RECENT DISCOVERIES OF CAMBRIAN BEDS IN THE NORTHWESTERN UNITED STATES

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The lifelong studies of Dr. Charles D. Walcott on the stratigraphy and paleontology of Cordilleran North America not only made this a classic area for geologic research, but also established here the most complete known sections of Cambrian strata. However, a considerable area in which Cambrian strata seem to be wanting existed between the definitely known outcrops of the Cambrian in Montana and in British Columbia. Dr. Walcott’s further plans included field work in the northern United States and southern Canada for the investigation of this problem, but his death prevented the completion of the project.

Recently, several fortunate discoveries of Cambrian beds have been made in northwestern United States which contribute to a better understanding of the fundamental structure of the Rocky Mountain region. To understand fully the significance of these recent discoveries it is necessary to have in mind both the geographic distribution of the concerned Cambrian outcrops, as well as the primary structural regions of the Cordilleras, especially with respect to the location and direction of geosynclines and basins at the beginning of Paleozoic sedimentation.

PREVIOUSLY KNOWN DISTRIBUTION OF THE CAMBRIAN

Hitherto, as a result of Walcott’s extensive studies, the Lower Cambrian was known to extend from southern California northward through the Great Basin as far as the Eureka District in central Nevada and the vicinity of Salt Lake City in the Wasatch Range of Utah. From these points northward, beds older than Middle Cambrian seemed to be lacking, not only in northern Utah, Idaho, and Montana, but also for a considerable distance along the southern part of the Canadian Rockies.

The Middle Cambrian, on the other hand, was known to extend beyond the mentioned points in Nevada and Utah, throughout the Wasatch and thence northward into the western side of the Teton Range, in western Wyoming, and to crop out widely about the headwaters of the streams forming the Missouri River in western Mon-
tana. North of the Belt Mountains or of the latitude passing through Helena, Mont., no Middle Cambrian was known in the vast expanse of Beltian sediments extending far north into Canada, except that discovered in 1905 by Walcott in a limited area near Ovando, Lewis and Clark County, north of Helena. In the Canadian Rockies Walcott traced similar Middle Cambrian beds southward at least as far as Elk Pass on the Continental Divide. Thus it is evident that the gap between the nearest exposures of Middle Cambrian in the Rockies of the United States and of Canada was much smaller—by the distance between Salt Lake City and the Ovando area—than that between the nearest exposures of the Lower Cambrian.

Finally, the Upper Cambrian was known to extend rather generally throughout the southern Rocky Mountains, as defined below, where it constitutes the sole Cambrian deposition. These strata are at present best designated as the Deadwood series. In Montana the upper portion of Peale’s Gallatin limestone series is of about the same age as the Cambrian in the Southern Rockies, and in Canada beds corresponding rather closely to the Gallatin series and younger strata are well developed. However, both in Montana and in Canada the Upper Cambrian has a more restricted distribution than the Middle Cambrian and does not exactly coincide with it. Thus, earlier observations indicated that Cambrian outcrops were confined to the Rocky Mountain system proper—as defined in the following paragraphs—and that in it an extensive area existed in western Montana, northern Idaho, and the southern parts of Alberta and British Columbia, in which Cambrian strata were apparently lacking.

PRIMARY STRUCTURAL UNITS OF THE ROCKY MOUNTAINS

Before the recent discoveries are described, a few words concerning the fundamental structure of this part of the Cordilleran region will be helpful. In the light of early Paleozoic history it is desirable to depart somewhat from the regional classification in vogue, which is based primarily on present topography and is, therefore, a delimitation of physiographic rather than of structural provinces. The structural provinces, as here outlined, take account of the persistently positive and negative elements, and amounts of total and differential movement, or, in short, the geographic conditions during the initiation of the Cambrian or of other initial early Paleozoic periods, in so far as they are determinable.

Southern Rocky Mountains.—According to conditions at the beginning of Paleozoic time, which persisted throughout that era, this
structural province is regarded as including the Southern and Middle Rockies as recently defined by Fenneman. This includes the ranges in central Colorado, Wyoming, and south-central Montana, but excludes the Wasatch and western Wyoming ranges.

Although the Southern Rockies are in line of strike with the ranges to the northwest, nevertheless they have a wholly different geologic history and consequent structure, consisting essentially of a Cryptozoic core fringed with belts of Paleozoic rocks. We may take the Big Horn Range as a typical example of the Southern Rockies. This range consists of an elongate dome of peneplaned Cryptozoic rocks, the edges of which are surrounded by a band of early Upper Cambrian overlain by younger strata. It is certain that the overlapping edges of the Upper Cambrian strata have been stripped back along the peneplaned surface on which they rest, but they appear never to have covered altogether the higher, central portions of the dome. Owing to the positive nature of these domes, coupled with their stability throughout long periods of time, it is not surprising that real geosynclines are apparently absent from the Southern Rockies, and that, in consequence, all sediments from Cambrian to Recent times are basin deposits laid down in the same manner as the Tertiary beds of the present Big Horn Basin.

