Bulletin No. 257

Series { B, Descriptive Geology, 64
C, Systematic Geology and Paleontology, 72

DEPARTMENT OF THE INTERIOR

UNITED STATES GEOLOGICAL SURVEY

CHARLES D. WALCOTT, DIRECTOR

GEOLOGY AND PALEONTOLOGY OF THE JUDITH RIVER BEDS

BY

T. W. STANTON

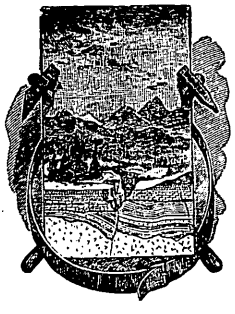
AND

J. B. HATCHER

WITH A CHAPTER ON THE FOSSIL PLANTS

BY

F. H. KNOWLTON



WASHINGTON

GOVERNMENT PRINTING OFFICE

1905

CONTENTS.

ILLUSTRATIONS.

LETTER OF TRANSMITTAL.

DEPARTMENT OF THE INTERIOR,
UNITED STATES GEOLOGICAL SURVEY,
Washington, D. C., May 11, 1904.

SIR: I have the honor to transmit herewith the manuscript of a report on the geology and paleontology of the Judith River beds, by T. W. Stanton and J. B. Hatcher, with a chapter on the fossil plants by F. H. Knowlton, and to recommend its publication as a bulletin.

The report embodies the results of field studies in Montana and adjacent regions during the season of 1903, and of a subsequent study of the collections. By combining careful stratigraphic observations with several lines of paleontologic investigation the authors have satisfactorily answered a much discussed question in Cretaceous stratigraphy, and the results stated in this report will have an important bearing on the geology of a large area in the Northwest.

Very respectfully,

C. W. HAYES,
Geologist in Charge of Geology.

Hon. CHARLES D. WALCOTT,
Director United States Geological Survey.

GEOLOGY AND PALEONTOLOGY OF THE JUDITH RIVER BEDS.

By T. W. STANTON and J. B. HATCHER.[a]

INTRODUCTION.

During the summer of 1903 we spent two months together in the field study of the Judith River and associated formations of northern and central Montana and adjacent areas of Canada. The principal results of this work were the accurate determination of the position of the Judith River beds in the Upper Cretaceous section, and the removal of all doubts as to the correlation of these beds with the Belly River beds of Canada, thus establishing more accurately the position of that Canadian formation. These results are offered as a slight contribution to the Mesozoic history of the north interior region, which is rendered more than usually difficult to decipher because land or nonmarine conditions prevailed during several recurring intervals, at least from the Upper Jurassic to the top of the Cretaceous. It is our purpose to give somewhat in detail the evidence on which our conclusions are based, restricting the descriptions to the areas which have been actually studied by us and which include practically all the known exposures of Judith River beds in Montana and the southeastern part of the Belly River area (including the bottom and the top of the formation) in Assiniboia. After a cursory review of previous work on the formations discussed, the local outcrops and sections in the different areas will be described. The descriptions of the areal and stratigraphic geology will be followed by brief accounts of the vertebrate fauna by Mr. Hatcher, of the invertebrate fauna by Mr. Stanton, and of the flora by Mr. Knowlton.

Working independently along different lines, we have long been interested in the stratigraphic and faunal problems connected with

[a] On July 4, 1904, soon after this manuscript was finished, Mr. J. B. Hatcher died at his home in Pittsburg, after a brief attack of typhoid fever. His death at the early age of 43 years is a serious loss to geology and paleontology, in which the important work he had already done gave promise of greater results in the future.—T. W. S.

the Judith River beds, and both of us had previously visited the typical area near the mouth of Judith River. In 1888 and 1892 Mr. Hatcher spent considerable time in collecting vertebrate fossils from the formation, making only incidental observations on the stratigraphy of the region. He traveled by wagon road, thus approaching the "badlands" exposures of these nonmarine beds from the higher divides, where he noticed outcrops of marine Cretaceous shales in such locations that he inferred that they might overlie the Judith River beds. He had also noticed similar relations of the outcrops on Willow Creek near Musselshell River. The study of the vertebrate fauna led him to the conclusion that it is older than the Laramie fauna of the uppermost Cretaceous. In the absence of data as to the exact age of the underlying formation, all of Mr. Hatcher's observations tended to place the Judith River beds well down in the Upper Cretaceous.

In 1894 Mr. Stanton spent a few days with Mr. W. H. Weed near the mouth of Judith River. They traveled by rowboat down the Missouri River from Fort Benton to Judith, passing over and studying the formations underlying the Judith River beds, beginning with the Fort Benton shales. Mr. Stanton confirmed the statements of previous observers that some of the strata beneath the Judith River beds contain a fauna that is elsewhere characteristic of the Montana group, or Fort Pierre and Fox Hills formations. He was especially impressed by the occurrence, in the upper part of these underlying beds, of a zone containing *Cardium speciosum*, *Mactra alta*, *Tancredia americana*, and other forms which in north-central Colorado are known to occur only in the Fox Hills beds immediately beneath the Laramie. No beds higher than the Judith River were seen, and the view was adopted that the Judith River overlies all of the Montana group and is referable to the Laramie. When a few days later the overlying marine Cretaceous shales were seen in contact with upturned Judith River beds near Havre, Mont., their apparent position was supposed to be due to faulting, of which there was abundant evidence in the neighborhood.

With these divergent views concerning the age of the Judith River beds the writers participated in the renewed discussion on that subject during the winter of 1902–3, to which reference will be made later. Mr. Hatcher then decided to make a field investigation of typical areas of the Judith River and Belly River beds, under the auspices of the Carnegie Museum, in Pittsburg, in which he had charge of the department of paleontology. Mr. Stanton expressed the desire to cooperate in such an expedition, and afterwards arrangements were made under which the expenses of the joint field work were borne by the United States Geological Survey.

DESCRIPTIVE GEOLOGY.

THE STRATIGRAPHIC COLUMN.

In order that the review of previous work on the Judith River beds may be made intelligible without too much circumlocution, it is necessary to introduce here a brief account of the stratigraphy of the Upper Cretaceous in this region. The principal facts, with the names of the new formations recognized, have been published in a preliminary note.[a]

Benton shales.—The lowest formation studied consists of dark clay shales with occasional intercalated bands of sandstone, especially in the upper portion. There are also frequent calcareous concretions, often of large size, which are usually fossiliferous. This is the well-known and widely distributed Fort Benton formation of the Meek and Hayden upper Missouri section. The name is derived from the town of Fort Benton, on Missouri River about 100 miles above the mouth of Judith River, but the original description and especially the stratigraphic limits are based largely on exposures in another area in Nebraska, where the Benton rests on the Dakota sandstone and is overlain by the Niobrara limestone and calcareous shales. In the neighborhood of Fort Benton and in all the region now under investigation there is no limestone corresponding to the Niobrara, and as there is no evidence of an erosion interval or unconformity, it is probably represented by shales or sandstones. The paleontologic indications are that in this region the Niobrara is represented by dark shales not separable stratigraphically from the Benton. If this be true the Benton shales of the upper Missouri represent more than the formation known by the same name in Nebraska, in Colorado east of the Front Range, and at other places, and really include the whole of the Colorado group, so that it is more appropriate to call them Colorado shales, as Weed has done in the Fort Benton folio. These shales are characterized in their lower portion by *Inoceramus labiatus*, *Scaphites warreni*, and a few other species, while toward the top they yield *Inoceramus umbonatus*, *I. exogyroides*, *Pholadomya papyracea*, *Scaphites ventricosus*, *Baculites asper* (?), and many other forms. The species of *Inoceramus* and *Baculites* occur in the Austin limestone of Texas; which is correlated with the Niobrara, and some of them have been found in the upper Niobrara shales of

[a] Science, n. s., vol. 18, 1903, pp. 211-212.

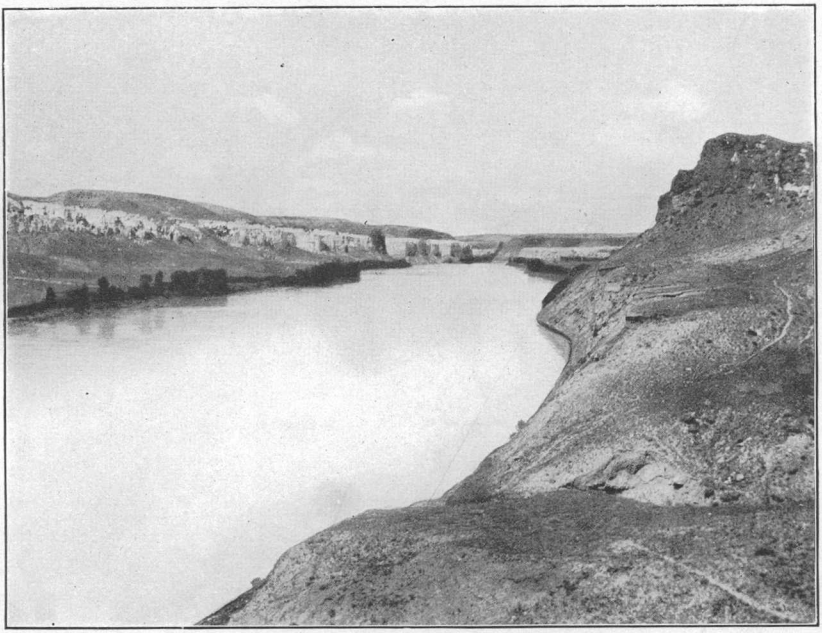
Colorado. The total thickness of the formation is estimated at 800 feet, but only the upper portion, 200 to 300 feet in thickness, is usually seen in the sections examined.

Eagle formation.—Immediately above the Benton shales is the Eagle formation, which was named by Weed from Eagle Creek. It is found along Missouri River for many miles above and below Eagle Creek, the exposures being continuous from a point less than 10 miles below the mouth of Marias River to the mouth of Arrow Creek. At its base it consists of laminated sandstones and shales grading down through 30 or 40 feet into the underlying formation, but its most conspicuous member is a heavy-bedded or massive, very light-yellowish to white cross-bedded sandstone 100 feet or more in thickness, which "weathers into cliffs or steep slopes with balcony ledges and striking monumental forms capped by ironstone masses." (See Pls. I and II.) These striking features of the landscape have been noticed and described by all the early explorers of the upper Missouri. In the neighborhood of Eagle Butte the sandstone is cut by many igneous dikes, which, however, do not cause any vertical displacement.

Above the massive white sandstone are softer beds consisting of alternating sandstones, shales, and many beds and seams of lignite. At many localities bands of small, flat, black pebbles occur near the top. The total thickness assigned by Mr. Weed to the formation along the Missouri is 200 feet, but if the similar lignitiferous beds that are predominantly sandstones be included the thickness is probably more than 300 feet. This greater thickness of beds that can not be consistently separated from the Eagle formation was observed especially on Dog Creek, and at other places in the neighborhood of Judith.

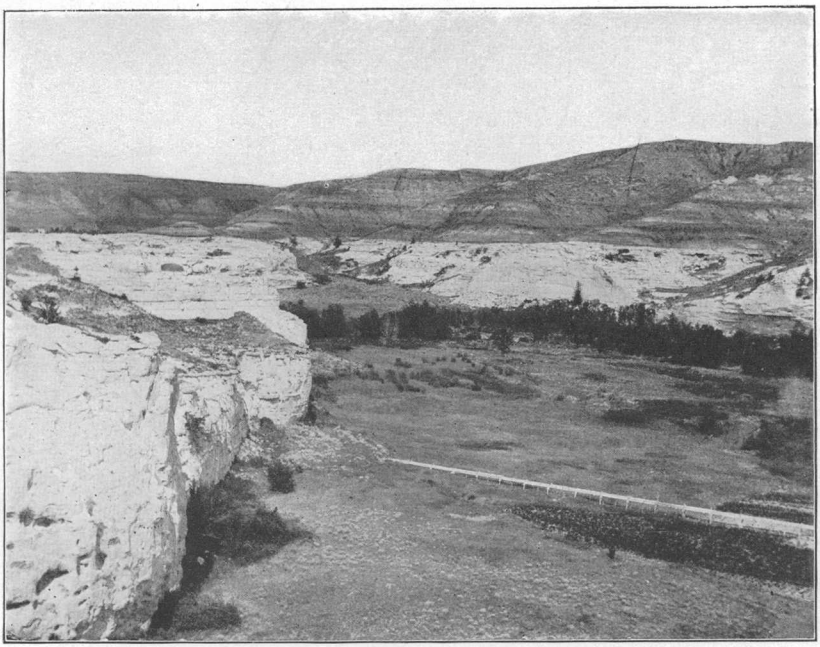
At many places the Eagle formation seems to be barren of fossils. This is especially true of the thick sandstone member. One locality on the Missouri, 7 miles below "Coal Banks," has yielded a few species of fossil plants, and a considerable invertebrate fauna has been collected, mainly from the upper portion, 5 or 6 miles below the mouth of Arrow Creek, and on Dog Creek and elsewhere in the neighborhood of Judith. The invertebrates include *Cardium speciosum*, *Thetis? circularis*, *Mactra alta*, *Placenticeras whitfieldi* (*?*), and undescribed species of *Crenella*, *Leptosolen*, *Baroda*, *Pholadomya*, and *Baculites*, all of which show much closer relation with the fauna of the overlying beds of the Montana group than with that of the Colorado group. This horizon has also yielded a few dinosaurian remains, including the type of *Ornithomimus grandis*, which was found near the mouth of Cow Creek, where the Eagle formation is brought up by faulting.

The formation has often been confused with several other horizons. In addition to the areas already mentioned it has been recognized in



A. EAGLE FORMATION. "STONE WALLS" ON MISSOURI RIVER BELOW MOUTH OF EAGLE CREEK.

Igneous dike in middle distance.



B. EAGLE FORMATION. SANDSTONE AND OVERLYING LIGNITE-BEARING BEDS AT MOUTH OF EAGLE CREEK.

prominent outcrops on Flatwillow and Willow creeks, on the Yellowstone at Billings, and on Fish Creek near Musselshell River.

Claggett formation.—The beds to which the name Claggett formation has been given lie above the Eagle formation and below the Judith River beds. In the neighborhood of Judith (old Fort Claggett), where they are well exposed, they have a total thickness of about 400 feet and consist largely of dark clay shales with variable intercalated bands and beds of sandstone, especially in the upper half. The dark shales of the lower part of the formation contain many calcareous concretions, which yield *Gervillia borealis*, *Baculites ovatus*, *Baculites compressus*, and a few other forms, elsewhere regarded as characteristic of the Fort Pierre. The yellowish sandstone beds higher in the formation, especially one about 200 feet from the top and another near the summit, are often locally very fossiliferous, and bear an invertebrate fauna, of which the most conspicuous species are the following:

Species from upper part of Claggett formation.

Tancredia americana.	Mactra formosa.
Cardium speciosum.	Mactra alta.
Sphæriola? endotrachys.	Lunatia subcrassa.
Tellina equilateralis.	Vanikoropsis tuomeyana.
Thracia gracilis.	Baculites sp.
Liopistha (Cymella) undata.	

This has long been considered a typical "Fox Hills" fauna, and a number of its species do recur at the top of the marine Cretaceous immediately below the Laramie in Colorado and elsewhere. It is now known that some of them also occur as low as the Eagle formation. The shale exposures of this formation in the neighborhood of Judith have been identified as Fort Pierre in previous publications. The "lower dark shales" mapped by Dawson on Milk River near Pakowki Lake, Assiniboia, are the upper part of the Claggett formation. There is usually a gradual transition upward into the Judith River beds, so that it is often difficult to determine the exact boundary.

Judith River beds.—The lithologic and paleontologic features of this formation are fully described on subsequent pages. The beds are mostly of fresh-water origin, but occasionally contain intercalated brackish-water layers, the most persistent of which is near the top of the formation. More rarely there are local marine deposits in the upper part. The formation is prevailingly light colored and tends to weather into "badlands" forms. The thickness near Judith is little more than 500 feet.

Bearpaw shales.—These shales rest on the Judith River beds, and have the lithologic character of the Pierre shales, part of which they represent. They consist chiefly of dark clays, which weather into rounded slopes and form an "adobe" soil. In certain zones there are

numerous calcareous concretions, most of which are fossiliferous and and yield a varied invertebrate fauna. Among the more common forms are the following:

Species found in Bearpaw shales.

Ostrea patina.
Avicula nebrascana.
Avicula linguiformis.
Inoceramus sagensis.
Inoceramus barabini.
Leda (Yoldia) evansi.
Lucina subundata.
Thetis circularis.
Callista deweyi.
Mactra gracilis.
Liopistha (Cymella) undata.
Anisomyon centrale.
Cinulia concinna.
Anchura americana.
Baculites ovatus.
Baculites compressus.
Placenticeras whitfieldi.
Placenticeras intercalare.
Scaphites nodosus.

This formation is named from the Bearpaw Mountains, around whose north, east, and south sides it is well developed. It is evidently the equivalent of only a part of the Pierre formation, which in South Dakota, Colorado, and elsewhere is defined to include all the strata between the Niobrara limestone and the Fox Hills sandstone. Whether the Bearpaw also includes the representative of the Fox Hills sandstone has not yet been definitely determined. Its limits are precisely the same as those of the beds in Alberta and Assiniboia described by the Canadian geologists as "Pierre-Fox Hills" group, whose thickness is estimated at 750 feet. The thickness in Montana probably approximates the Canadian estimate, but no section where an accurate measurement could be made was studied.

Higher horizons.—Along Musselshell River in the neighborhood of Musselshell post-office and between the Musselshell and the Yellowstone north of Billings and Bigtimber the Bearpaw shales are overlain by a thick series of beds in which sandstones predominate, with shales and several coal-bearing horizons. This series doubtless includes representatives of the Laramie, Livingston, and Fort Union formations as described by Weed in adjacent areas.

HISTORICAL REVIEW.

The earliest definite geologic descriptions of the region about the mouth of Judith River were by Dr. F. V. Hayden, who visited the area in 1854 or 1855,[a] and brought back collections of both invertebrate and vertebrate fossils. The invertebrates were described by Meek and Hayden in the Proceedings of the Academy of Natural Sciences, Philadelphia, beginning in 1856, while the few vertebrate

[a] The scenic features above the mouth of Judith River produced by the Eagle sandstone were described by Lewis and Clark (Expedition to the Sources of the Missouri, etc., 1814) and by Prinz Maximilian zu Wied (Reise in das Innere Nord-America in den Jahren 1832 bis 1834, Coblenz, 1839-1841). The latter gives excellent illustrations of some of the striking outcrops of the Eagle sandstone on pls. 34, 35, 41, and vignette 18.

remains were described by Doctor Leidy.[a] These joint papers by Meek and Hayden, and others written by Hayden independently, contain many notes describing the geology of the Judith River country and varying opinions as to the age of the beds exposed there. The presence of many faults and other disturbances, the lithologic similarity of several distinct formations, and the apparently contradictory character of the evidence from different classes of fossils conspired to make the interpretation of the section difficult, and it is not surprising that the necessarily hasty and imperfect examination of the stratigraphy made by Doctor Hayden left him in doubt as to the relations of some of the beds, or that he made mistakes in attempting to correlate these beds with the Cretaceous section exposed on Missouri River several hundred miles to the east, where the lithologic development of some parts of the section is very different. The members of that section had not then been named, and the formations subsequently called[b] Dakota, Fort Benton, Niobrara, Fort Pierre, and Fox Hills were known as Nos. 1, 2, 3, 4, and 5, respectively.

In these early papers the sandstone now known to form the most prominent member of the Eagle formation was doubtfully referred to "No. 1," but from the fossils that are cited it is evident that Hayden did not separate the sandstone bands of the Claggett formation from the underlying Eagle sandstone. The occurrence of *Hettangia americana* (afterwards referred to *Tancredia*) was especially commented on because it was believed to be a Jurassic type of shell, though its association with *Baculites* and other Cretaceous types was taken as evidence that the horizon was really near the base of the Cretaceous. This marine horizon was recognized to be beneath the nonmarine beds whose invertebrate fossils were all described as Tertiary species. The vertebrate remains from the same region were declared by Leidy[c] to be reptiles and fishes of old types, "which remains, I suspect, indicate the existence of a formation like that of the Wealden." At that time it was not certain whether the vertebrates came from the same horizon as the nonmarine invertebrates or from a lower bed with "No. 1," though apparently Hayden's original opinion was that the bones and part of the fresh-water Mollusca came from the lower horizon and that other fresh- and brackish-water fossils came from Tertiary beds in the same neighborhood, as the following quotation[d] from the first published geologic description shows:

> Some 4 or 5 miles below the mouth of Musselshell River a lower rock—a sandstone—rises above the water level. This is probably No. 1 of the series, No. 2 and

[a] Proc. Acad. Nat. Sci. Philadelphia, 1856, pp. 72, 73, and Trans. Am. Philos. Soc., vol. 11, 1860, pp. 139–154.

[b] Proc. Acad. Nat. Sci. Philadelphia, 1861, p. 419.

[c] Proc. Acad. Nat. Sci. Philadelphia, 1856, p. 73.

[d] Meek and Hayden, idem, p. 114.

No. 3 not being represented here. It is worthy of note that out of two species of *Mactra*, two of *Tellina*, two of *Inoceramus*, one of *Pholadomya*, two of *Natica*, and one *Baculite* found in this rock, not one is known to occur in any of the higher formations, and some of these species are not unlike Neocomian forms.

In consequence of the increasing inclination of the strata, this last-mentioned sandstone rises in the vicinity of North Mountain River [Little Rocky Mountain Creek] as much as 250 feet above the Missouri. Here, or near this, begins a wild and desolate region, known as the *Mauvaises Terres* or Bad Lands of the Judith. At various places in these Bad Lands a sandstone similar to No. 1 was seen alternating with beds of clay and lignite, all of which are upheaved and much distorted. It was found impossible to devote to the examination of these formations time enough to determine their relations to the Cretaceous and Tertiary strata of this region, without running the risk of being cut off from the party and murdered by the Indians. Among a few fossils that were collected here, however, Professor Leidy finds teeth which he refers to two or three genera of large *Saurians* allied to the *Iguanodon*, *Megalosaurus*, etc. There are also in the collection from some of these beds one or two species of Unio, one or more of Cyclas or Cyrena, and a few crushed specimens of *Gastropoda*, like *Paludina* and *Melania*. From these facts we are strongly inclined to think with Professor Leidy there may be here, at the base of the Cretaceous system, a fresh-water formation like the Wealden. Inasmuch, however, as there certainly are some outliers of fresh-water Tertiary in these Bad Lands, we would suggest that it is barely possible these remains may belong to that epoch, though the shells appear to be all distinct species from those found in the Tertiary at other localities in this region.

In this paper the Judith River invertebrates are described as Tertiary species. In a subsequent paper published in the same volume[a] Meek and Hayden again discuss the marine sandstones containing *Baculites* and *Hettangia* [*Tancredia*] *americana*, and suggest that they may be as old as Jurassic, though more probably Cretaceous. Their statement is as follows:

> If not older than Cretaceous, we think, from these facts, as well as from the stratigrapical position of these beds, they probably represent some of the older members of that system. What relation they bear to the formations near the same locality in which the saurian remains were found, supposed by Professor Leidy to be allied to the genera *Iguanodon* and *Megalosaurus*, is still an unsettled question.[b]

In 1857 Hayden published his "notes explanatory of a map and section illustrating the geological structure of the country bordering on the Missouri River." Among the "basins of the Tertiary system" he lists[c] the "Bad Lands of Judith River, which occupy an area of 40 miles in length and 15 to 30 in breadth, reposing on a sandstone,

---

[a] Pp. 265–286.

[b] It is noteworthy that in this article the terms "Judith River beds" and "Judith River formations" are used in a general, untechnical sense to include all the formations occurring near the mouth of Judith River. In Leidy's paper of 1860 "Judith River formation" appears in the title and in the caption of a section. The term was used rather loosely for some years, and when applied strictly to the formation now known by that name it usually took the form "Judith River Estuary beds." In 1871 Hayden proposed "Judith group" (Ann. Rept. U. S. Geol. Surv. Terr. for 1870, p. 97) as a formation name. In subsequent papers by Cope, Meek, and others "Judith River beds" was used with its present signification.

[c] Proc. Acad. Nat. Sci. Philadelphia, 1857, pp. 109–116.

the age of which has not been positively determined." This area is colored as Tertiary on the map, and is described as follows:

This exceedingly interesting deposit occupies a depression in a sandstone formation which rises to the water level at the mouth of Little Rocky Mountain Creek from beneath the well-known Cretaceous bed No. 4 of the vertical section. It presents perhaps the most rugged scenery on the Missouri River, the denudation and erosion having been much greater than at the Bad Lands of White River. But the most remarkable feature of this basin is the wonderful disturbance of the strata. So much are the beds disturbed and blended together by forces acting from beneath, that it seems almost hopeless to obtain a section showing with perfect accuracy the order of superposition of the different strata.

A paper by Meek and Hayden in the same volume[a] gives a further discussion of the subject and shows that the change of view was caused by the study of the invertebrate fauna, which seemed to show close relationship with that of the "Great Lignite basin" near Fort Union.

A Judith River species of turtle (*Trionyx*) had also been identified in a bed at the base of the "lignitic," which was then regarded as Miocene. Their rather guarded statement is as follows:

We would not for a moment hesitate in regarding the deposits of which we have spoken, near the Judith, as Tertiary, were it not for the fact that the saurian and fish remains occurring in these beds, as may be seen by reference to Professor Leidy's remarks respecting them, are allied to Wealden and older types.

In the midst of evidence of such a conflicting nature, it is, of course, unsafe to express any very positive opinion respecting the age of these formations. At the same time we are strongly inclined to the conclusion that they will prove not merely Tertiary, but about of the age of the lowest beds of the Great Lignite basin, or perhaps a little older. We have therefore placed them provisionally along with the Tertiary beds in the accompanying section of the Nebraska rocks.

A generalized section of the Judith River beds 415 feet thick is described as follows:

This section embraces all the deposits, as we believe, seen in the Bad Lands of the Judith, in which land and fresh-water shells are known to occur. They appear, as near as could be ascertained, to occupy a local basin in a series of marine deposits, consisting of beds of sandstone and impure lignite, which we have regarded provisionally as of the age of No. 1 of our general section.[b]

This view, however, evidently was not in harmony with some of Hayden's stratigraphic observations, for when explorations in the Black Hills brought to light a fresh-water fauna at the base of the Cretaceous section, in beds now generally referred to the Jurassic, the opinion as to the age of the Judith River beds was again changed, and in a new edition of Hayden's map[c] the area was colored as "Cretaceous No. 1," with the statement that the beds may be the American

[a] Pp. 117-148.

[b] This section and a general discussion of the geology of the region were also published by Hayden in Warren's "Report of explorations in Nebraska and Dakota," in report of Secretary of War, 1858, reprinted as separate document in 1875.

[c] Proc. Acad. Nat. Sci. Philadelphia, 1858, pp. 139-158.

representatives of the Wealden. A fuller statement by Meek and Hayden[a] is as follows:

> The occurrence of these forms at this horizon [in the Black Hills] also leads us to suspect that a considerable portion of the estuary beds at the mouth of Judith River, above Fort Union, in regard to the age of which we have been so much puzzled, may be, as first suggested by Doctor Leidy, a representative of the Wealden, and as we were then inclined to suppose, belong to our No. 1.
>
> The close similarity between the lithological characters of these deposits and those of some of the Tertiary formations of the Northwest, and the estuary character of their fossils, together with the analogy of many of the species of Mollusca found in one of the upper beds (which may be an outlier of Tertiary resting on older formations), taken in connection with the fact that amongst the fossils collected from one of the middle beds (see section p. 124, Vol. VIII, Proceedings, 1857) there were some fragments of a *Trionyx*, regarded by Doctor Leidy as identical with a species occuring in well-marked Tertiary deposits near Long Lake, below Fort Clark, led us subsequently to think the whole of these estuary beds near the Judith River might possibly be an outlier of Tertiary reposing upon deposits of the age of our No. 1. At the same time, in consequence of the occurrence in them of remains regarded by Doctor Leidy as analogous to *Lepidotus*, *Iguanodon*, and *Megalosaurus*, we stated that in the midst of evidence of such a conflicting nature, it is unsafe to express any very positive opinion respecting the age of these formations.
>
> Since we know that there is a similar group of beds at the base of No. 1, as we now understand it, near the Black Hills, containing a mingling of fresh-water and marine fossils—although we are not sure any of them are specifically identical with those found near the Judith—we are inclined to think our first views in regard to these Judith River formations will prove to be correct, or, in other words, the beds from which the saurian remains, described by Doctor Leidy, were obtained, will yet prove to be a part of the series we include in No. 1 of the Black Hills section. This view receives additional support, too, from the fact that the Judith River fresh-water or estuary formations were often seen much upheaved and distorted, while around the Black Hills the Tertiary deposits appear to lie undisturbed upon the upheaved older rocks in such a manner as to indicate that the last period of disturbance amongst the strata of this region occurred after the close of the Cretaceous epoch, but previous to the deposition of the Tertiary.

In 1860 Hayden published[b] a paper entitled "A Geological Sketch of the Estuary and Fresh-water Deposit of the Bad Lands of the Judith," which contains perhaps the fullest connected account of the region that he printed. The statements as to the stratigraphic position of the Judith River beds are somewhat equivocal, but show no definite change from the views expressed in the paper last cited. The sandstones of the Eagle formation are referred to "No. 1," and some of the sandstones of the Claggett formation are also referred to the same horizon, while the shales of the Claggett, which are called "No. 4," are said to rest on No. 1.

In the following year Meek and Hayden[c] published a review of the geology of the upper Missouri region as an introduction to a paleontologic paper. Here they first gave the geographic names Dakota, Fort

---

[a] Ibid., pp. 45, 46.

[b] Trans. Am. Philos. Soc., vol. 11, pp. 123-138.

[c] Proc. Acad. Nat. Sci. Philadelphia, 1861, pp. 415-447.

Benton, Niobrara, Fort Pierre, and Fox Hills groups to the five numbered divisions of their Cretaceous section and called the overlying beds near the mouth of the Yellowstone, and lower on the Missouri, the "Fort Union, or Great Lignite group," at the base of which they placed the Judith River beds. On page 417 the following statement is made:

> At the time we published these facts [concerning the fresh-water Jurassic of the Black Hills], we were led by the discovery here of fresh-water shells, in such a position, to think that some estuary deposits of doubtful age, near the mouth of Judith River, on the Missouri, from which Doctor Leidy had described some saurian remains resembling Wealden types, might be older than the Tertiary. Later examinations, however, have demonstrated, that the Judith beds contain an entirely different group of fossils from those found in the rock under consideration, and that they are really of Tertiary age, and hold a position at the base of the Great Lignite series of the Northwest.

Concerning the marine beds near the mouth of the Judith previously assigned to "No. 1," the authors say that it would be unsafe to refer them to the Dakota group.

In another paper, published by Hayden[a] in 1861, the Tertiary beds of the Northwest are classified as "first, estuary deposits; second, true lignite beds; third, Wind River Valley deposits; fourth, White River Tertiary deposits." Of the first class he says:

> The estuary deposits, of which the Judith basin may be regarded as the type, are quite remarkable and of a most interesting character. Opinions of a somewhat conflicting nature have been entertained in regard to them, owing to the peculiar character of the organic remains, but recent observations have convinced me that they are all of Tertiary age, and that they are quite widely distributed throughout the Far West.

In the subsequent writings of Hayden there are many brief references to the Judith River beds, in which he constantly referred them to the Tertiary, with an occasional expression of doubt as to their exact position. There is no record that he revisited the original Judith River area after his first observations were made, but when connected with the Raynolds expedition of 1859–60[b] he passed over the same horizons and in part recognized them in traveling from the Judith Mountains to the mouth of Bighorn River on the Yellowstone.

Judith group was definitely proposed by Hayden[c] as a formation name in 1871 when discussing the Tertiary as follows:

> There is one other basin near the sources of the Missouri which has already yielded many fossils of great interest, but which seems to be isolated from the others. This is what I have called the Judith basin, and inasmuch as it seems to be one of the ancient lake deposits, and characterized by a peculiar group of organic remains, I will designate the strata as the Judith group. The sediments do not differ materially from those of the Fort Union group, and they contain impure beds of lignite,

---

[a] Am. Jour. Sci., 2d ser., vol. 31, pp. 229-245.

[b] Rept. Geol. Expl. of the Yellowstone and Missouri rivers by Dr. F. V. Hayden, 1869. See pp. 12, 59, 93, and 94.

[c] Prelim. Rept. U. S. Geol. Survey of Wyoming, p. 97.

fresh-water Mollusca, and a few leaves of deciduous trees. But the most remarkable feature of this group is the number and variety of the curious reptilian remains, of which we have only yet caught a glimpse.

