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CRETACEOUS EOCENE CORRELATION IN NEW MEXICO, WYOMING, MONTANA, ALBERTA[1]

BY BARNUM BROWN

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CONTENTS

INTRODUCTION

For the American Museum I have been continuously engaged since June, 1900, in the exploration of the geology, flora, and fauna of three great formations which in their animal and plant life bridge over the passage from Cretaceous to Eocene time, as determined by comparison with the life of the same epochs in Europe. I propose to compare these formations with each other and with the typical Lance Creek formation of Wyoming. These formations are:

	Years
Hell Creek formation of northern Montana	1902–1909
Series embracing in descending order Paskapoo, Edmonton, Fort Pierre (upper), Belly River (intercalation), Fort Pierre (upper) of Red Deer River, Alberta	1909–1913
Ojo Alamo formation of northern New Mexico	1904
Lance Creek formation of Converse County, Wyoming	1900–1901

[1] Manuscript received by the Secretary of the Geological Society June 14, 1914.
Contribution to the symposium held by the Paleontological Society at the Princeton meeting December 31, 1913, and January 1, 1914.
In the absence of the author, presented by Doctor Osborn.

I have determined the geologic sequence in each of these formations and the succession of the species of reptiles. The mammals have been determined with the aid of Dr. W. D. Matthew, the invertebrates with the aid of Dr. T. W. Stanton, the flora with the aid of Dr. F. H. Knowlton and Dr. A. Hollick.

In this contribution to the present discussion as to what we shall consider the close of Cretaceous and opening of Eocene time in North America, I desire to add certain hitherto unpublished observations and to review observations already in print bearing on this important question.

In 1907 I published in the *American Museum Bulletin* an article on the Hell Creek beds of Montana, with lists of fauna and flora known up to that time. In 1908 and 1909 I continued work in the Hell Creek region, searching for fossils along the eastern exposure of the beds, and considerably increased the faunal list of the section.

Formations correlated with the Lance are indicated in quotation marks, thus, "Lance." It is very confusing to omit these quotation marks. The "Lance" formation should be known faunally as the TRICERATOPS ZONE. The application of the term "*Ceratops* Zone" or "*Ceratops* Beds" to this formation is absolutely erroneous and misleading because the genus *Ceratops* became extinct long before "Lance" times and is distinctive of the much more ancient Judith River or Belly River formations.

The Hell Creek and the typical Lance are the only formations which may now be absolutely correlated with each other by all the species of plants and animals which they contain. It is best, therefore, to first consider the Hell Creek.

HELL CREEK FORMATION, MONTANA

The notes on this section relate to the contact of the marine Fox Hills and the overlying "Lance" (Hell Creek beds).

Whatever the character of the Fox Hills formation may be in other localities, it is here clearly differentiated from the Pierre in lithologic structure. The partition plane separating the Fort Pierre and Fox Hills is the junction of the dark shales of the former, with the grayish-yellow sandy shales and sandstones of the latter. The formation is not extensively developed, and is here never more than 100 feet thick. It consists of arenaceous shales and soft, friable sandstones, with an increasing amount of sandstone toward the top, in marked contrast to the dark shales of the Pierre below. The sandstones are frequently rendered impure by more or less argillaceous material. In the exposures on Hell

Creek and Crooked Creek calcareous concretions similar to those of the Pierre are found in stratified planes, and the following invertebrates were taken from a concretion on Hell Creek about 20 feet below the overlying massive basal sandstone: *Cardium subquadratum* E. and S., *Nucula cancellata* M. and H., *Tellina scitula* M. and H., *Lunatia concinna* M. and H., *Scaphites conradi* Morton, and *Baculites ovatus* Say, all of which testify the marine character of the sediments at this point.

On the east fork of Crooked Creek near the old Cook ranch, on the west fork of Crooked Creek near the Gus Colin claim, and on the east fork of Hell Creek near the EE cattle camp these marine beds have been eroded in places, sometimes to a depth of 10 feet, before the succeeding massive sandstones of the fresh-water "Lance" were deposited. The strata are, however, in all cases parallel to the bedding plane of the succeeding sandstones, and the break is evidently of local erosional character.

It was observation of these local erosional breaks in the vicinity of Hell Creek that led to the statement that the beds did not represent a continuous sedimentation from the marine Fox Hills. In view of later work, this statement must be modified.

In the eastern exposures of these beds on tributaries of Big Dry, Prairie Elk, and the small streams emptying directly into the Missouri River the sandstones of the Fox Hills are finer grained, harder, and more compact. Along the eastern outcrop for a distance of nearly 30 miles and on the north side of the Missouri River these marine and brackish-water sandstones grade into the massive sandstones above without any sign of discordance.

A typical section may be seen on the east side of the Big Dry opposite the ranch-house of Mr. John Willis, 38 miles south of Glasgow, Montana. At this point there is a prominent mass of shells, *Corbula* cf. *subtrigonalis*, forming a layer 4 to 8 inches thick, which was traced for a quarter of a mile.

Above this shell layer there are 20 feet of rust-red sandstones that are arbitrarily chosen as the close of the Fox Hills. These are laminated shaly sandstones, usually capped by a thin layer of flattened limonite-covered concretions that mark the point of contact with the overlying fresh-water sandstones. At another point this upper stratum of Fox Hills is a thin layer of red sandstone marked off in irregular squares, which seem to indicate a drying up of ponds, where the cracks were later filled with sand. The shaly sandstones of these upper strata are frequently spotted with radiations of a removed crystallized mineral, presumably some soluble alkaline salt, as the stone reacts for sulphates.

Through this eastern exposure I have often found it impossible to establish any definite line of demarcation between the two beds.

The insensible gradation from marine through brackish-water into fresh-water sandstones is not confined to the eastern exposures of the "Lance" on Hell Creek. The same transition is found on the border of the Lance formation on Alkali Creek, Seven Mile Creek, and Robber's Roost, all tributaries of the Cheyenne River in Weston County, Wyoming.

No sign of an angular unconformity has been noted between the Fox Hills and the "Lance," and I have never yet seen any geologic evidence of the "great diastrophic break" which is alleged to occur here.

The actual geologic history appears to be as follows: There were areas in close proximity during the close of Fox Hills times where denudation was taking place simultaneously with deposition. In the case of the nonconformity, there was a cutting off and drying up of an area without freshening before the beginning of littoral deposition; in the other case there occurred the isolation of an arm of the sea and a gradual freshening of the impounded waters before drying up.

The lithologic structure of the Hell Creek beds is similar in nearly every respect to that of the Lance of Converse and Weston counties, Wyoming. Most genera and species of vertebrates and invertebrates are common to both deposits, and the faunal facies may be considered a unit.

List of Fauna and Flora

VERTEBRATES

Mammals:

Ptilodus sp.
Meniscoëssus conquistus Cope
Meniscoëssus sp.