The northern boundary of the Southern Rockies is naturally an irregular line. Along the main strike the province terminates with the Beartooth Mountains, northeast of the Yellowstone National Park. However, the Gallatin and other similar Montana ranges to the west of the Beartooth mass should be excluded, even though in their evident stability and peneplaned cores they retain characteristics of the Southern Rockies. Their Cambrian, or initial Paleozoic, strata clearly belong to the northern subdivision, so that they represent the southern shore line of that province. Eastward of the Beartooth mass the northern boundary of the Southern Rockies extends far northward to include the Little Rockies and Big Snowy Mountains of central Montana, and to the east to embrace the Black Hills in South Dakota.

Applying the same criteria to the delimitation of the western boundary of the Southern Rocky Mountains, it is necessary to exclude the Wasatch, Teton, and intervening ranges from this province and include them with the Great Basin, even though the Tetons and possibly the Salt River ranges partake somewhat of the structural nature of the Southern Rockies. Cambrian and other Paleozoic strata in

these ranges were apparently deposited in a geosyncline, and the contained faunas indicate their deposition in the seas covering the Great Basin. In other words this situation would naturally be expected if these ranges are the eastern margin of the Great Basin geosyncline.

The manner in which Cambrian distribution is related to the structural provinces is well shown in the Beartooth region. On the south and east sides of this dome Upper Cambrian strata of the Deadwood series rest directly on the peneplaned Cryptozoic, but on its northwestern flanks the older Middle Cambrian holds this relationship. This situation extends the Middle Cambrian shore line, described by Peale for the southern margin of the Gallatin Valley, a considerable distance toward the east.

*Northern Rocky Mountains.*—From the Beartooth Mountains in southern Montana, immediately northeast of the Yellowstone National Park, northward to the Yukon River in northern Canada, all ranges of the eastern Cordilleran element may be grouped as the Northern Rocky Mountains. Again, from the standpoint of Cambrian or early Paleozoic history, this usage departs from that of some physiographers, conforming more closely to that of Daly, who regards the Rockies as confined, in an east-west direction, to the mountains between the Great Plains on the east and the Rocky Mountain Trench on the west.

In contrast to conditions characterizing the Southern Rockies, the northern subdivision consists essentially of great thicknesses of folded and faulted sediments, evidently deposited in geosynclines. These geosynclines were, of course, the result of prevailingly negative movements, which allowed the accumulation of thicker, more continuous sedimentary series than were possible in basins of the Southern Rockies.

In the southern portion of the Northern Rockies, as stated above, the Gallatin, Madison, Jefferson, and McCartney Ranges exhibit Cryptozoic cores, on whose peneplaned surface Middle or Upper Cambrian strata rest without intervening Beltian beds, in which respect they assume characteristics of the Southern Rockies. However, only a few miles north of the mentioned ranges Beltian strata lie beneath the Cambrian, and continuing northward the Beltian at once thickens rapidly, covering most of northwestern Montana and extending into Canada beyond the Watertown Lakes Park. It has been estimated that these Beltian strata total fully 60,000 feet. For a long time it was thought that this enormous thickness of sedimentary deposits constituted the complete sedimentary record of the geosyn-
cline, but the recent discoveries indicate the possible presence of at least Middle Cambrian, as well as the previously known younger Paleozoics.

RECENT DISCOVERIES OF CAMBRIAN BEDS IN THE ROCKY MOUNTAINS

It will be easier to understand the true significance of the following finds if we take them up in the order of their discovery, which also automatically places them in their proper provincial grouping.

*Pend Oreille Lake.*—The first discovery extending the area of known Cambrian outcrops into the supposed gap across the Beltian area was made about 1920 by Dr. Edward Sampson, at that time a member of the United States Geological Survey. He found a good Cambrian section along the southern shores of Pend Oreille Lake in northern Idaho. Here limestones and shales contain abundant Middle Cambrian fossils, which recall both those of the Ovando region in central Montana and also others in the Canadian Rockies, thus showing that Cambrian seaways extended across the western as well as the eastern portions of the supposedly barren Beltian area, where Walcott’s studies in 1905 had shown the existence of Cambrian.