In 1875 the announcement was made independently by Meek[a] and by Hayden[b] that the marine sandstones near the mouth of Judith River whose position had so long been in doubt had been correlated by means of fossils with the Fox Hills. This correlation was based on the discovery of a fauna in a sandstone occurring at several localities in the South Platte Valley within a few miles of Greeley, Colo. The sandstone was referred to the Fox Hills, doubtless correctly, on account of its position at the top of the marine Cretaceous and beneath the Laramie, and because a large majority of the seventeen molluscan species recognized in it were known to be characteristic of the Fox Hills elsewhere. With these Fox Hills species there were four forms, *Tancredia americana*, *Cardium speciosum*, *Mactra formosa*, and *Mactra alta*, that had previously been known only from the Judith River country, in sandstones that we now refer in part to the Claggett formation, though part of the species range down into the Eagle. Meek says:

> From this blending together of the Fox Hills species and those of the marine Cretaceous beds found at the mouth of Judith River on the Upper Missouri it is evident, I think, that we can not be far wrong in regarding the latter beds as holding a position at the horizon of the top of the Fox Hills group.

The correlation was justified by the facts then available, but it is now known that some of these littoral species have a vertical range of many hundreds of feet and are not distributed throughout that interval in any one section, but recur whenever the conditions were suitable.

In Meek's last work,[c] published in 1876, there is an excellent résumé of the stratigraphy, in which he says:[d]

> We have long regarded the Judith River beds as forming a distinct group older than the Fort Union deposits.

He again identifies the beds underlying the Judith River as upper Fox Hills, and thinks it highly probable that the Judith River beds are Cretaceous, while the Fort Union may be Lower Eocene.

Prior to this time E. D. Cope had begun his contributions to the discussion. In his paper entitled "Synopsis of the Extinct Batrachia, Reptilia, and Aves of North America"[e] he listed the Judith River vertebrate fossils as Upper Jurassic species, probably meaning by that the Wealden. In 1874[f] he regarded the Judith River beds as the top of the Cretaceous and discussed them under the heading "Fort Union or Lignite group." Three years later, after a field season in the area,

---

[a] Bull. U. S. Geol. and Geog. Surv. Terr., vol. 1, pp. 39, 40.

[b] Idem, p. 403.

[c] A report on the invertebrate Cretaceous and Tertiary fossils of the upper Missouri country: Rept. U. S. Geol. Surv. Terr., vol. 9.

[d] Page xlvii.

[e] Trans. Am. Philos. Soc., vol. 14, 1870, pp. 1–252.

[f] Bull. U. S. Geol. and Geog. Surv. Terr., vol. 1, No. 2, pp. 6–8.

Cope[a] published his "Report on the Geology of the Region of the Judith River, Montana," in which some stratigraphic and paleontologic details are given. The Judith River beds are treated as a distinct formation, about 500 feet thick, immediately overlying the Fox Hills, and the dark shales now included in the Claggett formation are called "Fort Pierre," while other areas of shales on the Missouri farther east, which doubtless overlie the Judith River, are not recognized as distinct or in a different position. The white sandstone of the Eagle formation is tentatively correlated with "No. 3," or Niobrara, on account of its stratigraphic position. Cope's view as to the age of the Judith River beds is expressed in the following quotation:[b]

> The positive evidence, then, as to the age of the Judith River fauna is that it is Cretaceous, but, as might be supposed from its position, with some Tertiary affinities.
>
> * * * * * * *
>
> I will remark in conclusion that it is probable that the Lignitic formation will come to be regarded as a primary division of the Cretaceous, and equivalent as a whole to all or part of the older marine series. It will include as subdivisions the Judith River and Fort Union epochs, as already defined by Mr. Meek from the invertebrate fossils, and probably the Laramie or Bitter Creek epochs as distinct from them.

Similar views as to the classification and stratigraphic succession of the beds were expressed by Edward S. Dana and George B. Grinnell,[c] who visited the region in 1875. They spoke of the disturbed condition of the beds, but erroneously attributed it to the effects of local landslides, denying that there were any real faults or uplifts.

The review given thus far is confined to work on the original area in Montana. Meanwhile, however, the area of similar formations not far to the north and west in Canada began to be investigated. The first paper having any important bearing on the present subject was by James Hector[d] and was entitled "On the Geology of the Country between Lake Superior and the Pacific Ocean (between the Forty-eighth and Fifty-fourth Parallels of Latitude)." He gives a general section of the Cretaceous formations, at the base of which he places a great lignite-bearing group, including in it all the coal-bearing strata observed, although he admits that it may contain two distinct horizons, one Upper Cretaceous or Eocene and the other Cretaceous in the position assigned to it at the base of the section. His map extends as far south as Missouri River, where all the areas now known to consist of Eagle, Claggett, and Judith River formations are colored as the lowest member of his section.

The same region was more fully described in 1875 by Dr. George M. Dawson,[e] who then treated all the coal-bearing beds as Tertiary

---

[a] Bull. U. S. Geol. and Geog. Surv. Terr., vol. 3, pp. 565–597.

[b] Idem, pp. 576 and 577.

[c] Geological Report in Ludlow's Rept. Reconnaissance from Carroll, Mont., to Yellowstone National Park and Return, pp. 97–137, Washington, 1876.

[d] Quart. Jour. Geol. Soc. London, vol. 17, 1861, pp. 388–445 and map.

[e] British North American Boundary Commission. Report on the Geology and Resources of the Region in the Vicinity of the Forty-ninth Parallel from the Lake of the Woods to the Rocky Mountains.

and of the same horizon, though he recognized considerable differentiation in the widely separated areas and made stratigraphic observations that suggested a lower position for some of them. He speaks of the striking resemblance of the eastern (Souris River) area of Lignite Tertiary to the "typical Fort Union," while the badlands south of Wood Mountain have a somewhat different aspect, and westward from this point there is a gradual change until near the Buttes [Sweetgrass Hills] the appearance is entirely distinct. This western area includes the beds that were afterwards described as the Belly River series, whose correlation with the Judith River beds is first suggested[a] in the following words:

> Though I have not yet had an opportunity of comparing the fossils obtained in the western marine and brackish-water beds of the Tertiary on the forty-ninth parallel with those from the Judith River beds of the Missouri, I have little doubt of the identity of the formations. The age of these Judith River beds has long been an unsettled question, and they have only lately been included by some geologists with the remainder of the Lignite Tertiary and called Cretaceous. Doctor Hayden was only prevented from calling them Fort Union Tertiary by the occurrence of certain vertebrate remains—the meaning of which is now better understood. The lithological resemblance between these beds of the line and those of the Judith River is close.

A few vertebrate fossils are described in an appendix by Cope, who calls them Fort Union. Part of them are from Judith River beds on Milk River and the others from probably a much higher horizon near Wood Mountain.

In 1881 Dawson[b] described the Cretaceous section of the Peace River region in Athabasca and named the Dunvegan sandstone, a partly nonmarine formation, intercalated in the marine Cretaceous, which he correlated at that time with the Niobrara and later with the Belly River beds. Subsequent descriptions and references by McConnell[c] and by Whiteaves[d] indicate that its exact position is still uncertain, and as it lies far north of the area we have examined it need not be further considered except to remark that it may represent either the Eagle or the Judith River formation.

Dawson returned to a more detailed study of the western plains immediately north of the international boundary and soon discovered that a part of the beds he had previously grouped under the Lignite formation as Tertiary really underlies marine Cretaceous shales referred to the Fort Pierre. This lower formation was called the Belly River series, and in the preliminary announcements[e] was correlated with the Dunvegan, and also doubtfully with the Niobrara. In the official report just referred to the section shows Laramie at the

---

[a] Pp. 156, 157.

[b] Ann. Rept. Geol. Surv. Canada, 1879–80, p. 115B. See also Am. Jour. Sci., 3d ser., vol. 21, pp. 391–394, and Canadian Naturalist, new series, vol. 10, pp. 20–22.

[c] Ann. Rept. Geol. Surv. Canada, 1890–91, n. s., vol. 5, pt. 1, pp. 54–55D.

[d] Trans. Roy. Soc. Canada, vol. 11, 1893, sect. 4, pp. 9, 10.

[e] Rept. Geol. Surv. Canada for 1880–81–82, pp. 1–23B, 1883. Trans. Roy. Soc. Canada, vol. 1, 1883, sect. 4, pp. 42, 43.

top, consisting of the named subdivisions Porcupine Hills, Willow Creek, and St. Mary River, succeeded below by unnamed yellowish sandstones and shaly beds, with a mingling of fresh-water and brackish or marine mollusks, still referred to the Laramie. Beneath these are Fox Hills and Pierre beds. The lower part of the section, beneath the Pierre, is described as follows:

Belly River series.—Sandstone, shales, and sandy clays, generally of pale grayish tints. Marine and fresh-water fossils.

Series apparently underlying the last on the Bow and Belly, but on the stratigraphical position of which some doubt yet remains owing to the resemblance of its estuarine fauna to that of the Judith River. Brownish and yellowish sands and clays.

The Judith River beds are treated as a part of the Laramie, and the correlation of the Belly River beds is indicated in the following statements:

The pale beds underlying the Pierre in this region represent, with little doubt, the Dunvegan sandstones of the Peace River section. They are also evidently identical with those described by Professor Cope as occupying a similar position on the Missouri [now known as the Eagle formation]. This subdivision, which appears most probably to hold the position of the Niobrara in the Nebraska section, is therefore one of great persistence in the Cretaceous.

The same correlations are made in the paper published by the Royal Society of Canada.

In 1884 Dawson[a] extended the Belly River beds downward to include the yellowish and brownish sands and clays with a Judith River fauna, and repeated the correlation of the upper part of the formation with the Eagle sandstone, while suggesting a lower position for the Judith River beds. He says:

The upper part of the Belly River series evidently represents the pale, sandy beds which occur on the Missouri in a similar position with reference to the Pierre; and the latter holds coal or lignite at the base in this district, as described by Prof. E. D. Cope, on that river.

In reference to the fossils, he makes the following very proper suggestion:

The fossils of the Belly River series have not yet been critically examined; but their resemblance to those of the Judith River is so complete that I am strongly inclined to revert to Messrs. Meek and Hayden's original views respecting the stratigraphy of the latter beds and to suggest, though with some hesitation, that the species figured on pls. 37–39 of Meek's work on the Cretaceous and Tertiary fossils of the upper Missouri, as from a peculiar development of the Fox Hills group, have really been derived from beds underlying the Pierre.

The species referred to are from near the mouth of Judith River and are now known to have come from the Claggett and Eagle formations.

---

[a] Science, n. s., vol. 3, pp. 647, 648.

Dawson's final report[a] on the region in the vicinity of Bow and Belly rivers, Northwest Territory, published in 1885, gives detailed descriptions of the Belly River and associated formations and a full statement of the evidence for its accepted stratigraphic position beneath about 830 feet of marine Cretaceous correlated with the Fort Pierre and Fox Hills. The area mapped extends from a few miles south of the international boundary to latitude 51° 20′ and from longitude 110° 45′ to the Rocky Mountains. The Belly River beds are represented as covering a large area, broadening southward across the eastern portion of the map. West of this area of Belly River beds overlying formations occupy a low, broad syncline, while in the uplifted belt along the foothills of the Rocky Mountains all the Cretaceous formations are mapped together under one color, because the complex region was not studied in sufficient detail. In the general section Dawson assigns maximum thicknesses to the formations as follows: To the members of the Laramie 5,750 feet; Fox Hills, 80 feet; Fort Pierre, 750 feet; Belly River, 910 feet; "Lower dark shales," 800 feet.

The conclusions as to the Belly River and Judith River beds are summarized in these words:[b]

> Briefly stated, it would appear from the investigations now reported on that considerable areas of the beds which in 1874 I called "Lignite Tertiary"—here and in previous announcements designated as Belly River series—must be relegated to a position below the Pierre shales, or at least to one below an upper portion of these shales. The beds thus separated as the Belly River series were, in 1875, by me correlated with the Judith River series of the Missouri. Additional and extensive collections of fossils since obtained and now being worked out confirm and strengthen this correlation and lead to the presumption that the so-called Judith River series must also occupy a position well down in the undoubted Cretaceous. It may be added that this was the view originally held by Messrs. Meek and Hayden, and supported, it would appear, not alone on the supposed analogies of the vertebrate remains examined for them by Professor Leidy, but also on stratigraphical evidence—evidence which perfectly agrees with the impressions resulting from such cursory examination as I was able to make of the Missouri sections from the deck of a steamer while ascending the river in 1881.

An incidental reference in a footnote on page 122c makes it evident that Dawson still failed to discriminate between the Eagle and the Judith River formations on the Missouri, and he did not recognize any horizon in his area corresponding to the Eagle formation. It seems remarkable that this formation, which is so well developed on the Missouri only about 75 miles south of the Canadian boundary, should disappear completely from the sections in the Sweetgrass Hills and along Milk River near the boundary. Several facts gleaned from Dawson's careful descriptions and from the subsequent paleontologic report[c] favor the suggestion that the Eagle sandstone really occurs

---

[a] Geol. Surv. Canada, Rept. Prog. for 1882–1884, pp. 1–169c and map.
[b] Idem, p. 119c.
[c] Cont. Canadian Palæont., vol. 1, pt. 1, 1885.

here and has been referred to the Belly River. The castellated sandstones along Milk River between Verdigris Coulee and Dead Horse Coulee, as described on page 40c and as figured[a] in an earlier report, resemble the Eagle sandstone much more closely than any part of the Judith River or any other horizon in the general region. This same sandstone horizon was recognized in Rocky Spring Ridge and on the west flank of West Butte (Sweetgrass Hills) resting on dark shales which at the last-named locality have an estimated thickness of 800 feet. Now, this thickness is much too great for the shales of the Claggett formation, which underlies the Judith River and is the same as that of the Fort Benton shales beneath the Eagle. Dawson expressly states[b] that the dark shales of these two localities do not agree very satisfactorily with those farther east on Milk River, at the mouth of Pakowki Coulee, which we now recognize as belonging to the Claggett formation, and the fossils reported from them at both West Butte and Rocky Spring Ridge include *Baculites asper* and *Scaphites warreni*, of which the latter especially is a characteristic Fort Benton species. As the writers have not visited the localities nor seen the fossils in question, they can only suggest that possibly the structure has been misinterpreted and that part of the area mapped as Belly River really belongs to the Eagle formation.

The invertebrate fossils of the Belly River beds and associated formations have been described by Prof. J. F. Whiteaves,[c] and the fossil plants have been treated by Sir William Dawson,[d] with stratigraphic notes by Dr. George M. Dawson. Their general conclusions as to the evidence of the fossils are expressed in the following quotations. Whiteaves says:

> Judging by their respective invertebrate faunas, it would seem impracticable to separate the "Belly River series" from the Laramie, and more especially from the "Judith River group," on purely paleontological evidence.[e]
>
> The invertebrate fauna of the "Belly River series" seems to be essentially the same as that of the "Laramie" of the United States and Canada, unless more than one formation has been confounded under the latter name, and * * * it is at present scarcely possible to separate the "lower dark shales" of Doctor Dawson's Bow and Belly River report from the "Fort Pierre and Fox Hills" groups, on purely paleontological grounds.[f]

Sir William Dawson states in the first and third papers cited that "it scarcely seems possible to distinguish by fossil plants alone the lower Laramie beds from those of the Belly River." He also remarks that the Dunvegan series of the Peace River region probably corre-

---

[a] Rept. Prog. for 1880-1882, frontispiece of Doctor Dawson's report.
[b] Geol. Surv. Canada, Rept. Prog. for 1882-1884, p. 125c.
[c] Cont. Canadian Palæont., vol. 1, pt. 1, 1885.
[d] Trans. Roy. Soc. Canada, vol. 3, sec. 4, pp. 1-22, 1886. Idem, vol. 4, sec. 4, pp. 19-34, 1887. American Naturalist, vol. 22, 1888, pp. 953-959.
[e] Cont. Canadian Palæont., vol. 1, pt. 1, 1885, p. 55.
[f] Idem, p. 89.

sponds in time with the Niobrara. The paleontologic evidence and relationships will be fully discussed on later pages.

Additional areas of Belly River beds on the east and north of Dawson's area were described and mapped by R. G. McConnell[a] and by J. B. Tyrrell,[b] respectively, who confirmed Dawson's conclusions concerning the stratigraphic position of the formation so far as the overlying beds were concerned, but still left the exact age of the underlying formation undetermined.

In the United States the discussion concerning the age of the Laramie continued long after Meek and Hayden's publications ceased; and since the Laramie was generally held to include or to be the equivalent of the Judith River beds, the age of the latter was frequently involved in the discussion. The paleobotanists Newberry, Lesquereux, and Ward contributed many articles to this controversy, but they had no direct bearing on the Judith River question because no definitely described fossil plants were known from the Judith River beds.

From 1877 to 1891 Dr. C. A. White published many papers in which the invertebrate paleontology and the geologic relations of the Judith River beds are more or less fully treated. At first[c] the Judith River was treated as a separate formation immediately underlying the Fort Union and holding the same relative position as the Laramie in southern Wyoming, but in the following year the term "Laramie" was used in a broader sense, as follows:

> The Laramie group includes as either subordinate groups or regional divisions both the Judith River and Fort Union series of the Upper Missouri River; the Lignitic series east of the Rocky Mountains in Colorado; the Bitter Creek series of southern Wyoming and adjacent parts of Colorado; and also the Bear River Estuary beds, together with the Evanston coal series of the Valley of Bear River and adjacent parts of Utah.[d] * * *
>
> Some of the known portions of this great group doubtless represent different stages of the Laramie period, but the members just designated are, as a rule, understood to represent different geographical developments of its strata with modifications of its fauna rather than separate successive epochs of time in the geological period which is represented by the whole great group. The proof of the identity of these widely separated portions of the Laramie group consists in the recognition of various species of fossil mollusks in all of them that are found in some one or more of the others, thus connecting the whole by faunal continuity. Similar proof has also been obtained by Professor Cope in the discovery of certain species of vertebrate fossils in more than one of these geographical members of the Laramie group.[e]

So far as the Judith River, Fort Union, and Bitter Creek beds are concerned these views are consistently held in all of White's subse-

---

[a] Ann. Rept. Geol. Surv. Canada, n. s., vol. 1, 1886, pp. 1-78C.
[b] Idem, vol. 2, pp. 1-152E, 1887.
[c] Bull. U. S. Geol. and Geog. Surv. Terr., vol. 3, 1877, pp. 608-609.
[d] Idem, vol. 4, 1878, p. 721.
[e] Idem, p. 865.

quent papers. In 1883, accompanied by Prof. Lester F. Ward, he visited the Judith River and Fort Union areas along the Missouri, but he did not see any reason for changing the later conclusions of Meek and Hayden and of Cope, and his stratigraphic observations were not fully published. Concerning the Fort Union area he made the following statement:[a]

During the summer of 1882 I gave especial study to the geology of the region about Fort Union, extending up the Yellowstone Valley, and including all the localities from which Doctor Hayden obtained the fossil plants here referred to [Fort Union plants described by Newberry]. The result of that study has been to ascertain that only one formation, namely, the characteristic Fort Union group, which is nothing more or less than a part of the great Laramie group, occupies that whole region. That is, with the exception of one or two small exposures of the Fox Hills Cretaceous group, upon which the Laramie strata rest conformably, no other than Laramie strata are to be found there.

In the excellent correlation paper on the Cretaceous, White[b] gave a general discussion of both the Laramie[c] and the Belly River[d] formations, with a review of the literature. He still included the Judith River, Fort Union, etc., in the Laramie and held that it was deposited in a great land-locked sea of mainly brackish waters.

Concerning the Belly River beds he states that "certain observed conditions of strata exposed along the Missouri River in northern Montana apparently indicate its presence there. It also seems not improbable that some of the strata in the upper part of the valley of the Musselshell River, in Montana, which have been referred to the Laramie,[e] really belonged to the Belly River formation." The first reference is evidently to the occurrence of the Eagle formation between Fort Benton and Judith, and the second reference is probably to an actual occurrence of Judith River beds which will be referred to again. The position of the Belly River formation is thus stated:

The marine strata which overlie the Belly River are certainly referable to the Montana formation, but whether they represent the whole of that formation or not it is at present impossible to say. That is, it is not yet certainly known whether the Belly River formation is interposed between the top of the Colorado and the base of the Montana, or between a large upper and a small lower part of the last-named formation. The former condition is assumed to exist, although it is not yet certain that some of the fossil species discovered beneath the Belly River strata do not also occur in the Montana formation.

From the intimate relationship between the Belly River and Laramie faunas, especially the specific identity of certain gill-bearing Mollusca in both, White inferred that there must have been physical continuity between the formations. The assumed relations of the Belly River to

[a] Am. Jour. Sci., 3d ser., vol. 26, 1883, p. 121.
[b] Bull. U. S. Geol. Survey No. 82, 1891.
[c] Pages 145–153.
[d] Pages 173–177.
[e] See Lindgren, W., Tenth Census of the United States, vol. 15, pp. 743–746.

the associated formations are shown diagrammatically by representing the Belly River formation as a wedge inserted between the Colorado and Montana groups, gradually thickening so as to replace more and more of the Montana, until in some hypothetical area it becomes continuous with the overlying Laramie and is not separable from it.

In 1886 Mr. W. Lindgren[a] published a description, with sections, of a region between the Yellowstone and Musselshell rivers in Montana that is now known to contain Judith River beds. The section as described is remarkable for the very great thickness (8,600 feet) of beds assigned to the Laramie, and for the intercalation of marine beds with *Placenticeras* and *Baculites* within the Laramie. The writers have traveled along the line of Lindgren's section that extends northeasterly from Billings, and according to their interpretation the sandstone forming the cliffs at Billings, which he referred to the Fox Hills, really belongs to the Eagle formation, and his Laramie must include the Claggett, Judith River, and Bearpaw, as well as the Laramie and probably some overlying formations.

Cope[b] briefly discussed the Belly River beds of Canada in 1887. He stated that the flora and the fauna, vertebrate and invertebrate, are identical or nearly so with the Laramie, and expressed a suspicion that there had been some error of observation.

About this time horned dinosaurs began to be recognized at various localities in the West, and the beds yielding them were called by Prof. O. C. Marsh[c] Ceratops beds and referred to a single horizon of the Laramie. Mr. J. B. Hatcher, who had done the field work in collecting the vertebrate faunas of these beds, maintained that there was paleontologic and stratigraphic evidence that they include at least two horizons. His views are expressed in the following quotations:[d]

> The actually known area of the Ceratops beds is indeed very limited, and from these areas we should exclude certainly the Judith River or upper Missouri, and very likely the Black Butte locality in southwestern Wyoming. The beds of the former certainly and those of the latter almost certainly belong to an older horizon than those of the Denver or Converse County localities; the latter may be considered as the typical locality for the Ceratops beds. All of the dinosaurs from the Judith River country are smaller, less specialized forms than those from the Converse County and Denver localities, as has already been observed by Marsh.

Speaking of the Converse County locality, he says:

> It would doubtless be better to restrict the limits of the Ceratops beds to those strata in which horned dinosaurs occur, and to consider the underlying 400 feet of barren sandstones as the equivalent of the Judith River beds. * * *
>
> The terms Fox Hills and Laramie as now used can not be taken to represent distinct and different periods of time, for, as has been shown by G. M. Dawson,

---

[a] Tenth Census United States, vol. 15, pp. 743–746.

[b] American Naturalist, vol. 21, 1887, pp. 171, 172, and 445–462.

[c] Am. Jour. Sci., 3d ser., vol. 38, 1889, p. 501. Marsh definitely referred the Judith River beds to the same horizon as the Ceratops beds of Converse County, Wyo., in the Geology of the Denver Basin: Mon. U. S. Geol. Survey, vol. 27, 1896, p. 478.

[d] American Naturalist, vol. 30, 1896, pp. 116, 117.

Selwyn, and McConnell in the Belly River region in Canada, and frequently observed by the writer on the upper Missouri in Montana, marine beds with typical Fox Hills fossils have been found interstratified with fresh and brackish water beds containing characteristic Laramie fossils, showing conclusively that the two periods were in part at least contemporaneous; the one representing the marine and the other fresh or brackish water forms existing at the same time and in not widely separated regions, these alternations in the nature of the fauna in the same locality having been brought about by successive encroachments and recessions of the sea.

In 1896 Mr. Whitman Cross[a] discussed the age of the Arapahoe and Denver formations and referred to related beds in other regions, especially those yielding horned dinosaurs. He suggested that "the Judith River strata may perhaps represent the Arapahoe or some other post-Laramie formation, and not the true Laramie of Colorado and Wyoming." He quoted from the manuscript notes of Mr. T. W. Stanton the description of a section on Dog Creek, near Judith, Mont., which includes the lower 300 feet of Judith River beds and underlying strata then referred to the Fox Hills, but now designated as the Claggett and the upper part of the Eagle formation.

Mr. W. H. Weed[b] has described the section in the region of the Crazy Mountains between Yellowstone and Musselshell rivers, where the Judith River beds are now known to exist, but he failed to recognize the formation. It is very probable that the brackish-water fossils cited[c] as coming from the Livingston formation north of the Crazy Mountains were collected from an outcrop of Judith River beds.

In the Fort Benton folio,[d] published in 1899, Weed named and described the Eagle formation, stating that it rests on the Colorado shales and is overlain by 2,000 feet of marine beds referred to the Montana formation, and that it has yielded fossil plants similar to those of the Belly River beds. The area mapped on the Missouri is west of all the outcrops of Judith River beds.

A few fossil plants from the Eagle formation near "Coal Banks" on the Missouri were described by Dr. F. H. Knowlton[e] in treating the flora of the Montana formation. These were described as Belly River species, and in justification of this correlation a brief manuscript note by Stanton, giving his views on the stratigraphy and correlation of that part of the section, was published. The concluding portion of Stanton's note is as follows:

It is evident from the stratigraphy and from the marine invertebrate fauna of the underlying and overlying strata that the sandstones and the associated coal beds and

[a] Geology of the Denver Basin: Mon. U. S. Geol. Survey, vol. 27, pp. 239–241.

[b] The Laramie and the overlying Livingston formation in Montana: Bull. U. S. Geol. Survey No. 105, 1893. The Fort Union formation: Am. Geologist, vol. 18, 1896, pp. 201–211.

[c] Bull. U. S. Geol. Survey No. 105, p. 33.

[d] Geologic Atlas of the United States, folio 55.

[e] Bull. U. S. Geol. Survey No. 163, 1900. This paper was submitted for publication before the Fort Benton folio was issued, and consequently the name Eagle is not used for the formation.

plant-bearing horizons in the neighborhood of Coal Banks on the Missouri River are on essentially the same horizon to which the Belly River series was assigned by Dr. G. M. Dawson, and to which a part of the Canadian beds so named undoubtedly belong. But in Doctor Dawson's full and careful description of the Belly River series it is pointed out that in certain areas referred to that series the stratigraphy is not clear, and the beds may overlie the Montana shales instead of underlying them. It happens that most of the Belly River fauna, which consists chiefly of Laramie species, was collected in those doubtful areas. I suspect that in Canada two distinct formations, separated by marine beds, have been confused under the term Belly River series, and that a large part of the fauna, and possibly also of the flora, was collected from the upper horizon, which included the Laramie and possibly even later beds.

In 1902 Mr. Earl Douglas[a] described a formation under the local name Fish Creek beds, which he correctly correlated with the Belly River. The locality is a few miles east of the Crazy Mountains area previously described by Weed. The Eagle formation also occurs in the section, but was called Niobrara.

In the same year the vertebrate fauna of the Belly River beds in Canada was reviewed and described by Prof. H. F. Osborn[b] and Mr. L. M. Lambe, the former contributing the general discussion and the latter the paleontologic descriptions. The conclusions as to correlation and stratigraphic position were more concisely stated in an abstract by Osborn,[c] from which the following brief extracts are taken:

> The [Canadian] Survey had established beyond question, geologically, that the Belly River series is mid-Cretaceous, that it underlies the Montana or Fort Pierre-Fox Hills group, and overlies the Fort Benton and Dakota groups. * * * It soon appeared * * * that the Belly River vertebrates were of decidedly different and apparently of older type than those from the Laramie beds of Converse County, Wyo., described by Marsh, and were rather to be compared with those described by Leidy, Cope, and Marsh, from Montana, chiefly from the Judith River beds, which overlie the Fort Pierre in a region by no means distant geographically.
>
> * * * * * * *
>
> The fossil land vertebrates hitherto described from Montana probably are, in part at least, of mid-Cretaceous or Belly River age, although the true Judith River beds certainly overlie the Fort Pierre and are of more recent age.

Hatcher[d] commented on the paper last cited, correcting a statement concerning the locality of certain fossils, and giving reasons for believing that the stratigraphic position of the Judith River beds is lower than the horizon to which he assigned them in 1896. Stanton[e] replied to this note, asserting that the formation in question overlies the Pierre and Fox Hills, called attention to the Eagle formation, and again suggested that two or more horizons may have been confused in the Belly River beds of Canada.

---

[a] Proc. Am. Philos. Soc., vol. 41, pp. 210, 211. The section is partly described in an earlier note. (Science, n. s., vol. 15, 1902, pp. 31–32.)

[b] On Vertebrata of the mid-Cretaceous of the Northwest Territory: Cont. to Canadian Palæont., vol. 3, pt. 2, 1902.

[c] Science, n. s., vol. 16, 1902, pp. 673–676.

[d] Idem, pp. 831–832.

[e] Idem, pp. 1031–1032.

Prof. S. W. Williston[a] contributed to the discussion in a note on the Laramie of Converse County, Wyo., holding that these deposits as well as the Judith River are contemporary, in part at least, with the Fox Hills, and that the fauna presents in some respects "a startling resemblance to that of the Judith River and Belly River series."

Additional notes bearing on various phases of the discussion were published during 1903 by Osborn,[b] Hatcher,[c] C. H. Sternberg,[d] and O. P. Hay,[e] and ending with a brief note by Hatcher and Stanton[f] on "the stratigraphic position of the Judith River beds and their correlation with the Belly River beds," in which they give the principal results of the field work which is fully described in the present paper.

DESCRIPTION OF JUDITH RIVER BEDS, BY AREAS.

ORIGINAL AREA.

GENERAL FEATURES.

The history of the exploration of the region along Missouri River near the mouth of Judith River and of the description of its geologic and topographic features by Dr. F. V. Hayden has been briefly given in preceding pages. While some of Doctor Hayden's determinations and correlations have since been shown to be erroneous, as was to be expected from the pioneer nature of his work, the reader of his most extended sketch,[g] if familiar with the region, can not fail to be impressed with his ability as an observer and the fidelity and clearness with which he describes the chief geologic features of the country.

The following extracts from Doctor Hayden's paper are quoted here as bearing directly upon the stratigraphic limits and geographic distribution of the Judith River beds as originally understood and defined by that author:

> Near the mouth of the Judith River, not far from the sources of the Missouri, in latitude 47° 30′, longitude 109° 30′, is a wild, desolate, and rugged region which I have called the "Bad Lands of the Judith," in contradistinction to those of White River. No other portion of the upper Missouri country exhibits the effects of erosion and denudation on so large a scale, and to add to the picturesque effect of the country the variegated strata are distorted and folded in a wonderful manner by the action of the subterranean forces that have elevated the mountain masses in the vicinity. The surface of the country occupied by the deposit I am about to describe is cut up into ravines and canyons, with nearly vertical sides, rising to a height of 400 to 600 feet above the bed of the river, with scarcely a tree or shrub to greet the eye of the

---

[a] Science, n. s., vol. 16, 1902, pp. 952–953.
[b] Idem, vol. 17, pp. 356, 357.
[c] Idem, pp. 471, 472, and Am. Geologist, vol. 31, pp. 369–375.
[d] Science, n. s., vol. 17, pp. 870–872.
[e] Am. Geologist, vol. 32, pp. 115–120.
[f] Science, n. s., vol. 18, pp 211–212.
[g] Trans. Am. Philos. Soc., 1860, pp. 123–138, with a map.

explorer. A few scattering pines cap the summits of the hills and draw a scanty nourishment from a thin, dry soil, but it may be regarded for the most part as an inaccessible desert suited only as a retreat for the buffalo and mountain sheep.

