly energetic in its action, as some of the breaks are of huge proportions, and are accompanied by displacements of many thousands of feet. The faulted region is now about twenty-five miles wide, but a rough estimate places its original width at over fifty miles, the difference indicating the amount of compression it has suffered. Overturned folds were observed along the courses of some of the faults, but they are usually small, and are of minor importance as a structural feature, and the great earth rents of the district seem to have been produced without much preliminary bending. The tilted blocks form a series of more or less parallel ridges running lengthwise with the chain, but the intervening depressions, unlike those of the Great Basin, where the structure is somewhat similar, are true valleys of erosion, and although their direction is determined by the course of the fault, are due to the unequal hardness of the formations. In one of these valleys the fault is invariably found along the base of the cliff like part of the ridge bounding it on the west—the cliff being formed by the truncated edges of one or more of the older formations,—while the greater part of the valley is dug out of the inclined Carboniferous or Cretaceous shales which always cover the western slopes of the ridges, and mark the beginning of a repetition of the formations.

Two provinces.

Faults.

Thrust from the west.

Compression of faulted region.

Overturned folds.

Parallel ridges.

Valleys of erosion.

A section through a typical ridge, starting from the west, shows first Cretaceous shales faulted under one of the older formations, and underlaid by the Banff shales and limestones. The Banff limestones usually form the central portion of the ridge, and rise into the higher peaks. They are underlain by the Intermediate limestone, followed below by the beds of the Castle Mountain group. The latter is broken through and faulted up over the Cretaceous shales, and the same succession is again repeated.

Typical section.

Varying throws

The faults have, however, varying throws, and all the beds from the Upper Banff shales to the Castle Mountain group inclusively, are brought in different places in contact with the Cretaceous shales, which here form the top of the series.

Type of structure unusual.

The type of mountain structure described above is somewhat unusual, and has not, so far as I am aware, been noticed as a prominent feature in any of the reports treating of the disturbed belt of the western part of the continent.. The Basin range structure, which produces a similar system of parallel ridges, is caused by normal faulting, and the intervening valleys are not due to erosion but to a sinking of the beds on the downthrow side of the fault.

Similar structure in Appalachian region.

In the southern extenston of the Appalachian region, however, the valley of East Tennessee presents an almost identical structure, and Professor J. M. Safford's interesting section across this valley might almost be taken for an illustration of the structure of this part of the Rocky Mountains. The close parallelism between the structures of the two regions may be seen by comparing the following description with what has been written:—"The length of the section is fifty-two miles. Eight great faults are crossed. It is to be observed that no great flexures occur. This is the most crowded part of the valley. The incipient folds were split open longitudinally, and the south-eastern side of each heaved up and over the north-western. The older formation is on the south-eastern side of a fault. In passing from one fault in a south-easterly direction to another, the successive formations are met with in ascending order, until the second fault is reached; passing this, an older formation occurs again, to be followed, as before, by newer ones. The formations are thus arranged by the faults into successive series, the series being much alike, in fact, to a great extent, repetitions of the same thing. In the section there are eight of these series between Walden's Ridge and Chilhowee Mountain."*

The recent investigations in the Scotch Highlands have also shown that the beds there are affected by a similar system of faulting.†

Structure of western part of chain different.

In the western part of the chain, between the Sawback range and the Columbia, the structure is entirely changed; no reversed faults have yet been recognized there, and ordinary and overturned folds play the most important role. The greater part of this district has also been subjected to regional metamorphism, and all the beds, except the purer limestones, are in a more or less altered condition.

The constituent formations of the two regions, as well as the structure, are very dissimilar, and some of the formations, when traced westwards, become greatly changed.