Reptiles:

Triceratops serratus Marsh
Triceratops brevicornus Marsh
Triceratops sp.
Trachodon mirabilis
Trachodon annectens Marsh
Trachodon sp.
Thescelosaurus neglectus Gilmore
Ankylosaurus magniventris Brown
Palæoscincus sp.
Tyrannosaurus rex Osborn
Aublysodon sp.
Ornithomimus altus ? Lambe
Champsosaurus laramiensis Brown
Champsosaurus ambulator Brown
Brachychampsa montana Gilmore
Leidyosuchus sternbergii Gilmore
Basilemys sinuosa Riggs
? Adocus lineolatus Cope
Compsemys victa Leidy
Compsemys obscura Leidy
Helopanoplia distincta
Aspideretes sp. nov.
Aspideretes (Trionyx) foveatus Leidy
Aspideretes beecheri Hay
Scaphirpeton tectum ? Cope
Diphyodus sp.
Rhineastes sp. indet.
Pappichthys sp. indet.
Scaphirhynchus
Lepisosteus occidentalis
Lamna sp.

INVERTEBRATES

Unio æsopiformis Whitf.
" *corbiculoides* Whitf.
" *pyramidellus* Whitf.
" *verrucosiformis* Whitf.
" *retusoides* Whitf.
" *browni* Whitf.
" *percorrugata* Whitf.
" *postbiplicata* Whitf.
" *aldrichi* White
" *danæ* White
" *holmesiana* White
" *vetusta* Meek
" *cryptorhynchus* White
" *biasopoides* Whitf.
Unio cylindricoides Whitf.
" *letsoni* Whitf.
" *gibbosoides* Whitf.
" *pyramidatoides* Whitf.
" *subtrigonalis* Whitf.
Sphærium planum M. and H.
Corbicula subelliptica M. and H.
Campeloma multolineata M. and H.
" *vetula* M. and H.
" *producta* White
Vivipara plicapressa White
Cassiopella turricula White
Thaumastus limmæiformis White
Bulinus rhomboideus M. and H.

FLORA

Equisetum lævigatum
Rhamnus salicifolius
Ficus spectabilis
Sequoia heerii?

Red Deer River, Alberta, Canada

This river presents one of the finest sections for the study of Mesozoic and Eocene rocks to be seen on the continent. In a distance of approximately 300 miles, starting from the town of Red Deer, it cuts through and into sediments of four distinct formations, Paskapoo, Edmonton, Pierre, Belly River, well defined by the character of sedimentation and fossil remains.

The latest determination of these formations by the Canadian Geological Survey, 1913, is as follows:

Paskapoo, Edmonton	Laramie	Tertiary
Fort Pierre, Belly River, Fort Pierre	Cretaceous	Mesozoic

The term Laramie is used by the Canadian Survey with the implied meaning given by G. M. Dawson in the "Report of Progress" for 1880–'81–'82, page 4B, as a group term to include all the stratigraphically conformable formations from the top of the Pierre-Fox Hill to the unconformity below the Oligocene.

The river canyon averages about a mile in width at the prairie level and ranges from 200 to 500 feet in depth, presenting for the most part

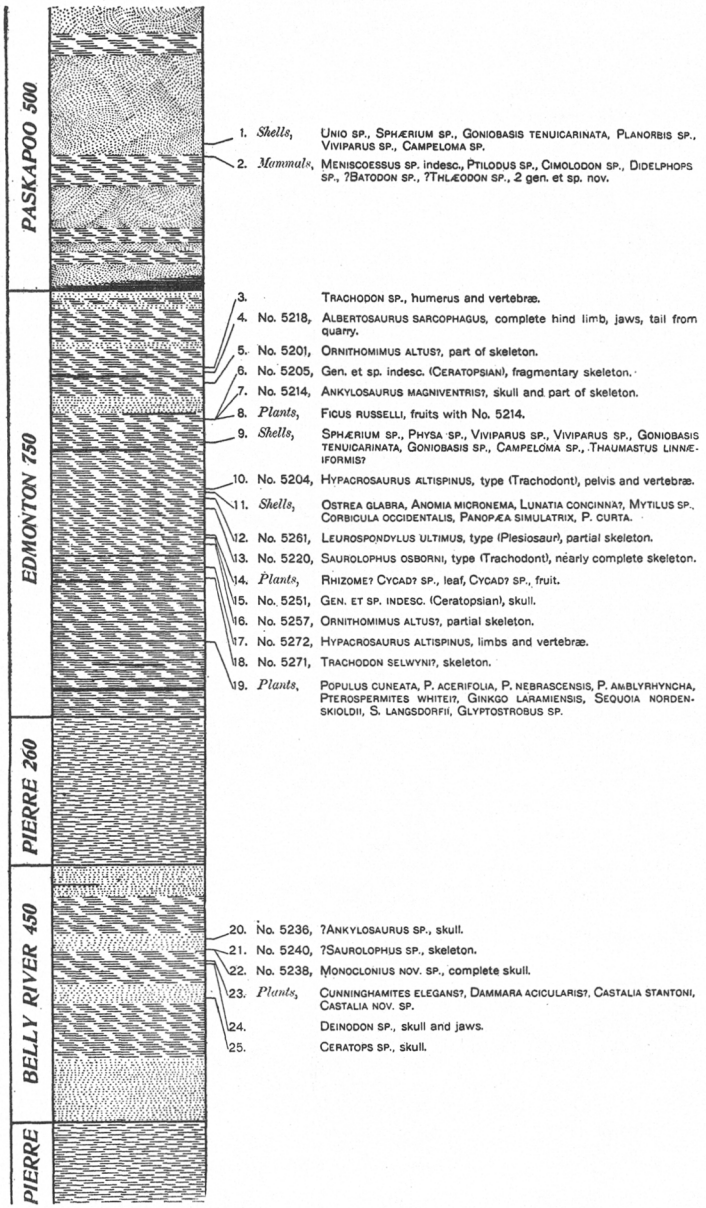

FIGURE 1.—*Formations Sectioned by the Red Deer River between Red Deer and the Mouth of Sand Creek, with Location of important Fossils in the American Museum Collection.*

clean-cut escarpements throughout the course examined. Pleistocene drift covers the surface of the country, and on the cut banks of the river it is usually present at the top of a given section and varies from 10 to 20 feet in depth.

In the forested section near the mountains, where the sediments are composed largely of sandstones, the river follows a rather devious course generally to the northeastward, but coming to the softer sediments of the prairie country it straightens out and follows a course generally southeastward, joining the South Saskatchewan near the fourth meridian.

The average drop of the prairie surface from Red Deer to the mouth of the Rosebud is about 13 feet to the mile, while the river falls from Red Deer to Tail Creek 5½ feet to the mile; from Tail Creek to Willow Creek, 3 feet to the mile, and from Willow Creek to Berry Creek, about 2½ feet to the mile. The beds dip slightly to the southwest, but are nearly horizontal; consequently the strata of each formation are exposed for long distances on either side of the river.

The Paskapoo formation, according to Mr. J. B. Tyrrell, "Geological Survey of Canada, Report of Progress" (new series), volume ii, 1887, page 135E, includes Dr. Dawson's Porcupine Hills and Willow Creek series and the upper part of his Saint Mary series, and on the Little Red Deer River the entire series attains a thickness of 5,700 feet. Near the mountains the strata lie directly on the marine Pierre, where they were deposited in a great synclinal trough, as determined by the Canadian Geological Survey. On the Red Deer River below the town of Red Deer the lowest 500 feet of these rocks are exposed. The beds are chiefly light-gray and yellowish sandstones, usually thick-bedded, frequently cross-bedded, and composed of rather coarse grains of quartz, feldspar, and mica loosely cemented together; also of light bluish-gray and olive sandy clays, frequently interstratified with bands of hard lamellar sandstone, and sometimes with layers of concretionary blue limestone. The proportion of sandstone to clay is much greater than in the underlying Edmonton formation, and the massive beds lack the coherence of the Edmonton sandstones.