The area occupied by this peculiar basin I could not determine with precision, but have estimated it at about 40 miles from east to west and from 15 to 30 from north to south, and it is separated into two nearly equal portions by the Missouri. The Judith River rises in the Judith Mountains, pursues a course nearly due north, for the most part through Cretaceous strata, and empties into the Missouri in latitude 48°, longitude 106°. The Judith River forms the north [western] boundary of this basin. The Muscleshell River also rises near the Judith Mountains, but takes a course a little east of north, flows through Cretaceous formation No. 4, and empties into the Missouri near latitude 47° 30′ and longitude 108°. That portion of the "Bad Lands" which is formed of the estuary deposit under consideration lies between these two streams. About 30 miles north of the entrance of the Judith River into the Missouri is the Bear's Paw Mountain, a small range, the highest peak of which is elevated about 2,000 feet. On the same side of the Missouri and in nearly a northeasterly direction are the Little Rocky Mountains, a range similar to the Bear's Paw, though apparently disconnected from it. On the south side of the Missouri, about 15 miles southwest of the mouth of the Judith, the Square Buttes may be seen rising 400 or 500 feet above the surrounding prairie, and are the nearest upheaval of trappean rocks to the Missouri in this region. From 30 to 50 miles south is quite an extensive range, called the Judith Mountains, which have not yet been explored geologically. Here comparatively small local upheavals seem to represent the dying out of the intense subterranean forces which uplifted the vast Rocky Mountain chain. It will be important to understand the geographical position of these mountains in order to fully appreciate the sources of the power which has disturbed the strata of the more recent fossiliferous rocks, a point which will be again referred to in this paper.

Lewis and Clarke, in their interesting account of an expedition to the sources of the Missouri, gave a brief but accurate description of the physical features of this remarkable region, but dwell more in detail on the picturesque portions near the "Stone Walls," which are composed of a basis strata upon which the estuary deposits of the "Bad Lands" of the Judith rest, which are doubtless of the age of Cretaceous formation No. 1, or upper Jurassic.

In the above description there are some errors relating to the geography, such as the statement that Musselshell River rises near the Judith Mountains; and the sandstones ("Stone Walls" of Lewis and Clarke) upon which, according to Hayden's statement, the estuary deposits of this region rest, were erroneously identified with Cretaceous No. 1, although they are now known to represent the Eagle formation and to be immediately underlain by the Benton and overlain by the Claggett formation. However, the stratigraphic limits of the Judith River beds are fixed with reasonable accuracy, while the geographic limits of the type exposure is very accurately outlined on the map accompanying his paper.

From Doctor Hayden's paper and the personal observations of the present authors the original area of the Judith River formation may be defined as lying between the mouths of Judith River on the west and Little Rocky Mountain Creek on the east and extending both north and south of Missouri River for an average distance of about 20

miles. Throughout almost this entire region typical and characteristic exposures of these beds are everywhere observable. They rest, with at least apparent conformity, upon the darker-colored marine sandstones and shales of the Claggett formation, and in certain favored localities are overlain by material resembling the typical Pierre shales, in this region known as the Bearpaw shales. As these shales are soft and friable they yield readily to erosion, and over large areas, especially in the vicinity of Missouri River, where erosion has been most rapid, they have been completely carried away and the Judith River beds appear as the uppermost of the series. This fact, together with the resemblance between the lithology and fauna of the underlying marine sandstones and those of the Fox Hills sandstones in the regions farther south, for years caused many geologists to mistake the true stratigraphic position of the Judith River beds, and to refer them unhesitatingly to the Laramie. In certain localities, however, the Bearpaw shales have resisted erosion and are seen in their normal position conformably above the harder and lighter-colored beds of the Judith River formation. This is especially true on Cow Creek, a small northern tributary of the Missouri rising in the eastern end of the Bearpaw Mountains. At many places along this stream the Bearpaw shales rest upon the Judith River beds, and along the old Fort Benton and Cow Island trail between Cow Creek and the southeastern extremity of the Bearpaw Mountains the Judith River beds are overlain by about 600 feet of these shales.

The Judith River beds of this region consist of light ash-colored sandstones, alternating with usually darker colored and more friable shales and clays mingled with frequent seams of lignite, which in places, more especially toward the top of the series, attain considerable importance, not infrequently forming beds of fairly pure lignite with a thickness of several feet. The most important and most constant of this series of lignite seams occurs very near the top of the Judith River beds and is frequently overlain by a shell breccia from 1 foot to 3 feet thick, and in most instances is composed almost entirely of the shells of *Ostrea subtrigonalis*, although at some places *Corbicula cytheriformis*, *Corbula subtrigonalis*, and other brackish-water forms are common.

The average thickness of the Judith River beds in this region is about 500 feet, if there is included in them the brackish (sometimes apparently purely marine) beds at the top and bottom of the series. These brackish beds are lithologically very similar to the intermediate fresh-water deposits, which are frequently rich in the remains of fresh-water Mollusca, and contain also in some abundance, but usually in a very fragmentary condition, the bones and teeth of fresh-water fishes and reptiles and of terrestrial dinosaurs. Everywhere through these beds

fossil plants are found in considerable abundance, but usually are not well preserved.

The frequency with which the different strata of sandstones and clays replace one another, both laterally and vertically, together with the great disturbances that have taken place subsequent to the deposition of the Judith River beds, renders it extremely difficult, if not impossible, to fix upon any definite horizons or strata within the limits of the fresh-water series that may be followed and recognized with certainty, even in reasonably adjacent sections. A detailed section taken at any point is of little value, since a similar section made at a distance of only a mile or two would give a quite different sequence of the alternating strata of sandstones and shales.

Almost every traveler has noted the complicated folding and faulting. Grinnell and Dana[a] attributed these disturbances to landslides due to the action of water, but Cope[b] pointed out the error of this view. No better description of the frequency of these disturbances, and the difficulties they have caused the stratigrapher, can be given than that of Doctor Hayden, which is as follows:[c]

> It presents perhaps the most rugged scenery on the Missouri River, the denudation and erosion having been much greater than at the Bad Lands of White River. But the most remarkable feature of this basin is the wonderful disturbance of the strata. So much are the beds disturbed and blended together by forces acting from beneath that it seems almost hopeless to obtain a section showing with perfect accuracy the order of superposition of the different strata.

EXPOSURES ON DOG CREEK.

Although the deposits under consideration were named from Judith River, they are rather poorly represented on that stream. They are well shown in the bluffs of Dog Creek, a small tributary emptying into the Missouri from the south, about 2 miles below the mouth of Judith River. The exposures on Dog Creek and on the north side of Missouri River immediately opposite the mouth of Dog Creek have been most frequently visited by geologists and paleontologists, and are therefore the best known of all the areas of the Judith River beds. Here, unfortunately, the beds are not of much value to the paleontologist, and are even more unsatisfactory to the stratigrapher, since the overlying Bearpaw shales are not adequately represented.

Dog Creek, or Dog River, as it is given on some maps, rises in the Moccasin Mountains, a small outlier of the Judith Mountains. After leaving these mountains it flows for perhaps 25 or 30 miles in a northerly direction through a narrow and shallow valley with rolling, grass-covered table-lands on either side. At intervals along the banks

---

[a] Geol. Rept. in Ludlows's Rept. on a Reconnoissance from Carroll, Mont., to Yellowstone National Park, 1876, pp. 97–137.

[b] Bull. U. S. Geol. and Geog. Surv. Terr., vol. 3, pp. 565–597.

[c] Proc. Acad. Nat. Sci. Philadelphia, 1857, pp. 115–116.

of the stream and its tributaries and on the slopes of the steeper hills exposures of the sandstones and shales of the Judith River beds may be seen. About 12 or 15 miles above its mouth the stream leaves this comparatively open country and enters a deep, rugged canyon. The surrounding country now suddenly changes from a rolling, grass-covered plain to a wild, desolate, but picturesque region, deeply dissected by numerous canyons, presenting mile after mile of almost perpendicular walls with jutting headlands capped with spires and minarets or flanked perhaps by numerous pillars detached from the perpendicular sides of the canyon wall, each threatening at any moment to add its towering mass to the talus-covered slope below. About the crest of the bluffs are considerable forests of pine and spruce which formerly afforded a sufficient supply of fuel for the river steamers that plied between Fort Benton and the lower Missouri. A few of these trees may also be seen clinging even to the perpendicular cliffs of the canyon walls, while on the less rugged slopes there is a sparse and scattered growth of small shrubs and bushes belonging for the most part to the genus *Artemisia*. In favored localities, especially at the summits of landslides, where disturbances in the beds have formed small basins which receive and retain the moisture brought by heavy rains, the chokecherry, *Prunus virginiana*, often forms considerable thickets. In the bottom of the canyons the banks of the streams are fringed with broad and long-leaved cottonwood, while scattered about and often forming impenetrable thickets are buffalo or bullberry bushes. Such are the badlands of the upper Missouri. The nature of the topography made this region the last retreat for the larger game animals of this district. The inaccessible nature of the region afforded these animals their greatest protection, and they lingered here long after they disappeared from the surrounding plains and mountains. This was especially true of the deer and bighorn or mountain sheep, both of which animals were still abundant when the region was first visited by one of the present writers in 1888. During our visit the past season, however, the mountain sheep seemed to have been nearly or quite exterminated, while only a few deer remained.

Dog Creek flows through this badland country in a deep and rugged canyon until it emerges upon the narrow valley of the Missouri, about a mile above its mouth. The walls of the canyon on either side are composed for the most part of the light ash-colored sandstones and darker shales and clays of the Judith River beds. This is especially the case in the upper portion of the canyon. In the lower half of the canyon the darker buff-colored sandstones and dark sandy or black clay shales of the underlying Claggett formation constitute a considerable portion of the bluffs. For considerable distances the Judith River beds are nearly or quite horizontal, and conformably overlie

the Claggett formation in such a manner that it is difficult to determine where one formation ends and the other begins, although in the field a bed of yellowish brown sandstone varying in thickness from 1 foot to 20 feet or more was regarded as the upper limit of the Claggett formation. This bed of sandstone appeared fairly constant, not only in this, but in other areas of the exposures, and it was referred to in our notes as the *Tancredia* sandstone, owing to the presence in it in considerable abundance of fossil shells belonging to that genus. From the persistence of this sandstone and from the fact that it marked the beginning of a decided change in the lithology of the underlying and overlying beds it would certainly form a convenient delimitation between the two series of deposits, and should perhaps be considered as the uppermost member of the Claggett formation, notwithstanding that in a number of instances typically marine fossils extended for some distance above in the basal members of those lighter-colored sandstones and shales usually referred to the Judith River beds and generally considered as entirely of fresh- or brackish-water origin.

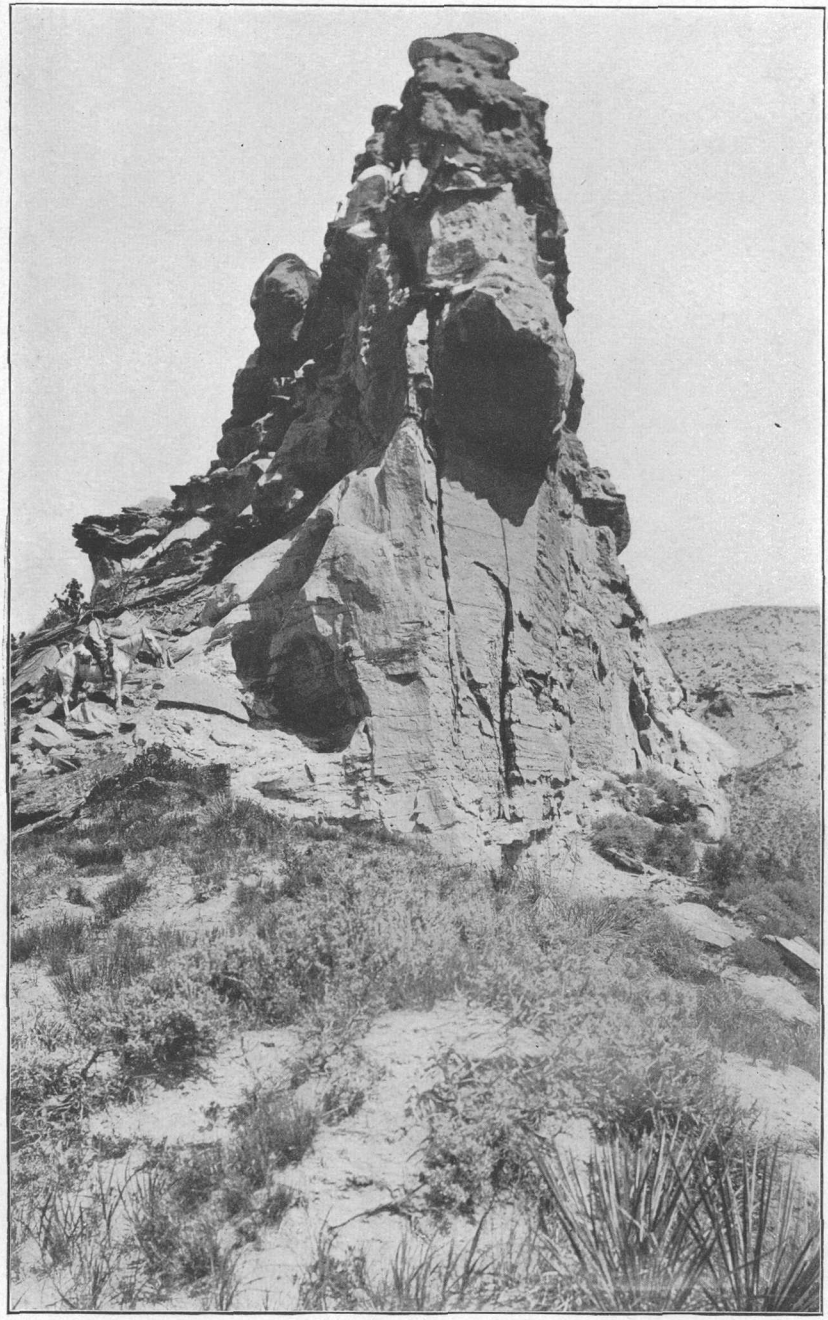
At frequent intervals along the canyon of Dog Creek the beds are much disturbed by faults and folds, and at several places not only the Claggett formation is exposed, but the underlying Eagle sandstones have been thrust up and appear as prominent cliffs. (See Pl. II.)

On the east side of Dog Creek 1 mile above its mouth the Eagle sandstones are seen near the bottom of the valley dipping westward at various angles. They continue to appear at frequent intervals for 2 miles farther up the creek, and at a distance of 1 mile above the mouth of the canyon on the west side of the creek they cap the higher bluffs. In this vicinity the Eagle formation is composed of an upper and a lower stratum of light-colored, heavy-bedded sandstone, separated by a series of lignites and shales, the latter near the bottom bearing *Baculites* and other marine invertebrates. Above the upper and below the lower strata of sandstones are arenaceous shales and thin-bedded sandstones and lignites. The upper of these bear *Cardium speciosum* and *Mactra alta* in great abundance. On the west side of the creek the crest of the divide between Dog Creek and Judith River is composed entirely of the Claggett and Eagle formations and the underlying Benton shales. The Benton shales are not well exposed in any section seen in this vicinity.

At the point where Dog Creek leaves the canyon and opens into the valley of the Missouri, a prominent cliff or butte of upper Eagle sandstones is seen on the east side of and not far from the creek. It is very fossiliferous, and from it the following invertebrates were secured:

Species found on Dog Creek.

Cardium speciosum.
Tellina montanaensis.
Baroda? sp.
Callista sp. cf. C. deweyi.
Mactra alta.
Mactra formosa.
Lunatia subcrassa.



CLIFF OF UPPER EAGLE SANDSTONE NEAR MOUTH OF DOG CREEK.

A little farther up and on the same side of the creek the following section was obtained:

Section on Dog Creek.

	Feet.
9. Lower Judith River beds with a heavy bed of brown sandstone at base resembling the *Tancredia* sandstone mentioned above, but apparently destitute of fossils. The overlying lighter-colored beds yield many fresh-water invertebrates	200
8. Black shales weathered in gentle slopes with numerous concretions containing *Baculites ovatus, Placenticeras, Inoceramus,* and other marine invertebrates. The whole referred to the Claggett formation. The sandstone bands of the upper half with *Tancredia,* etc., are not well exposed in this section	300
7. Cross-bedded, sometimes finely laminated, light-colored sandstones and fine conglomerates with harder layers and concretions weathering brown; and lenses containing *Cardium speciosum, Mactra alta,* etc., especially abundant toward the top. An additional 20 feet of soft sandstones and arenaceous shales forms the transition to the Claggett formation	100
6. Light, soft sandstone and shale	90
5. Arenaceous shale with 1 to 3 foot band of very impure lignite in middle	10
4. Yellowish sandstones consisting at base of 1 to 3 foot band of hard sandstones with ferruginous masses, overlain by 8 feet of finely laminated sands and thin lignite seams, passing above into 30-foot bed of yellow, massive, coarse sandstone with thin seams of lignite, overlain by 1 foot of lignitic sands, followed by 20 feet of soft buff sandstones	60
3. Soft sandstones and shales consisting at base of 10 to 15 feet of soft, usually light-colored sandstones, passing upward into more shaly material having at top a few feet of light sands. More shaly layer yielded *Placenticeras whitfieldi*	60
2. Sandstone with *Thetis? circularis, Leptosolen, Baroda, Pholadomya, Lunatia, Placenticeras, Baculites,* etc., regarded as base of Eagle	3–5
1. Benton shales with very hard grayish concretions. Lower 40 feet consists of rather soft shales, the upper 35 feet of more arenaceous and harder shales; no fossils	75

For a distance of between 5 and 8 miles from the mouth of Dog Creek the beds in the bluffs of the creek continue practically horizontal and undisturbed. The light ash-colored sandstones and shales of the Judith River beds are exposed to a thickness of from 300 to 400 feet and form the greater portion of the canyon's walls, but the upper members of the Claggett formation are still seen at the bases of the cliffs. While in this portion of the canyon the rocks appear undisturbed, not far to the east of the creek two prominent folds may be seen extending for several miles in a northwest-southeast direction, and along the crest of these the sandstones and shales of the Claggett formation appear flanked on either side by the Judith River beds.

A little farther up Dog Creek, in undisturbed areas, the Claggett formation disappears beneath the bed of the stream and the bluffs of the canyon are formed entirely of the Judith River beds, which have a maximum thickness here of perhaps 500 feet and are composed below of alternating layers of light ash-colored sandstones and darker shales

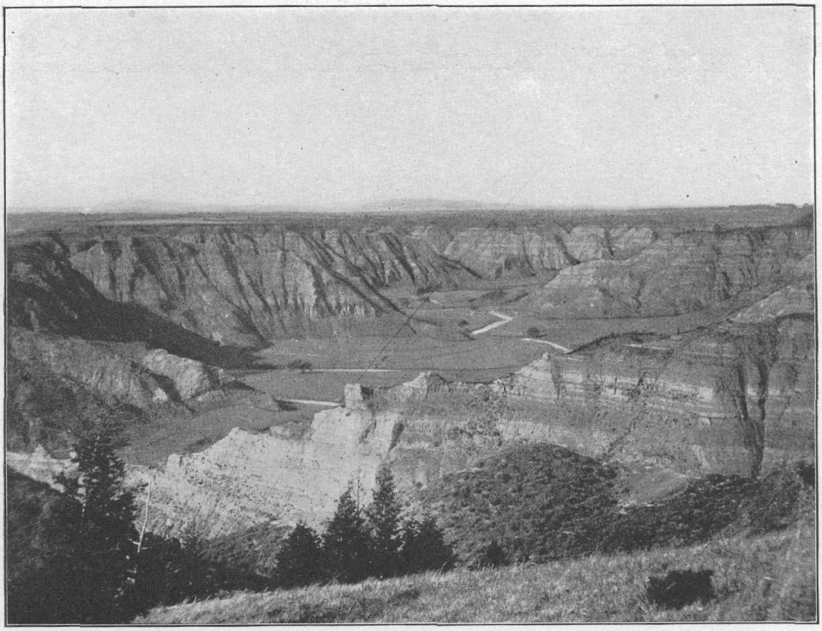
abounding in numerous fresh-water Mollusca. Such invertebrates as *Unio*, *Anodonta*, *Sphærium*, *Physa*, *Planorbis*, and *Goniobasis* are common, while the remains of *Trachodon*, *Ceratops*, *Monoclonius*, *Deinodon*, *Palæoscincus*, *Ischyrotherium*, *Trionyx*, *Emys*, *Crocodilus*, *Lepidotus*, *Myledaphus*, etc., represent the vertebrate life of the period.

Toward the top of the series the characteristic light-colored sandstones and shales of the Judith River beds give way to darker-colored lignites and shales, which are usually overlain by a stratum of shell breccia or marl ranging from a few inches to 3 feet in thickness, and composed for the most part of the shells of *Ostrea subtrigonalis*, indicative of brackish waters and a later return of marine conditions. These upper beds are well shown on Dog Creek where it leaves the grass-covered plain and enters the canyon, and also on its tributaries. In the plains country to the south the highest hills are capped with the *Ostrea subtrigonalis* layer of the upper Judith River beds. The upper part of the Judith River beds in this region has the same general appearance as on Cow Creek, about the foot of the Bearpaw Mountains, near Havre on Milk River, and on Sage Creek in Canada. It is well shown on an eastern tributary of Dog Creek, where, a few miles from its junction with the main stream, a heavy bed of lignite 5 to 10 feet thick is underlain and overlain by 10 to 15 feet of light, soft sandstone capped by the *Ostrea subtrigonalis* layer, which in some places contains shells of *Corbicula cytheriformis*, *Corbula subtrigonalis*, *Goniobasis convexa*, etc., in considerable abundance. In some exposures there is a thinner bed of lignite above or below the main lignite seam, with an *Ostrea* layer immediately capping it. About 3 miles east of Dog Creek and on the south side of the tributary mentioned above the uppermost *Ostrea* bed is overlain by about 30 feet of black shales with concretions, but no fossils were found in them. These shales resemble very closely the Bearpaw shales, and doubtless represent the base of that formation.

EXPOSURES ON BIRCH CREEK.

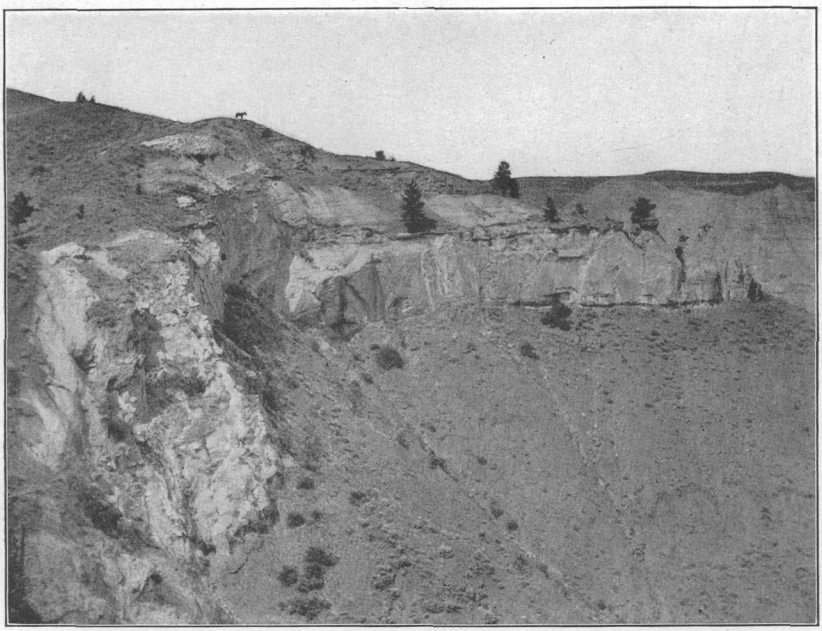
Birch Creek rises in the Bearpaw Mountains and flows south, emptying into Missouri River nearly opposite the mouth of Dog Creek and about 2 miles below the mouth of Judith River. A short distance below the point at which it leaves the mountains it enters a canyon, which, like Dog Creek Canyon, is deep and rugged and is cut in the Judith River and underlying formations. Above this canyon the hills on either side of the creek are formed of the Bearpaw shales.

The creek leaves the mountains by two branches, the east and west forks, known respectively as Birch Creek and Little Birch Creek. On the east side of Little Birch Creek, near the foot of the mountains and just below the Fort Benton–Cow Island road, the Judith River beds are brought to the surface by a prominent northeast-southwest anti-



A. BIRCH CREEK CANYON FROM TOP OF BLUFFS NEAR MOUTH.

Looking toward Bearpaw Mountains. Shows full thickness of Judith River beds and top of Claggett formation



B. BROKEN ANTICLINE OF EAGLE SANDSTONE ON NORTH SIDE OF MISSOURI RIVER 1 MILE BELOW MOUTH OF BIRCH CREEK.

Judith River beds form the more distant cliffs on right

cline and protrude from beneath the Bearpaw shales. On either side of this anticline the Judith River beds dip gently and soon pass beneath the Bearpaw shales.

A few miles west of Little Birch Creek, 1 mile above the bridge on the east fork of Eagle Creek, locally known as Dog Creek, a ridge of Judith River beds runs in a northeast-southwest direction and dips northwesterly, toward the mountains, at a high angle and soon passes beneath the Bearpaw shales.

Between the point where Birch Creek enters the canyon and Missouri River the adjacent country is deeply dissected. It is a typical badland region and presents all the features already described as prevailing in the badlands of Dog Creek on the opposite side of the Missouri (Pl. III, *A*). The beds composing the canyon walls have in some places been much faulted and folded, often in such a complicated manner as to render difficult the determination of the proper sequence of the strata.

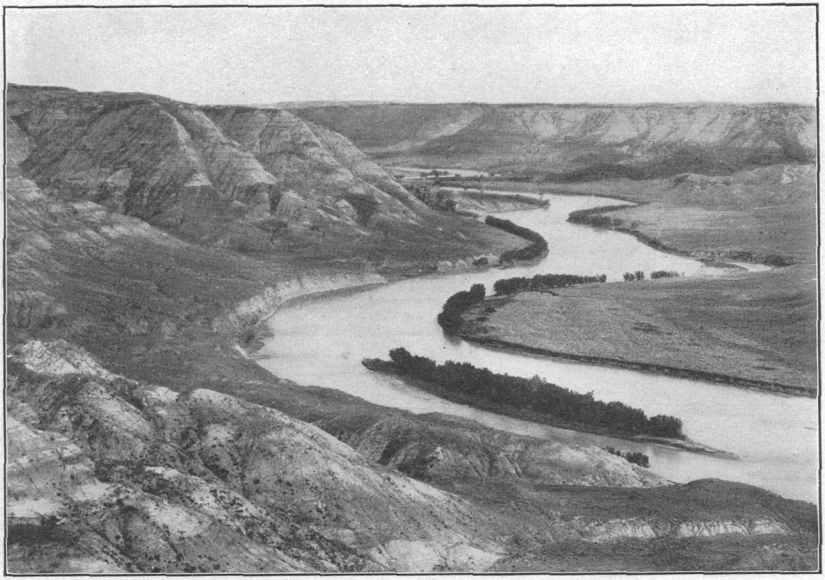
One mile above its mouth Birch Creek has cut its way through a prominent anticline which extends for several miles in a north of west by south of east direction, and brings to the surface the Eagle and Benton formations. About 1 mile below Birch Creek this anticline is faulted and in the bluffs of a small canyon opening into the Missouri about 300 feet of Benton shales appear beneath an escarpment of yellowish-brown Eagle sandstones which here forms a most conspicuous topographic feature (see Pl. III, *B*). At this locality the upper Eagle sandstone is in places very fossiliferous, and such forms as *Cardium speciosum*, *Thetis* (*?*) *circularis*, *Callista*, *Leptosolen*, *Baroda*, *Pholadomya*, and *Baculites* are very common. Above the Eagle sandstones are about 400 feet or more of shales and sandstones belonging to the Claggett formation. The lower 200 feet or more consist of dark shales weathering to soft clay on the slope and containing *Baculites ovatus*, *Placenticeras whitfieldi*, and *Gervillia borealis*. About 200 feet below the top of the formation is a band of brown sandstones and shales about 30 feet in thickness, with *Avicula nebrascana* (*?*), *Sphæriola endotrachys*, *Tancredia americana*, *Tellina equilateralis*, and *Lunatia subcrassa*. Above this bed are frequent bands of sandstone intercalated in the shales, and one of these, about 160 feet higher and therefore very near the upper limit of the formation, yielded practically the same fauna, as follows: *Cardium speciosum*, *Tancredia americana*, *Sphæriola* (*?*) *endotrachys*, *Mactra formosa*, *Liopistha* (*Cymella*) *undata*, *Lunatia subcrassa*, and *Baculites* sp.

The upper portion of the Claggett formation is well exposed on the east side of Birch Creek 1½ miles above its mouth, at the first bend in the creek, just above the point where a difficult and little-used trail descends from the east. At this point about 20 feet of dark, sandy, and rather compact shale at the base are overlain by 10 to 15 feet of

yellowish-brown sandstone with sharks' teeth, *Tancredia americana*, and other invertebrates in abundance. Then come 30 feet of arenaceous shales, followed by 5 feet of sandstone overlain by 40 feet of shale. Then 3 feet of sandstone is separated by about 40 feet of shale from the 5-foot stratum of *Tancredia* sandstone which has been taken as the upper limit of the Claggett formation. This exposure is well shown in Pl. IV, *B*, where the trees mark the limit between the Claggett formation and the overlying Judith River beds, which here have a thickness of 510 feet from the *Tancredia* sandstone at the base to the *Ostrea subtrigonalis* layer at the top. The overlying Bearpaw shales are not represented in this immediate region, having been entirely removed by erosion. It was from the sandstones near the base of the Judith River beds near the mouth of Birch Creek that Professor Cope in 1876 secured the type of *Monoclonius crassus*. From this point for a distance of 2 or 3 miles up Birch Creek the Judith River beds are quite undisturbed and present a continuous section from their base to the *Ostrea subtrigonalis* zone.

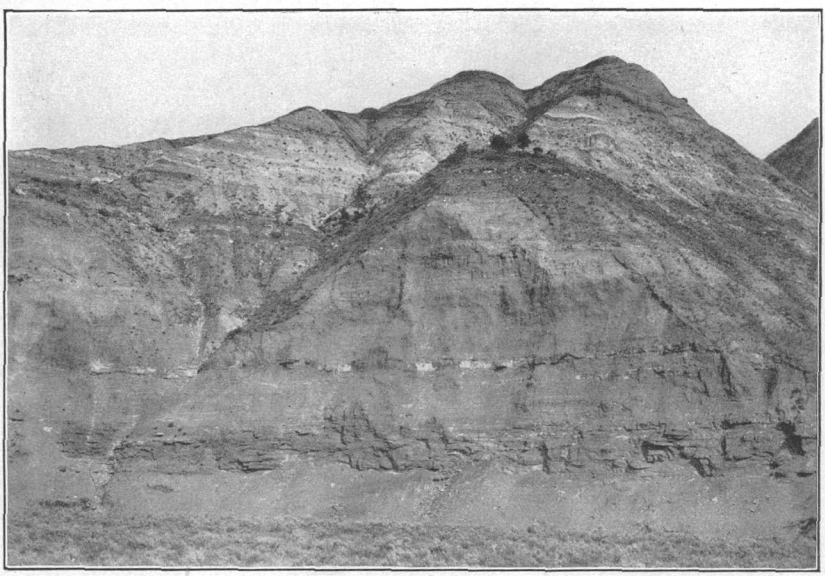
EXPOSURES ON MISSOURI RIVER BETWEEN BIRCH AND COW CREEKS.

On either side of Missouri River between Birch and Cow creeks the country is deeply dissected and presents the appearance of a wild badland region (see Pl. IV, *A*). As on the lower courses of Dog and Birch creeks, the rocks belong to the Judith River beds and the underlying Claggett formation, save at intervals where disturbances in the strata have brought to the surface the Eagle sandstones and underlying Benton shales. Everywhere in the vicinity of the river in this region the overlying Bearpaw shales have been removed by erosion. In places, however, not far from the river, especially on the south side near Cow Island, these shales overlie the Judith River beds, while they occur almost continuously along the old Benton and Cow Island trail along the southern foot of the Bearpaw Mountains between Birch and Cow creeks. From Bearpaw Springs, at the southeastern base of these mountains, this trail continues westward over the Bearpaw shales with only occasional exposures of the underlying Judith River beds at intervals in the bluffs of the coulees. At Black Coulee, about 6 or 8 miles west of Bearpaw Springs, the Judith River beds outcrop from beneath the Bearpaw shales only a half mile below the point where the road crosses the bed of the coulee, and 1½ miles farther down the coulee is a larger similar exposure. At the upper of these two exposures a section on the east side of the creek shows at the top a 1-foot bed of shell breccia with *Ostrea subtrigonalis*, *Corbicula*, *Corbula*, and *Anomia*, underlain by 20 feet of light sandy clays followed by 10 feet of lignite underlain by an ash-colored sandstone with thin seams of lignite to bed of creek. These beds have a northerly dip of about 15°



A MISSOURI RIVER BELOW MOUTH OF BIRCH CREEK.

Looking downstream.



B. CLAGGETT FORMATION AND OVERLYING JUDITH RIVER BEDS ON BIRCH CREEK.

The contact is marked by the small pine trees.

and are overlain by the Bearpaw shales with nodules containing *Baculites ovatus*, *Placenticeras whitfieldi*, and *Inoceramus*. At the next lower bend in the creek the beds are still inclined to the north, but in the succeeding exposure the crest of a low anticline appears, and below this the beds dip to the south and soon pass beneath the Bearpaw shales, which occupy a basin between this and the more important exposure of Judith River beds already spoken of as occurring farther down the creek. The upper exposures of these Judith River beds contain *Ostrea subtrigonalis*, *Anomia gryphorhynchus*, and *Corbicula cytheriformis*, and a bed a few feet lower yielded *Sphærium planum*, *Campeloma vetula*, *Goniobasis invenusta*, and other fresh-water forms.