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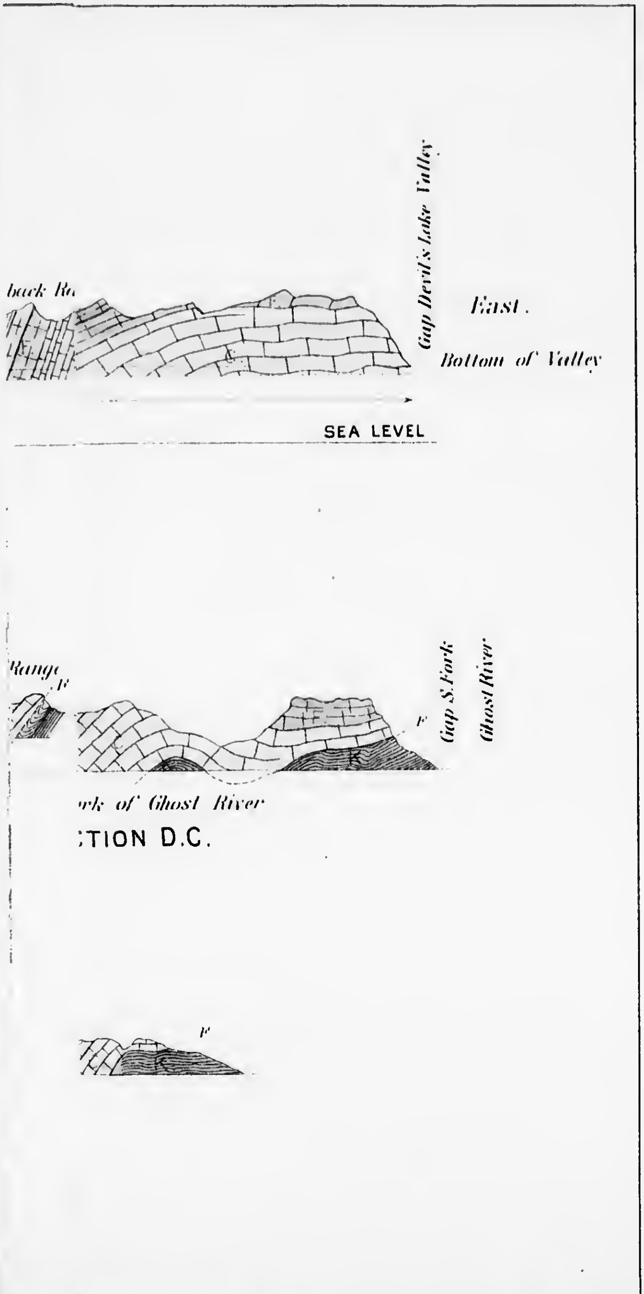
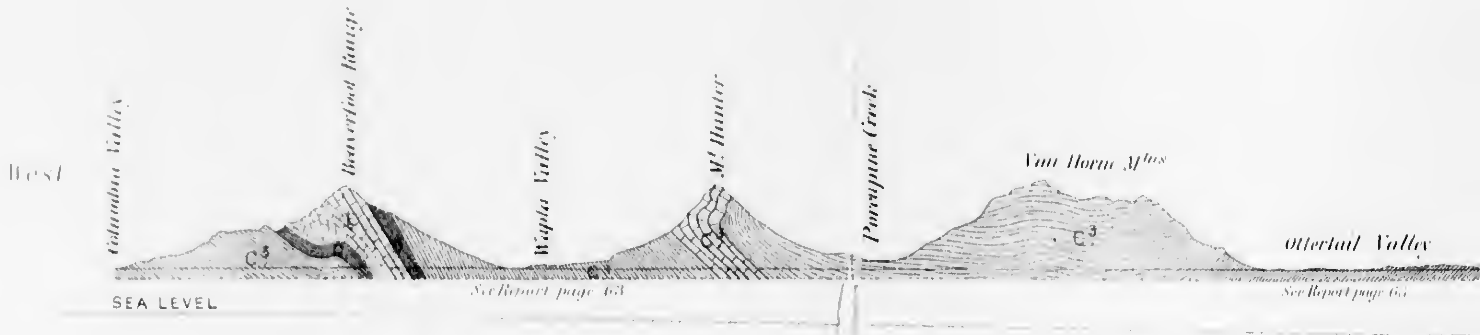
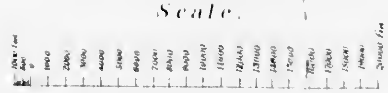
* Geology of Tennessee, page 190.
† Nature, vol. xxxi., page 29.



The Burland Lithographic Company Montreal



Scale.



Vertical and Horizontal Scales 2 Miles to 1 inch.

SECTION ACROSS THE ROCKY MOUNTAINS IN THE VICINITY OF THE CANADIAN PACIFIC RAILWAY,

Near the Fifty-First Parallel,

BY

R. G Mc CONNELL, B.A.

To accompany Report D.