At the point of contact between the hard sandstone layers and the clay underneath frequently occur clay pebbles and poorly preserved *Unio* shells representing old river channels.

Near Erickson's Landing, about 20 miles below the town of Red Deer, there is an enormous slide, the largest seen along the river, where a full section of the canyon wall 100 yards in length has slipped down to the river level. In this fallen material there are many blocks of

sandstone carrying on the lower side clay pebbles, *Unios,* and a few jaws, teeth, and bones of mammals, identified as follows:

Multituberculata:

Meniscoëssus sp. indesc.
Ptilodus sp.
Cimolodon sp.

Trituberculata:

Didelphops sp.
? Batodon sp.
? Thlœodon sp.
} ? Marsupiala

? Gen. indesc.
? Gen. indesc.
Pantolestidæ gen. indet.
} ? Insectivora

? Creodonta
? Taligrada

The Multituberculates and Trituberculates are unmistakably those of the Lance, but the placental mammals have not been found in the Lance and appear to belong to the Paleocene groups of mammals, although they do not compare closely with Puerco or Torrejon genera. This layer was located in the bluff at a point 150 feet above the river. Apparently it was a local deposit, an old river channel of the Paskapoo period which crossed the present river at right angles. Twenty-five feet above the mammal stratum there is a bed of shells 8 inches thick from which Dr. T. W. Stanton has identified *Unio* sp., *Sphærium* sp., *Goniobasis tenuicarinata* M. and H., *Planorbis* sp., *Viviparus* sp., *Campeloma* sp., which he says are suggestive of Fort Union rather than earlier forms.

From Gaetz Valley for a distance of 3 miles appears, first on one side, then on the other, a nearly perpendicular cliff of massive brownish sandstone nearly 100 feet high in places. It is composed of loosely cemented rounded grains of quartz and feldspar, with a few lenses of harder concretionary sandstone usually capping pillars of the softer sandstone underneath. This sandstone overlies the lignite and belongs to the Paskapoo series. It does not appear to contain fossils.

Edmonton Formation

Near the middle of range XXIV the first large coal seam appears on the right bank at the water level. "This seam occupies the same geological position as the big coal seam on the Saskatchewan River farther north, namely, the top of the clays and sandstones of the Edmonton subdivision of the Laramie, and it is not improbable that it is a continuation of the

same seam" (Tyrrell: Annual Report Canadian Geological Survey, volume ii, page 61E (new series), 1886). Where first seen it is from 4 to 6 feet thick, impure in quality, and is composed of layers of pure coal separated by bands of clay and shale. At this point it is bedded on an uneven surface of rust-brown sandstone and gravel. It is exposed for 400 yards downstream, where it disappears or dips under the tree-covered bank. For the next few miles it appears first on one side, then on the opposite side, wherever there is a cut bank. About 5 miles upstream from the present crossing of the Grand Trunk Railroad the big vein is about 18 feet thick where exposed on the north bank. This coal vein, on account of its widespread distribution separating as it does strata of markedly different character and different faunæ, is considered by Tyrrell to be the upper limit of the Cretaceous strata, an opinion in which I concur. But the underlying Cretaceous rocks are, as I shall show later by the vertebrate fossils, older than before suspected.

Under the big vein several thinner coal seams appear at intervals and the intervening sediments change rapidly in character. In color they are much lighter than the olive shales above; in some places

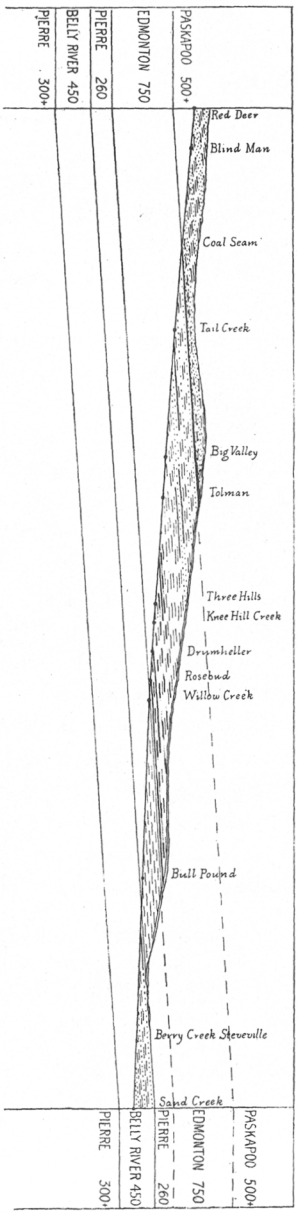

FIGURE 2.—*Horizontal Section of Red Deer River Canyon between Red Deer and Mouth of Sand Creek*

Average erosion of bluff, 13½ feet to the mile
Average fall of Red Deer River between Red Deer and Tail Creek, 5½ feet to the mile
Average fall of Red Deer River between Tail Creek and Willow Creek, 3 feet to the mile
Average fall of Red Deer River between Willow Creek and Berry Creek, 2½ feet to the mile

Horizontal scale: 3 millimeters = 1 mile Vertical scale: 1 millimeter = 20 feet Glacial drift = double line

almost white. No massive sandstones characteristic of the Paskapoo series were seen under the thick coal vein.

At a point about 1½ miles below the Grand Trunk Railroad bridge the river cuts through a nearly white sandy clay filled with glistening particles of mica. This stratum is very homogeneous and weathers in vertical faces. It continues down the river several miles, and in the valley of Tail Creek forms the conspicuous white band near the top of the formation.

Below this conspicuous white layer the beds are as a whole lighter than those above the big coal vein and are distinctly banded in light colored sandy-clay strata, thin coal seams, and carbonaceous clays.

The first dinosaur bones, a humerus and vertebræ of *Trachodon* sp., were found at water level 1 mile above the wagon bridge across the Red Deer River at the mouth of Tail Creek. This is the highest level in the Edmonton beds in which dinosaur bones were found, approximately 100 feet below the big coal seam that marks the top of the formation.

For several miles below this point there is little appreciable change in the character of the beds; talus and brush obscure most of the banks and clean-cut escarpments are seen only in bends of the river.

About 30 miles below Tail Creek opposite the mouth of Big Valley occurs the most rugged exposure of this formation along the river. Here on the west side for a distance of a mile the beds are eroded into bad lands that extend a mile back from the river. The beds are composed chiefly of clays, with sandstone layers toward the top, and are distinctly banded light and dark toward the top and light blue-gray at the base, with an occasional thin seam of ironstone that weathers to a rust-brown color. The prairie level is 470 feet above the river, and no less than 50 feet of the upper strata seen at Tail Creek, including the big coal seam and some of the white sandstone layers, are missing.