*Extension of the Ovando area.*—During recent years the Montana State geologists have been studying the sedimentary beds of northwestern Montana, particularly with the view to unraveling the complicated Beltian sedimentary record. This work greatly extended the Cambrian, both geographically and stratigraphically, in the Ovando region about the head of Sun River observed by Walcott in 1905. Study of these data is now under way by Dr. C. F. Deiss of the State University at Missoula, Mont.

*South Kootenay Pass.*—The third significant discovery was made by Dr. G. S. Hume, of the Canadian Geological Survey, during the field season of 1932, when he collected what appear to be Middle Cambrian fossils north of Red Deer River, in the vicinity of North Kootenay Pass, southern Alberta. Here shales, with layers and lenses of limestone, overlie about 100 feet of quartzites, which in turn rest on the Beltian with an erosional unconformity between. The Middle Cambrian is said to be overlain by Silurian strata in the southernmost locality found, but a little farther north is directly succeeded by Devonian. The Cambrian, as well as the other mentioned Paleozoic beds, vary rather rapidly in thickness. This discovery reduces the gap, as previously outlined, by many miles in a north-south direction, as the Pend Oreille find did in the east-west direction.
Beartooth Mountains.—The recent work of the Princeton University group studying the geology of the Beartooth region has shown the presence of Middle Cambrian on the northwestern quadrant of the Beartooth Mountains. On the eastern and southern sides of this uplift only the Southern Rocky Mountain Upper Cambrian series is present, but west of a gap where Cambrian is lacking, the presence of northern Middle Cambrian apparently determines the southeastern extent of the geosynclinal seas washing the margins of the more stable lands which prevented their continuation southward through Wyoming or the Southern Rockies.

All four new localities mentioned lie within the Rocky Mountains proper, and in every respect their strata resemble those previously determined by Walcott’s studies; consequently they serve merely to close the gap between the previously known Cambrian areas in the southern part of the Northern Rockies. In other words, these discoveries were to be expected as long as definite evidence was not at hand that the known Middle Cambrian seaways had detoured around this supposedly barren Beltian area. From our knowledge we may, therefore, infer that a thin, probably discontinuous sheet of Middle Cambrian once covered some of this Beltian area, but no evidence exists pointing to the extension of younger Cambrian beds across the area. Naturally, thin beds, lying on top of great masses folded and faulted into the high ranges such as exist here at present, would suffer severely from erosion, with the result that only patches of Cambrian are left here and there in the bottoms of synclines. Nevertheless, it is the opinion of all who have studied the region that the Middle Cambrian sheet never extended all the way across the gap.

DISCOVERIES WEST OF THE ROCKY MOUNTAINS

In contrast to the four finds described, another group located in northeastern Washington contribute not so much toward closing the gap, but have a much greater significance, since they occur west of the Rocky Mountains in the strike of the Selkirk and Purcell systems.

Metaline Falls.—Recently Washington State geologists searched patiently the hitherto supposedly unfossiliferous metamorphosed rocks in the eastern part of their State and were rewarded by finding fossils which prove the presence of Paleozoic strata as was previously suspected. Last winter, Mr. W. G. Bennett, a student of Washington State College, found a shale containing good Middle Cambrian fossils at Metaline Falls on the Pend Oreille or Clark Fork River in the northeastern corner of the State, a few miles south of the international
boundary. This shale occurs in the southward extension of Daly's Pend Oreille group or Summit series. This does not necessarily remove either series from the Beltian, but probably indicates conditions similar to those described for the Rocky Mountain Beltian area north of Helena, Mont. This shale is part of a limestone belt lying between two mountain ranges of quartzite and schist. Besides the shale and limestone, from which other Paleozoic faunas have been collected, graptolitic argillites are present, which are now being studied by Dr. Ruedemann. The Middle Cambrian fossils in the shales are Elrathia aff. cordillerac, Pagetia cf. bootes, Kootenia sp., Olenoides, and Westonia, all typical of the Stephen formation, very common in the Rockies about Lake Louise, Alberta, and Field, British Columbia.

Localities near Colville.—In 1931 C. C. Branson reported Kutorgina, a genus confined to the Lower Cambrian, from the Stevens series on the Colville River, 6 miles north of Chewalah, Wash., a locality about 40 miles southwest of Metaline Falls. The Stevens series formerly was also regarded as Beltian in age, and as stated for the Pend Oreille group, it probably is Beltian but was covered with Cambrian beds, fragments of which remain in the infolded synclines.