Just to the left of the point where the Benton and Cow Island trail begins its descent into the valley of Sand Creek in going west toward Benton the upper Judith River beds dip northward at an angle of 30° and pass beneath the Bearpaw shales. A stratum of brown sandstone a few feet thick and about 100 feet below the top of the Judith River beds yielded *Sphærium planum*, *Sphærium recticardinale*, *Goniobasis sublævis*, and *Campeloma vetula(?)*. Farther down the creek better exposures of the Judith River beds are to be seen, and at several places along the Benton trail near the forks of Sand Creek the Judith River beds are overlain by the Bearpaw shales, while 2 or 3 miles still farther downstream extensive exposures of the Judith River beds are capped by the Bearpaw shales.

EXPOSURES ON COW CREEK.

Cow Creek flows in a deep, rugged canyon from a place a short distance below the point where it leaves the Bearpaw Mountains to its confluence with the Missouri. On the east side of Cow Creek and at its mouth there is a prominent exposure of Eagle sandstone (see Pl. V). At this point these sandstones have been uplifted and form a conspicuous ledge extending for several miles in a nearly north-south direction and dipping to the west at an angle of about 45°. These sandstones at this locality yielded the type of *Ornithomimus grandis* Marsh. Another nearly parallel and very similar exposure of the Eagle sandstones crosses 2 miles above the mouth of Bull Creek, a small tributary of the Missouri just below Cow Creek.

The bluffs on both sides of Cow Creek for several miles above its mouth are made up largely of rocks belonging to the Claggett formation overlain by the lighter-colored materials of the Judith River beds. The rocks here do not differ materially from those already described as belonging to the same formations on Dog and Birch creeks farther up Missouri River. At frequent intervals the beds are much faulted and disturbed and the underlying Eagle sandstones and Benton shales are exposed.

About 6 or 7 miles above its mouth Cow Creek is crossed by a dike

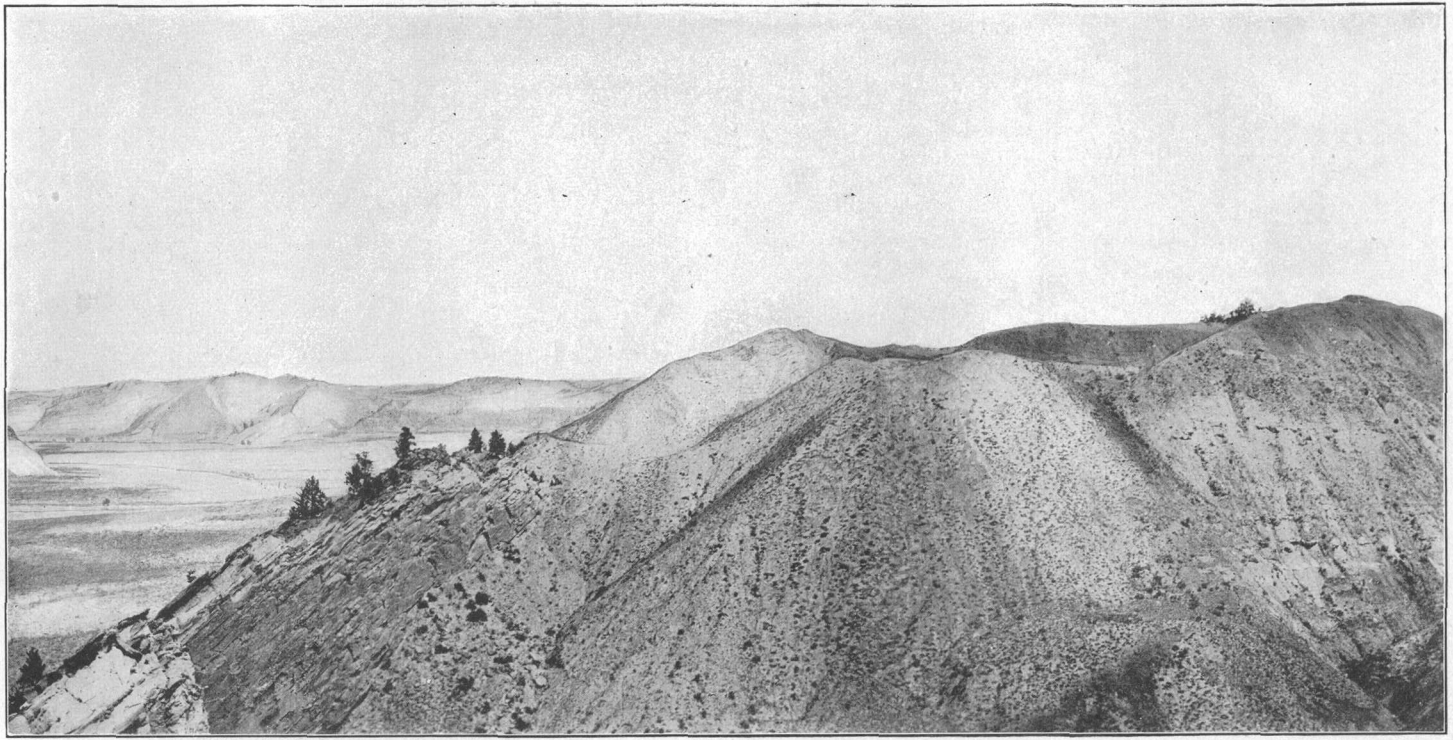
of igneous material, in places attaining a thickness of 10 feet. On the east side of Cow Creek about a mile below this dike is a section in which are exposed about 200 feet of Judith River beds overlain by the Bearpaw shales, and which is different from all other sections examined, as it contains a strictly marine horizon well within the limits of the Judith River beds. The section is as follows:

Section on east side of Cow Creek.

	Feet.
12. Dark shales of the Bearpaw formation	200
11. Similar ash-colored sands or arenaceous clays	25
10. Ash-colored sands with many *Ostrea subtrigonalis*	1
9. Lignite	4
8. Soft ash-colored sandstone	40
7. Lignite	1–4
6. Very soft buff sandstone	10
5. Ash-colored arenaceous clays with bands and nodules of brown sandstone and occasional nodules of clay-ironstone in lower portion	40
4. Yellowish, more or less lenticular sandstone with teeth of sharks and other fishes and bones of marine and fresh-water turtles	2–5
3. Soft, friable, ash-colored argillaceous sandstone, the upper 2 or 3 feet containing numerous vertebrate remains, including sharks' teeth, mosasaur bones, vertebræ of *Palæoscincus*, *Ischyrotherium*, and a horn core of *Ceratops montanus* (?)	30
2. Yellowish sandstone weathering into large nodular masses	10
1. Soft, friable, light-gray or ash-colored sandstones not well exposed. A band about 20 feet from the top yielded *Leda*, *Nucula*, *Tellina*, *Liopistha* (*Cymella*) *undata*, *Mactra warrenana* (?), *Lunatia*, and *Placenticeras* (?). These are mostly not specifically determinable, but they indicate a strictly marine fauna	30

The upper lignite and the *Ostrea* bed (Nos. 9 and 10) may unquestionably be assigned to the horizon that has been recognized throughout this region as belonging near the top of the Judith River formation, and all of the beds below No. 12 must be assigned to that formation on account of their stratigraphic position and general lithologic character. The land and fresh-water vertebrates found 100 feet below the *Ostrea* bed belong to the Judith River fauna, while the marine mosasaurs found with them and the marine invertebrates occurring 60 feet lower show plainly that locally the conditions under which the formation was deposited were different from those that generally prevailed. As these marine beds appear to pass horizontally into fresh-water deposits within a short distance, it is probable that they were laid down in a narrow bay or inlet which was not very far west of the ocean.

Farther up Cow Creek the Judith River beds form an increasing proportion of the walls of the canyon, and about 13 miles above its mouth the bluffs are composed of them exclusively, save at intervals where disturbances have brought the underlying marine deposits to the surface.



FAULT CONTACT OF HIGHLY INCLINED EAGLE SANDSTONE WITH HORIZONTAL JUDITH RIVER BEDS NEAR MOUTH OF COW CREEK.

About 10 miles above the mouth of Cow Creek, at the point where the old Fort Benton and Cow Island freight road leaves the creek and turns westward toward the Bearpaw Mountains, there is a conspicuous fault in the Judith River beds, which is shown on Pl. VI, *B*. North of the fault for some distance up the creek and almost uninterruptedly westward to the base of the Bearpaw Mountains the Bearpaw shales conformably overlie the Judith River beds. This is the locality mentioned by Hatcher[a], where, in 1888, he observed about 400 feet of what appeared to be Pierre shales overlying the Judith River beds.

Immediately south of the fault mentioned above, a prominent ridge composed of sediments belonging to the Judith River beds projects into the valley of the creek. The type of *Ceratops montanus* was obtained near the summit of this ridge, and the beds yielded also the remains of *Trachodon mirabilis*, turtles, crocodiles, and fishes of Judith River types and a considerable number of fresh-water invertebrates, including *Unio danae*, *Unio primævus*, *Sphærium planum*, *Sphærium recticardinale*, *Goniobasis invenusta*, *Goniobasis judithensis*, *Physa copei*, *Hyalina occidentalis*, and *Valvata montanaensis*.

Near our camp, at the point where a new trail enters the valley from the west, 2 or 3 miles above the point where the old Fort Benton and Cow Island trail leaves the valley, is an area that is extremely interesting and will therefore be described with some detail. On the summit of the bluff west of Cow Creek, just to the left of the Benton trail, a short distance above its junction with the new trail, is an important fault running N. 15° E. and bringing the Judith River beds up on a level with the Bearpaw shales. This fault strikes across the head of one of the tributaries of Cow Creek, and a mile or two below in the valley on either side of this tributary undisturbed Judith River beds underlie the Bearpaw shales in a nearly horizontal position. An aneroid measurement gave a thickness of 535 feet for the Bearpaw shales, assuming them to be horizontal. Just above our camp, on Cow Creek, a sharp anticline crosses the creek in a northwest-southeast direction. Save for this local disturbance the Judith River beds in the immediate vicinity of camp on both sides of the valley of Cow Creek are undisturbed and lie beneath the Bearpaw shales. The base of these shales is here composed of about 25 feet of light-colored shales and sands, 10 feet of rather dark shale at base, and 15 feet of ash-colored arenaceous shales above, with numerous large claystone concretions weathering yellow. The sands contain *Liopistha* (*Cymella*) *undata*, *Mactra warrenana*, *Lunatia subcrassa*, and *Placenticeras whitfieldi*. Above these come 535 feet of typical Pierre (Bearpaw) shales with their characteristic fossils. Below these marine beds, at the base of the hill directly in front of our camp, are exposed

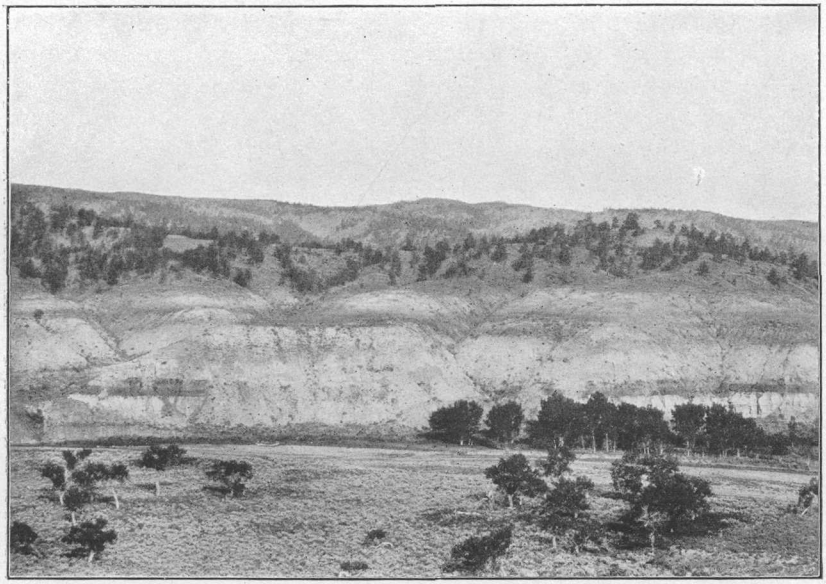
[a] Science, n. s., vol. 16, 1902, pp. 831–832.

75 feet of the upper Judith River beds, consisting of 25 feet of ash-colored sandstones with numerous very large, irregularly conical brown sandstone concretions, underlain by 10 feet of lignite, very impure at base, which in turn is underlain by 40 feet of light-colored sandstones. These beds contain remains of turtles and dinosaurs. At the point of junction between the Judith River beds and the overlying Bearpaw shales there is a 1-foot stratum of shell breccia composed of *Ostrea subtrigonalis* with *Goniobasis convexa* var. *impressa*, *Panopaea simulatrix*, *Corbula subtrigonalis*, *Anomia gryphorhynchus*, *Corbicula cytheriformis*, and *Corbicula occidentalis* (?). The same horizon at another locality in the neighborhood yielded *Viviparus conradi* associated with *Corbicula*, *Ostrea*, and *Anomia*.

One mile below camp on the east side of the creek there is an important uplift, bringing up the entire Judith River series and several hundred feet of the lower marine beds. The section to which the Bearpaw shales are added from exposures west of camp is as follows:

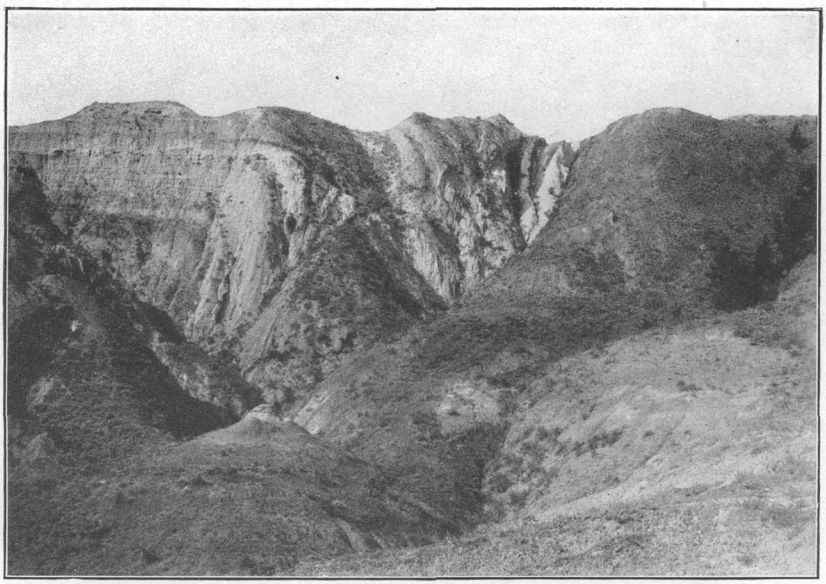
Section on east side of Cow Creek.

	Feet.	Feet.
5. Bearpaw shales, including the marine light-colored sands and shales at base, but not allowing for westerly dip, which, if continuous, as shown in front of exposure on west side of Cow Creek, would give a thickness of nearly, or quite, 700 feet		560
4. Judith River beds, the middle portion covered in bed of creek. One hundred and fifty feet of lower Judith River beds are continuously exposed in the upper section, and one-half mile east, where the Judith River beds are horizontal, a thickness of 490 feet was measured, but the base is not exposed at this point. A shale bed about 30 feet above the base of the formation yielded many leaves of *Trapa? microphylla*, together with abundant fresh-water Mollusca, including *Sphærium planum*, *Sphærium recticardinale*, *Physa copei(?)*, and *Goniobasis subtortuosa*. Another horizon about 300 feet from the top, in the exposure one-half mile east of the section, yielded *Sphærium planum*, *Anodonta propatoris*, *Unio danæ(?)*, *Unio primævus*, *Valvata montanaensis*, *Hyalina? evansi*, *Hyalina? occidentalis*, *Planorbis amplexus*, *Physa copei*, *Goniobasis subtortuosa*, and *Goniobasis gracilenta*		490
3. Claggett formation:		
c. Light-colored shales or sandy clays with band of brown sandstone containing *Tancredia americana* in middle. Top of marine	50	
b. Yellowish-brown sandstones, generally soft, but with harder layers and lenses, with *Tancredia americana*, *Cardium speciosum*, *Tellina equilateralis*, *Liopistha (Cymella) undata*, *Lunatia subcrassa*, *Baculites* sp., and fragment of vertebrate jaw	20	
a. Dark shales with concretions bearing *Baculites ovatus*, *B. compressus*, *Nucula cancellata*, *Leda.(Yoldia) evansi*, and *Gervillia borealis*. These shales weather much as the Bearpaw, but with a reddish tinge. The concretions are different and		

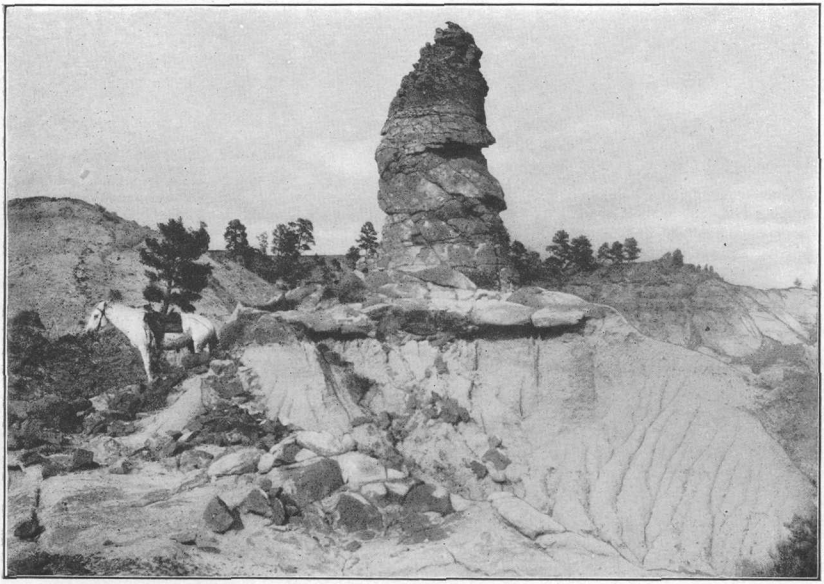


A. UNDISTURBED JUDITH RIVER BEDS WITH OVERLYING BEARPAW SHALES ON COW CREEK.

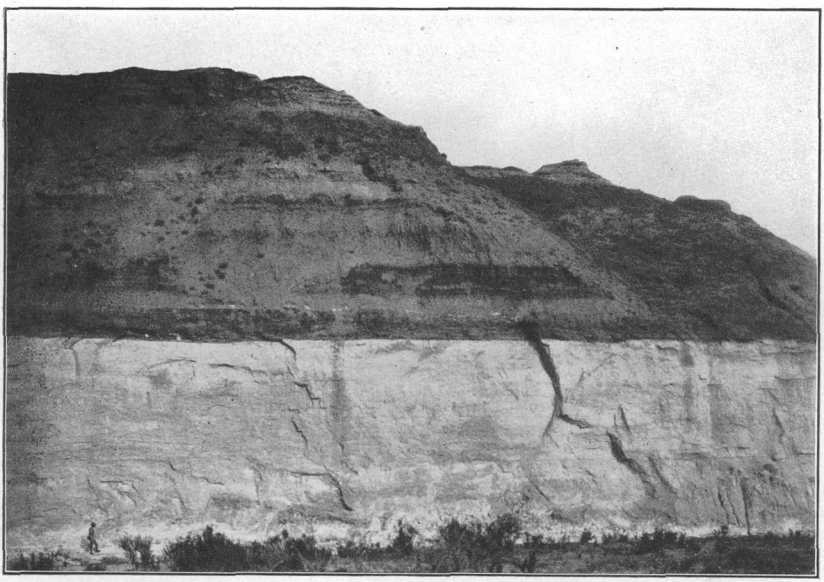
The contact is below the pine trees on ridge in middle distance.



B. FAULT CONTACT OF JUDITH RIVER BEDS WITH BEARPAW SHALES ON COW CREEK 10 MILES ABOVE MOUTH.



A. INDURATED OR CONCRETIONARY MASS IN UPPER PART OF JUDITH RIVER BEDS ON COW CREEK 13 MILES ABOVE MOUTH.



B. UPPER PART OF JUDITH RIVER BEDS WITH HEAVY BED OF LIGNITE ON COW CREEK.

Opposite to view on Pl. VI, *A*.

	Feet.	Feet.
3. Claggett formation—Continued. with fewer fossils and not so great a variety. These beds become lighter toward the top, the upper 50 feet containing two seams of thin brown sandstone, each 2 to 3 feet thick	300–400	
Total thickness of Claggett formation		370–470
2. Eagle formation. No fossils:		
e. Cross-bedded and finely laminated sands with thin seams of lignites, in places becoming more massive	125	
d. Very light-colored, fine, heavy-bedded sandstone	40	
c. Heavy-bedded buff sandstones, soft at base, but harder above, and with indurated lenses and numerous large concretions, weathering brown at top. The thickness of b and c is very variable	50	
b. Heavy-bedded buff sandstones with lenses of lignite and shales sometimes exhibiting cross-bedding	30	
a. Regularly-bedded buff sandstones with several thin seams of dark shales	20	
Total thickness of Eagle formation		265
1. Dark Benton shales with *Baculites* and other invertebrates in concretions, and containing several layers of sandstones in upper 100 feet. The following fossils were found in these shales near the base: *Inoceramus* sp., fragments of a thick-shelled form; *Prionotropis?* sp., fragment; *Scaphites ventricosus; Baculites* sp., a slender, strongly nodose form. Several genera of invertebrates not specifically determinable were collected in the upper portion		300

Above our camp for several miles the bluffs of Cow Creek show important exposures of the Judith River beds, everywhere overlain by the Bearpaw shales. These shales are everywhere more or less fossiliferous and near Hedge Brothers ranch, on upper Cow Creek, the following species were obtained:

Fossils obtained on upper Cow Creek.

Gervillia borealis.
Inoceramus barabini
Leda (Yoldia) evansi.
Lucina subundata.
Thetis? circularis.
Lunatia.
Anchura americana.
Cinulia.
Anisomyon centrale.
Anisomyon alveolus.
Baculites ovatus.
Baculites compressus.
Scaphites subglobosus.
Scaphites nodosus.
Placenticeras whitfieldi.

Pls. VI and VII show well the chief lithologic and stratigraphic features displayed by the various horizons in this region.

AREA NEAR HAVRE, MONT.

The most extensive exposures of the Judith River beds in this area are on the north side of Milk River from 1 to 4 miles above the town of Havre, a small station on the Great Northern Railway just north of

the Bearpaw Mountains. This is perhaps the most accessible of all the exposures of these beds. Here is a rather large and picturesque badland region composed entirely of the Judith River beds. On the north side of Milk River about one-half mile above Havre the road crosses a deep gulch by a small bridge. At the point where this gulch emerges from the bluffs into the river valley, about 80 yards above the bridge, there is on its right side a cut bank, some 20 feet in height, showing two seams of impure lignite. The lower and thicker of these is about 6 feet above the bed of the gulch; the upper is thinner and less pure and is about 10 feet higher than the lower. These two lignites are overlain by the Bearpaw shales, though these shales are probably not in position and are somewhat more arenaceous than usual. In them were found in place two limestone concretions, one of which contained shells of *Ostrea patina* and the other *Inoceramus sagensis*. Immediately beneath, in the wash at the bottom of the gulch, but evidently derived from the shales, was found a similar limestone concretion containing *Placenticeras whitfieldi*.

Up the river these lignite seams outcrop at frequent intervals in the bluffs. They rapidly assume a more elevated position and show at this point a decided easterly dip, amounting to perhaps 4° or 5°.

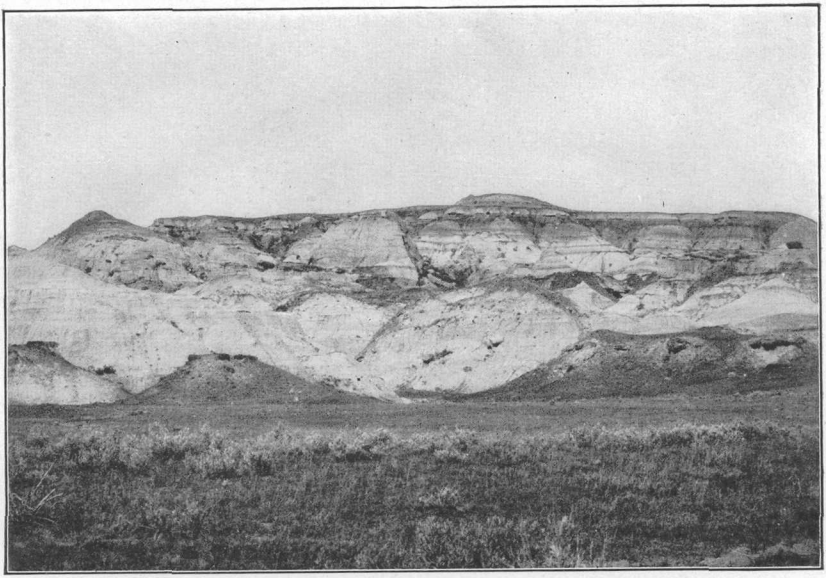
About 100 yards west of the exposure just described a prospecting tunnel has been driven into the lower and more important lignite seam, and between it and the overlying seam is a light horizontally cleaving sandstone.

Three hundred or 400 yards farther west these lignites are no longer visible, having perhaps passed above the present upper limits of the bluffs and been carried away by erosion.

A half mile farther up the river the bluffs on the north side present a picturesque badland area, consisting at the base of 150 to 200 feet of usually light-colored sandstones and clays, with brown sandstone concretions and occasionally thin seams of lignite. (See Pl. VIII, *A*.) In these beds at several horizons were found in considerable abundance dinosaur bones, crocodiles, garpike scales, turtles, and other vertebrates with fresh-water Mollusca, including *Unio danæ*, *Unio supenawensis*, *Anodonta propatoris*, *Sphærium planum*, *Physa copei*, *Goniobasis subtortuosa*, *Goniobasis invenusta*, *Goniobasis judithensis*, etc. The assemblage of fossils as well as the lithologic features of these beds are those of the Judith River beds.

Above these light-colored, fresh-water deposits are two lignite seams which are very similar to those occurring at the locality where the marine fossils were found and bear the same relation to each other. This badland exposure continues for 3 or 4 miles farther up Milk River and the beds in every way resemble the Judith River beds at the type locality.

On the south side of Milk River for 3 miles west of Havre, or to a



A. BADLANDS EXPOSURES OF JUDITH RIVER BEDS ON NORTH SIDE OF MILK RIVER NEAR HAVRE, MONT.

B. UPPER PART OF JUDITH RIVER BEDS AND OVERLYING BEARPAW SHALES ON SOUTH SIDE OF MILK RIVER 3 MILES WEST OF HAVRE, MONT.

point about 1 mile above the mouth of Beaver Creek, are frequent exposures of the Judith River beds, overlain by the Bearpaw shales. The strata in these exposures have suffered much disturbance and are inclined at varying angles, in two or three places being nearly vertical. The exposures are not sufficient to reveal the structure completely, but in general the beds seem to have been folded sharply and faulted to some extent. Wherever the top of the Judith River formation is exposed it is overlain by the Bearpaw shales, with their characteristic fossils. This is especially noticeable in the bluff just below the mouth of Beaver Creek. Here the beds are inclined at a very high angle, perhaps 60°, with a southwesterly dip. At the bottom they are composed of about 200 feet of light-colored sandstones and arenaceous shales resembling the upper Belly River beds, as described by Dawson. These light sandy materials are succeeded by a series of light-colored clays and shales with 8 or 10 seams of lignite, which become thicker and purer toward the top and are overlain by a bed of *Ostrea subtrigonalis*, about 2 feet in thickness. This upper series of light-colored shales, lignites, and oysters has a thickness of about 60 or 75 feet and appears to represent the extreme top of the Judith River formation. It is overlain by dark marine Bearpaw shales, best seen at the foot of the exposure facing Beaver Creek and on the south side of the railroad track, and containing *Inoceramus*, *Avicula linguiformis*, *Modiola meekii*, and *Baculites compressus*.

Below the mouth of Beaver Creek a high ridge that faces Milk River continues a mile or more toward Havre. The upper part of the exposure is composed of the light-colored sands and shales of the Judith River beds. For perhaps half a mile there is exposed a lower thick stratum of heavy-bedded brown sandstone, which outcrops just above the railroad tracks and contains numerous spherical and irregular concretionary masses. This brown sandstone has an observed maximum thickness of about 30 feet. No fossils were found in it, but near its eastern extremity it is immediately overlain by some brown cherts with the shells of *Corbula subtrigonalis* in great abundance. This sandstone may be the top of the Claggett formation.

Above Beaver Creek, in the narrow ridge between this creek and Milk River, the sequence and relative positions of the fresh-water Judith River formation and overlying Bearpaw shales are well shown. (See Pl. VIII, *B*.) In the valley of Milk River a short distance above the mouth of the creek there is a small uplift with the axis running in a northwest-southeast direction. Above this for a distance of 300 or 400 yards, in the bluffs facing Milk River, there is a shallow syncline, the trough of which at its deepest portion is filled with Bearpaw shales containing *Ostrea patina*, *Liopistha* (*Cymella*) *undata*, *Baculites compressus*, and *Placenticeras whitfieldi*. In the uplift just mentioned and in the eastern and central portion of the syncline only the upper por-

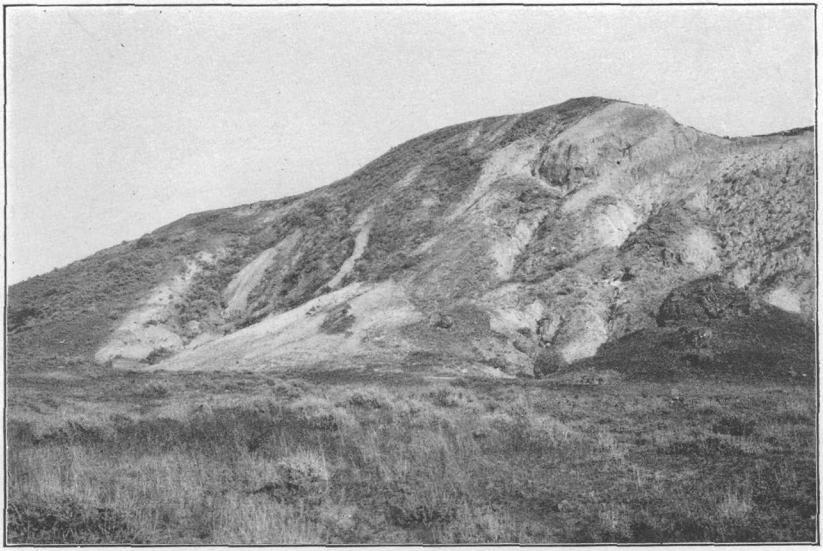
tion of the Judith River beds as seen below the mouth of the creek is shown. The lignites and overlying oyster bed, which here contains *Ostrea subtrigonalis*, *Corbicula cytheriformis*, *Anomia gryphorhynchus*, and *Goniobasis convexa*, are especially prominent. On the western limb of the syncline the lower and more arenaceous members appear. Here the entire series is inclined at a higher angle and is clearly seen to pass beneath the Bearpaw shales.

Owing to the disturbances in the beds about Havre, it is not easy to determine in a perfectly satisfactory manner the sequence of the different horizons. This is especially true of the above-described exposures in the bluffs above the town, where, unless one is familiar with the character of the different formations and has determined their true sequence in less disturbed regions, the confusion is indeed perplexing. The most satisfactory locality for studying the Judith River beds in the vicinity of Havre is on the south side of Milk River about 6 miles below Havre, on Boxelder Creek, about 2 miles south of Toledo, a small station of the Great Northern Railway. Here the tops of the high hills are capped with 25 to 50 feet of Bearpaw shales conformably overlying the Judith River beds. Considerable disturbance is noticeable in the bluffs of the creek at this point, but in the hills 1 mile to the north the sequence of the strata is quite evident.