A generalized section taken at the lower end of the bad lands, not the highest point, shows as follows:

	Feet
Boulder-clay	10
Loosely cemented white sandstone and clay	40
Impure lignite	1
Light clay	10
Lignite	3
Clay, dark gray	20
Lignite	1
Sandy clay, light gray above, darker below	25
Impure lignite and carbonaceous clay	6
White sandy clay	20
Brown-gray clay with ironstone	40

	Feet
Sandy white clay	15
Hard laminated sandstone, generally persistent	4
Light clay, occasional sandstones	100
Laminated reddish sandstone, fossils numerous	5
Clay and iron-encrusted pebbles, fossils numerous	30
Sandstone	8
Light blue-gray clay	70
	408

Many vertebrate fossils were collected at Big Valley, ranging from near the top to the bottom of the exposures. In the upper 50 feet of sandstone a few vertebræ of *Champsosaurus* sp., an occipital condyle of a crocodile, and fragments of a Trionychid turtle were secured, the only representatives of those families seen in the Edmonton formation, with exception of one Trionychid turtle collected near the bottom of the beds at Willow Creek.

The following invertebrates were secured from a stratum about 100 feet above the river: *Sphærium* sp., *Physa* sp., *Viviparus* sp. related to *V. raynoldsanus* M. and H., *Viviparus* sp. related to *V. prudentius* White, *Goniobasis tenuicarinata* M. and H., *Goniobasis tenuicarinata* var., *Goniobasis* sp., *Campeloma* sp., *Thaumastus linnæiformis* M. and H.? In his comments Dr. T. W. Stanton says that "there is nothing characteristic of either Lance or Judith River in this lot and some of the forms are more suggestive of Fort Union."

Below Big Valley the banks are clean scarped and the beds continue of similar character for several miles. A workable seam of lignite, about 3 feet thick, appears near the top of the bank 3 miles below the mouth of Big Valley and a seam, probably the same one, appears again just above Tolman Ferry. The upper part of the beds continues banded in light and dark color, with white argillaceous sandstones interstratified with impure lignite and carbonaceous clays. Iron-encrusted sandstone lenses increase toward the base and the lower strata are composed chiefly of light gray clays.

From Big Valley down to the end of the formation the upper strata disappear about as rapidly as the fall of the river brings the lower strata to view, so there is no great variation in the height of the banks. Not less than 200 feet of the upper strata have been eroded at Tolman, where the canyon walls are estimated to be 300 feet high.

Throughout the Edmonton formation water ripple-marked sandstones are common. At a point 2 miles above Tolman Ferry on the left bank there is a bed 100 yards square, and in which four successive series of

ripples are preserved one above the other. Each series was evidently formed by currents coming to the shoreline from a different angle, as no two are parallel. On one of these slabs collected there are worm tracks and several impressions of a horsetail rush, identified by Dr. A. Hollick as *Equisetum* sp. nov.

One and one-half miles above Tolman, at a point 190 feet above the river, a skull and partial skeleton of *Ankylosaurus* was collected, and with it were associated several fruits, identified by Dr. F. H. Knowlton as *Ficus russelli*. At this same station several poorly preserved plant remains were secured from a hard argillaceous sandstone at the water level. They are identified by Dr. A. Hollick as a rhizome ?, possibly of an aquatic plant, Cycad ? sp., a leaf, and Cycad ? sp., a fruit, but are not diagnostic of the age of the beds.

Below Tolman for 16 miles there is little appreciable change in the appearance of the beds, which are chiefly clay; local strata of hard sandstones appear and disappear in a short distance, and in two or three places there are beds, unmistakably, of stream channels. One particularly noticeable is seen at water level 3 miles above Tolman and another at a point capping the section 16 miles below Tolman.

Four miles below Tolman on the right bank, at a point 100 feet above the river, there is a conspicuous bed of shells: *Anomia micronema* Meek, *Corbicula occidentalis* M. and H., *Panopæa simulatrix* Whiteaves, *Panopæa curta* Whiteaves, all brackish-water forms, associated with broken shells of *Ostrea* sp. This shell bed appears again 6 miles below Tolman on the left bank, about 110 feet above the river, and 1 mile farther down the river, where shells, *Corbicula occidentalis*, form a solid bed 18 inches thick.

At Stauffer's, 16 miles below Tolman on the left bank, there is a bed of *Ostrea* sp. 2 feet thick in approximately this same horizon. The same oyster-bed appears at the head of Fox Coulee, 1 mile from Munson, in the cut of the Canadian Pacific Railroad, 20 feet below the prairie level, where the following shells were collected: *Ostrea glabra* M. and H., *Anomia* sp., *Mytilus* sp., *Lunatia concinna* M. and H.?, all brackish-water and marine Cretaceous types that are common to the Judith River and the base of the Lance.

The stations represented by these four lots of shells do not vary 25 feet above or below a horizontal plane, and I think they are on the same level.

A Plesiosaur skeleton, which I have described under the name *Leurospondylus ultimus*, was found in approximately the same stratum, 6 miles below Tolman on the left bank, 120 feet above the river. This specimen is interesting chiefly because it extends the history of the group of Meso-

zoic marine vertebrates considerably later in time than any heretofore recorded. In the same level, close by, was found a fragmentary skull of a Ceratopsian, number 5259, soon to be described as the paratype of a new genus.

About 14 miles below Tolman another prominent coal seam comes to view at water level, but does not continue downstream more than a mile. Carbonaceous layers are, however, more numerous and the exposures become in consequence darker in appearance. Iron-encrusted lenses and pebbles also increase in number, uniform layers frequently extending long distances. There is a greater amount of ironstone and evidently more plant remains in the lower part of the beds from here down to the Pierre and the clays become more and more shaly. Limbs and sections of trees usually encrusted by chalcedony, with brilliant quartz crystals at points of fracture, are abundant, though the mass of vegetal material is poorly preserved.

Near the home of Mr. Simpson, on the left bank, 20 feet above the river and almost opposite the mouth of Kneehills Creek, there is a bed of leaves from which several well preserved specimens were secured. They are identified as follows: *Populus cuneata* Newb., *Populus acerifolia* Newb., *Populus nebrascensis* Newb., *Populus amblyrhyncha* Ward, *Pterospermites* prob. *Whitei* Ward, *Ginkgo laramiensis* Ward, *Sequoia nordenskioldii* Heer, *Sequoia langsdorfii* (Brgh.) Heer, *Glyptostrobus* sp.

After examination of the plants collected in 1911—that is, *Sequoia nordenskioldii, S. langsdorfii, Glyptostrobus ?* sp., *Pterospermites* prob. *Whitei,* and *Populus cuneata*—Dr. Knowlton reports that "the species indicate beyond all manner of question or doubt that the age is Fort Union." Additional better material was secured from the same spot in 1912, and the species enumerated in the complete list above were determined by Doctor Hollick, who says that "the specimens from the Edmonton formation (near Simpson's house, opposite mouth of Kneehills Creek, etcetera) indicate, unquestionably, the Fort Union age of this horizon."