VOLUME II

1886.

Geological and Natural

ALFRED R.C. SELWYN C.M.G.

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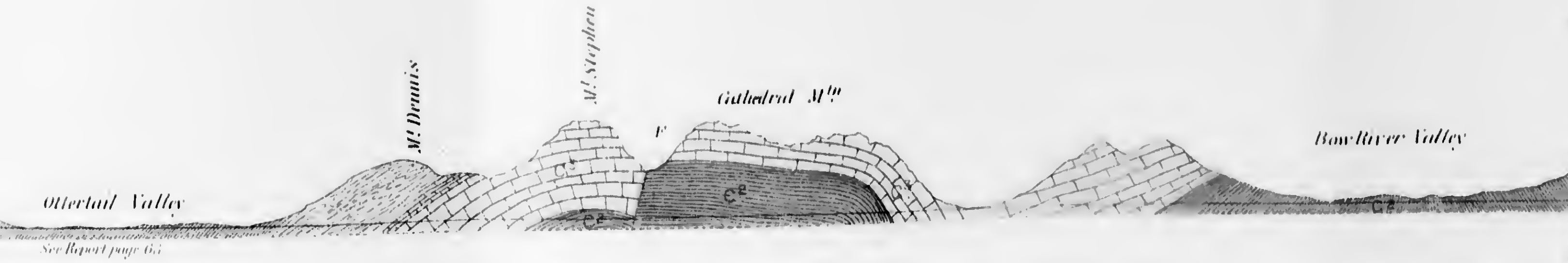
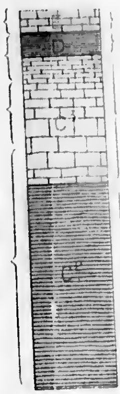
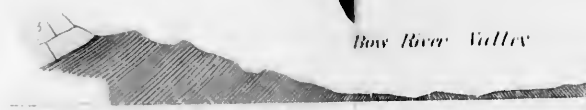


FORMATIONS REPRESENTED IN THE SECTIONS TO THE WEST OF THE CASTLE MOUNTAIN RANGE.





CIFIC RAILWAY,

SECTION O

l History Survey of Canada.

M.G., LL.D., F.R.S. &c., DIRECTOR.

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SECTION A.B.

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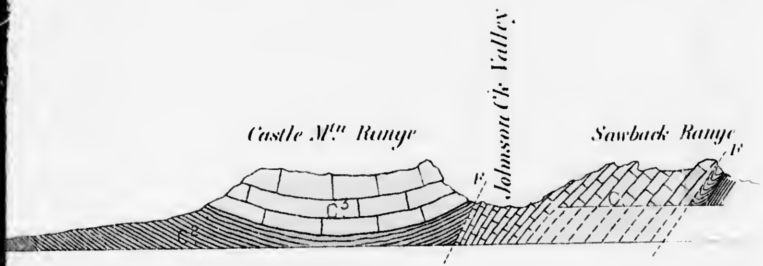
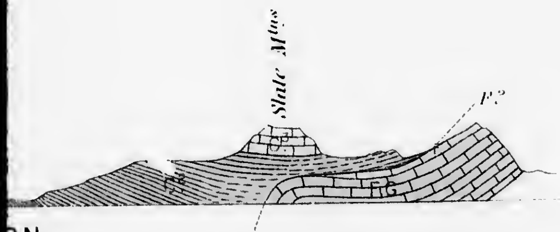


SECTION M.L.

SECTION H.



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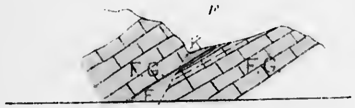
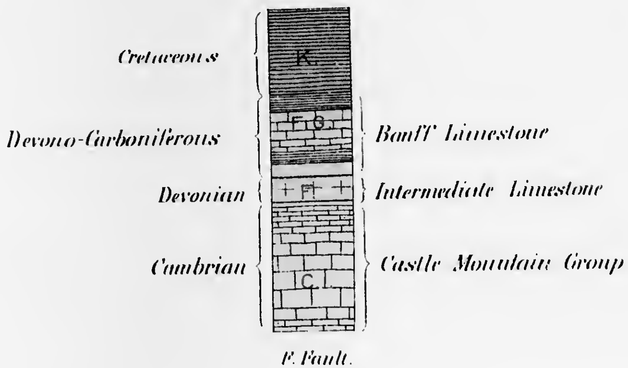
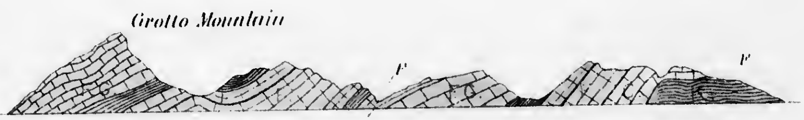


SECTION G.