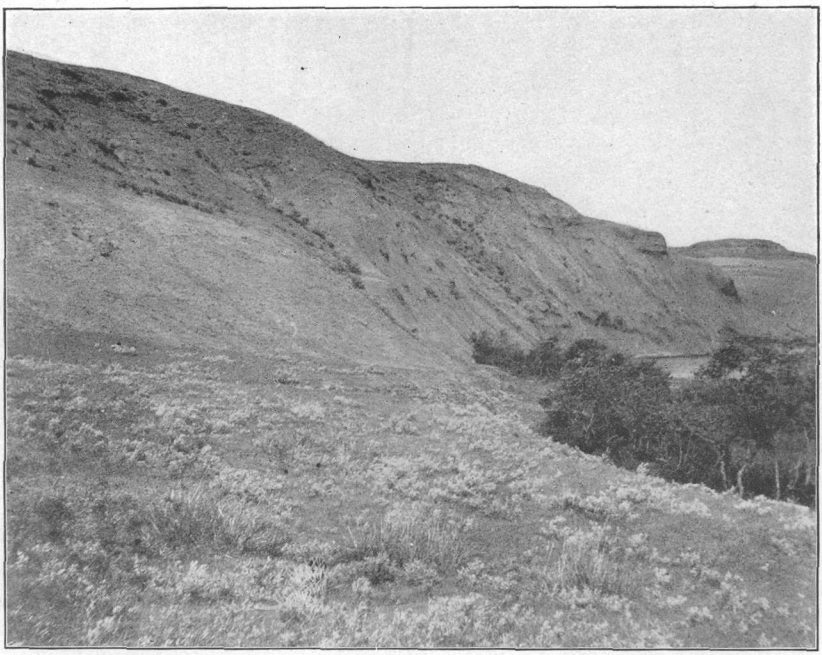
At the Black Diamond Coal Company's mines, 9 to 11 miles southeast of Havre, in a draw on the west side of Boxelder Creek, there is, in the uppermost Judith River beds, a coal vein 6 to 7 feet thick. It has a gentle southerly dip and is overlain by 20 feet of Judith River deposits and 160 feet of Bearpaw shales, from which were collected *Inoceramus sagensis*, *Placenticeras whitfieldi*, *Placenticeras intercalare*, and *Baculites ovatus*. From this point a range of hills, composed at the base of Judith River beds and capped with the Bearpaw shales, extends in a northwesterly direction to near the mouth of Boxelder Creek. The Bearpaw shales here, as elsewhere, in weathered exposures show loose black shales with limestone concretions. Some of the concretions are 12 to 15 feet in diameter and very symmetrical.

EXPOSURES ON MILK RIVER FROM HAVRE TO THE INTERNATIONAL BOUNDARY.

Above Havre the Judith River beds are exposed almost continuously in the bluffs on either side of Milk River to and beyond the international boundary. There are also occasional exposures of the underlying Claggett formation and less frequently of the overlying Bearpaw shales. Although the region is a plains country, the strata have been much disturbed and are faulted and folded in a remarkable manner. In many narrow belts the disturbances are as great as those usually encountered in an intensely mountainous country, though in the larger areas between the disturbed zones the beds



A. UPTURNED JUDITH RIVER BEDS AND BASE OF BEARPAW SHALES ON MEILI COULEE NEAR HAVRE, MONT.



B. CLAGGETT SHALES AND BASE OF JUDITH RIVER BEDS ON MILK RIVER ONE-HALF MILE BELOW PENDANT D'OREILLE, ASSINIBOIA.

are practically horizontal. Since the uplifts occurred the country has been planed off by erosion and covered with thin Pleistocene deposits, so that it is only along the modern drainage courses that there is any evidence of such disturbances, and it is not always easy to determine definitely the exact relations of the various strata.

About 5 miles above Havre a small tributary known as Meili Coulee enters the Milk River Valley from the north, about half a mile above a conspicuous red butte, the color of which is due to burned-out lignite seams. At the mouth of Meili Coulee are prominent exposures of the Judith River beds dipping northward at a high angle and overlain by the Bearpaw shales. (See Pl. IX, *A*.) For half a mile before entering the valley of Milk River the bluffs on the east side of this coulee show the following section:

Section on east side of Meili Coulee.

	Feet.
4. Bearpaw shales with *Baculites ovatus* and *Placenticeras whitfieldi*, etc	50
3. Shales underlain and overlain by shell breccia composed largely of *Ostrea subtrigonalis*, forming the top of the Judith River beds	20
2. Lignites, shales, and sandstones	40
1. Light-colored sandstones and shales of the Judith River beds with their characteristic fossils	250

The beds up to this point are inclined at a high angle and dip to the north, and the sequence and relations of the strata are quite evident, but above this point the beds have a different character and are much more nearly horizontal, although they are still gently inclined to the north. At this point in the section the beds have been faulted and the sandstones and shales of the Claggett formation abut against the Bearpaw shales, having been elevated far above their normal position relative to these shales.

Farther up the draw from this point the following section is seen in the bluffs on the east side:

Section on east side of Meili Coulee.

	Feet.	Feet.
2. Judith River beds		
f. Light-colored sandstones and shale with lignite and stratum of shell breccia at the top	100	
e. Sandstones, shales, and thin seams of lignite	130	
d. Shell breccia	3	
c. Shales and lignite	20	
b. *Ostrea subtrigonalis* bed	2	
a. Lignite and shales	20	
		275
1. Sandstones and shales of the Claggett formation with marine invertebrates		160

A little way above its mouth Meili Coulee is crossed by the fault mentioned above. This fault bears N. 60° W. by S. 30° E., and above it the sandstones and shales of the Claggett formation dip gently to the north until, at a distance of perhaps half a mile farther up the coulee, they pass beneath the Judith River beds. In a yellow sandstone layer

near the top of the Claggett formation were collected *Tancredia americana*, *Mactra formosa*, and a few other invertebrates.

Just north of the red butte situated below the mouth of Meili Coulee is a rather extensive exposure of Judith River beds with numerous sandstone lenses and concretions exhibiting cross-bedding and other evidences of strong currents. From these we secured remains of *Trachodon mirabilis*, *Palæoscincus costatus*, and the mammal jaw shown in fig. 1 (p. 100).

In various small draws or coulees between Meili Coulee and Supenaw Coulee, 6 miles farther up the river, conditions similar to those prevailing in Meili Coulee were observed. The fault that crosses Meili Coulee near its mouth is continuous and crosses each of these coulees with about the same trend of N. 60° W. by S. 30° E. This fault crosses Supenaw Coulee about a mile above its mouth and just above Thackeray Brothers' reservoir. Above the fault the sandstones and shales of the Claggett formation dip gently to the north and soon pass beneath the Judith River beds, which here attain their normal development, and at a distance of about 3 miles, or near the head of the west fork of the Coulee, the lignite series at the top of these beds appears in much the same manner as in the other regions described. In Supenaw Coulee the lignite beds are partly burned out and the adjoining clays and sandstones are baked red. They were still burning when visited. Interstratified with these lignites are beds of fresh-water Mollusca, *Campeloma vetula*, and *Unios*, associated with *Corbula perundata*, and three strata of *Ostrea subtrigonalis*.

At the head of Browns Coulee, about 12 miles farther up the river, the Judith River beds are well developed, and on this coulee, about 2 miles above its mouth, is an area of much disturbance, in which a brown sandstone of the lower Judith River beds appears in a steep anticline. There are here two sandstones separated by 30 feet of shales. In the upper of these we obtained shells of *Hyalina occidentalis* and *H. evansi*, dinosaur bones, and fragments of a very large turtle. About 100 yards below this anticline there is a second and larger fold affecting the Claggett formation, which on the north side passes beneath the Judith River beds. The northern limb of this anticline dips at an angle of 45°, while the southern is nearly or quite perpendicular, the sandstones and shales having the appearance of a vertical dike with its southern border resting against the lower brown sandstones of the Judith River beds, which are here only moderately inclined. There is thus unmistakable evidence of a fault as well as a fold at this point.

From Browns Coulee the bluffs of Milk River exhibit frequent evidences of disturbances as far as Simpson's ranch, about 9 miles nearly due south of Wild Horse Lake, which is on the international boundary. About 1½ miles below Simpson's ranch the Judith River beds are well exposed, and we secured remains of *Ceratops*, *Aublysodon*, and *Acipen-*

ser, with *Unio* sp., *Sphærium planum*, *Goniobasis invenusta*, *Goniobasis judithensis*, *Physa copei*, and *Viviparus*.

Above Simpson's ranch, to and beyond the international boundary, disturbances in the beds are less frequent, and the bluffs of the river, which have an average height of about 200 feet, are composed almost entirely of the light-colored sandstones and shales of the Judith River beds.

At Black Butte, a low prominence on the north side of Milk River about 7 miles west of south of Wild Horse Lake, the river valley has a width of scarcely more than a mile and a depth of perhaps 250 feet. The butte stands on the crest of the bluff and, on account of the levelness of the surrounding country, is visible from a considerable distance and forms a rather conspicuous landmark, notwithstanding its low altitude. At the top of this butte are 75 feet of glacial material, beneath which there are about 175 feet of the Judith River beds. At about the middle of the exposure are several feet of shell-marl and in this we secured numerous teeth of *Trachodon*, *Lælaps*, and other dinosaurs, lizards, fishes, etc., together with *Unio priscus* (?), *Unio primævus*, *Sphærium planum*, *S. recticardinale*, *Goniobasis sublævis*, and *G. subtortuosa*.

There are also local developments of cross-bedded brown sandstones with numerous concretions, and these afforded a few vertebræ, teeth, and other remains of *Trachodon*, *Ceratops*, and *Lælaps*.

No lignites were seen here. The upper lignites, so characteristic of the Judith River beds, are wanting in this section and have doubtless been eroded away. They were last seen on the summit of the highest hills about the head of Cottonwood Coulee, 18 miles from Wild Horse Lake, on the road from Havre.

EXPOSURES ON MILK RIVER NORTH OF THE INTERNATIONAL BOUNDARY.

For some distance beyond the international boundary Milk River flows through a narrow and picturesque valley, about 200 feet in depth, carved out of the Judith River beds. A few miles below Pendant d'Oreille, a northwest mounted police station on Milk River about a mile below the mouth of Pakowki Coulee, the uppermost members of the "lower dark shales," as described and mapped by the late Dr. George M. Dawson, appear above the level of the river and occupy successively more elevated positions in the bluffs until, at a distance of about 1 mile above the police station, these shales and sandstones, constituting the Claggett formation, form almost the entire bluffs of the river, the overlying Judith River beds having here been almost entirely removed by erosion. In a bluff on the north side, and at the first bend of the river below Pendant d'Oreille, about 160 feet of beds are exposed (Pl. IX, *B*). The lower 100 feet of this exposure are composed of

the Claggett formation, the "lower dark shales" of Dawson, while the upper 60 feet belong to the Judith River beds, "Belly River series" of Dawson. The section is as follows:

Section on Milk River near Pendant d'Oreille.

	Feet.
8. Light sandstones and soil	10
7. Light sandstones with *Unio* at top	5
6. Light sandstones with shells of *Corbula* at top	19
5. *Ostrea subtrigonalis* breccia	4
4. Light-yellow sandy material	10
3. Impure lignite and shell breccia with *Corbula subtrigonalis, C. perundata, Corbicula cytheriformis, Unio priscus* (?), and *Neritina*	4
2. Light-colored arenaceous shales	20
1. Dark shales belonging to the Claggett formation with limestone concretions and bands of sandstone containing *Nucula, Leda,* and *Liopistha* (*Cymella*) *undata*	100

Nos. 2 to 8 belong to the base of the Judith River beds.

The bluffs of Milk River at the mouth of Pakowki Coulee, immediately above the police camp, are formed almost entirely of marine deposits, consisting, at the base, of dark shales with bands and nodules of limestone and at the top of light-yellow soft sands and arenaceous shales with harder layers of blue sandstones, weathering brown. The latter yielded *Baculites asper* (?), *Lunatia subcrassa*, *Tancredia americana*, *Cardium speciosum*, *Tellina* (?) sp., and *Mactra*. On the highest points these beds are capped by about 3 feet of impure lignite overlain by light sandy shales with a few *Unios* and turtle fragments. In the marine sandstones underlying these lignites, along with the invertebrates just mentioned, were found several species of sharks' teeth.

Two and a half miles below the police station, in the bluff on the north side of the river, is a bed of well-preserved shells, about 2 feet thick, immediately overlying the 4-foot lignite seam seen in the bluff just below the police station. In this shell bed we collected *Unio subspatulatus*, *Unio supragibbosus* (?), *Modiola*, *Corbicula occidentalis*, *Corbicula cytheriformis* (?), *Corbula subtrigonalis*, *Corbula perundata*, *Rhytophorus glaber*, and *Goniobasis invenusta*, all in a good state of preservation. This shell bed is overlain by about 10 feet of arenaceous shale, which is light at the base and dark above, and is followed by a 3-foot vein of lignite.

In a canyon tributary to Milk River about 8 miles below Pendant d'Oreille the following section is shown:

Section in canyon tributary to Milk River 8 miles below Pendant d'Oreille.

	Feet.	Feet.
2. Judith River beds:		
d. Light-colored sandstones and shales with a variable upper member of yellow, cross-bedded, concretionary sandstone which shows a maximum thickness of 100 feet in the upper course of the canyon	300	

	Feet.	Feet.
2. Judith River beds—Continued.		
c. Sandstones, lignites, and shales with several layers of *Ostrea subtrigonalis* and some fresh-water shells. The principal lignite bed, 6 to 8 feet in thickness, is at the base	50	
b. Light-colored sandstones, becoming yellow toward the top	50	
a. Buff arenaceous shales with remains of turtles and fragments of dinosaur bones	25	
		425
1. Marine beds belonging to the Claggett formation, consisting of dark shales with bands and lenticular layers of brown sandstone, containing *Tancredia americana*, *Tellina* (?) sp., and *Vanikoropsis tuomeyana*, with an admixture of such brackish-water forms as *Ostrea glabra*, *Corbula subtrigonalis*, and *Melania ? whiteavesi*, about		100

From Pendant d'Oreille to Hooper's ranch, on Many Berries Creek, about 5 miles northwest of Pakowki (Badwater) Lake, the Judith River beds are exposed at frequent intervals in the slopes of the hills a few miles east of the trail. They also appear in the bluffs of the creek both above and below the ranch. Some miles northeast and east of Hooper's ranch there is a high ridge forming the divide between Sage Creek and Many Berries Creek (Big Timber Creek of some maps). Along the western slope of this ridge the Judith River beds are extensively exposed and are overlain by the Bearpaw shales.

SAGE CREEK AREA, ASSINIBOIA.

On Sage Creek, a small stream from the overflow of which Wild Horse Lake has its origin, there are important exposures of the Judith River beds, which have been described and mapped by Mr. R. G. McConnell. These occur north of the lake on the west side of the road, about 8 miles north of the international boundary, and also about 2 miles below Carroll's ranch, on Sage Creek. At the place last named some excellent exposures of the Judith River beds in the bluffs of a western tributary of the creek yielded *Sphærium planum*, *Goniobasis sublævis*, *Viviparus*, and plant fragments, including a cone. The lignite-bearing strata at the top of the Judith River beds are not represented here, but just above Carroll's house, on the west side of the creek, they appear, and they are frequently exposed for several miles in the bluffs of Sage Creek and its tributaries with characteristic vertebrate and invertebrate fossils. About 5 miles above Carroll's ranch and a mile or two above the mouth of the West Fork, Sage Creek flows through a deep, narrow gorge, the hills being much higher on the west side than on the east, and somewhat higher than the plain to the southeast. In the upper part of this bluff are about 50 feet of Bearpaw shales with *Baculites ovatus*, *Placenticeras whitfieldi*, *Callista deweyi*, *Cyprina ovata*, and *Ostrea patina*. Underlying these shales are about 150 feet of the upper Judith River beds, with the lignites at

the top and light ash-colored and brown sandstones at the bottom (see Pl. X, *B*). In a brown sandstone about 10 feet above the creek are *Unios* and other fresh-water invertebrates, and 75 feet above the creek, near the base of 15 feet of light ash-colored sandstones overlying a bed of impure lignite, we found a considerable portion of a *Trachodon* skeleton. (See Pl. X, *A*.)

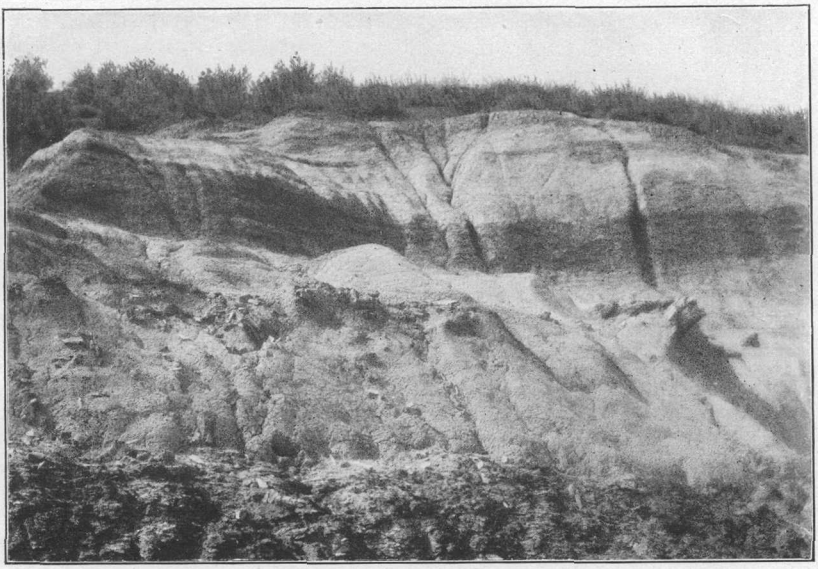
The following is a section from the bed of the creek to the top of the hill as displayed at this place:

Section on Sage Creek, Assiniboia.

	Feet.
4. Bearpaw shales with characteristic fossils, *Ostrea patina*, *Placenticeras whitfieldi*, and *Baculites ovatus*, etc	50
3. Finely banded shales with 4 feet of impure lignite at base and several feet of same at top. Occasional thin seams of lignite in main body of shales	50
2. Light ash-colored sandstones with *Trachodon* skeleton at base	15
1. Sandstones and shales with lignites, the latter especially well developed toward the top. Ten feet from the base is a heavy bed of hard sandstone, weathering brown, with *Unio danæ*, *Anodonta propatoris*, *Sphærium*, *Physa*, and *Hyalina occidentalis*. In the middle there is an exposure of about 10 feet of light ash-colored sandstones with ferruginous nodules and lenses of brown sandstones. The nodules have numerous fragmentary plant remains. This is overlain by 15 feet of arenaceous shales and lignites	75

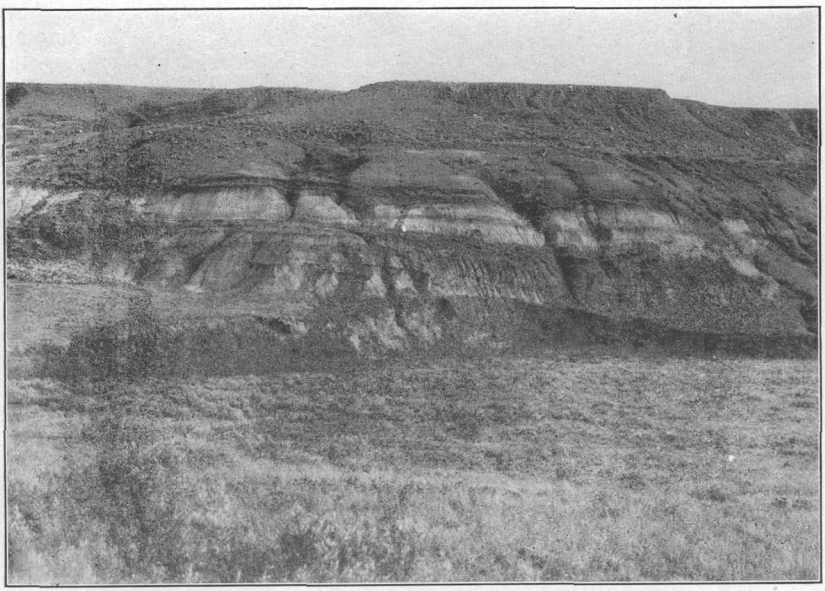
About 4 miles farther up Sage Creek, in the vicinity of McClean's ranch, are important exposures of the Bearpaw shales with such characteristic fossils as *Baculites ovatus*, *Placenticeras whitfieldi*, *Ostrea patina*, and *Inoceramus sagensis*. This is a typical development of the Bearpaw shales, consisting of dark, finely laminated shales with limestone nodules inclosing numerous specimens of *Baculites* and *Placenticeras*. These shales are clearly seen to be the same as those overlying the Judith River beds farther down the creek. The aneroid gave them a thickness of 110 feet, but the base was not shown. On the west side of the creek, a mile below McClean's fence, there is a small exposure of the Judith River beds just at the bottom of the creek bluff. This is the uppermost member of these beds, the main body having here passed beneath the level of the stream. About 65 feet of the uppermost lignitiferous beds are represented.

Opposite McClean's ranch, on the south side of Sage Creek, 100 feet of upper Judith River beds overlain by 200 feet of Bearpaw shales form a range of hills 3 miles west of south of McClean's house. The Bearpaw shales at this locality yielded *Baculites ovatus*, *B. compressus*, *Placenticeras whitfieldi*, *P. intercalare*, *Nautilus dekayi*, *Ostrea patina*, *Cyprina ovata*, *Callista deweyi*, gasteropods, and crustaceans. No fossils were found in the Judith River beds, which here consist of the uppermost 100 feet of that formation and carry much impure lignite. The Bearpaw shales are here cut by two or three sandstone dikes, each



A. EXPOSURE OF JUDITH RIVER BEDS ON SAGE CREEK, ASSINIBOIA.

Showing remains of Trachodon skeleton.



B. CONTACT BETWEEN JUDITH RIVER BEDS AND OVERLYING BEARPAW SHALES ON SAGE CREEK, ASSINIBOIA.

about 10 inches wide and several hundred yards in length. These dikes have a northwest-southeast direction and dip 60° NE. At this locality the Bearpaw shales are very fossiliferous and present four distinct white alkali bands. From this point northward the divide between Sage Creek and Willow Creek, along the road to the Cypress Hills, consists of Bearpaw shales covered by a thin veneer of glacial drift.

On Willow Creek, a small stream rising in the western end of the Cypress Hills, are extensive exposures of Bearpaw shales containing *Baculites compressus*, *Anchura americana*, *Cinulia concinna*, *Lucina subundata*, *Pecten* (*Chlamys*) *nebrascensis*, and *Avicula linguiformis*. Just below John Reed's ranch, on Willow Creek, a heavy bed of brown sandstone caps these shales. In no place in this vicinity were we able to find the base of the shales exposed, so that we were unable to estimate their thickness. As one ascends Willow Creek the brown sandstones mentioned above rapidly increase in prominence and at the head of the creek form the greater portion of the western extremity of the Cypress Hills. They constitute the highest marine horizon seen in the Cretaceous of this region and on account of their stratigraphic position and lithologic features are comparable with the Fox Hills sandstones of South Dakota. We collected from them a considerable number of marine invertebrates, including *Leda* (*Yoldia*) *evansi*, *Avicula nebrascana*, *Protocardia borealis*, *Tancredia americana*, *Callista nebrascensis*, and *Scaphites nodosus* var. *quadrangularis*. Part of these species are known from the Fox Hills beds in other regions, and most of them occur also in the Pierre and Bearpaw shales. It has long been known that the faunas of the Fox Hills and Fort Pierre are too closely related to be considered really distinct.

Toward the summit of the Cypress Hills, on the western end, are about 60 feet of soft, light-colored, yellow sandstones with a 6-foot vein of lignite near the base. These beds may belong to the Laramie as it has been mapped by McConnell, although we were unable to find any fossils in them by which to determine their age.

The exposures examined by us in Canada are all in the southeastern portion of the large, continuous area of Belly River beds mapped by Dawson, McConnell, and Tyrrell. They include both the top and the bottom of the formation, as well as good exposures of the overlying and underlying beds, and hence give a fair idea of the formation as described by Dawson. The principal localities that have yielded the Belly River vertebrate fossils described by Lambe are on Red Deer River some distance north of the most northern point visited by us, but we have no doubt that they are on the same horizons that we studied.

WILLOW CREEK AREA, IN CENTRAL MONTANA.

In addition to the above-described exposures of the Judith River beds in northern Montana and southern Canada, there are others in central Montana, first observed by Hatcher in 1888. One of these occurs between Musselshell River and Flatwillow Creek. Near Flatwillow post-office a conspicuous ledge of yellow sandstone forms an almost continuous and in places perpendicular wall, extending for miles up and down the south side of the creek. These sandstones weather into pyramid-like forms, dip gently to the southeast, and form the roadbed for about 2 miles along the old freight road from Fort Maginnis to Junction City, where they pass beneath the Claggett formation. In weathering, color, and lithologic character these sandstones resemble the brown phase of the Eagle formation as developed at the type locality at the mouth of Eagle Creek on Missouri River, about 20 miles above the mouth of Judith River. Their stratigraphic position between the Benton and Claggett formations also favors this correlation. Some obscure fragments of *Baculites* were the only fossils yielded by them.

After passing over these sandstones, which have an estimated total thickness of 200 feet, the Claggett formation is reached where the road crosses the first coulee, 2½ miles south of Flatwillow. The Claggett overlies the Eagle sandstones and dips gently to the southeast. The shales of this formation yielded *Baculites* sp., *B. ovatus*, *Placenticeras* sp., *Inoceramus barabini*, *Lucina occidentalis*, and *Nucula*. Both species of *Baculites* were very abundant. Other fossils were rare. About 10 miles from Flatwillow the road crosses a broad, deep coulee which occupies the trough of a wide synclinal fold, and in the bottom of which may be seen considerable exposures of the lower 100 feet of the Judith River beds resting upon the Claggett formation. From the Judith River beds at this point we collected remains of turtles and dinosaurs, and saw a number of more or less fragmentary bones and much petrified wood.

For a mile or more the road crosses the trough of this syncline, and there are beautiful exposures of the Judith River beds on either side. It then once more traverses the shales of the Claggett formation for 7 miles, or until Willow Creek is reached. From the higher points along the road the Eagle sandstones appear in prominent bluffs on the right at a distance of several miles. In this locality the Claggett formation can scarcely have a thickness of less than 500 feet. At Nolan and Archer's ranch, on Willow Creek about 10 miles north of Musselshell River, the Judith River beds again rest on the shales of the Claggett formation, and a series of exposures on the south side of the creek form a low, broken wall. The beds have a slight dip (2° or 3°) southeastward, and consist of light-colored argillaceous sandstones

and sandy clays with occasional lenses and masses of hard brown or gray sandstone. The sandstones are nearly all strongly cross-bedded. The rocks are weathered into typical badland forms and have a thickness of 75 to 100 feet in the principal bluffs and buttes. (See Pl. XI, *A*.) There are some lower beds not so well exposed, as well as higher strata to the southeast that are usually covered, but it is probable that the total thickness of Judith River beds does not exceed 200 feet. Vertebrate remains are common in almost every exposure. Silicified wood is common also, and at one point about a mile east of the wagon road a local deposit of well-preserved plants was found, from which all the plants credited to Willow Creek and described by Dr. F. H. Knowlton in this paper were obtained. These plants were all collected in an area of 3 or 4 square yards, from a bed about 1 foot in thickness. About 2 feet below the plants in the same exposure the femur, tibia, and fibula of a large *Trachodon* were obtained. Half a mile east of this locality and on about the same horizon fresh-water Mollusca are common, including *Goniobasis sublævis*, *Anodonta propatoris*, *Sphærium*, and three or four species of *Unio*.

West of the wagon-road crossing of Willow Creek the strata immediately underlying the Judith River beds are scarcely at all exposed, but about 6 miles west of the road there are conspicuous bluffs of light brownish or yellowish sandstone, dipping 5° or 6° NE., that probably belongs to the Eagle formation. South of the creek is a line of cliffs several miles long that often show vertical exposures 75 feet in height. At the base of the cliffs there are small exposures of dark shales, like the Benton, near the top of which an imperfect specimen of *Placenticeras* was collected. The overlying sandstones are exposed to a thickness of about 100 feet, and after a covered interval of 50 feet these are succeeded by 15 feet of similar sandstone. In the lower 25 feet these sandstones are strongly cross-bedded and weather into large, rounded masses. These are succeeded by 50 feet of more massive sandstone, overlain by 25 feet of thicker bedded sandstone. Fossils are rare except in occasional nodules, some of which yield numerous specimens. Near the base of the formation we collected *Pecten*, *Avicula linguiformis*, *Nucula*, *Lucina subundata*, *Cinulia*, *Nautilus dekayi* (?), *Scaphites* related to *S. hippocrepis*, and young individuals of a small, slender *Baculites* that occurs in the Eagle formation on the Missouri. About 75 feet higher specimens of *Inoceramus*, related to *I. fragilis*, were obtained.

About 2 miles east of the road, in a bend of the creek, is a good exposure showing the contact of the Judith River beds with the Claggett formation. In a distance of about 5 miles along the road from Willow Creek to Musselshell post-office there is obtained a complete section from the base of the Judith River beds up through the Bear-paw shales into the overlying formations, which latter we did not study

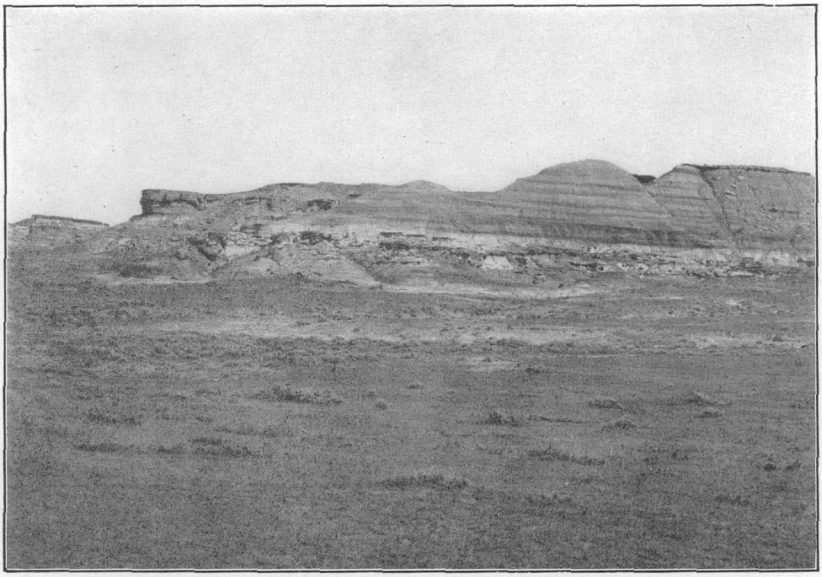
in detail. All the beds dip gently to the southeast. The dip increases in the upper part of the section, being greater in the upper Bearpaw shales than in the Judith River beds, which are here clearly seen to pass beneath the Bearpaw shales. These shales, especially the upper portion, are rich in marine invertebrates, including the following species:

Fossils obtained from Bearpaw shales near Musselshell post-office.

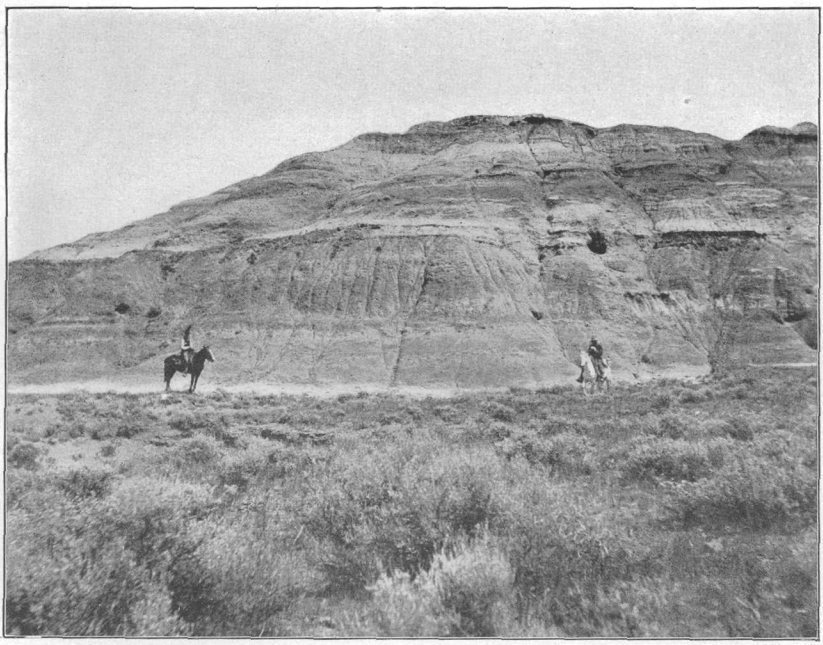
Ostrea pellucida.
Syncyclonema rigida.
Pecten (Chlamys) nebrascensis.
Avicula nebrascana.
Avicula linguiformis.
Inoceramus barabini.
Nucula subplana (?).
Nucula planimarginata (?).
Nucula cancellata (?).
Leda (Yoldia) evansi.
Trigonarca exigua.
Lucina subundata.
Protocardia rara.
Cuspidaria ventricosa.
Liopistha (Cymella) undata.
Thetis? circularis.
Anchura americana.
Acmæa occidentalis.
Vanikoro ambigua.
Lunatia occidentalis (?)
Haminea subcylindrica.
Cinulia concinna.
Baculites compressus.
Baculites ovatus.
Scaphites nodosus var. brevis.
Placenticeras whitfieldi.
Placenticeras intercalare.