The position of this plant layer in the Edmonton beds is not less than 250 feet below the Ostrea layer, in which the Plesiosaur skeleton *Leurospondylus* was collected. The definite location of these horizons is most important, for whereas the age of the land reptiles has been considered debatable, the marine reptiles are clearly of Mesozoic age, and the same species of land reptiles are found above and below the marine forms. From the vertebrate and invertebrate remains it seems very clear that these rocks are not of Fort Union age, but as shown by the plants the climatic conditions of Fort Union time were long foreshadowed toward the close of the Cretaceous.

From Kneehills to the end of the formation there is no marked lithologic change. The beds are chiefly shaly clays, alternating with indurated sands and pronounced dark carbonaceous layers. There are many lignite seams of good quality, several of which are mined at Drumheller, near the mouth of Michichi Creek and at the mouth of the Rosebud. One large seam, which apparently continues over a large area, is prominent below the mouth of the Rosebud on the left bank. One mile below the mouth of the Rosebud it has been burned, and the clays above and below to a depth of 50 feet indurated sufficiently to resist erosion, so that brilliant vermilion cliffs stand out in front of the somber background. Four miles below the mouth of the Rosebud this seam measures over 6 feet in thickness where it is approximately 100 feet above the Pierre.

Edmonton-Pierre Contact

Twelve miles below the Rosebud a small stream—Willow or Saule Creek—joins the Red Deer from the east. Many fine sections, showing the contact of the Edmonton and Pierre, appear near the junction of these two streams.

The first unmistakable marine beds containing fragments of *Ammonites* sp., *Scaplites* sp. were observed 1 mile above the mouth of Willow Creek. The clay-shales of these beds are thin, finely laminated layers from one-half inch to 3 inches thick, interstratified with seams of ocher, and vary from buff to a deep coffee color, the colors alternating with one another. Above the shales and *conformably overlying* them in all observed points of contact are 50 feet of light, almost white, sandy clays, sometimes cross-bedded and interstratified with layers of dark carbonaceous clays. Selinite crystals occur all through these strata. The overlying sandy clays mark the transition from purely marine to brackish-water beds. In them frequently occur beds of oysters and considerable wood. At the mouth of Willow Creek, in the bluffs back of the home of Mr. J. H. Caldwell and 50 feet above the coffee-colored shales, I collected the following shells: *Ostrea subtrigonalis* E and S., *Ostrea glabra* M. and H.? Doctor Stanton comments on this lot: "These two species are found in both Judith River and Lance formations." Near by in the same horizon were the remains of a Trionichid turtle.

The Edmonton formation differs greatly in lithologic character from the Fox Hills, which occupies the same relative position in the United States where it is a sandstone formation, but I believe it to have been, in part at least, synchronous with the Fox Hills. It may possibly be correlated with the Laramie, according to its original definition.

The following section was taken 3 miles below the mouth of Willow Creek:

	Feet
Glacial boulders and yellowish fine-grained Pleistocene (?) silt unconformably overlying beds below	30
Light slate-colored clay	20
Dark carbonaceous clay	4
Lignite	1
Gray-white sandy clay	8
Ocherous yellow clay	15
Carbonaceous material	2
White indurated sand, some concretions	15
Coffee-colored fine-lined Pierre shale	50
	145

The upper 30 feet of material in this section is a fine-grained yellowish sandy silt, non-fossiliferous and without lines of stratification. It unconformably overlies the beds below and varies from a few feet to 50 feet in thickness, and is present in most sections. In the upper part there are frequently glacial boulders and gravel. This material may have been derived from the Miocene rocks of the Hand Hills during Pleistocene times.

The coffee-colored Pierre shales are about 100 feet thick and continue down the river as far as Dorothy, where dark slate-colored shales appear below similar to the typical Pierre shales of the United States. Fragmentary *Ammonites,* Scaphites, wood, and occasionally fish bones were seen in these strata.

The Pierre shales are seen along the river for a distance of nearly 30 miles below Willow Creek, with clean-cut escarpments in the bends of the river, though the banks are mostly sloping and grass-covered.

Belly River Beds

Near Fieldholme, the old Marquis of Lorne Crossing, about 6 miles below the mouth of Bullpound Creek, a new series, the Belly River beds, appear underlying the marine Pierre. This is distinctly a fresh and brackish-water series composed chiefly of soft sandstones and clays. Vegetal matter is less abundant than in the Edmonton formation and there are few beds of lignite. The sedimentation of the Belly River beds is exactly comparable to that of the Judith River beds with one exception—the false or cross-bedding is much more pronounced throughout the Judith River area.

The first stratum recognized was seen on the left bank of the river, a

light-gray sandy clay layer 4 feet thick overlying a seam of impure lignite 1½ feet thick. Twelve miles below Fieldholme, in the big bend of the Red Deer, where it again turns east, a thick vein of lignite, probably the same one noted above, appears on the left bank. At this point the full section of the cut-bank is composed of Belly River beds capped by glacial gravel and large boulders. The overlying Pierre entirely disappears near Matjiwin Creek. Below this point the banks of the river gradually increase in height, and at the mouth of Berry Creek, near Steveville, are eroded back into the prairie in picturesque bad lands on either side of the river. At water level, on the left bank 100 yards above the ferry at Steveville, there is a compact ledge of sandstone in which plant remains are well preserved. The following species were collected from this ledge: *Dammara* sp., possibly *D. acicularis* Knowlton, *Castalia stantoni* Knowlton, *Castalia* sp. nov., *Aspidium* sp. Dr. A. Hollick identified these fossils, and says that "the specimens from the Belly River formation (Steveville, Alta., etcetera) are nearly all species which are typical of the Judith River formation and indicate the stratigraphic identify of these two formation." Extensive bad lands continue down the river as far as the mouth of Sand Creek, 12 miles below Steveville, where the banks are about 300 feet in height.

Below Sand Creek for 15 miles, in what is known as "Dead Lodge Canyon," the banks gradually decrease in height and near the end of this course become sloping and grass-covered. A few clean-scarped exposures again appear near the ranch-house of Mr. M. J. Stapleton, in section 15, range IX, township 22, where the lower strata of the Belly River beds are composed chiefly of compact yellowish indurated sand and lamellar sandstones. In this yellow compact sand, 1 mile below Stapleton's, I collected a nearly complete skull of *Monoclonius* sp. The lower sand strata exposed on the Red Deer River closely resembles the lower part of the Belly River series exposed on the Belly River at Big Island, 12 miles below Lethbridge, described by Dawson in *Canadian Geological Survey, Report of Progress*, 1882–'83–'84, pages 73–74C.

The upper strata of the few clean-scarped exposures near the mouth of Blood Indian Creek contain *Baculites* sp. and *Scaphites* sp., and undoubtedly belong to the Pierre. The lower 50 feet are composed chiefly of yellowish sand and sandstone, the base of the Belly River series. Below Blood Indian Creek the banks are mostly sloping and grass-covered, with few exposures, which are said by McConnell to be chiefly yellowish sand and sandstones, representing the base of the Belly River series, which are exposed at intervals down to a point 25 miles west of the confluence of the Red Deer River with the South Saskatchewan.

Beyond these determinable exposures the sloping banks are grass-covered, and below the forks of the river the underlying Pierre appears.