FORMATIONS REPRESENTED IN THE SECTIONS
TO THE EAST OF THE CASTLE MOUNTAIN RANGE.



SECTION D.C.



SECTION E.F.

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The formations found in the eastern province consist, in descending order, of the Cretaceous shales, the Banff limestones and shales of Devono-Carboniferous age, the Intermediate limestone of Devonian age, and part of the Castle Mountain group of Middle and Lower Cambrian age, measuring altogether about 18,000 feet. The whole series, notwithstanding the gaps in the sequence, is conformable throughout. The Castle Mountain group, in its occurrence along the eastern edge of the mountains, contains no beds newer than the Cambrian, and is overlain directly by the Devonian, but in its western extension appears to pass up gradually into the Cambro-Silurian. Formations in eastern province.

In the western province the Cretaceous shales, the Banff limestone and the Intermediate Limestone are wanting, and the highest beds belong to the Silurian—a formation unknown in the eastern district. The Silurian or Halysites beds are followed conformably, in descending order, by the graptolitic shales of Utica-Trenton age, the Castle Mountain group, and the Bow River group of Middle and Lower Cambrian age. The section here has a thickness of 23,000 feet, the greater part of which is Cambrian. Formations in western province.

The dominant structural features of the eastern district, as stated before, are due to a series of gigantic thrust faults, which have carried the older formations forward, and placed them in a number of places above the highest beds of the series. One of the largest and most important of these occurs along the eastern base of the chain, and brings the Cambrian limestones of the Castle Mountain group over the Cretaceous of the foot-hills. This fault has a vertical displacement of more than 15,000 feet, and an estimated horizontal displacement of the Cambrian beds of about seven miles in an easterly section. The actually observed overlap of the older beds as shown on section D–C amounts to nearly two miles. The angle of inclination of its plane to the horizon is very low, and in consequence of this its outcrop follows a very sinuous line along the base of the mountains, and acts exactly like the line of contact of two nearly horizontal formations. Dominant features. Great fault at base of range.

The best places for examining this fault are at the gaps of the Bow and of the south fork of Ghost River. At the former place the Cretaceous shales form the floor of the bay which the Bow has cut in the eastern wall of the range, and rise to a considerable height in the surrounding slopes. Their line of contact with the massive grey limestones of the overlying Castle Mountain group, is well seen near the entrance to the gap, in the hills to the north. The fault plane here is nearly horizontal, and the two formations, viewed from the valley, appear to succeed one another conformably. The line of junction can be traced westward for about half a mile, but towards the upper part of the gap becomes concealed, and soon afterwards the

Cretaceous rocks bend down and are carried below the surface by a westerly dip. This undulation in the fault plane must indicate a period of disturbance subsequent to that in which the main faulting was produced.

Undulation in fault plane.

The Cretaceous shales are bent sharply towards the east in a number of places, but with this exception have suffered little by the sliding of the limestone over them, and their comparatively undisturbed condition seems hardly compatible with the extreme faulting which was necessary to bring them into their present inferior position. They are, however, very soft, and doubtless owe their immunity to this fact. It is otherwise with the overlying limestones, which have been strongly corrugated in many places, and are often whitened and cracked in the vicinity of the fault plane, the cracks having been subsequently filled with calc-spar. Enclosed argillaceous beds have also been turned into schists, and the banded appearance of much of the limestone is, no doubt, due to the shearing caused by the thrust.

Shales little disturbed.

Limestones much altered.