Immediately above the Bearpaw shales is a very thick series of sandstones with intercalated shales and occasional lignite beds, which we were unable to study in the limited time at our disposal, though we made a brief fruitless search for fossils in the lower portion. At the base the dip is 15° to 20° to the south, and higher in the section it increases to 30° or more, these tilted beds forming a belt about 2 miles in width and consequently several thousand feet thick. From a point about 2 miles north of Musselshell post-office southward to Musselshell River similar beds occur with very low dips, and we saw such exposures of the same formation for many miles along the Musselshell above the post-office. The only paleontologic evidence of the age of the formation overlying the Bearpaw shales in this region was found at two localities about 14 and 17 miles west of Musselshell post-office, where we obtained a few plants from a horizon probably high in the section. Doctor Knowlton has identified among them *Taxodium occidentalis* Newberry, *Populus speciosa* Ward, *Populus* related to *P. cuneata* Newberry, *Platanus*, *Ulmus rhamnifolia?* Ward, *Sapindus grandifolius?* Ward, *Cocculus haydenianus* Ward. Concerning them he says: "These species are typically Fort Union and I do not hesitate to refer them to this horizon."

The beds between this horizon and the top of the Bearpaw shales should, from their stratigraphic position, contain the equivalent of the Fox Hills and the Laramie as well as the Livingston formation, which was described by Weed in the Crazy Mountains, less than 100 miles to the west.



A. JUDITH RIVER BEDS ON WILLOW CREEK 10 MILES NORTH OF MUSSELSHELL, MONT.



B. JUDITH RIVER BEDS ON FISH CREEK, MONT.

FISH CREEK AREA.

There is a considerable exposure of the Judith River beds between Fish Creek and Mud Creek, small tributaries of Musselshell River near Melville, Mont., a few miles northeast of the Crazy Mountains. These exposures were first discovered by Mr. Earl Douglass and were described by him under the name of the Fish Creek beds, with the suggestion that they are the probable equivalents of the Belly River beds. Not being familiar with the Judith River beds, Mr. Douglass was unable to recognize the identity of the Fish Creek and Judith River outcrops. In their stratigraphic position as well as in their lithologic and faunal characters they are almost identical with the Judith River beds farther north and should be referred to that formation.

These beds are best exposed on Crawford's ranch between Fish and Mud creeks, where they occur in a typical badland region of limited extent. (See Pl. XI, *B*.) Throughout most of this area the Judith River beds have a very gentle southerly dip. This is especially true on the slope looking toward Fish Creek, but at the divide between Fish and Mud creeks the beds are faulted, the fault running irregularly in an east-west direction. Immediately south of this fault the Judith River beds are nearly horizontal, while to the north they are much inclined, in places being nearly vertical or dipping southwesterly at angles varying from 30° upward, so that they appear to be unconformable with and to pass beneath the Judith River beds to the south of the fault. The upper part of the disturbed series is clearly Judith River, and it is evident that the strata have been faulted and that the unconformity is only apparent. To the south and west of this badland area the Judith River beds are overlain by Bearpaw shales bearing the same fauna that has been listed from Willow Creek and other localities. These have an aggregate thickness of several hundred feet and occupy most of the region to the west between the two creeks. South and west of Fish Creek these shales are overlain by marine Cretaceous sandstones and by a thick series of beds that have been referred to the Laramie, Livingston, and Fort Union formations. The Judith River beds in this region are very similar to those on Willow Creek, Dog Creek, and the Missouri at and below the mouth of Judith River. They contain remains of *Trachodon*, *Ceratops*, turtles, and crocodiles of Judith River types in fair abundance, much petrified wood, and beds of fresh-water Mollusca. The beds are usually light ash-colored sands and sandy shales with frequent bands of impure lignite and black ferruginous concretions. In a small draw or canyon running west by north from the badlands to Mud Creek (the draw in

which the Crawfords get their coal) the following section is exposed, commencing at the fault mentioned above and going down the draw:

Section in small draw north of Mud Creek.

	Feet.
4. Lower Judith River beds	200?
3. Claggett beds (sandstones and shales with *Inoceramus* and *Baculites*)	300?
2. Eagle sandstones and shales, with thick bed of coal 100 feet from the base	400?
1. Benton shales, base not exposed	300?

The above thicknesses are mere guesses and can not be considered even as an estimate. No. 3 is probably much below the actual thickness.

The Claggett beds are here made up very largely of sandstones, though there are several beds of shales which are usually poorly exposed.

The Eagle sandstones present the usual characters of that formation, and the lignite is especially good.

The passage from the Eagle to the Claggett formation and from the Claggett to the Judith River beds is so gradual that it is difficult to say where the one commences and the other ends. The Bearpaw shales are well differentiated from the underlying Judith River beds, and the line of demarcation between the Benton and the Eagle formations is likewise very distinct. Northward down the draw toward Mud Creek the dip of the Benton gradually decreases and a few calcareous and ferruginous nodular layers are seen here and there, always more or less fossiliferous with *Scaphites ventricosus*, *Baculites asper* (*?*), *Inoceramus umbonatus*, *I. exogyroides*, and *Pholadomya papyracea*.

The influence of the various horizons on the topography is marked. South and southwest of Widdecombe Creek, a branch of Fish Creek, the alternating sandstones and shales of the formations overlying the Bearpaw have produced a rugged topography characterized by a series of low sawtooth ridges of harder sandstones, separated by gentle valleys occupied by the intervening beds of shales and other soft material. Between this creek and the Crawford badlands there is an area of low rolling hills about 6 miles wide that is composed of weathered Bearpaw shales. Northward, in the area of the Judith River, Claggett, and Eagle beds, is another series of rugged ridges separated by narrow valleys. Still farther north is a low rolling country which extends northward to and beyond Musselshell River and which is the result of the erosion and weathering of the Benton shales.

Two miles west of the small draw mentioned above, where Mud Creek has cut its way through the upturned beds of the Judith River, Claggett, and Eagle formations, a fairly good section is shown from the Bearpaw shales down through the above-mentioned formations into the Benton. Through most of this section the beds are inclined to the northwest at an angle of about 60°.

OTHER PROBABLE AREAS.

Along Milk River the Judith River formation is known to extend far east of Havre, where we studied it. Its limits in that direction have not been determined. It is very probable that this area is connected with the Cow Creek area by almost continuous exposures across the divide separating the drainage of the Missouri from that of Milk River east of the Bearpaw Mountains. On our journey from Havre to Cow Creek we passed through the eastern foothills of these mountains and crossed several areas of igneous rocks, but on Bean Creek near Lloyd post-office we saw outcrops apparently belonging to the Judith River beds, and if our route had been a few miles farther east we could probably have had the formation in sight all the time.

A few miles north of Billings, on the road from Roundup post-office on the Musselshell to Billings, Mont., we noticed outcrops that almost certainly belong to the Judith River formation. This area is along the line of a section described by Lindgren in volume 15 of the Tenth Census and was referred by him to the Laramie.

About 50 miles farther east on the Yellowstone, near the mouth of Bighorn River, Hayden has described exposures that may also belong to the Judith River formation.

There are certainly other areas of Judith River beds in the valley of Musselshell River north and west of the Fish Creek area which we have described. One of these is indicated by Lindgren's [a] description of the occurrence of marine Cretaceous above so-called Laramie beds near the mouth of Swimming Woman Creek. Another of these probable areas is indicated by the reported occurrence of Judith River species of brackish-water Mollusca at a locality north of the Crazy Mountains, where the beds containing them were referred by Weed[b] to the Livingston formation.

In this connection attention may be called to the occurrence of non-marine coal-bearing beds within the Montana group at Coalville, Utah, at Point of Rocks, Wyo., and at several points on the Laramie Plains, southern Wyoming.[c] These beds are probably not very far from the horizon of the Judith River beds, but it is not believed that the facts would justify their reference to that formation.

---

[a] Tenth Census U. S., vol. 15, p. 743.

[b] Bull. U. S. Geol. Survey No. 105, p. 33.

[c] See Stanton and Knowlton, Stratigraphy and paleontology of the Laramie and related formations in Wyoming: Bull. Geol. Soc. America, vol. 8, pp. 127–156.

RÉSUMÉ AND CONCLUSIONS.

Our field studies in the original Judith River area have established the stratigraphic succession of the Upper Cretaceous section and show that the Judith River beds lie beneath several hundred feet of marine Cretaceous shales with a characteristic invertebrate fauna, and that they rest upon another marine formation which also bears an abundant fauna. The overlying formation we have called the Bearpaw shales, because it is well exposed in the area south, east, and north of the Bearpaw Mountains. The name Claggett formation has been given to the underlying beds because they are well developed around the site of old Fort Claggett, near the mouth of Judith River. Wherever the exposures in this region show lower beds the lignite and conspicuous sandstone ledges of the Eagle formation are seen, and still lower the dark Benton shales with a characteristic fauna are revealed. The Judith River formation itself has yielded a fauna of both vertebrates and invertebrates, most of which are peculiar to it. Its lithologic features also are different from those of any other formation in the section and make it easily recognizable.

Beyond the typical area, we found on Milk River in the neighborhood of Havre a similar succession of formations from the Claggett to the Bearpaw, inclusive. The formation occupying the position of the Judith River beds here has the same lithologic and paleontologic characteristics as in the original area, with which it probably has direct connections around the east end of the Bearpaw Mountains. It is therefore unhesitatingly identified with the Judith River beds. From Havre this formation was traced by means of practically continuous exposures and without essential change of lithologic and paleontologic characters into an area of Belly River beds mapped by Dawson. Here again the underlying Claggett formation was recognized by its fossils and lithologic features, and above the Judith River (Belly River) beds the Pierre shales of the Canadian geologists are clearly identical with the Bearpaw shales of our Montana section.

In other areas studied by us in Montana the same succession of formations was observed. Two horizons in this region are especially well characterized by marine invertebrates—one in the upper part of the Benton shales and the other in the Bearpaw shales. Wherever these were both present in one section the succession and recognition of the intervening formations were unmistakable.

The stratigraphic relations are more clearly shown in the following diagrammatic arrangement of comparative sections:

Sections in South Dakota, Montana, and Assiniboia.

	South Dakota section.	Central and northern Montana section.	Southern Assiniboia section.
	Laramie.	Laramie?	Laramie?
	Fox Hills.	Fox Hills?	Fox Hills?
Montana group.	Pierre.	Bearpaw. Judith River. Claggett. Eagle.	Bearpaw. Belly River (Judith River). Claggett. (?)
Colorado group.	Niobrara. Benton.	Benton.	(?)
	Dakota.	Dakota?	(?)

The Montana and Colorado groups are generally recognized as larger subdivisions of the strata lying between the Dakota and the Laramie. The South Dakota and Nebraska section is the Meek and Hayden section with the Laramie added, while the other two columns represent the sections studied by us. The queries in the lower part of the columns indicate formations not seen by us in the regions mentioned, and the queries in the upper part of the column indicate our doubts as to the correlation of any particular horizon in these sections with the Fox Hills, and as to the limits of the Laramie and its relationship with overlying formations that have been described in the region.

A few words of explanation are necessary concerning the general correlations expressed and the introduction of new formation names. In the first place, the entire Upper Cretaceous section as described by Meek and Hayden along Missouri River in South Dakota and Nebraska is very much thinner than the Montana section, and in some portions the lithologic development is not at all similar. Consequently the comparison of individual formations or horizons is in several cases made difficult.

Beginning the examination at the base of the section and leaving the Dakota out of consideration at present, the first difficulty is in connection with the Benton, especially as to its upper limits. In the upper Missouri section near Fort Benton a continuous body of shales extends up to the base of the Eagle sandstone, and so far as is now known there is no lithologic basis for a division in it. There are,

however, two well-marked faunal zones—a lower one characterized by *Inoceramus labiatus*, *Scaphites warreni*, and the keeled ammonite genera *Prionotropis* and *Prionocyclus*, and an upper zone with *Inoceramus umbonatus*, *Inoceramus exogyroides*, and *Scaphites ventricosus*. In the section farther east in South Dakota and Nebraska the shales referred to the Benton are limited above by the Niobrara limestone, and their fauna corresponds closely to that of the lower zone above mentioned. If it is assumed that the upper limit of the Benton shales in the two sections is identical, and that the sequence upward is continuous in both cases, then it must follow that the Eagle sandstone is or includes the equivalent of the Niobrara limestone, and should be correlated with it, though, of course, distinctive formation names are necessary. But all the paleontologic evidence is opposed to their correlation. On the one hand, the fauna in the upper Benton zone of the western section has its nearest representative in Colorado and Texas in beds that are referable to the upper Niobrara, and on the other hand the fauna of the Eagle formation is much more closely allied to the fauna of the overlying marine formations than to the Benton fauna, and consequently the formation belongs to the Montana rather than to the Colorado group. The objection may be raised that the Eagle is a littoral formation, and that its fauna would therefore be different from the Niobrara faunas, but there are littoral faunas known at the top of the Benton in Colorado, northern Utah, and southwestern Wyoming, and these are wholly different from the Eagle fauna. The most reasonable view seems to be that the Fort Benton of the western section includes the representatives of both the so-called Fort Benton and the Niobrara of the eastern section.

The second serious difficulty in the Montana section is in determining the exact equivalent of the Pierre shales. This formation was named from Fort Pierre on the Missouri, now Pierre, S. Dak., and was defined as dark clays, limited above by the Fox Hills sandstone and below by the Niobrara limestone, with exposures along the Missouri for some distance both above and below Fort Pierre. Meek and Hayden's estimate of the thickness was 700 feet, but more recent estimates by Darton in the same general region place it at 1,200 to 2,000 feet. It contains a large and characteristic invertebrate fauna. In the Montana section the shales we have called Bearpaw shales are very similar to the Pierre in lithologic character, and they bear a fauna composed in the main of identical species, showing an assemblage especially similar to that of the upper fossiliferous zone of the Pierre. The thickness possibly also approaches that of the Pierre in the typical area.

That the Bearpaw shales represent a part of the Pierre is unquestionable, but if they are strictly equivalent to the Pierre, so that they should be called by the same name, then in the South Dakota section

there is a long unrepresented interval between the Niobrara and the Pierre, for, as we have shown, there is considerable evidence that the Eagle formation is later than the Niobrara. The overlying Claggett and Judith River formations certainly come within the Montana group. It is true that Meek and Hayden observed some evidences of erosion at the top of the Niobrara, but it does not seem probable that erosion or nondeposition could have continued throughout the time represented by the three formations just named without showing greater effects than have been observed. It is well known that along the western margin of the Great Plains in Colorado there is a great thickening of the Pierre, or at least of the formation in the corresponding position, so that in the Denver region it attains the thickness of 7,000 feet, while farther south, in the Arkansas Valley, its thickness is over 4,000 feet. Although in all this great thickness several zones have been more or less clearly recognized by minor differences in the fauna and in lithologic features, no basis for separation into distinct formations has been found. In the Montana section the shaly portion of the Claggett formation does not differ very greatly in lithologic character from the Bearpaw shales, and though the fossils are less numerous they are all of species that occur in the Bearpaw and the Pierre, while the sandstone members of the Claggett bear a littoral fauna that is closely related to that of the Fox Hills and even contains many of the same species. It is very probable, therefore, that the Claggett would not have been separated from the Bearpaw as a distinct formation if the totally different Judith River beds had not been interpolated between them, for the intermingling of Fox Hills and Pierre species has long been known elsewhere.

In view of the facts above stated it seemed expedient to give the local name Bearpaw shales to the formation immediately overlying the Judith River beds, rather than to regard it as the strict equivalent of the Pierre and to call it by that name, although we do not doubt that the one formation can be traced directly into the other and that some zones in both are identical. The Claggett formation is a stratigraphic unit, distinct and easily separable from the previously defined formations above and below it, and hence it required a new name.

Returning to the correlation diagram (p. 63), we wish to leave the question open whether the Pierre fills *all* of the space corresponding to that occupied by the Bearpaw, Judith River, Claggett, and Eagle formations, although we are confident that all of these belong to the Montana group. The identification of the Fox Hills formation in the Montana section is left in doubt partly because we did no detail work on that part of the section, and more especially because we have found that many of the Fox Hills species have a great vertical range, throughout which they may be expected to occur wherever suitable

conditions are found, so that paleontologic identification of the formation without the most careful stratigraphic work is extremely unreliable. The problem of the Laramie and associated later formations in this region is a very complex one, to which we were able to devote very little time, and consequently we do not desire to express any definite opinions concerning it.

Our principal conclusions from the season's work may be summarized as follows:

1. The Judith River beds are distinctly older than the Laramie, being separated from the latter by at least several hundred feet of marine shales identical in their faunal and lithologic features with the Pierre to which we have given the local name Bearpaw shales, from the Bearpaw Mountains about which they are well exposed.

2. The Belly River beds of Canada are identical with the Judith River beds of Montana. The name Judith River beds, having priority, should be the accepted name for this formation and the terms Belly River and Fish Creek beds should be dropped.

3. The marine sandstones and shales immediately underlying the Judith River beds do not represent either the Benton, as some Canadian geologists have supposed, or the Fox Hills and upper Pierre, as most geologists of the United States who have examined them have believed, but they constitute a distinct horizon within the Montana group which we have called the Claggett formation, from old Fort Claggett at the mouth of Judith River, near which they are well developed.

4. The Eagle formation, from its stratigraphic position and faunal relations, marks the base of the Montana group in this region.

5. The Bearpaw shales, the Judith River beds, the Claggett and the Eagle formations all belong to the Montana group, and together probably form the equivalent of the Pierre as that term is generally understood, though the possibility is recognized that in the typical area the Pierre may have more restricted limits.

6. Faunas similar to that of the Fox Hills sandstone have a great vertical range and are likely to be found at any horizon within the Montana group where a littoral or shallow-water facies is developed. The use of the term Fox Hills as a formation or horizon name outside of the original area in South Dakota is therefore of doubtful propriety, as experience has shown.

VERTEBRATE FAUNA.

By J. B. HATCHER.

Leidy, Cope, Marsh, Osborn, and Lambe have been the chief contributors to our knowledge of the vertebrate fauna of the Judith River beds. A considerable number of genera and species pertaining to all five of the known classes of vertebrates have been described. Unfortunately these genera and species are for the most part based on exceedingly fragmentary and unsatisfactory material, and it has been quite impossible to determine with accuracy even the principal osteological or dental characters of most of the genera or to compare them intelligently with related forms from older or more recent formations. As an aid to future students there is given here a list of the various genera and species of vertebrates that have been described by various authors, with a reference to the original description and a brief statement concerning the nature of the types upon which they were based.

PISCES.

Altogether six genera and eight species of fish have been described from deposits referred by us to the Judith River beds. These genera and species are known only from detached scales, teeth, and bones. They doubtless represent only a small fraction of the fish fauna of these beds. While they give an indication of the character of some of the fishes that inhabited the waters of this region in Judith River times, they are at present known from such insufficient material as to render them of little value for purposes of correlation, as is abundantly evidenced by the apparent similarity existing between the fish remains known from these beds and those from the Laramie. This similarity is so striking that some paleontologists have been led, largely from such evidence, to correlate the Judith River beds with the Laramie, disregarding the more important evidence afforded by the dinosaurian fauna and the stratigraphy.

LEPIDOTUS OCCIDENTALIS Leidy.

Lepidotus occidentalis Leidy, 1856, Proc. Acad. Nat. Sci. Philadelphia, 1856, p. 73.

Leidy described the species as follows:

A species proposed on five specimens of thick lozenge-shaped scales, with the root prolonged in the direction of the long diameter. The enameled surface of the scales is smooth and shining. The largest one has its sides about 4 lines long, the smallest one about 2½ lines long.

LEPIDOTUS HAYDENI Leidy.

Lepidotus haydeni Leidy, 1856, Proc. Acad. Nat. Sci. Philadelphia, 1856, p. 73.

The original description of the species was as follows:

A species proposed on a single specimen of a thick oblong square scale, the long sides of which measure 5 lines and the short 3½ lines. The root projects forward from one of the long sides, and the enameled surface of the scales is covered with parallel square lines.

CERATODUS ERUCIFERUS Cope.

Ceratodus eruciferus Cope, 1876, Proc. Acad. Nat. Sci. Philadelphia, 1876, p. 259.

This species was described by Cope as follows:

A basal lamina separable from the dentigerous lamina. The latter supports ribs which diverge from a single marginal rib which extends along one side. The marginal rib is separated by a deep groove from the radiating ribs, which is continuous with the grooves between the latter. The ribs are of irregular diameter and not perfectly straight; they are interrupted by weak transverse ridges, which project beyond the margin. The ridges rise abruptly from their common base and are separated distally by notches of the margin.

Measurements.

	M.
Long diameter of dental surface	0.011
Short diameter of dental surface	.007
Thickness of plate	.003

There are six ridges in the length.

CERATODUS HIEROGLYPHUS Cope.

Ceratodus hieroglyphus Cope, 1876, Proc. Acad. Nat. Sci. Philadelphia, 1876, p. 260.

This species was described by Cope as follows:

The dentigerous plate is thin and dense, and has the appearance of a short-toothed comb with a handle. The tooth-like points are the extremities of low ridges, which are arranged nearly at right angles to a wide longitudinal elevated half of the osseous base. They are separated by shallow grooves from each other, and are not continuous with the basis just mentioned, which rises abruptly above them. They are smooth. The "handle" above alluded to is triangular in section, having two bevels on the side supporting the tooth ridges. The lower face of the bone is smooth.

Measurements.

	M.
Total length	0.013
Length of dentigerous portion	.010
Total width	.0045
Width of dentigerous portion	.0020

There are thirteen teeth in the length.

MYLEDAPHUS BIPARTITUS Cope.

Myledaphus bipartitus Cope, 1876, Proc. Acad. Nat. Sci. Philadelphia, 1876, p. 260.

This species is founded on detached and isolated teeth. Teeth of this pattern and of varying size are abundant both in the Judith River beds and in the Laramie. It would be quite impossible to identify either genera or species from teeth of such simple form.

HEDRONCHUS STERNBERGII Cope.

Hedronchus sternbergii Cope, 1876, Proc. Acad. Nat. Sci. Philadelphia, 1876, p. 259.

Cope described this species as follows:

Char. Gen.—The bone on which this genus reposes has the appearance of the crown of a young tooth. Its central cavity is large and expands to the margin of the basis; its apex is unworn. It appears to be too protuberant for the position of a dermal tubercle. It may be distinguished as a short crown on a shorter slightly constricted portion or neck. The crown culminates in three crests, which together form a letter T, and which descends toward the neck. There is no investment of cement or enamel, and the material of which it is composed resembles dense bone.

Char. Specif.—The faces on each side of the stem of the T are concave and divided by an oblique crest, which descends from the common apex. The other face is gently convex, and the inferior part of each of its bounding crests projects ear-like. The base is an oval.

Measurements.

		M.
Elevation of crown		0.006
Diameter of base	longitudinal	.005
	transverse	.004

ACIPENSER ALBERTENSIS Lambe.

Acipenser albertensis Lambe, 1902, Cont. Canadian Palæont, vol. 3, pt. 2, p. 29.

This species is founded on a detached keeled dermal shield from the Judith River beds of Red Deer River, Canada. Similar ossifications are common in the Judith River beds and in the Laramie of Converse County, Wyo., and probably represent more than one species.

DIPHYODUS LONGIROSTRIS Lambe.

Diphyodus longirostris Lambe, 1902, Cont. Canadian Palæont, vol. 3, pt. 2, p. 30.

This species is founded on a jaw fragment from the Judith River beds of Canada, with numerous tooth scars which show the teeth to have been simple and conical and ankylosed with the jaw. Fragments of similar jaws are common both in the Judith River beds of Montana and in the Laramie deposits of Converse County, Wyo.

AMPHIBIA.

Two genera and five species of tailed Batrachia have been described from the Judith River beds. All of these have been founded on very fragmentary and insufficient material, consisting for the most part of detached vertebræ, with an occasional limb bone or jaw fragment. Similar remains, for the most part undescribed, are common also in the Laramie.

All five of the species of Batrachia mentioned were described by Cope from material secured in the Judith River beds of Montana. Lambe[a] has reported *Scapherpeton tectum* Cope from the same beds on

[a] Cont. Canadian Palæont., vol. 3, pt. 2, p. 31.

Red Deer River in Canada. From the fragmentary nature of the types on which were based Cope's descriptions of the various genera and species, it will readily appear how extremely difficult it will be to refer any material with certainty to any of his species. Moreover, the fragmentary nature of all the remains of Batrachia thus far recovered from this formation renders them of little value for purposes of correlation, and were these remains better preserved it is improbable that they would afford any very reliable evidence as to the exact or relative age of the deposits, owing to the apparently slight modification which has taken place in these Batrachia throughout Cretaceous and Tertiary times. The Batracia of the Judith River beds can not be regarded as of any special value in determining the age of the deposits or in correlating them with other formations.

SCAPHERPETON Cope.

Scapherpeton Cope, 1876, Proc. Acad. Nat. Sci. Philadelphia, 1876, p. 353.

This genus was described by Cope as follows:

Vertebræ deeply biconcave, with opposed, but not continuous, foramina for the chorda dorsalis. Neural arch with zygapophyses, and well-developed neural spine. Centrum with vertically compressed, short diapophysis near the posterior extremity, a prominent hypapophysial keel, and prolonged neural spine. Supposed proximal limb bone with a branch-like trochanter. Supposed teeth in several rows, attached in shallow alveoli, those of the marginal series larger; the crowns obtusely conic and simple.

SCAPHERPETON TECTUM Cope.

Scapherpeton tectum Cope, 1876, Proc. Acad. Nat. Sci. Philadelphia, 1876, p. 355.

This species is founded on a single vertebra accompanied by a fragment which, according to Cope, "resembles the articular portion of the mandible."

SCAPHERPETON LATICOLLE Cope.

Scapherpeton laticolle Cope, 1876, Proc. Acad. Nat. Sci. Philadelphia, 1876, p. 356.

This species was founded on an atlas and several dorsal vertebræ of different individuals, which latter, according to the author of the species, may pertain to the preceding species. An imperfect limb bone was found associated with the neural arch of a vertebra of the character ascribed to this species, and was described by Cope in connection with the type.

SCAPHERPETON EXCISUM Cope.

Scapherpeton excisum Cope, 1876, Proc. Acad. Nat. Sci. Philadelphia, 1876, p. 357.

This species was founded on scattered vertebræ from three individuals of different sizes.

SCAPHERPETON FAVOSUM Cope.

Scapherpeton favosum Cope, 1876, Proc. Acad. Nat. Sci. Philadelphia, 1876, p. 357.

This species is founded on a single vertebra.

HEMITRYPUS JORDANIANUS Cope.

Hemitrypus jordanianus Cope, 1876, Proc. Acad. Nat. Sci. Philadelphia, 1876, p. 358.

This genus and species were founded on a single vertebra from the Judith River beds. This genus is distinguished from the preceding genus by the position of the foramen chordæ dorsalis.

REPTILIA.

The Reptilia are far better represented in the Judith River beds than the other classes of Vertebrata. Not only are most of the larger subdivisions of the group represented, but the fauna is rich also in genera and species which in Judith River times were evidently undergoing a rather rapid development and acquiring a considerable degree of specialization. Genera and species such as these, which may be termed progressive types, afford the most reliable paleontological evidences upon which to base accurate correlations. The more specialized Reptilia offer more trustworthy evidence as to the age of these beds than any other group of vertebrates. Furthermore, from the abundance and condition of the remains the reptilian fauna of this formation and of other formations can be more carefully compared than is practicable with other classes of vertebrates.

PLESIOSAURIA.

While the Judith River beds are for the most part of fresh- and brackish-water origin, it is evident that at certain periods during their deposition the sea had access to limited areas of the region over which these beds are distributed. At certain localities like that mentioned on page 42, remains of typically marine invertebrates and vertebrates occur well within the limits of the Judith River beds. From such marine deposits we obtained shark's teeth pertaining to a number of distinct species, and remains of plesiosaurs and chelonians, some of which latter appear also to belong to marine species.

CIMOLIASAURUS MAGNUS Leidy.

Cimoliasaurus magnus Leidy, 1853, Proc. Acad. Nat. Sci. Philadelphia, 1853, p. 325. Smithsonian Contrb. to Knowl., vol. 14, p. 25.

Lambe[a] has reported vertebræ pertaining to this genus and species from the Judith River beds of the Red Deer River, Canada. The original description of this genus and species was based on vertebræ from the Greensands of New Jersey, for the most part of much larger size than those described by Lambe, and it is not improbable that the material described by the latter may pertain to a distinct genus and species. In some respects they more nearly resemble the vertebræ on which Leidy based his description of *Ischyrotherium antiquum*.[b]

[a] Cont. Can. Pal., vol. 3, pt. 2, 1902, p. 32. [b] Proc. Acad. Nat. Sci. Philadelphia, 1856, p. 89.

URONAITES CETIFORMIS Cope.

Uronaites cetiformis Cope, 1876, Proc. Acad. Nat. Sci. Philadelphia, 1876, p. 346.

Founded on "cervical, dorsal, and caudal vertebræ, portions of limb, and rib bones" found near the top of the Claggett or base of the Judith River beds near Armell's (Amell's) Creek, a small tributary of Missouri River in northern Montana, at about the eastern limits of the Judith River basin as defined by Hayden.

ISCHYROTHERIUM cf. ANTIQUUM Leidy.

Ischyrotherium cf. *antiquum* Leidy, 1857, Proc. Acad. Nat. Sci. Philadelphia, 1856, p. 89.

We collected a number of vertebral centra from the marine horizon mentioned on page 42 as occurring within the usually recognized limits of the Judith River beds, which closely resemble those described and figured by Leidy[a] as the type of the present genus and species and which were obtained between Moreau and Grand rivers in South Dakota. Although Leidy states in his description that they were obtained "from an outlyer of the Great Lignite Tertiary formation" of that region, it is more than likely that the exact horizon was more nearly that of the Fox Hills or Pierre. However this may be, the vertebræ collected by us doubtless are from beds older than those which yielded the type of the genus and species. Whether the vertebræ in question pertain to *Ischyrotherium*, to one of the two previously mentioned genera of plesiosaurs, or to a distinct genus can be determined only by careful comparisons with the types, and the material is so incomplete that even then a fairly conservative paleontologist could not feel sure of his determination.

The plesiosaurs, like the fishes and the batrachians in the Judith River beds, afford very scanty and unsatisfactory evidence as to the age and proper correlation of the deposits.

CHELONIA.

Remains of chelonians are common in the Judith River beds. Altogether eight genera and fourteen species have been described from these deposits; most of these, unfortunately, are known from very fragmentary material, consisting for the most part of fragments of the carapace or plastron. In only a few instances is anything known of either the skull or the endo-skeleton.

TRIONYX FOVEATUS Leidy.

Trionyx foveatus Leidy, 1857, Proc. Acad. Nat. Sci. Philadelphia, 1856, p. 73.

The type of this species was collected by Doctor Hayden in the Judith River beds. The nature of the material upon which Leidy's

[a] Trans. Am. Philos. Soc., vol. 11, p. 150.

description of the species was based can be best appreciated by quoting his original description, which is as follows:

The species is founded on fragments of several costal and sternal plates. The exterior surface of the costal plates is covered with pits, excepting close to the margins; and the pits are small and round at the vertebral extremity, and gradually increase in size outwardly and become antero-posteriorly oblong, oval, and reniform. A vertebral fragment of a third or fourth costal plate, a little over an inch in length, is 11 lines wide and 2 lines thick. Small fragments of the sternal plates present an exterior surface covered with broken vermicular ridges and tubercles separated by wide intervals. Fragments of a hyposternal plate are 3 lines in thickness.

In a later paper[a] Doctor Leidy figures the type material and associates with it remains of another specimen collected by Hayden in the "Great Lignite Tertiary [probably Laramie] basin, near Long Lake, below Fort Clark," on Missouri River. He says of these remains that they are "not distinguishable from *Trionyx foveatus*," but adds that "the specimens are too imperfect positively to determine whether they actually belong to the same species." Considering the difference in the age of the deposits, it is quite probable that had better material been at the disposal of Doctor Leidy he would have found them to be at least specifically distinct.

Lambe[b] has described and figured much better material which he refers to this genus and species. His material was secured from the Judith River beds on the Red Deer River in Canada.

TRIONYX VAGANS Cope.

Trionyx vagans Cope, 1874, Ann. Rept. U. S. Geol. and Geog. Surv. Terr. for 1873, p. 453.

The original description of this species was as follows:

Represented by a number of costal bones and perhaps of sternals also. The former are rather light or thin for their width, and are marked with a honeycomb pattern of sculpture, in which the ridges are thin and much narrower than the intervening pits. They incline to longitudinal confluence at and near the lateral sutures. Several areæ are not infrequently confluent in a transverse direction near the middle of the bone.