Summary of the Red Deer River Section

PASKAPOO FORMATION

The Paskapoo beds consist of more or less hard, light gray, or yellowish sandstones, usually thick-bedded and sometimes cross-bedded; also of light bluish-gray and olive shales, often interstratified with bands of concretionary blue limestone. It is essentially a sandstone formation.

The strata are purely of fresh water and eolean origin.

Near the mountains these beds, according to Tyrrell, appear to rest conformably on the Pierre shales. On the Red Deer River and elsewhere they are separated from the underlying brackish-water Edmonton beds by a widely distributed coal seam of varying thickness. No other sign of unconformity has been recognized, but a considerable time elapsed between the close of the Edmonton and the beginning of the Paskapoo—a time interval represented by all or the greater part of the Lance. No dinosaurs are found in these beds, and the abundant and varied dinosaurs of the underlying Edmonton formation are an older facies than those of the Lance.

Before the sedimentation began the entire group of dinosaurs had become extinct. A mammalian fauna now takes its place. This fauna is more varied than that of the Lance and is comparable to it, according to Dr. Matthew.

The invertebrates are all fresh-water species. Eocene climatic conditions had by this time become well established, as shown by the varied species of plant life.

VERTEBRATES

Multituberculata:

Meniscœssus **sp. indesc.**
Ptilodus **sp.**
Cimolodon **sp.**

Trituberculata:

Didelphops sp.	? Marsupiala
? ***Batodon*** sp.	
? ***Thlœodon*** sp.	
? Gen. indesc.	? Insectivora
? Gen. indesc.	
Pantolestidæ gen. indet.	

? Creodonta
? Taligrada

In the lists of plants accredited to this formation by Tyrrell and Penhallow some errors may have been made in determination and location of horizons, so I have given them separately.

INVERTEBRATES

Red Deer American Museum Collection	Red Deer River and elsewhere listed by Tyrrell
Unio sp.	*Unio Danæ* M. and H.
Sphærium sp.	*Sphærium formosum* var.
Goniobasis tenuicarinata M. and H.	*Limnæ tenuicosta* M. and H.
Planorbis sp.	*Physa copei* White.
Viviparus sp.	*Acroloxus radiatulus* Whiteaves
Campeloma sp.	*Thaumasters limnæ formis* M. and H.
	Goniobasis tenuicarinata M. and H.
	Hydrobia sp.
	Campeloma producta White
	Viviparus Leai M. and H.
	Valvata filosa Whiteaves
	Valvata bicincta Whiteaves.

PLANTS

List published by Tyrrell for entire series of Paskapoo specimens identified by Sir William Dawson

Onoclea sensibilis Linn	*Populus arctica* Heer
Sequoia nordenskioldii Heer	*Ficus* sp.
Sequoia langsdorfii Heer	*Salix laramiana* Dawson
Sequoia conttsiæ Heer	*Viburnum asperum* Newb.
Taxodium occidentale Newb.	*Viburnum saskatchnense* Dawson
Platanus nobilis Newb.	*Catalpa crassifolia* Newb.
Corylus macquarrii Heer	*Sapindus* sp.
Quercus sp.	*Carya antiquorum* Newb.
Populus acerifolia Newb.	*Juglaus* sp.
Populus richardsoni ? Heer	*Nelumbium saskatchnense* Dawson

To this list Sir William Dawson added a year later:

Podocarpites tyrrellii Dawson	*Populus nervosa ?* Newb.
Populus genetrix Newb.	*Trapa borealis* Heer.

Complete list from Red Deer region published by D. P. Penhallow, Department of Mines, Canadian Geological Survey Report Number 1013, pages 14–15, 1908

Almites grandifolia Newb.	*Cornus rhamnifolia* O. Web.
Carya antiquorum Newb.	*Corylus americana fossilis* Newb.
Catalpa crassifolia Newb.	*Corylus macquarri* (Forbes) Heer
Cercis parvifolia Lesq.	*Equisetum arcticum* Heer
Clintonia oblongifolia Penh.	*Ficus* sp.

Glyptostrobus europœus (Brongn.) Heer
Juglaus sp.
Juglaus acuminata A. Br.
Juglaus laurifolia Knowlton
Juglaus leconteana Lesq.
Juglaus occidentalis Newb.
Lastrea fischeri Heer
Maiantherium grandifolium Penh.
Nelumbium saskatchnense Dawson
Osmunda macrophylla Penh.
Phyllites carneosus Newb.
Populus acerifolia Newb.
Populus arctica Heer
Populus cuneata Newb.
Populus daplinogenoides Ward
Populus obtrita Dawson
Populus richardsoni Heer
Quercus ellisiana Lesq.
Quercus sp.
Quercus ellisiana Lesq.
Salix laramiana Dawson
Sapindus sp.
Sequoia conttsiæ Heer
Sequoia langsdorfii (Brongn.) Heer
Sequoia nordenskioldii Heer
Sphenopteris blœmstrandi Heer
Sphenopteris guyotti Lesq.
Sphenoxamites oblanceolatus Penh.
Taxodium distichum miocenum Heer
Taxodium occidentale Newb.
Typha sp.
Viburnum ovatum n. sp.
Viburnum asperum Newb.
Viburnum saskatchnense Dawson.

EDMONTON FORMATION

The terms Upper and Lower Edmonton should not be employed, for the formation is lithologically and faunistically an indivisible unit. The terms were originally used by the present writer as a check on the location of fossils. When the entire series of beds were closely examined it was found that such distinction was not warranted.

The Edmonton formation consists chiefly of siliceous clays interstratified with seams of lignite and thin strata of whitish sandstones. It is essentially a lignite formation.

The strata are of marine and brackish-water origin and everywhere *conformably* overlie the marine beds below. The whole series shows an uninterrupted successive sedimentation from purely marine conditions at the base through brackish-water during most of the period, with a gradual freshening toward the top.

This formation fulfills the original definition of the term Laramie.

Vertebrate remains are abundant. Neither mammalian nor fish remains have been recorded.

One turtle has been found at the base of the beds, and a turtle associated with a rhynchocephalian and a crocodile were found near the top of the formation. These are semi-aquatic forms, and their remains would be expected in sediments deposited chiefly in water, but they are noticeably absent. It is evident that the environment was not suitable to such forms. Marine vertebrates (plesiosaurs) are found as high as the middle of the beds.

Dinosaurs are found in great numbers from near the top to the bottom of the beds, and the same species occur throughout the formation. The remains occur as individual skeletons and partial skeletons, but are frequently massed together in great numbers as separate bones and partial skeletons. The bones are silicified and frequently they are filled with calcite.

The vertebrate fauna is distinct from that of the Lance and few species are common to the two formations. Most of the Edmonton genera are structurally more primitive than those of the Lance and several genera not found in the Lance are common to the Judith River. The faunal facies, as a whole, is intermediate, but closer to that of the Judith River formation than to the Lance.

Trachodonts are most numerous of all the dinosaurs in this formation. All are papillate-toothed species. Three well defined genera—*Trachodon, Saurolophus,* and *Hypacrosaurus*—are known. Of these *Trachodon* ranges from the Belly River beds through the Edmonton and to the close of the Lance, but the Lance species, *T. mirabilis* and *T. annectens,* have not been recorded. *Hypacrosaurus* occurs in the Belly River and *Saurolophus,* or a closely related genus, occurs there also.