At the gap of the south fork of Ghost River, where the fault was next examined, the Cretaceous shales, after dipping below the surface, rise again about a mile farther up the valley, and remain exposed for some distance before they finally disappear. The Castle Mountain group here is reduced to a mere tongue, only a few hundred feet thick, separating the Intermediate limestone from the Cretaceous, but, as it thickens out greatly when traced westwards, its faulted character is very evident. The section at this point has a further interest in the fact that a number of Benton fossils were found in the shales directly under the limestone, while a couple of miles north, along the strike of the beds, the overlying limestone yielded Cambrian fossils.

Character of fault at south fork of Ghost River.

Underlying shales hold Benton fossils.

The plane of the fault dips to the north after passing the south fork of Ghost River, and at the gap of the Devil's Lake valley the shales have disappeared, and the section shows only the overlying limestones.

The small area of Cretaceous shales observed by Dr. Dawson in the bottom of the valley of the Elbow River, about two miles west of the edge of the Palæozoic rocks, is probably to be accounted for by the continuation of the same great thrust fault to the south of the Bow, repeating the conditions described on the south fork of Ghost River.

Going up the Devil's Lake valley, along which the main section is measured, the flat lying beds of the Castle Mountain group, overlain in the higher peaks by the Intermediate limestone, are observed to occupy both sides of the valley for some miles. Farther up they dip to the west, and are overlain successively by the Banff limestone and the Cretaceous shales, and then the sequence is again broken, and the latter are faulted for a second time under the older beds. This fault has a steeper hade, and consequently a straighter outcrop than the one

Second fault.

described before, and its throw is also much less, as it nowhere exposes beds lower than the Banff limestone. It follows a large straight valley running lengthwise through the whole extent of the Fairholme Mountains, and has also been traced north of the Devil's Lake valley for some miles. It runs about N. 25° W.

The distribution of the Cretaceous shales along the eastern side of this fault is somewhat peculiar, as they have been preserved only in patches at the summits along the longitudinal valley which accompanies the fault, and have been removed from all the lower parts by denudation. They are consequently not seen at the low elevations at which deep transverse valleys, like those of the Devil's Head and Bow, cross the line of fault. Distribution of shales.

About a mile farther west, still going up the Devil's Head valley, the beds in the mountains to the north suddenly become violently folded, indicating that a third line of disturbance is reached. The folding here is not accompanied by much faulting, and is caused by the disturbance of the beds in the prolongation of a faulted line. Traced to the north, however, it soon develops into a well-defined fault, and in a few miles has a throw of several thousand feet, and brings the Lower Banff limestone up against the Upper Banff shales. The line of this fault strikes more to the west than the preceding one, and if continued south would join the latter a short distance south of the valley. Beds much disturbed.

A fourth fault crosses the valley about two miles east of the west end of Devil's Lake, and as it brings the Intermediate limestone over the Banff, must have a throw of about 6000 feet. This fault, like the one last referred to, dies out when followed southwards, and near the Bow is represented by an anticlinal fold. Traced northwards into the Palliser Range, newer beds are introduced in consequence of the increased elevation, and in place of the Intermediate limestone overlying the Banff series, as in the valley of Devil's Lake, the Banff series overlies the Cretaceous shales. A comparison of section G, in the accompanying series of sections, with the corresponding part of the general section, will make this clear. Fourth fault.

West of this faulted region comes the Cascade trough, a wide depression based mainly on Cretaceous shales. The shales here are coal-bearing, and on this account the basin was examined with some care by Dr. Dawson during the course of his exploration, and a detailed account published in the Annual Report for 1885. (See Part B, p. 126.) The synclinal fold described by him is not evident along the line of the general section, but is well shown a few miles farther south, in the transverse ridges between the Bow and the Kananaskis. The attitude of the beds here is illustrated in the two sections H and K. The limestones on the west have been broken and shoved forcibly over the Cascade trough. Synclinal fold.

Cretaceous shales, and in their forward movement have folded the latter and even overturned them in places. The axis of this fold gradually approaches the western boundary of the basin to the northward, and must become nearly coincident with the eastern edge of the limestone in the vicinity of the entrance to the White Man's Pass. North of this, it is highly probable that, for some distance at least, only the eastern limb of the fold is present, but the fragmentary character of the sections exposed in this part of the valley made it impossible to prove this satisfactorily.

Only eastern limb of fold present.

Length of fault.