Measurements.

	M.
Width of costal bone	0.0370
Thickness of costal bone	.0045
Four and five areæ in 0.010 m.	

This species differs from the *T. foveatus* Leidy in the much narrower interareolar ridges and larger areæ, and in their longitudinal confluence at the margins, characters exhibited by numerous specimens.

Lignite Cretaceous of Colorado; near the mouth of the Bighorn River, Montana; Long Lake, Nebraska; found at the last two localities by Doctor Hayden.

---

[a] Trans. Am. Philos. Soc., vol. 11, 1860, p. 148, Pl. XI.
[b] Cont. Canadian Palæont., vol. 3, pt. 2, 1902, p. 33, Pl. I.

Lambe[a] has described and figured from the Judith River beds of the Red Deer River in Canada remains of a turtle which he refers to this species. By reference to his figures, however, it will be apparent to all that the specimen described by Lambe pertains to a species distinct from *T. vagans*. According to Lambe's figures the ridges on the surface sculpturing, instead of being "thin and much narrower than the intervening pits," as described by Cope, are heavy and broader than the intervening pits. There are other differences also of no less importance. It seems clear, therefore, that so far as our present knowledge goes the distribution of this species is limited to the Laramie, and that it should not be considered as a Judith River form.

PLASTOMENUS COALESCENS Cope.

Plastomenus coalescens Cope, 1875, Rept. U. S. Geol. Surv. Terr., vol. 2, p. 93, Pl. VIII.

This species is founded on fragments of plastron and carapace collected by George M. Dawson near Milk River, in Canada, from beds referred by Cope to the "Transition series, probably the Fort Union or Lignite epoch," but now known to belong to the Judith River series. The type material is extremely fragmentary and it would be difficult to identify other material by a comparison with Cope's description, his figures, or the type.

PLASTOMENUS COSTATUS Cope.

Plastomenus costatus Cope, 1875, Rept. U. S. Geol. Surv. Terr., vol. 2, p. 94, Pl. VIII.

Founded on fragments of carapace and plastron collected by Doctor Dawson in the same region and from the horizon from which he secured the type of the preceding species. The observations made concerning the preceding species apply also to this. While we do not doubt that the remains upon which these two species have been founded are specifically distinct, yet from their exceedingly fragmentary nature they are of little value in determining other material. It would scarcely be possible to definitely refer any material with certainty to either species, so imperfect are the types.

PLASTOMENUS PUNCTULATUS Cope.

Plastomenus punctulatus Cope, 1874, Ann. Rept. U. S. Geol. and Geog. Surv. Terr. for 1873, p. 453; 1875, Rept. U. S. Geol. Surv. Terr., vol. 2, p. 94, Pl. VI.

This species was "established on a costal bone found in association with the preceding species and referred to the genus *Plastomenus* provisionally, and with a possibility that it will be found not to pertain to it when fully known." Cope reports it also from the Lignite Cretaceous of Colorado and from Long Lake, Nebraska. The type of the present species is even more fragmentary than the types of the last two species.

---

[a] Cont. Canadian Palæont., vol. 3, pt. 2, 1902, p. 36, Pl. I.

PLASTOMENUS INSIGNIS Cope.

Plastomenus insignis Cope, 1874, Ann. Rept. U. S. Geol. and Geog. Surv. Terr. for 1873, p. 454; 1875, Rept. U. S. Geol. Surv. Terr., vol. 2, p. 95, Pl. VI.

This species is founded on "a portion of the right hyposternal bone of a tortoise about the size of the last species and from the same locality." A reference to the figure of the type published by Cope will serve to further emphasize the extremely fragmentary nature of the material upon which he based his description and the absolute hopelessness of referring with any degree of certainty other and better preserved material to this species.

Cope is not at all clear as to the locality or horizon from which the types of the last two species were derived. In describing *P. punctulatus* he says the type was found in association with the preceding species (*P. costatus*). The only locality given by him for the latter species is south of Woody Mount, near latitude 49°, British America. Then, in describing *P. insignis*, he says that the type was found in the same locality as the last species (*P. punctulatus*), the inference being, therefore, that it also was found near Woody Mount. At the close of his description of *P. punctulatus* he adds "Lignite Cretaceous of Colorado; also several fragments from Long Lake, Nebraska, from Doctor Hayden," while after the description of *P. insignis* he says, "Lignite Cretaceous of Colorado"—in neither instance making any reference to the Canadian locality. Now the localities given in the body of his descriptions of both these two species and those appended at the close are not only widely separated geographically, but the beds referred to are now known also to occupy very different stratigraphic positions. It would seem best to relegate both these species to the paleontologic scrap basket, since they are valueless from both a biologic and a stratigraphic standpoint.

ADOCUS LINEOLATUS Cope.

Adocus lineolatus Cope, 1874, Bull. U. S. Geol. and Geog. Surv. Terr., vol. 1, No. 2, p. 30; 1875, Rept. U. S. Geol. Surv. Terr., vol. 2, p. 92, Pl. VI.

According to Cope, this species was "established on a number of fragments from different exposures of the lignite beds primarily on a vertebral and sternal bone." The locality is given as "from lignite of Colorado, and mouth of Bighorn River, Montana," at neither of which localities are there any known exposures of the Judith River beds. The types were almost surely secured from the Laramie.

Lambe[a] has reported this species from the Judith River beds of Canada, and Cope[b] has included it in a list of vertebrates from the Judith River beds of Montana. Since in his several descriptions of material referred to this species Cope has nowhere mentioned any of

[a] Cont. Canadian Palæont., vol. 3, pt. 2, 1902, p. 38.
[b] Bull. U. S. Geol. and Geog. Surv. Terr., vol. 3, 1877, p. 573.

it as having been derived from the Judith River beds, it is more than probable that its appearance in Cope's list of Judith River vertebrates is due to an oversight. Considering the difference in age between the Judith River beds and the deposits which yielded the types of the species, together with the extremely fragmentary nature of the latter, as will readily appear from an examination of Cope's figures, it would seem quite probable that Lambe's identification of the "two well preserved fragments" from the Judith River beds of Canada, as pertaining to this species, may be incorrect, notwithstanding his remark that "this species is readily recognized by its neat and characteristic sculpture."

BASILEMYS OGMIUS (Cope).

Compsemys ogmius Cope, 1875, Rept. U. S. Geol. Surv. Terr., vol. 2, p. 91.
Compsemys variolosus Cope, 1876, Proc. Acad. Nat. Sci. Philadelphia, 1876, p. 257.

This genus and species is based on fairly good material discovered by the Canadian Boundary Survey near Milk River, Canada, and supplemented by other material discovered by Mr. Charles H. Sternberg in the Judith River beds of Montana. Cope's original description was as follows:

Compsemys ogmius Cope. Represented in the collections of the British-American Boundary Commission by portions of the carapace and plastron. These are massive, and indicate a species of large size. As in other species of the genus, the external surface is a dense layer of cement or allied substance, which is sculptured with shallow pits.

A portion of the costal bone is concave and increases rapidly in thickness in one direction. The suture is coarse, but neither gomphosial nor squamosal. A portion of the plastron is thinner, not curved, and displays a very coarse median suture, in part squamosal in character. The sculpture consists of shallow pits not wider than the low, smooth ridges which separate them. There are deep superficial grooves marking the boundaries of dermal areas, a feature in which this tortoise differs much from the *P. coalescens* and resembles the species of *Compsemys*. Should marginal bones be found to exist in the *P. ogmius*, its reference to that genus will be further established.

From 6 miles west of first branch of Milk River, near latitude 49°.

The material discovered in Montana was referred to a distinct species, *Compsemys variolosus*, and described as follows:[a]

One of the most abundant and the largest species of the Fort Union beds. The carapace is convex and the plastron flat; the marginal bones are heavy and strongly convex on the inferior side. The margin of the plastron is thickened and heavy—characters which also belong to all parts of the carapace. The sutures of the dermal scuta are deeply impressed, and the surface of the bone is strongly sculptured above and below and even on the superior face of the thickened margins of the free lobes of the plastron. The sculpture consists of round fossæ, which are deeply impressed and are arranged quincuncially, so that their borders never form straight lines. The latter are also more or less angulate on the edge, so that the surface has a more than usually rugose character.

The typical specimen equals those of the large land tortoises of the Eocene in dimensions.

[a] Proc. Acad. Nat. Sci. Philadelphia, 1876, p. 257.

Lambe[a] has described and figured material pertaining to this species from the Judith River beds of Canada. He has also reported it from the Willow Creek division of the Canadian Laramie. It is not improbable that the latter reference is incorrect. Lambe has placed this species in the genus *Adocus*, but Hay[b] has made it the type of a new genus, *Basilemys*. Both these authors have accepted the specific name *variolosus* Cope, making *ogmius* Cope a synonym of *variolosus*, although *ogmius* was described a year before *variolosus*. We collected remains of this species at several localities.

BASILEMYS IMBRICARIUS (Cope).

Compsemys imbricarius Cope, 1876, Proc. Acad. Nat. Sci. Philadelphia, 1876, p. 257.

This species is based on material from the Judith River beds of Montana. The original description was as follows:

This species like the others of the genus, has the scutal sutures well defined, and the superficial surface of the carapace sculptured. The character of this sculpture distinguishes the species, and in the present instance in a special manner. It consists in the *C. imbricarius*, of excavations bounded on the sides by a short ridge each, which alternate with each other. Thus each bounding ridge terminates abruptly at the fundus of one of the fossæ, while the other end of the fossa rises and contracts to another ridge. The result is precisely that seen in the interior sculpture of Saracenic domes or niches, and is one which is quite unique among tortoises. The direction of the ridges is at right angles to the costal dermal sutures. This species was about as large as the snapping tortoise (*Chelydra serpentina*).

Measurements.

		M.
Thickness of a costal bone		0.0050
Three fossæ measure	lengthwise	.0065
	crosswise	.0050

POLYTHORAX MISSURIENSIS Cope.

Polythorax missuriensis Cope, 1876, Proc. Acad. Nat. Sci. Philadelphia, 1876, p. 258.

This genus and species was described by Cope from the Judith River beds of Montana. From his description, which is quoted below, it would appear to have been founded on ample material.

Char. Gen.—Plastron with contracted fixed lobes and wide bridge; carapace with well-developed marginal bones; mandibular ramus narrow; alveolar face with acute external margin; the symphysis neither produced nor recurved. Dermal scuta everywhere distinct, those of the plastron the usual ones, with the addition of the two marginal intergulars, and two large interhumerals. The latter scuta are separated from the humerals by sutures running parallel with the humeral margin of the anterior lobe between the gular and pectoral scuta.

In the possession of interhumeral scuta, *Polythorax* differs from any known genus of *Testudinata*. The general structure is much like that of *Adocus* and *Baëna*, with nearer resemblance to the latter in its double intergular scuta. It is impossible to ascertain whether there are intersternal bones, as the plastron is ossified throughout.

[a] Ottawa Naturalist, vol. 15, p. 63, Pls. III–VI, and Cont. Canadian Palæont., vol. 3, pt. 2, 1902, p. 39, Pl. II.

[b] Bull. U. S. Geol. Survey No. 179, 1902, p. 445.

The presence or absence of intermarginal scuta can not yet be determined, although it is clear, that if existing, their position is quite external.

This genus is interesting as connecting in its stratigraphical position allied types of Cretaceous No. 5 (*Adocus*), with those of the Wahsatch and Bridger Eocenes (*Baëna*).

Char. Specif.—Carapace with openly dentate posterior border. The surface is irregularly swollen, especially on the median line near the margins of the vertebral scuta. The vertebral scuta are wide, the costals short, and the marginals narrow. The anterior lobe of the plastron is a little shorter and more contracted than the posterior; its base is narrower than the antero-posterior extent of the bridge. Its extremity is rounded, while that of the posterior lobe is truncate with rounded angles. The gular and intergular scuta are each wider than long, while the interhumerals are much longer than wide. The humerals are narrow, while the pectorals are wide from the anterior position of the pectero-humeral suture. Each anal scutum is longer than wide.

The surface of the plastron is obsoletely but coarsely rugose; the roughness greatest anteriorly, where it consists of short raised lines irregularly disposed.

Measurements.

	M.
Length of plastron	0.183
Length of anterior lobe	.049
Length of bridge	.076
Width of bridge	.076
Width of extremity of posterior lobe	.035
Thickness of inguinal region	.010

From our present knowledge concerning the stratigraphic position of the Judith River beds it is evident that Cope was in error in supposing that this genus was intermediate between certain forms (*Adocus*) from the Fox Hills (Cretaceous, No. 5) and others pertaining to the genus *Baëna*, from the Wasatch and Bridger Eocenes.

BAËNA ANTIQUA Lambe.

Baëna antiqua Lambe, Cont. Canadian Palæont., vol. 3, pt. 2, 1902, p. 44.

This species is founded on portions of carapace and plastron, probably pertaining to a single individual, from the Judith River beds of the Red Deer River, Canada. Lambe's description of the species is as follows:

What is preserved of the carapace is in an excellent state of preservation. Five neurals in all are represented, with five pairs of costals. The sutures are sinuous and fine, but can be traced with ease. The sulci are very distinct.

The neurals are rather irregular in shape and of nearly equal size. The costals partake of the same irregularity of outline. The outer surface is almost smooth, the only unevenness being due to a few striations and depressed, roughened markings erratically disposed. Striations also occur at right angles to the sutures, forming an obscure border sculpture. The vertebral shields are broader than long, more especially the first one. The rib heads are well developed. There is a strong and abrupt thickening in the axillary region, but elsewhere the shell is thin. The anterior border is evenly rounded.

The front end of the plastron is rather broad in proportion to the length of its component parts, of which the epiplastrals, the entoplastral, and small portions of the hypoplastrals are preserved. The entoplastral, seen from below, is diamond shaped, a little broader than long, and placed far forward on account of the shortness of the

suture between the epiplastrals in front. Seen from above, or within, the entoplastral is much longer than broad, its breadth being reduced and its posterior half being prolonged backward. Similar extensions of the posterior border also occur in the upper surface of the epiplastrals. Sulci, as indicated in the figure, define the boundaries of the gular and intergular shields.

BAËNA HATCHERI Hay.

Baëna hatcheri Hay, Annals Carnegie Museum, vol. 1, p. 325.

The type of the present species was described by Hay from the Laramie deposits of Converse County, Wyo. It has been reported by Lambe[a] from the Judith River beds of Canada. Considering the difference in size, the variation shown in the different elements of the plastron as figured and described by Lambe, and the difference in stratigraphic position, there can be little doubt that Lambe was in error in referring his material to the present species, which may therefore be very properly excluded from the known species of the Judith River fauna. The material referred by Lambe to *B. hatcheri* should either be included in *B. antiqua* or made the type of a new species.

NEURANKYLUS EXIMIUS Lambe.

Neurankylus eximius Lambe, Cont. Canadian Palæont., vol. 3, pt. 2, 1902, p. 42.

This genus and species is based on portions of the posterior half of a carapace from the Judith River beds of Montana. According to Lambe, "the great development of the last neural by apparent coalescence with a suprapygal, the resulting compression of the pygal region, and the addition of a ninth pair of bones to the series of costals form a combination of characters that is both interesting and unique." The genus is considered by its author to show "greater affinity to the Chelydridæ than to any other group."

In addition to the forms mentioned above, Osborn[b] has mentioned *Compsemys victus* Leidy and *C. obscurus* Leidy as occurring in the Cretaceous of Montana, which might be taken as evidence that they also are Judith River forms. In no descriptions of either of these species can I find any suggestion that remains of either have been described from Montana. The types of both were from the Cretaceous near Long Lake, on Missouri River below Fort Clarke.

From the above remarks concerning the turtles of the Judith River beds it will be seen that while several of the included species have been founded on very fragmentary material, a few of them have been based on fairly complete specimens of either the carapace or plastron, or both. While some of the genera mentioned, like *Baëna* and *Adocus*, are of such persistent types that they may be considered, at present at least, as of comparatively little value for purposes of correlation, nevertheless when the chelonian fauna of these beds is known from more

[a] Cont. Canadian Palæont., vol. 3, pt. 2, 1902, p. 43.
[b] Ibid., p. 12.

complete material and is thoroughly studied it will doubtless prove to be quite different from that of the Laramie.

RHYNCOCEPHALIA.

CHAMPSOSAURUS Cope.

Champsosaurus Cope, Proc. Acad. Nat. Sci. Philadelphia, 1876, p. 348.

This genus was described by Cope from material consisting for the most part of detached and scattered vertebræ from the Judith River and Claggett beds of Montana. Vertebræ pertaining to representatives of the genus are common almost everywhere in the Judith River beds. They are perhaps the most abundant of the vertebrates of these beds. The vertebræ are easily recognized, though, as a rule, only the centra are preserved. These are biconcave or amphiplatyan, slightly keeled below and flat above, with a broad rib facet situated on the upper border and at about the middle of the centrum. Cope has distinguished four species of *Champsosaurus* from remains found in these beds.

CHAMPSOSAURUS PROFUNDUS Cope.

Champsosaurus profundus Cope, Proc. Acad. Nat. Sci. Philadelphia, 1876, p. 350.

This, the type species of the genus, was founded on a cervical, three dorsals, and a sacral, presumably from the same individual, from the Judith River beds. Distinguished chiefly by the great development of the inferior keel.

CHAMPSOSAURUS ANNECTENS Cope.

Champsosaurus annectens Cope, Proc. Acad. Nat. Sci. Philadelphia, 1876, p. 351.

In describing this species Cope remarks that "the greater number of vertebræ obtained belong to this saurian, which may therefore be looked upon as the type of the genus." Since, however, the preceding species was described first, it would perhaps be better to follow the regular rule in such cases and regard it as the type of the genus, as was done by Hay in his Catalogue of American Fossil Vertebrates. The species is founded on several vertebræ, of which Cope remarks: "I can not certainly connect the vertebræ of a series as those of a single individual."

This species has been reported by Lambe[a] from the Judith River beds of Canada.

CHAMPSOSAURUS BREVICOLLIS Cope.

Champsosaurus brevicollis Cope, 1876, Proc. Acad. Nat. Sci. Philadelphia, 1876, p. 352.

This species is founded on a single cervical vertebra, of which Cope remarks as follows:

The evidence for the existence of this species must be allowed to rest at present on a cervical vertebra, with free hypapophysis. This body differs from the corresponding

[a] Cont. Canadian Palæont., vol. 3, pt. 2, 1902, p. 45.

one in the *C. annectens* in its greater brevity as compared with its length. The vertical and transverse diameters exceed the longitudinal in the *C. brevicollis*, while in the *C. annectens* the length exceeds both. The inferior aspect of this centrum is broadly rounded, not carinate as in *C. annectens*. The value of this character is uncertain, but a centrum similarly rounded below (above alluded to) has the more elongate form of the *C. annectens*.

CHAMPSOSAURUS VACCINSULENSIS Cope.

Champsosaurus vaccinsulensis Cope, 1876, Proc. Acad. Nat. Sci. Philadelphia, 1876, p. 353.

This species is founded on a single vertebra. It is defined by Cope as follows:

This reptile is indicated by a posterior dorsal vertebra in which the common base of the neural arch and diapophysis is decurved to below the middle of the side of the centrum. This surface has somewhat the outline of the section of a T-rail, the inner portion being on the superior face of the centrum. The centrum is shorter than the corresponding ones of the *C. annectens* and *C. profundus*, so that the basis of the neural arch approaches near the borders of the articular faces above. The centrum is perforated by two vertical foramina as in most *Sauropterygia*. The osseous tissue of the bone is quite dense and the surface is smooth.

Measurements.

		M.
Diameter of centrum.	antero-posterior	0.026
	vertical	.029
	transverse	.045

Besides the much larger size, this species differs from those previously referred to this genus in almost all details of proportion, etc.

From Cope's description of the vertebra which constitutes the type of this species it would appear not unlikely that it pertains to a genus distinct from *Champsosaurus*, though from the nature of the type it must be evident to all that it is impossible to properly define either the genus or the species to which it pertains.

Of the three preceding species of *Champsosaurus* it may be remarked that, while it is more than probable that several species pertaining to this genus are represented in the Judith River beds, yet, owing to the fragmentary and disarticulated nature of the remains upon which Cope based his descriptions, he was unable to properly define any of the species, and it would be quite impossible to refer any material with certainty to any of the species described by him. It has yet to be shown that most of the characters mentioned by Cope as distinguishing his species are not present in vertebræ from different regions of the vertebral column in the same individual. Mr. Barnum Brown has been recently engaged in making a study of some most excellent skeletons of *Champsosaurus* collected by himself in the Laramie. When the results of his studies are published we shall doubtless know more of the structure of the Cretaceous rhyncocephalians and be able to arrive at a more definite conclusion concerning the nature and validity

of the various species named by Cope. Owing to the fact that these Judith River forms are known almost exclusively from disarticulated vertebral centra, and considering the usually very simple structure of these throughout the entire vertebral column in this group, it may at present be considered difficult, if not impossible, to distinguish the Judith River forms from one another or from the later Laramie forms. Vertebræ of the character now known to pertain to *Champsosaurus* were first described and figured by Leidy[a] as belonging to *Palæoscincus costatus*. They are now, however, known to have been associated with teeth entirely different from those described and figured as the type of that genus and species.

CROCODILIA.

CROCODILUS HUMILIS Leidy.

Crocodilus humilis Leidy, 1857, Proc. Acad. Nat. Sci. Philadelphia, 1856, p. 73.

This species was founded on a number of teeth from the Judith River beds of Montana. Leidy's original description was as follows:

The species is founded on ten specimens of shed crowns of teeth, apparently of a small species of crocodile. The largest specimen is 7½ lines long and 3½ lines in diameter at base, which is nearly circular. Another specimen is 7 lines long and 2½ lines in diameter at base, and a third specimen is 6 lines long and 3½ lines in diameter at base. These are all moderately curved conical, nearly circular in transverse section, with the two usual internal acute ridges, and with the intervening surfaces slightly striate or nearly smooth. The crown of a posterior tooth is compressed, mammillary in form, 2½ lines long and 2½ wide at base, with the summit obtuse, and the sides finely and longitudinally rugose.

From the above description it will readily appear that the simple conical teeth upon which the species was based furnish no characters for the positive identification of other material.

BOTTOSAURUS PERRUGOSUS Cope.

Bottosaurus perrugosus Cope, 1874, Bull. U. S. Geol. and Geog. Surv. Terr., vol. 1, No. 2, p. 26.

This species is founded on "numerous fragments with vertebræ and portions of skull" from Laramie deposits of eastern Colorado.

Lambe[b] has reported this species from the Judith River beds of the Red Deer River in Canada. Considering the fragmentary nature of the type material and the difference in the age of the deposits, Lambe's identification may be incorrect. It would seem better to accept it as only provisional until such time as the Crocodilia of the Judith River beds and the Laramie have been studied from more perfect material.

---

[a] Trans. Am. Philos. Soc., vol. 2, p. 146, Pl. IX.
[b] Cont. Canadian Paleont., vol. 3, pt. 2, 1902, p. 48.

DINOSAURIA.

A number of genera and species of dinosaurs have been proposed by Leidy, Cope, and Marsh, based upon detached teeth from the Judith River beds, although nothing definite is known concerning the nature of the animals to which they pertained. Some of these have been considered as pertaining to the Lacertilia, others to the Dinosauria, and still others to the Mammalia. I shall consider them collectively, however, as doubtfully pertaining to the Dinosauria. They are all founded on such fragmentary material as to be of little value except as bearing evidence of the diversity of the fauna.

TROÖDON FORMOSUS Leidy.

Troödon formosus Leidy, 1857, Proc. Acad. Nat. Sci. Philadelphia, 1856, p. 72; 1860, Trans. Am. Philos. Soc., vol. 11, p. 147, Pl. IX.

This genus and species was founded on the crown of a single tooth from the Judith River beds of Montana. Teeth of very similar size and pattern are not uncommon in the Laramie of Converse County, Wyo. Lambe[a] has reported the genus and species from the Judith River beds of Canada.

DEINODON HORRIDUS Leidy.

Deinodon horridus Leidy, 1857, Proc. Acad. Nat. Sci. Philadelphia, 1856, p. 72; 1860, Trans. Am. Philos. Soc., vol. 11, p. 143.

This species was originally founded on a number of detached teeth from the Judith River beds, evidently pertaining to more than one genus and species, as was subsequently recognized by Leidy[b] when he made the more problematical of the teeth at first referred to this genus and species the type of a new genus and species, *Aublysodon mirandus*. The remaining teeth referred by Leidy to the present genus clearly pertain to members of the carnivorous Dinosauria.

AUBLYSODON MIRANDUS Leidy.

Aublysodon mirandus Leidy, 1868, Proc. Acad. Nat. Sci. Philadelphia, 1868, p. 198.

This species was founded on detached teeth from the Judith River beds of Montana. These teeth are variable in size and character. Their nature is problematical. Marsh has suggested that some of the smaller forms might possibly be mammalian. It seems more probable, however, that they are all reptilian and that they pertain to some form of carnivorous dinosaur. In general form the teeth are subconical, flattened on one side and convex on the other, with a rather blunt apex. Teeth of this character are fairly common both in the Judith River beds and the Laramie. Marsh[c] has named without

[a] Cont. Canadian Palæont., vol. 3, pt. 2, 1902, p. 47.
[b] Proc. Acad. Nat. Sci. Philadelphia, 1868, p. 198.
[c] Am. Jour. Sci., 3d ser., vol. 44, 1892, pp. 174 and 175, Pl. III.

describing two species of the present genus, *A. amplus* and *A. cristatus*, from material found "in the Ceratops beds of Montana and Wyoming." Since neither of these species was properly described by Marsh, they may as well be abandoned. While, as remarked above, teeth of the same pattern as those described and figured by Leidy are common in both the Laramie and the Judith River beds, they do not of themselves afford characters of sufficient importance to distinguish either genera or species.

PARONYCHODON LACUSTRIS Cope.

Paronychodon lacustris Cope, 1876, Proc. Acad. Nat. Sci. Philadelphia, 1876, p. 256.

This species was founded on detached teeth with subconic crowns, "one side of which is convex and the other side plane." After a comparison of Cope's description of the present genus and species with Leidy's description and figures of the preceding, it is evident that the teeth described by Cope are of the same form as those described by Leidy. Since Cope's material was derived from the same general locality in the Judith River beds as Leidy's, the last-named genus and species may well be considered a synonym of the first.

ZAPHSALIS ABRADUS Cope.

Zaphsalis abradus Cope, 1876, Proc. Acad. Nat. Sci. Philadelphia, 1876, p. 344.

This species was founded on detached teeth from the Judith River beds of Montana. The meager description given by Cope without figures renders it impossible to certainly identify any of the forms of teeth known from these deposits with those referred to by Cope in his description. It seems probable, however, that his description was based on certain small teeth found not very abundantly in both the Laramie and the Judith River beds and characterized by sharp, compressed crowns, broad at base and pointed above, flat on one side and gently convex on the other, with denticulate posterior and smooth anterior border. The flat surfaces of these teeth are distinctly striated and have the appearance of having been applied to one another in a manner like that of the inner surfaces of the anterior pair of incisors in some rodents. They evidently pertain to the Reptilia, and may represent anterior teeth which occupied a position in the jaw similar to that of the incisors in certain Mammalia. Their exact nature must, however, for the present at least, remain uncertain.

THEROPODA.

DEINODON Leidy.

Deinodon Leidy, 1857, Proc. Acad. Nat. Sci. Philadelphia, 1856, p. 72.

Cope[a] has pointed out that *Deinodon* Leidy was essentially preoccupied by *Dinodon*, applied by Dumferil in 1853 to a genus of reptiles. Cope by reason of this substituted the genus *Lælaps*,[b] founded in 1866 on material from the Greensands of New Jersey, overlooking the fact, later pointed out by Marsh[c], that *Lælaps* was also preoccupied, having been applied by Koch in 1835 to a genus of Arachnida. At the same time Marsh proposed the generic name *Dryptosaurus* to replace *Lælaps*. Considering that Leidy's spelling of the name *Deinodon* differed from that of Dumferil, not a few naturalists would be in favor of retaining the former as a good generic name. It is retained here for those carnivorous dinosaurs with teeth after the pattern of those to which it was restricted by Leidy in 1859. Should this name be abandoned as preoccupied it would perhaps be best to give to these Judith River carnivorous dinosaurs a new generic name rather than to refer them to *Dryptosaurus*, founded, as we have seen, on material from the New Jersey Greensands.

Besides the type species, *D. horridus*, already mentioned as having been described by Leidy from detached teeth from the Judith River beds of Montana, a number of other specific names have been proposed, more especially by Cope, for fragmentary remains from these deposits. These so-called species have been referred sometimes to the present genus, sometimes to *Lælaps*, *Aublysodon*, *Dryptosaurus*, etc. I shall refer to them all under the present genus.

DEINODON LATERALIS (Cope).

Aublysodon lateralis Cope, 1876, Proc. Acad. Nat. Sci. Philadelphia, 1876, p. 248.

This species is founded on detached teeth from the Judith River beds of Montana. From Cope's description of this species it is evident that the teeth upon which it is based belonged to the genus *Deinodon* rather than *Aublysodon*, as those genera were restricted by Leidy. Considering the heterodont nature of the teeth in those carnivorous dinosaurs, it is doubtful if the present species is distinct from the type of the genus.

DEINODON INCRASSATUS (Cope).

Lælaps incrassatus Cope, 1876, Proc. Acad. Nat. Sci. Philadelpia, 1876, p. 248.

This species was founded on "two teeth, a larger and a smaller, which were found near each other, but not sufficiently so as to war-

[a] Trans. Am. Philos. Soc., vol. 14, 1870, p. 117.
[b] Proc. Acad. Nat. Sci. Philadelphia, 1866, p. 276.
[c] Am. Jour. Sci., 2d ser., vol. 14, 1877, p. 88.

rant the belief that they pertain to the same individual." These teeth are probably from near the anterior and posterior extremities of the series in some representative of *D. horridus* Leidy.

DEINODON EXPLANATUS (Cope).

Lælaps explanatus Cope, 1876, Proc. Acad. Nat. Sci. Philadelphia, 1876, p. 249.

This species was founded on numerous teeth of an apparently small carnivorous dinosaur from the Judith River beds of Montana. So far as it is possible to determine its characters from the teeth alone, it appears to be quite distinct from any of the others. Teeth similar in character to those described by Cope are common in both the Judith River beds and the Laramie. Cope has described the crowns of these teeth as "strongly compressed and curved; one side is flat, the other gently convex." It is probable that the teeth described by Cope occupied a median position in the jaw and that the flat surface was the inner.

DEINODON FALCULUS (Cope).

Lælaps falculus Cope, 1876, Proc. Acad. Nat. Sci. Philadelphia, 1876, p. 249.

This species is founded on several teeth from the Judith River beds of Montana. According to Cope, they are of about half the size of those of the last-mentioned species and are relatively shorter, stouter, and less sectorial in character. They may represent anterior teeth of that species.

DEINODON HAZENIANUS (Cope).

Lælaps hazenianus Cope, 1876, Proc. Acad. Nat. Sci. Philadelphia, 1876, p. 343.

This species is founded on seven detached teeth from different localities. Teeth of the character of those described by Cope are not uncommon in both the Laramie and the Judith River beds. They appear to pertain to the anterior dentition of some of these carnivorous dinosaurs, probably of *D. horridus*.

DEINODON LÆVIFRONS (Cope).

Lælaps lævifrons Cope, 1876, Proc. Acad. Nat. Sci. Philadelphia, 1876, p. 344.

This species is founded on a single tooth from the Judith River beds of Montana. It is distinguished by the absolutely smooth character of the anterior edge, a character of doubtful value.

DEINODON CRISTATUS (Cope).

Lælaps cristatus Cope, 1876, Proc. Acad. Nat. Sci. Philadelphia, 1876, p. 344.

This species is founded on detached teeth from the Judith River beds resembling those of *Troödon* in character and size, and possibly pertaining to that genus.

ORNITHOMIMUS Marsh.

Ornithomimus Marsh 1890, Am. Jour. Sci., 3d ser., vol. 34, p. 84.

The present genus was based upon material from the Laramie (Denver) beds of eastern Colorado. Other species referred to the same genus by Marsh were secured in Cretaceous deposits in the Judith River region of Montana.

ORNITHOMIMUS TENUIS Marsh.

Ornithomimus tenuis Marsh, 1890, Am. Jour. Sci., 3d ser., vol. 34, p. 85.

This species is founded on a portion of a third metatarsal from the Judith River beds of Montana.

ORNITHOMIMUS GRANDIS Marsh.

Ornithomimus grandis Marsh, 1890, Am. Jour. Sci., 3d ser., vol. 34, p. 85.