Ceratopsians are comparatively rare and are represented by a large form of primitive skull structure and a small aberrant form, neither of which has been described. The characteristic genus, *Triceratops,* and its less abundant contemporary, *Torosaurus* of the Lance, do not occur in the Edmonton.

Armored dinosaurs are somewhat more numerous than the Ceratopsia. The Lance genus and species *Ankylosaurus magniventris* occurs in this formation and *A. tutus* is found in the Belly River. An allied genus, not yet described, is common to this formation and to the Belly River, but does not occur in the Lance. *Palæoscincus,* another related genus, occurs in the Belly River and in the Lance, but has not been recorded in the Edmonton.

Carnivorous dinosaurs are as numerous as the armored forms. *Tyrannosaurus* of the Lance does not occur, but a common form about one half as large and ancestral to it is *Albertosaurus sarcophagus. Ornithomimus altus* is a Belly River species which occurs here and has also been noted in the Lance.

The dinosaur fauna forms a series of successive genera, the phyletic relationship of which is determined by the evolutionary development of skeletal parts, and there is no break in this series from its first appearance low down in the Cretaceous to the final disappearance of the entire group in what we propose to call the close of the Cretaceous.

The invertebrates corroborate the testimony of the vertebrates. The identifications were made by Dr. T. W. Stanton, whose comments are as follows:

"I have recently examined your invertebrates from the Edmonton and Paskapoo formations of Alberta. Those which you have already sent from the Edmonton beds include several lots composed of brackish-water shells, with a slighter mixture of marine forms (Lunatia) and several lots of purely fresh-water shells. The brackish-water collections are certainly Cretaceous, and consist of species which all occur either in identical or very closely related forms in both the Judith River and in the brackish-water bed, which occurs at the top of the Fox Hills and the base of the Lance.

"The fresh-water collections contain no species characteristic of either the Judith River or the Lance, and while some of them, like *Goniobasis tenuicarinata*, occur in the Lance, the general aspect of the fossils is somewhat more suggestive of the Fort Union species as occurring in the Belly River beds of Alberta, and it may be that more of these types than we have supposed range down as low as the Judith River."

The plant remains from this formation, though not extensive, are nevertheless of considerable importance. Practically all of the described species were made known from later deposits, and few if any of the species have been found in earlier deposits. The paleobotanists (Dr. F. H. Knowlton and Dr. A. Hollick) who have examined this collection are of one opinion that the plants are of Fort Union age. The Edmonton beds are practically horizontal, and the stratum containing all but one of the identified species of plants lies 250 feet below that in which plesiosaurs (animals of accepted Mesozoic age) occur.

It seems not impossible to reconcile the evidence of the flora with that of the fauna. The location of the plants is positive and the determination admitted, but their significance has probably been misinterpreted.

Lesquereaux, in the study of Cretaceous floras, long ago expressed the opinion "that groups of identical fossils, especially vegetable ones, do not prove or indicate contemporaneity of the formations which they characterize when these formations are observed at great distances or under different degrees of latitude."

In this upper part of the Cretaceous called into question by the presence of Eocene plants it is probable that Eocene climatic conditions had already begun. During the close of the Cretaceous and the beginning of the Tertiary there was a long period of equable climate, and it is evident that the flora was temperate and of wide-spread distribution. For these very good reasons the plant remains do not prove whether widely separated beds that contain the same species are strictly contemporaneous or successive.

VERTEBRATES

Red Deer River, American Museum Collection

Saurolophus osborni Brown
Hypacrosaurus altispinus Brown
Trachodon sp.
Certopsia gen. et sp. nov.
" gen. et sp. nov.
Ankylosaurus magniventris Brown
Ankylosauridæ gen. et sp. nov.
" sp.
Albertosaurus sarcophagus Osborn
Ornithomimus ? altus Lambe
" sp.
Leurospondylus ultimus Brown
Champsosaurus sp.
Trionychidæ
Crocodilia

INVERTEBRATES

Red Deer River, American Museum Collection

Sphærium sp.
Physa sp.
Viviparus sp., related to *V. raynoldanus* M. and H.
Viviparus sp,, related to *V. prudentius* White
Viviparus sp., probably undescribed
Goniobasis tenuicarinata M. and H.
Goniobasis " var.
Goniobasis sp.
Campeloma sp.
Thaumastus limnæiformis M. and H.
Unio sp., related to *Unio danæ* M. and H.
Ostrea glabra M. and H.
Ostrea subtrigonalis E. and S.
Anomia micronema Meek
Mytilus sp.
Corbicula occidentalis M. and H.
Corbicula cytheriformis M. and H.
Panopsæa simulatrix Whiteaves
Panopæa curta Whiteaves
Lunatia concinna M. and H.

PLANTS

Red Deer River, American Museum Collection

Populus cuneata Newb.
Populus acerifolia Newb.
Populus nebrascensis Newb.
Populus amblyrhyncha Ward.
Ginkgo laramiensis Ward
Sequoia nordenskioldii Heer
Sequoia langsdorfii (Brgh.) Heer
Glyptostrobus sp.
Carpites cf. *C. lineatus* Newb.
Pterospermites prob. *P. Whitei* Ward
Equisetum sp. nov.
Ficus russelli Knowlton
Cycad ? sp.

Other species accredited to this formation by Tyrrell:

Trapa borealis Heer
Salisburia sp.

BELLY RIVER BEDS

This series consists of light-gray clays and soft whitish sandstones interbedded with ironstone-encrusted pebbles in the upper two-thirds of the formation and soft yellowish, massive sandstones at the base.

The beds are chiefly of fresh-water origin and appear to be a continuation of the Judith River Beds.

Cross-bedding is less frequent and sedimentation took place under quieter and more uniform conditions than in the Judith River Beds.

Only two or three local beds of lignite of inferior quality appear in the upper part of these beds on the Red Deer River and vegetal remains are less common than in the Edmonton.

Fossil remains are more abundant than in any of the Cretaceous formations and the dinosaurs are more varied in genera and species than in earlier or later formations. The dinosaurs are distinctly more primitive than those of the Lance, but there is no change in facies. This is conclusively demonstrated in those families adequately known from both formations, such as Deinodontidæ, Ceratopsidæ, Trachodontidæ, and Ankylosauridæ.

While there is a marked contrast between different genera that do not run through, several in the Lance are clearly derivable from Belly River genera through intermediate forms in the Edmonton.

In the Deinodontidæ *Deinodon* of the Belly River, *Albertosaurus* of the Edmonton, and *Tyrannosaurus* of the Lance form a phylogenetic series.

In the Ceratopsidæ the phyla are not so clear, but it seems probable that *Triceratops* of the Lance was derived from *Ceratops* of the Belly River through a known but not yet described genus of the Edmonton.

The Trachodontidæ may now be divided into two groups which share in common a ducklike bill.

In the first group the skull is without ornamentation, pelvis with ischium terminating in a blunt rounded point. *Trachodon,* typical of this group, ranges through the Belly River, Edmonton, and Lance. Closely related to it is the genus *Kritosaurus,* which is known only from the Belly River Beds and the Ojo Alamo Beds.