The fault along the western edge of this trough has been traced from the Kananaskis River, in a direction about N. 35° W., for about forty miles, and must also extend southwards for some considerable distance, as it is found there in full force. It appears to attain its maximum throw nearly opposite Canmore, where it cuts through the Intermediate limestone, the whole Banff series, and at least 4000 feet of Cretaceous, indicating altogether a displacement of over 10,000 feet. To the north the throw rapidly diminishes, and the Intermediate limestone, followed by the various members of the Banff series, are successively buried by the Cretaceous shales east of the fault. The gradual disappearance of these formations is plainly shown in the naked easterly slopes of Cascade Mountain, and in the same range the intimate relations existing between ranges and faults may also be observed. This range is built of limestone beds dipping westwards, and presenting their truncated edges to the east, and where cut by the Bow Valley has an elevation of over 5000 feet. It descends to the north in close connection with the decrease in the throw of the fault, and, after the latter passes into an anticlinal fold, becomes reduced to a low, rounded ridge.

Extent of throw.

Connection between ranges and faults.

Limestones west of fault.

The limestones west of the fault are often bent by their pressure against the beds on the eastern side into a succession of sharp folds, and are occasionally completely overturned. They also show disturbances in the altered and cracked appearance of the strata in the immediate vicinity of the faulted line.

Smaller faults.

In addition to the principal dislocation along the western edge of the Cascade basin, a couple of smaller faults are also known to occur on the eastern side, but were not accurately determined. They are instrumental in repeating some of the upper beds of the Banff series, but are otherwise of little structural importance.

Fault east of Vermilion Lake Range.

West of the Cascade basin and range, and running along the eastern base of the Vermilion Lake range and Terrace Mountain, is a second great fault, almost equal in importance to that just described. The Cretaceous is absent here, so far as known, and the Upper Banff limestones and overlying quartzites and shales, which now form the top of the series, are folded back on the eastern side of the fault, and are overlaid by the older Intermediate limestone. The thermal springs previously mentioned are situated in close proximity to the line of this fault.

A third fault occurs east of the Sawback Range, and has displaced the beds to a greater extent than any met with west of the gap, as it cuts through the Banff series and the Intermediate limestone, and exposes about 5000 feet of the Castle Mountain group. The fracture here is either compound or encloses fragments of both the Intermediate and the Banff limestones, which have been sliced off and carried to the surface. Incomplete sections of both these formations are found along the line of fault between the Castle Mountain group and the Upper Banff shales, and in one case the beds of the latter, folded closely together and thrown into an upright position, form a series of sharp peaks running parallel with the range. The high hade of this fault, and close parallelism of the beds both above and below it, are somewhat remarkable. but are features not infrequently met with in the reversed faults of highly disturbed regions. In most of the faults already noted the hade corresponds very closely with the dip of the overlying beds, and a steeper tilting of the strata enclosing the fault plane would cause them to assume much the same appearance. Fault east of Sawback Range. Steep hade.

A fourth line of fracture and disturbance—counting from the Cascade basin—but the eighth from the gap, and the last of the series, occurs at the eastern base of the Castle Mountain range, and forms the dividing line between the two geological provinces. The faults and foldings along this line are as yet imperfectly understood, and will require much additional examination. They are extremely complicated, and a glance at the accompanying section will show their rapid change in character along the strike, and the little correspondence existing between neighboring parallel sections. Fault east of Castle Mountain.

The general section crosses the Bow Valley opposite Pilot Mountain, and is continued on to the Bow River anticlinal, and then jogged northwards along the strike to the entrance to the Hector Pass. In this section the beds are bent into a synclinal attitude, and the formations represented in the Sawback Range, after dipping below the Bow Valley, are repeated on the other side in Pilot Mountain, and their easterly dip is then maintained until the beds of the Bow River group are exposed. Disturbed lines, probably accompanied with some faulting, cross this section near the centre of the Bow Valley, and again west of Pilot Mountain near the point of contact of the Bow River and Castle Mountain groups. Direction of general section. Disturbed lines.

Section M—L crosses the disturbed belt about fourteen miles further north, near the summit of Johnson Creek, and is broken by two large

Section near summit of Johnson Creek.

faults. The most easterly of these places the Castle Mountain group over the Banff series, and brings beds together which are normally separated by over 12,000 feet of intervening strata, and the one to the west lifts the beds of the Bow River group over the upper part of the Castle Mountain group. The latter group, in its recurrence here, is continued upwards into beds holding Cambro-Silurian fossils, while farther east it is Cambrian throughout, and is overlain by the Devonian.