A second Lower Cambrian locality was found by Mr. Bennett, who sent in a single piece of limestone from the town of Colville. This limestone contains fragments that appear to represent Wanneria, or at least an olenellid trilobite, accompanied by several cups of Archaeocyathus. Taken together, these two discoveries unquestionably extend the known range of Lower Cambrian strata far southwest of the most southerly locality previously known in Canada. This was at Cranbrook in southeastern British Columbia, and in or west of the Rocky Mountain Trench, which is the western limiting feature for the Rocky Mountain system. However, it is not clear whether we should regard this occurrence as being in the Purcell or in the Rocky Mountain systems. On the other hand, without doubt, the Washington Lower Cambrian localities are west of the Purcell Trench and, therefore, in the Selkirk system.

Kettle Falls.—Finally, Mr. Bennett secured another piece of fossiliferous rock a few miles east of the Columbia River, at Kettle Falls, 10 miles west of Colville, containing a pocket in which occur silicified fragments of Nisusia, Hyolithes, and a small, smooth trilobite suggesting Agnostus. This small fauna could be either Lower or Middle Cambrian, but seems to be the latter. This piece of rock is from an argillaceous quartz conglomerate, lying between two masses of schistose greenstone and grit. The conglomerate itself is much metamor-
phosed and sheared, and since the fossils are not distorted, it is likely that originally they occurred in a limestone pebble forming a part of the conglomerate. This, therefore, raises the question as to whether the conglomerate is of Cambrian age or younger.

PRESENT CAMBRIAN DISTRIBUTION

With the data furnished by these recent discoveries, the general picture of Cambrian distribution has been considerably altered, and several generalizations become possible.

The Lower Cambrian is still unknown both throughout the Southern Rockies and in the northern division as far north as the Bow Valley, near Lake Louise, Alberta. This statement, of course, disregards the possibility that the Cranbrook occurrence in the Rocky Mountain Trench should be included with the Rocky Mountains and not placed in the Selkirk system. On the other hand, the distribution of the Lower Cambrian has been extended in the ranges west of the Rockies a considerable distance farther south than it was formerly known to occur.

Middle Cambrian distribution was expanded to a greater extent. In the Rocky Mountain system it has reduced the Beltian gap to several hundred miles, and to the west its range has been expanded equally with that of the Lower Cambrian.

On the other hand, the Upper Cambrian received no unquestioned additions, so that the Deadwood series still constitutes the sole record in the Southern Rockies and retains approximately its previously known distribution to the north.

DEDUCTIONS REGARDING CAMBRIAN SEAWAYS

When Lower Cambrian seas first penetrated the continent in western North America, it appears to have been along a single great geosyncline, the complete course of which was outlined by Philip King (1933). Judging from Lower Cambrian occurrences, it seems that this geosyncline developed by growing simultaneously from its two extremities. Thus Lower Cambrian waters entered its southern portion, the Great Basin geosyncline, and passed through what is now southern California as far northward as central Nevada and Utah. From the north, marine waters apparently came down from the Arctic to northeastern Washington, leaving an unoccupied gap of several hundred miles, because existing evidence does not indicate removal of Lower Cambrian here prior to deposition of the Middle Cambrian. It will be noted that this interpretation considers the existence of but one geo-
syncline, which follows the trend of the northern Rockies south from their northern extremity to Montana, where it swings westward around the Southern Rocky Mountain region and thence continues southwestward through the Great Basin, to enter the Pacific in southern California. Or possibly one might consider this as two geosynclines joined by a crossover in Montana; but the faunas in both are the same.

By Middle Cambrian time floods apparently penetrated the entire length of this long negative area. It is not to be understood that all Middle Cambrian formations are thought to have covered the entire width and length of the geosyncline, for they were evidently deposited in relatively narrow, often parallel, and always very shallow troughs, and differential movements within the larger depressed area must have operated everywhere and during all time so that every formation was a discontinuous sheet. (See Walcott, 1927.)

With the beginning of Upper Cambrian time, subsidence appears to have affected the whole continent to such an extent that marine waters were enabled not only to flood portions of this long geosyncline, but also to extend themselves out across the smoothed surfaces of interior portions of North America. Thus in the Southern Rocky Mountains Cambrian seas were able to enter the basins between certain positive elements which were then islands and are now the cores of existing ranges. It seems that possibly all of the Cordilleran geosyncline was drained at the close of Middle Cambrian, because the basal Upper Cambrian beds usually contain salt crystals, ripple marks, and other shallow-water features. On the other hand, relatively soon after the seas reached their maximum extent in lower Upper Cambrian, emergence began west of the Mississippi Valley, so that the younger members of the Cambrian are less and less widely distributed. With no change in dip, the Mons, Garden City, Manitou, or equivalent formations again spread widely both within and without the geosyncline, overlapping the Cambrian beds of various ages but apparently never reaching beyond them to rest directly on the Cryptozoic. In other words, diastrophic movements creating early Paleozoic basins or geosynclines were fully determined by early Upper Cambrian.

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