In the second group the skull is ornamented by a crest; pelvis with ischium terminating in a large footlike end. This group is not known to occur in the Lance, but three genera are now known from lower horizons.

Hypacrosaurus occurs in the Edmonton: also in the Belly River. *Saurolophus* occurs in the Edmonton, and a closely related genus not yet described is at present known only from the Belly River.

In the Ankylosauridæ the genus *Ankylosaurus* passes through the Belly River, the Edmonton, and the Lance. A closely related genus not yet described occurs in the Belly River and the Edmonton, but is not known from the Lance.

In the Ornithomimidæ *Ornithomimus* passes directly through the Belly River, Edmonton, and Lance.

The invertebrates and plants are determined unquestionably of Judith

River age, and the plants are said to have very little affinity with the flora of the Lance or Fort Union.

The vertebrates, on the other hand, are of Judith River age and are beyond question closely related and in most genera and species directly ancestral to those of the Edmonton and Lance.

Many of the genera and species of dinosaurs founded by Leidy, Cope, and Marsh were based on material inadequate for the present standard of classification. The characters assigned to many species by these early investigators are now known to have only generic or family value. For this reason it seems inadvisable to append the long list of species of each formation.

Species known from the Belly River Beds on the Red Deer River

INVERTEBRATES

Unio danæ M. and H.
Unio sp., cf. *U. supenawensis* Stanton
Anadonta propatoris White
Anadonta ? sp.

PLANTS

Cunninghamites elegans ? (Corda) Endlicher
Dammara sp.
Castalia stantoni Knowlton
Castalia nov. sp.
Aspidium sp.

VERTEBRATES

Pisces:

Myledaphus bipartitus Cope
Acipenser albertensis Lambe
Lepisosteus occidentalis Leidy
Rhineastes (Ceratodus) eruciferus Cope
Diphyodus longirostris Lambe

Batrachia:

Scapherpeton tectum Cope

Reptilia:

Plesiosauria

Cimoliasaurus magnus Leidy

Chelonia

Aspideretes (Trionyx) foveatus Leidy
Basilemys (Adocus) variolosa Cope
Bœna antiqua Lambe
Boremys pulchra Lambe
Neurankylus eximius Lambe

Lacertilia and Incertæ Sedis

Troödon formosus Leidy
Stegoceras validus Lambe

Crocodilia

Crocodilus humilis Leidy
Leidyosuchus canadensis Lambe

Megalosauria: Theropoda

Deinodon horridus Leidy
? " *explanatus* Cope
? " *hazenianus* Cope
Aublysodon mirandus Leidy

Stegosauria

Palæoscincus costatus Leidy
?Ankylosaurus tutus Lambe

Ornithomimidæ

Ornithomimus altus Lambe

Ceratopsia

Monoclonius (Centrosaurus) dawsoni Lambe
Brachyceratops montanensis Gilmore
Ceratops (Monoclonius) canadensis Lambe
Ceratops (Chasmosaurus) belli
Styracosaurus albertensis Lambe

Iguanodontia: Ornithopoda

Kritosaurus (Gryposaurus) notabilis Lambe
Hypacrosaurus altispinus Brown
Trachodon selwyni Lambe
" *marginatus* Lambe
" *altidens* Lambe

Rhynchocephalia

Champsosaurus profundus Cope
" *annectens*
" *brevicollis* Cope

Mammalia:

Ptilodus primævus Lambe
Borcodon matutinus Lambe

The Ojo Alamo Beds

This name was proposed by the writer (Bulletin of the American Museum of Natural History, volume XXVIII, article XXIV, pages 267-274, 1910) for the upper part of the Cretaceous series which unconformably underlies the Puerco formation at Ojo Alamo in New Mexico.

The Puerco is a clay formation, approximately 250 feet thick in the Ojo Alamo section, probably of fluviatile origin. It contains an extensive and varied mammalian fauna of Paleocene age. The reptilian fauna, which is limited, embraces several genera and species of turtles, several undescribed species of crocodiles, three species of the Rhynocephalian *Champsosaurus,* and a single species of the Ophidia. *Dinosaurs are notably absent.*

Invertebrates are not abundant and all are land and fresh water types. A small collection of plant remains has been identified by Doctor Knowlton, who states that "the age indicated is that of the Denver or perhaps as late as Fort Union."

On Coal Creek, in the immediate vicinity of Ojo Alamo, the Puerco clays rest on massive sandstones which mark the top of a distinct series of sediments. At the point of contact Messrs. Granger and Sinclair have noted a distinct erosional unconformity, and 30 to 70 feet below this point another discordance appears where the sandstones rest on a thick bed of conglomerates. The underlying shales and sandstones, more than 200 feet thick, are lithologically distinct from the clays of the Puerco and the fauna is totally different.

No mammals have been recorded from this horizon, but reptilian remains, chiefly dinosaurs, are abundant.

Most of this material is poorly preserved and bones are rarely associated.

The Ceratopsian genera *Triceratops* and *Torosaurus,* which are characteristic of the Lance, do not occur in these beds, but the known fragmentary remains pertain to a more primitive smaller form comparable to *Monoclonius* or *Ceratops.*

The large carnivorous dinosaurs are smaller than *Tyrannosaurus* of the Lance and may be compared with *Albertosaurus* of the Edmonton or *Deinodon* of the Judith River.

The Trachodont dinosaurs furnish the most satisfactory evidence for the correlation of these beds. The genus *Trachodon,* which represents the family in the Lance formation, is not known here, but a primitive genus, *Kritosaurus,* of extraordinary skull development, described from this formation, is common.

Recently Mr. Lawrence M. Lambe, Ottawa Naturalist, volume XXXVII, number 11, February, 1914, described a perfect Trachodont skull from the Belly River beds of Canada. In all respects, including the remarkable development of the nasals, premaxillaries and predentary and the reduction of the orbital portion of the frontal, it agrees with the type of *Kritosaurus,* and there is no doubt of its generic identity.

A single species of turtle, *Thescelus rapiens* Hay, is not known elsewhere, though a closely related species, *T. insiliens,* is described from the base of the Lance.

Invertebrates are as yet unknown and the flora, represented by numerous fossil trees, has not been determined.

The vertebrate fauna is distinctly older than that of the Lance. I have expressed the opinion that it was comparable to the Edmonton, but from the recent discovery of *Kritosaurus* in the Belly River formation and the primitive structure of the contemporary dinosaurs the Ojo Alamo beds appear to be synchronous with the Judith (Belly River) formation.

The vertebrate fauna now known is as follows:

Kritosaurus navajovius Brown
? Monoclonius sp.
? Dienodon sp.
Crocodilia
Thescelus rapiens Hay
Lepisosteus sp.

Conclusion

Briefly, in conclusion there is no doubt that the Hell Creek beds were synchronous with the "Lance," and little doubt that the Belly River and Ojo Alamo beds should be correlated with the Judith River. The Edmonton is intermediate in age between the Judith River and the Lance.

A comparison of the reptilian faunæ shows an uninterrupted succession of genera from the Judith River through to the close of the Lance. In some cases genera pass through without any marked change. They show those changes brought about through a lapse of time, but there is no evidence of any great migration changes which would be apparent as a result of any great diastrophic movement.