Section north of Baker's Creek.

Section O—N, sketched north of Baker Creek, about eight miles farther along the strike, shows a great thrust fault, something like that occurring along the eastern edge of the mountains. The beds here seem to have been first completely overturned, and then the upper limb of the anticlinal torn from the lower and slidden along it for miles, as the beds brought in contact indicate a vertical displacement of over 10,000 feet. The disturbance east of this fault has been intense, and has produced much folding and alteration. In one case, about a mile north of the section, some of the Bow River group conglomerate was found interbedded with the Banff limestone, either folded or faulted in, in some way not easily understood. This section shows the relations of the formations, north of the valley of Baker Creek, but going south the fault plane must either bend suddenly downwards or is let down by a cross fault, as the southern bank of this valley shows only the beds of the Castle Mountain group. This uneveness of the fault plane probably indicates a second period of disturbance.

Great Disturbance.

West of this line of disturbance the structure of the mountains changes completely, and reversed faults and westerly dips, hitherto all important, cease to be the prevailing features. The Castle Mountain range—the first range in the western geological division—has the form of a gentle syncline, and is built of the shales, quartzites and conglomerates of the Bow River group, overlain by the massive dolomites and the limestones and shales of the Castle Mountain group. This syncline is followed by a great anticlinal fold, which brings up the lowest beds found in the range. The seemingly prodigious thickness of the Bow River group in this anticlinal, as shown in sections M—L and O—N, is probably due, to some extent at least, to repetitions caused by subsidiary foldings. Farther west in the watershed range the beds bend under a second moderately flat synclinal, and are then displaced by a steep fault. These folds all strike about N. 35° W. The dips are shown in the accompanying section and need not be described. The fault mentioned above passes between Mount Stephen and Cathedral Mountain, and on the opposite side of the valley runs through the eastern shoulder of Mount Field. It has a hade of 75° and a downthrow to the west of about 3000 feet.

Synclinal and anticlinal folds.

Bow River group.

The beds of the Bow River group, almost buried by this fault, are arched up again by a second anticlinal, and are then exposed for some distance along the base of Mount Stephen, but disappear finally about a mile east of Field. They are overlain and followed round the anticlinal by the dolomites of the Castle Mountain group, of which the upper and greater part of the mountain consists.

West of Mount Stephen, in Mount Dennis, the beds become violently flexed, and at the same time the dolomites are replaced by cleaved dolomitic argillites. These beds have been classed with the Castle Mountain group, but the reference is not altogether free from doubt. They are sharply separated from known horizons by the disturbed belt noted above, are destitute of determinable fossils, and are also much more argillaceous than the typical Castle Mountain dolomites, but closely resemble in this respect the shaly bands which occur all through that formation, but which are especially charcteristic of its upper part. To establish their relationship satisfactorily, however, it would be necessary to measure a connecting section in a less disturbed district. Mount Dennis.

These beds are cut by a series of small calcite or quartzite veins, which run nearly parallel with the bedding, and are often metalliferous. They are found in the valley of the Otter-tail, where they consist of soft, greenish, imperfectly schistose beds, dipping to the west at a high angle, and in the Van Horne and Otter-tail ranges, where they are characterized by lower dips and are associated with reddish slates and limestones. Both these ranges are traversed by a longitudinal system of nearly vertical cleavage planes, and also by a second less conspicuous set running nearly at right angles to the first.

Mount Hunter, west of the Van Horne Mountains, owes its origin to a band of heavy bedded limestones, which here occurs in this series, and has been bent almost at right angles in the peculiar manner shown in the section. West of this point the prevailing dips are to the east. The valleys of the Wapta and Beaver-foot are underlain by soft, greenish schists, almost exactly the same as those found in the valley of the Otter-tail, but dipping in the opposite direction. In the Beaver-foot Range the Castle Mountain group is overlain by newer beds, and the whole series along the section cut by the Wapta River is bent into a synclinal attitude and overturned to the west. South along the range this syncline flattens out, and opposite Palliser the upper beds are only slightly bent. There is reason to suspect, however, that the beds here are displaced by a fault. West of the Beaver-foot range,—the most westerly range of the chain—in the Columbia valley, the beds of the Castle Mountain group are represented by impure shaly limestones, passing into calcareous and often somewhat altered argillites. These beds have a westerly dip, and are sharply corrugated in places. They are cut by a set of small calc-spar veins, which have usually nearly the Mount Hunter.

same inclinations as the strata, and are crumpled in a similar manner with the beds.

Conclusion.

The portion of the Rocky Mountains examined in the construction of the accompanying section is thus characterized in its eastern part by a series of great fractures and thrust faults, in the centre by broad, sweeping folds, and in the west by folding and crumpling, accompanied by the development of cleavage-planes and a limited amount of metamorphism. Among its other more important features, may also be noted the absence of recognizable unconformities, the absence of any of the older crystalline schists, the relatively smaller amount of disturbance in the central parts of the range than towards the edges, the want of similarity in the sequence of the formations east and west of the axis, and the marked preponderance of calcareous beds between the Middle Cambrian and the Cretaceous.

Notes on Economic Minerals.

The following notes are partly reprinted from the Preliminary Report given to the Director on my return last autumn, and since published in the Report of the Minister of the Interior.

The section of the mountains in the vicinity of the railway contains a variety of mineral deposits, and has every indication of becoming an important mining region. The Cretaceous beds of the Cascade trough hold a number of seams of excellent coal, while farther west the Cambrian and Cambro-Silurian limestones and schists, which cover most of the country between Silver City and the Columbia, are almost everywhere metalliferous, and few mountains have been prospected in this district which have not yielded ores of some kind.

In the past season, with the exception of some work in the Otter-tail valley and in the Banff coal mines, little mining of any importance has been attempted, but prospecting has been actively and successfully engaged in, and a number of valuable discoveries are reported.

In the Silver City district, mining at present is at a standstill, and, beyond prospecting, nothing is being done.

In the Otter-tail district, the Otter-tail Gold and Silver Mining Company have worked three claims during the season. One of these, the "Louis" claim, is situated directly under the railway track, about one and a quarter miles east of the Otter-tail station; the other two are on the east side of the creek, about a mile and a half up the stream from the railway crossing. A good road has been constructed from the railway to the mines, and effective preparations made for handling the ore. A little farther up, the Otter-tail is joined from the south by the

Wet-feet Creek, on which is situated the "Copper Bonanza," one of the best seams in the district. A large number of other claims have been staked out, one company alone owning twenty, within a circuit of a few miles; but, with the exception of those mentioned above, none are being worked at present. The uncertain state of the mining laws, and the extra expense and trouble necessitated by having to register both with the Dominion and Provincial Governments, is largely responsible for this state of affairs. The ore in this locality is an argentiferous galena, associated with some copper, zinc and traces of gold, and occurs in small quartz or calcite veins running parallel, or nearly so, to the strike of the calcareous schists, shales and limestones, which form the country rock of the district. The seams are small, seldom exceeding eighteen inches in thickness, but the ore is reported to contain a high percentage of silver. A stamping mill has been put up near the Canadian Pacific Railway crossing of the Ottertail, by the "Rocky Mountain Mining and Ore Reduction Company," and the ore from the different mines is now crushed and concentrated before shipment.

Near Field, Messrs. Coffman & Weitman have opened up the "Monarch" and "Cornucopia" claims in Mount Stephen, and the former especially now presents a very favorable appearance, showing over six feet of solid galena. The ore here is deposited in what miners call a "blanket-lode," and appears to impregnate a zone of interbedded calcareous rocks. It has been traced along the face of the mountain for several hundred yards, and, since I was there, Mr. Pattie, of Carleton Place, by blasting out a trail around an almost vertical cliff, has been enabled to explore it still farther, and reports the discovery of a nine-feet deposit. The galena is low-grade in silver, containing only from four to eleven ounces to the ton, (see assays 19-22, Part M, Annual Report of the Geological Survey for 1885,) but possesses compensating advantages in the extent of the deposit, the easy and comparatively inexpensive manner in which it can be worked, and in its proximity to a railway station.

A vein of calcite, flecked through with grains of cinnabar, is being opened near Golden City, and is interesting as being the only deposit of the kind known in the entire region.