This species is founded on fragments representing a considerable portion of a skeleton from the Eagle sandstones near the mouth of Cow Creek, opposite Cow Island, on the north side of Missouri River, Montana. This species, which is much the largest of this genus, has been erroneously referred to the Judith River beds. Our researches in the season of 1903 demonstrated conclusively that the sandstones from which it was obtained belong to the Eagle formation and pertain to a horizon decidedly older than the Judith River beds. Hereafter it should be referred to the Eagle formation. It was a reptile of enormous proportions. The third metatarsal, according to Marsh, has a length of 600 mm., and was 90 mm. in transverse and 80 mm. in antero-posterior diameter at its distal extremity.

ORNITHOMIMUS ALTUS Lambe.

Ornithomimus altus Lambe, 1902, Cont. Canadian Palæont., vol. 3, pt. 2, p. 50.

This species is based on considerable portions of the skeleton from the Judith River beds of the Red Deer River region in Canada. According to Lambe's description of the species, the type may be considered as consisting of "a complete hind limb (including the foot), the phalanges of the left foot in place, a pubic bone, and an ischium, of one individual (No. 930 Can. Geol. Survey)." The present species appears, from Marsh's very meager description, to be very closely related to, if not identical with, that of *O. tenuis* Marsh, based upon material from the same beds in Montana.

Although the genus *Ornithomimus* represents the most highly specialized theropod dinosaurs found in these beds, they are at present represented in our various museums by such meager material that it is as yet quite impossible to determine many of the more important characters of the genus or to satisfactorily compare the various species with one another. Whenever by the discovery of more

perfect material it shall become possible to make comparative studies of the various species of Ornithomimidæ now reported from the Eagle formation, the Judith River beds, and the Laramie, they will doubtless prove to exhibit many anatomical differences, perhaps even of generic importance, and show various degrees of specialization which are at present not discernible.

PREDENTATA.

STEGOSAURIA.

PALÆOSCINCUS COSTATUS Leidy.

Palæoscincus costatus Leidy, 1857, Proc. Acad. Nat. Sci. Philadelphia, 1856, p. 72.

In proposing the genus and species Leidy remarks as follows:

The genus and species is founded on a single specimen of a tooth of a lacertian, discovered by Doctor Hayden.

The crown of the tooth is palmate, with eight radiating costæ terminating at the margin in more or less developed points. The fang is flattened, cylindrical, and is hollow; and it expands into a ridge surrounding the base of the crown. Breadth of the crown 4 lines, length 2½ lines; width of the fang 2 lines, thickness 1 line. Whole length of the specimen 4 lines.

This tooth was subsequently figured and described[a] in greater detail by Doctor Leidy. In this description it was provisionally associated with certain vertebræ now known to belong to the rhyncocephalian genus *Champsosaurus*.

Teeth of the same general form and pattern as that described and figured by Leidy are common in the Judith River beds and the Laramie. As yet they have only been found detached, so that nothing is positively known as to the nature of the animals to which they belonged. On account of their close resemblance to the teeth of stegosaurian reptiles from the Jurassic, they have been very generally considered as pertaining to representatives of the Stegosauridæ.

Lambe[b] has reported this species from the Judith River beds of the Red Deer River region in Canada. We found teeth not specifically distinguishable at various localities both in Canada and in Montana.

PALÆOSCINCUS ASPER Lambe.

Palæoscincus asper Lambe, 1902, Cont. Canadian Palæont., vol. 3, pt. 2, p. 54, Pl. XVII.

This species is founded on the crown of a single tooth from the Judith River beds of the Red Deer River region in Canada. According to Lambe, the present species is distinguished as follows: "The serrations are more numerous, the sides more conspicuously ridged, whilst the double row of denticles at one end of the cutting edge, besides being novel, is most interesting and instructive, in that it is

[a] Trans. Am. Philos. Soc., vol. 11, 1860, p. 146, Pl. IX.
[b] Cont. Canadian Palæont., vol. 3, pt. 2, 1902, p. 53.

suggestive of a progressive step toward the development of a double row of tubercles such as is found in the molars of the Multituberculates." I am of the opinion that the characters mentioned above may be due to age or the position occupied by the tooth in the jaw, rather than to any specific distinction.

STEREOCEPHALUS TUTUS Lambe.

Stereocephalus tutus Lambe, 1902, Cont. Canadian Palæont., vol. 3, pt. 2, p. 55, Pls. XI, XII, XXI.

The present genus and species has been described by Lambe from remains pertaining to several individuals, for the most part found dissociated in the Judith River beds of the Red Deer River region in Canada. Lambe's description was based on material believed by him to represent parts of the skull, the ribs, teeth, dermal scutes, and spines or plates. He refers the genus to the Stegosauridæ, and it appears more than probable that the tooth figured by him in the text may pertain to some member of that family, though it remains to be shown that it is distinct from the previously mentioned genus. This tooth certainly resembles very closely a large and worn tooth of *Palæoscincus*.

The fragment of skull, together with the five-keeled bony scutes found in connection with it, may or may not pertain to the same genus as the tooth and detached dermal plate. There is considerable evidence, however, for referring them to the Crocodilia rather than the Dinosauria. Scutes very similar to those figured and described by Lambe, though of much smaller size, are common in the living cayman and other members of the Crocodilia, while remains of crocodiles of gigantic size are known to occur in the Judith River beds. It seems not impossible, therefore, that remains of reptiles pertaining to two distinct orders have been associated in the description of this genus.

CERATOPSOIDEA.

CERATOPSIDÆ.

Marsh[a] proposed the family name Ceratopsidæ, from the genus *Ceratops*, to include a group of quadrupedal horned herbivorous dinosaurs from the Judith River beds and the Laramie. This family included, perhaps, the most highly specialized members of the predentate dinosaurs. It reached its culmination in the Laramie, where it was represented by numerous individuals pertaining to several genera and species. In Judith River times, however, the family had already acquired a marked degree of specialization, and was represented by at least two or three genera and several species pertaining to decidedly more primitive types than the later Laramie forms. At

[a] Am. Jour. Sci., 3d ser., vol. 36, 1888, p. 478.

present two genera are clearly recognizable among the remains of Judith River Ceratopsidæ. A number of other genera supposed to belong to this family have been referred to these beds. Some of these genera are based on such fragmentary material that it is quite impossible to identify them specifically or to determine their relations. Some genera are known to belong to other families of the Dinosauria, and one or two have been referred by some authors to these beds the types of which it seems more than probable were derived from the Laramie, although no definite statement was made by their author as to their geographic or stratigraphic position beyond the fact that they were from the Laramie. This assertion might now be taken as meaning anywhere from the base of the Judith River beds to the top of the Fort Union.

DYSGANUS Cope.

Dysganus Cope, 1876, Proc. Acad. Nat. Sci. Philadelphia, 1876, p. 250.

The present genus was the first to be proposed for these dinosaurs. Unfortunately it was based on such imperfect material that Cope was unable to describe it in such a manner that it can be identified with certainty. The genus was founded on a number of detached teeth pertaining both to members of the present family and to the Trachodontidæ, a family of bipedal dinosaurs common also in the Judith River beds. Cope proposed four species based upon the remains of teeth referred to *Dysganus*. Since all of these species are unidentifiable, it is only necessary to mention them in this connection. They are as follows: *Dysganus bicarinatus*, *D. encaustus*, *D. haydenianus*, *D. peiganus*.

MONOCLONIUS Cope.

Monoclonius Cope, 1876, Proc. Acad. Nat. Sci. Philadelphia, 1876, p. 255.

This is perhaps the best known dinosaurian genus from the Judith River beds. Although distinguished chiefly by its cranial characters, the remainder of the skeleton is also fairly well known. Altogether seven species have been referred to this genus—four by Cope and three by Lambe. After a careful study of the remains upon which these various species were based, it is evident that they pertain to more than one genus.

Considering *Monoclonius crassus* Cope, the first species described, as the type of the genus and basing our diagnosis of the genus upon the material used by Cope in defining this species, the present genus may be distinguished by the following characters: Parietals perforated by lateral fontanelles of moderate dimensions separated by a broad, thin, median parietal bar. Sutures for squamosals much abbreviated, indicative of short and proportionally broad squamosals. Supraorbital horn cores very short, straight, and triangular in cross section. Nasal horn long and curved backward.

MONOCLONIUS CRASSUS Cope.

Monoclonius crassus Cope, 1876, Proc. Acad. Nat. Sci. Philadelphia, 1876, p. 255.

This species is founded on a sacrum, several vertebræ, limb bones, portions of skull, teeth, etc., from the Judith River beds of Montana. Owing to the imperfect nature of the material, together with the unusual form of some of the elements, which are so strikingly different from those in all other known reptiles, Cope's description of this species was erroneous in many respects, as will appear from the following quotation:

> Sacrum with ten vertebræ, the last centrum much compressed, the dyapophyses extending horizontally from the neural arch above, and connected by a vertical lamina with the iliac supports; length, 27.33 inches. The bones of the limbs are robust, the hinder the longer, but not so much so as in some other genera. Length of femur, 22 inches; greatest diameter, proximally, 8 inches; distally, 7.25 inches. The three anterior dorsal vertebræ are coossified, and the first exhibits a deep cup for articulation with the preceding vertebra. The episternum is a T-shaped bone, thin and keeled on the median line below. Length of transverse portion, 21 inches.

The three coossified vertebræ are now known to be the anterior cervicles instead of the dorsals, while the "episternum" is in reality the parietal. Cope's description of the teeth and their method of replacement is likewise erroneous. The teeth in the present genus, instead of resembling those of *Hadrosaurus* and being replaced from in front as in that genus as stated by Cope, differ markedly from the teeth in any of the bipedal dinosaurs. The crowns of the teeth in *Monoclonius*, as in all the Ceratopsidæ, are compressed and acuminate, There is a strong median vertical keel on the external wall in the upper teeth and a similar one on the internal wall of the lower teeth. In the unworn teeth the opposite walls of both the inferior and the superior teeth present a broad keel. The teeth are replaced from beneath and not from the "front," as in *Hydrosaurus*. All the adult teeth, save, perhaps, those at either extremity of the dental series, are two rooted.

MONOCLONIUS DAWSONI Lambe.

Monoclonius dawsoni Lambe, 1902, Cont. Canadian Palæont., vol. 3, pt. 2, p. 57, Pl. XVI, XIX, XX.

This species is founded on a considerable portion of a skull from the Judith River beds of Canada. The type (No. 1173, Can. Geol. Survey) consists of a very fragmentary skull with large and somewhat compressed nasal horn core curved backward, ovate in cross section with the broad end of the oval directed anteriorly. The orbit is nearly circular, and there still remains in the type the base of a small rudimentary supraorbital horn core, notwithstanding Lambe's statement that it shows no trace of a horn core. This rudimentary horn core is flattened on its external surface as in the cotype of *Monoclonius crassus* Cope. The apex of this horn is wanting in the present specimen. A

fragment of the parietal is preserved, showing three or four of the marginal undulations. These resemble those seen in the type of *Monoclonius crassus* Cope, and I am inclined to regard the present species as closely allied to, if not identical with, the *M. crassus* of Cope. The nasal horn and orbit are very large when compared with the occipital condyle, the maxillaries, and the quadrate.

The peculiar parietal associated by Lambe with the type of *M. dawsoni* may be regarded as pertaining to a distinct species and perhaps also to a distinct genus. The median parietal bar is very heavy and deeply emarginate posteriorly, where on either side it gives off an elongated process which is pointed and curves inward and slightly downward. The bases of these processes are separated from one another by a distance of 300 mm. They are each 109 mm. in length, have a breadth of 112 mm. at the base, and a thickness of 30 mm. They are acutely pointed, have rugose surfaces with deep vascular grooves, and in life were evidently ensheathed in horn. The posterior border of the parietal between the bases of these processes is very thick and rounded. On the superior surface, in the middle just in front of the posterior border, there is a rather deep concavity. The median bar of the parietal is very thick throughout its entire length. Its superior surface is marked by a number of very gentle elevations; it is rugose and shows shallow vascular impressions. Besides the processes already mentioned as present on the posterior portion of the parietals, there is on either side a series of seven emarginations on the parietal borders, separated by as many prominences. The posterior of these prominences are the larger, and they each bear evidence of having supported a distinct epoccipital bone during the life of the animal, save perhaps the two anterior, which appear to have been overlapped by the squamosal, since the parietal in this region presents a rather distinct sutural surface for contact with the squamosal. The parietals on either side of the median bar present a large fontanelle, and the margin of bone inclosing this is very thin. These fontanelles have a length of 292 mm. and a breadth of 254 mm. The parietal bar is concave on its inferior surface, and more especially anteriorly. At its anterior extremity it presents a number of cavities and articulates with the postfrontals.

One-half of a horn core, split longitudinally and found with this peculiar parietal (No. 971, Can. Geol. Survey) referred by Lambe, though I think erroneously, to *M. dawsoni*, appears to represent one-half of a nasal horn of the type described by Cope as *M. sphenocerus*. Owing to the imperfect nature of this specimen it is not possible to determine positively whether it represents a nasal or a supraorbital horn core. It seems more than probable that this type of parietal was associated with a nasal horn similar to that of *M. sphenocerus*. If the horn core should prove to be a supraorbital the evidence would be equally in favor of excluding it and the associated parietals

from the present species, whose very rudimentary supraorbital horn core is widely different. It seems quite probable that this peculiar parietal may pertain to *M. sphenocerus*. From the nature of the associated horn core it can not pertain to *M. dawsoni*.

MONOCLONIUS SPHENOCERUS Cope.

Monoclonius sphenocerus Cope, 1889, Am. Naturalist, vol. 23, p. 716, Pl. XXXIII.

This species is founded on a premaxillary, a nasal, and a nasal horn core from the Judith River beds. The nasal horn core of the present species is the largest and most powerful observed in the Ceratopsidæ. It is perfectly straight and was directed upward and slightly backward. The anterior border is sharp throughout its entire length; the posterior is broadly rounded. No other portions of the skull are associated with the type, so that it is impossible to determine from it the character of the frill or parietal crest. As stated above, a portion of a horn core found associated with the peculiar parietal referred by Lambe to *M. dawsoni* resembles the nasal horn of the present species, and it is not improbable that the parietal figured and described by Lambe pertains to the present species rather than to *M. dawsoni*. If so, this would seem to emphasize the distinctive characters of the present species, which might then even be considered as generically distinct from the other known species.

MONOCLONIUS FISSUS Cope.

Monoclonius fissus Cope, 1889, Am. Naturalist, vol. 23, p. 717.

This species is founded on an imperfect pterygoid described as a squamosal. The type is not sufficient to afford an adequate description of the species, and the latter should be abandoned.

The three remaining species referred by their authors to this genus are here regarded as pertaining to the next genus.

CERATOPS Marsh.

Ceratops Marsh, 1888, Am. Jour. Sci., 3d ser., vol. 36, p. 477, Pl. II.

This genus was founded on an occipital condyle and a pair of supraorbital horn cores from near the summit of the Judith River beds in Montana. The horn cores toward the top are nearly circular in cross section instead of being flattened on the external side as in *Monoclonius* Cope. They are much longer than in the type of that genus and are somewhat curved, though not so much so in *C. montanus* Marsh, the type species, as in some of the other forms here referred to this genus. Combining the characters shown by the types of the several species referred to the present genus, it may be defined as follows: Parietals reduced to a narrow median bar and slender posterolateral processes, inclosing on either side large elongated parietal fontanelles. External branches of parietals overlapped by the elongated

and triangular squamosals. Supraorbital horn cores well developed, circular in cross section except near the base, and curving backward and outward. Nasal horn core strong and curved forward instead of backward as in *Monoclonius*.

CERATOPS MONTANUS Marsh.

Ceratops montanus Marsh, 1888, Am. Jour. Sci., 3d ser., vol. 36, p. 477, Pl. II.

This, the type species of the genus, was founded, as stated above, on an occipital condyle and a pair of supraorbital horn cores from the Judith River beds of Montana. The elongate supraorbital horn cores, circular in cross section, easily serve to distingush the present genus and species from *Monoclonius crassus*, and subsequent discoveries have shown that this type of horn core was associated with other distinctive cranial characters of still greater importance.

CERATOPS RECURVICORNIS (Cope).

Monoclonius recurvicornis Cope, 1889, Am. Naturalist, vol. 23, p. 716, Pl. XXXIV [XXIV].

The species is founded on nasal and supraorbital horn cores and other parts of the skull pertaining to the same individual from the Judith River beds of Montana. The forward curve of the nasal horn, the presence of a rudimentary horn on the surface of the frontals a little in advance of the orbit, and the well-developed supraorbital horn cores are characteristic of this species. Owing to the immature age of the individual to which the type pertained, the supraorbital horn cores have not assumed their adult form and appear somewhat intermediate between those forms which are characteristic of *Ceratops* and those found in *Monoclonius*, though they are decidedly nearer that of the former genus.

CERATOPS CANADENSIS (Lambe).

Monoclonius canadensis Lambe, 1902, Cont. Canadian Palæont., vol. 3, pt. 2, p. 63, Pls. XVII, XVIII.

This species is founded on a portion of a skull and a lower jaw. With the skull there is a nasal without the horn, erroneously considered by Lambe as a jugal part of the frontal region with the horn, a squamosal, and a portion of the slender external bar of the parietal. The supraorbital horn core in the present species is well developed, circular in cross section, and curves backward, all of which characters readily distinguish it from the short triangular horn cores of *Monoclonius*. The long triangular squamosal is quite different from that which the squamosal suture of the parietal would indicate as having been present in the latter genus. The fortunate discovery made by Mr. Lambe in the Judith River beds of Canada, in which he found the type of the present species, fixes with reasonable certainty the character of parietal and squamosal that were associated with the type of supraorbital horn seen in *Ceratops montanus*.

CERATOPS BELLI (Lambe).

Monoclonius belli Lambe, 1902, Cont. Canadian Palæont., vol. 3, pt. 2, p. 66, Pl. XX.

This species is founded on a portion of a parietal from the Judith River beds of Canada. The portion of parietal found in place with the squamosal in the type of the preceding species is of such a character as to render it more than probable that the present species is not specifically distinguishable from *C. canadensis*, as will appear from the following quotation taken from Lambe's description of the squamosal of *Ceratops canadensis*.

> The lower surface near and parallel to the inner posterior end is broadly and shallowly grooved for the reception of a long, slender bone, triangular in section, that projects backward and inward, its outer edge continuing the curve of the squamosal. Probably this slender bone represents the anterior end of a forwardly bent, side extension of the parietal, such as occurs in the species *Monoclonius belli*.

The type of the present species would seem, therefore, to be of more value as furnishing direct evidence as to the character of the parietals in the genus *Ceratops* than as representing a new species.

CERATOPS PAUCIDUS Marsh.

Ceratops paucidus Marsh, 1889, Am. Jour. Sci., 3d ser., vol. 37, p. 336; 1890, Am. Jour. Sci., 3d ser., vol. 39, p. 83.

Founded on a fragmentary maxillary and premaxillary from the Judith River beds of Montana. These remains may very well pertain to some one of the species of Ceratopsidæ previously described. It can not certainly be determined whether they belong to *Ceratops* or to *Monoclonius*. Owing to the uncharacteristic nature of the type material, Marsh was unable to properly define the species, and it would be better to abandon it as a nomen nudum.

Besides the above-mentioned genera and species of Ceratopsidæ based on material from the Judith River beds there remain to be considered a number of others erroneously referred by some authors to this family.

STEGOCERAS VALIDUS Lambe.

Stegoceras validus Lambe, 1902, Cont. Canadian Palæont., vol. 3, pt. 2, p. 68, Pl. XXI.

This species is based on two anomalous bones from the Judith River beds of Canada. Although both these elements were referred by Lambe to a single species which he placed in the Ceratopsidæ, it is evident upon examination that they pertain to two different species and belong to another family. Lambe says of these elements: "It is probable that these bones were situated in the median line of the head, in advance of the nasals." It seems more probable, after a careful study of them, that they represent the roof of the brain case and the frontal region of the skull of some unknown reptile. For the exact determination of their homologies and the nature of the reptile to which they belonged we must await the discovery of more complete material.

MONOSPONDYLUS GIGAS Cope.

Monospondylus gigas Cope, 1892, Am. Naturalist, vol. 26, p. 757.

This species is based on two detached vertebral centra from the Cretaceous of South Dakota, referred by Cope to the Ceratopsidæ, but now known to pertain to the Theropoda. The present genus and species are referred to in this connection on account of their having been erroneously included by Osborn[a] in his list of genera and species from the Cretaceous of Montana. In showing these vertebræ to the writer Cope stated definitely that they were from the Laramie of South Dakota.

CLAORHYNCHUS TRIHEDRUS Cope.

Claorhynchus trihedrus Cope, 1892, Am. Naturalist, vol. 26, p. 757.

This species is based on a rostral and predentary presumably from the Laramie of South Dakota, although it is included by Osborn in his list from Montana. It has been referred by Cope to the Ceratopsidæ, but the parts described differ materially from the same elements in any known member of that family. From Cope's description they would appear to resemble more nearly the predentary and premaxillary of some member of the Trachodontidæ. The types are not accessible and their nature and relations can at present only be judged by the description given by Cope. Unfortunately Cope omitted to state where they were found and nothing is positively known concerning either their geographic or their stratigraphic position.

ORNITHOPODA.

TRACHODONTIDÆ.

TRACHODON Leidy.

This genus is perhaps more abundant than any other dinosaurian genus of the Judith River beds. Altogether five or six species, more or less distinct, have been described, while an equal number of species have been referred to other genera, some of which may prove to belong to *Trachodon*. Unfortunately the genus *Trachodon* and its included species, as well as the allied genera and species from the Judith River beds, are all based on such fragmentary material as to render their identification uncertain.

TRACHODON MIRABILIS Leidy.

Trachodon mirabilis Leidy, 1857, Proc. Acad. Nat. Sci. Philadelphia, 1856, p. 72.

Leidy states that this species is "founded upon specimens of teeth, generally very much worn and in a fragmentary condition." Although the trachodonts are easily distinguishable by their teeth from the

[a] Cont. Canadian Palæont., vol. 3, pt. 2, 1902, p. 15.

other Dinosauria of these beds, it is scarcely possible to identify the various species of this genus or the genera of the family from the teeth alone, although Lambe[a] has ventured to do so. The type of the present species was from the Judith River beds of Montana.

TRACHODON BREVICEPS (Marsh.)

Hadrosaurus breviceps Marsh, 1889, Am. Jour. Sci., 3d ser., vol. 37, p. 335.

This species is founded on a portion of right maxillary, with teeth in an admirable state of preservation. The label accompanying the specimen states that it is from the Bearpaw Mountains. There is no doubt, therefore, that it is from the Judith River beds. In form and general character the teeth resemble very closely those of *Trachodon selwyni* Lambe from the Judith River beds of Canada, as will be seen by a comparison of the figures published by Marsh and Lambe.

TRACHODON SELWYNI Lambe.

Trachodon selwyni Lambe, 1902, Cont. Canadian Palæont., vol. 3, pt. 2, p. 69, Pl. III.

This species is founded "principally on the evidence of teeth," distinguished "from those of *T. mirabilis* Leidy in being rounded oval above instead of terminating in a point." As stated above, in pattern and size the teeth of the present species as figured by Lambe agree very well with those of the type of *T. breviceps*, from the same beds in Montana as figured by Marsh, and it is quite possible that the present species is a synonym of *T. breviceps*.

TRACHODON MARGINATUS Lambe.

Trachodon marginatus Lambe, 1902, Cont. Canadian Palæont., vol. 3, pt. 2, p. 71, Pls. III–X.

This species is based on numerous teeth and remains of the skeleton representing almost all the different elements, for the most part found dissociated in the Judith River beds of Canada. That this species is based on material pertaining not only to different individuals, but to different species, genera, families, and even orders, is clear from a reference to Lambe's figures and descriptions. The ischium figured on Pl. X of his memoir as pertaining to the present species has nothing to do with the present genus, but is the ischium of some member of the Theropoda.

Of the abundant material figured and described by Lambe as belonging to this species, none of it has been designated as the type, and the identification of the species might best be considered as resting upon dental characters alone. On page 77 of his memoir Lambe distinguishes this species by the teeth, which he says are "rounded above, with a marginal sculpture."

[a] Cont. Canadian Palæont., vol. 3, pt. 2, 1902, p. 77.

TRACHODON ALTIDENS Lambe.

Trachodon altidens Lambe, 1902, Cont. Canadian Palæont., vol. 3, pt. 2, p. 76, Pl. IV.

This species is founded on a left maxilla with the teeth from the Judith River beds of Canada. Distinguished by the small, narrow, elongate teeth "beautifully marked for a short distance above the apex of the crown, on the raised edges of the outer enameled face by a few obliquely placed, transversely elongated embossments." The present species appears to represent one of the smaller members of the genus.

PTEROPELYX GRALLIPES Cope.

Pteropelyx grallipes Cope, 1889, Am. Naturalist, vol. 23, p. 904.

This species is based on a considerable portion of a skeleton without skull or teeth, from the Judith River beds of Montana. Distinguished from the preceding genus and species by its more slender proportions, pubis coössified with ischium, four digits in pes, and probably more elongate fore limbs.

Lambe[a] has distinguished the various species of *Trachodon* and *Pteropelyx* as follows:

Comparative table of teeth of species of Trachodon and Pteropelyx.

Trachodon mirabilis Leidy	Teeth pointed above; margins smooth.
Trachodon (Pteropelyx) selwyni Lambe.	Teeth rounded oval above; margins smooth or with the faintest indications of oblique transverse striæ.
Trachodon (Pteropelyx) marginatus Lambe.	Teeth rounded above; with a marginal sculpture.
Pteropelyx grallipes Cope	Teeth rounded above; with a border sculpture.
Trachodon (Pteropelyx) altidens Lambe.	Teeth of small size, long in proportion to the breadth, and pointed above; with a border sculpture near the apex.

In this table Lambe has omitted *Trachodon breviceps* Marsh, which, as I have already remarked, is probably identical with *T. selwyni* Lambe. While in the Trachodontidae, the teeth from various parts of the jaw of the same individual vary greatly in the form and markings, and great care should be taken in determining or proposing species from teeth alone, the teeth have certain characters, such as have been pointed out by Lambe in the above table, by which they may, within certain limits at least, be distinguished specifically. Before accepting such dental characters as distinctive of the various species the cranial and skeletal features associated with each should be determined. If those species founded on dental characters alone are valid, such characters will doubtless prove to be supplemented by other characters.

[a] Cont. Canadian Palæont., vol. 3, pt. 2, p. 76, Pl. IV.

CIONODON (CINODON) Cope.

Cionodon (*Cinodon*) Cope, 1874, Bull. U. S. Geol. and Geog. Surv. Terr., vol. 1, no. 1, p. 10.

This genus is founded on detached teeth from the Laramie of northeastern Colorado. It was afterwards reported from the Judith River beds. It may be regarded as a genus based on insufficient material, and so poorly defined as to be indeterminable.

CIONODON STENOPSIS Cope.

Cionodon stenopsis Cope, 1875, Proc. Acad. Nat. Sci. Philadelphia, 1875, p. 9.

This species is based on a maxillary and teeth from the Judith River beds near Milk River in Canada. According to Cope it is distinguished by the absence of a longitudinal keel on the lower part of the crown. It is quite probable that the present species is neither generically nor specifically distinct from some of the species of *Trachodon* mentioned above.

DICLONIUS Cope.

Diclonius Cope 1876, Proc. Acad. Nat. Sci. Philadelphia, 1876, p. 253.

This genus and three species—*D. pentagonus*, *D. perangulatus*, and *D. calamarius*—were proposed by Cope from shed teeth found scattered throughout the Judith River beds of Montana. The genus should be, and has very generally been, considered as a synonym of *Trachodon*. From Cope's descriptions of the teeth referred by him to the various species mentioned above, it seems probable that more than one species were represented. In the absence of any figures, and considering the nature of the characters ascribed by Cope to the various species, it is doubtful if any of them are at present identifiable without access to the types, and since the latter seem no longer to be certainly determinable in the Cope collection, it would not be amiss to drop also the specific names referred to this genus.

AVES.

CONIORNIS ALTUS Marsh.

Coniornis altus Marsh, 1893, Am. Jour. Sci., 3d ser., vol. 45, p. 82.

A single bird has been described from these beds. It was referred to the present genus and species. The type consisted of the distal portion of a tibia found near the base of the Judith River beds on Dog Creek, Montana. According to Marsh, its affinities are with *Hesperornis*, a genus of toothed birds from the Niobrara chalk of Kansas.

MAMMALIA.

Thus far only two species of mammals have been described from the Judith River beds. These were referred to two genera, and both were described by Lambe from material collected by him in Canada.

PTILODUS PRIMÆVUS Lambe.

Ptilodus primævus Lambe, 1902, Cont. Canadian Palæont, vol. 3, pt. 2, p. 79, Pl. XV.

This species is based on a fragment of a mandible with a first molar and fourth premolar in place. It is clearly related to, but somewhat more primitive than, *Meniscoëssus conquistis* Cope[a] from the Laramie of South Dakota.

BOREODON MATUTINUS Lambe.

Boreodon matutinus Lambe, 1902, Cont. Canadian Palæont, vol. 3, pt. 2, p. 79, Pl. XV.

This species is founded on a single premolar from the Judith River beds of Canada, resembling in some respects the teeth referred by Marsh to the genus *Stagodon*[b] from the Laramie of Converse County, Wyo. The jaw shown here in fig. 1 was found in the Judith River beds on the north side of Milk River, about half a mile below Meili Coulee and directly north of the red butte mentioned on page 50. It was found in place in a lens of rather hard, cross-bedded sandstone. Associated with it were remains of *Trachodon* and turtles. It is provisionally referred to the present genus and species, although, from the absence of any teeth with which to make direct comparison, it is impossible to establish their identity.

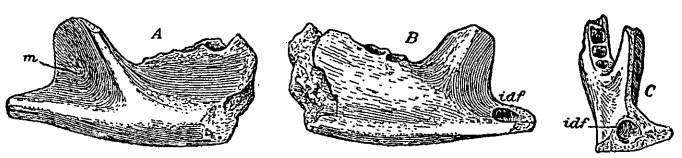


FIG. 1.—Posterior portion of right ramus referred to *Boreodon matutinus* Lambe. *A*, external view; *B*, internal; *C*, posterior; *m*, masseteric fossa; *idf.*, inferior dental foramen. Natural size.

The jaw is extremely heavy. While the coronoid process is imperfect, it is sufficiently preserved to show that it was high and strong. The angle was inflected much as in modern marsupials. The masseteric fossa was deep. The inferior dental foramen is placed well back and opens far down on the floor of the inflected angle, as shown in fig. 1. There is no mylohoid or Meckelian groove. Unfortunately no teeth are preserved, though there are a number of alveoli. The appearance of these alveoli suggests that there was a last, small, tubercular, single-rooted molar preceded by a double-rooted molar of mod-

[a] Am. Naturalist, 1882, p. 830. [b] Am. Jour. Sci., 3d ser., vol. 43, 1892, pl. 8, figs. 4, 5.

erate dimensions, while the preceding or first molar, assuming that there were three and only three true molars, was the largest of the series, as is indicated by its posterior root, which is still in place in the alveolus. It is laterally compressed and has the surface marked by faint striæ similar to those seen on the root of the type of the species, though not shown in Lambe's figure. The jaw was broken through the anterior alveolus of this tooth, and that portion of the ramus anterior to this is wanting.

SUMMARY.

From the foregoing review of the known vertebrates from the Judith River beds it will be seen that, while the fauna is one of considerable diversity, most of the genera and species are at present known from such insufficient and fragmentary material that it has not been possible hitherto to properly define them. It thus happens that a considerable number of genera and species that have been proposed for remains from these beds are not now determinable, and owing to the scanty material upon which not a few of these were originally founded it is quite impossible to refer to these with any degree of certainty, subsequently discovered and more perfect material, and thereby to further define and describe them. This is true to a greater or lesser extent of all the Vertebrata of these beds, but it is especially applicable to the fishes, amphibians, and by far the larger portion of the reptiles, while the birds and mammals of Judith River times are at present known from such exceedingly scanty material as of themselves to offer almost no evidence of the character of the avian and mammalian life of those times. Our knowledge of the vertebrate fauna of these beds, now that their geographic distribution is known not to be so limited as had been previously supposed, will doubtless be greatly increased by more persistent collecting, aided by modern methods. At present, however, while we are in many cases unable to adequately define many of the genera and species, we know enough of the fauna as a whole to form a very good general idea of its character, and although we can not compare it closely with the related faunas of other horizons, yet enough is known of it to establish certain similarities and dissimilarities. These are especially pronounced in certain groups like the Ceratopsidæ and the Trachodontidæ, where there was already a high degree of specialization and where many of the different species are known from fairly satisfactory material.

When considered in its entirety, the vertebrate fauna of these beds is remarkably similar to, though distinctly more primitive than, that of the Laramie. Almost or quite all of the Laramie types of vertebrates are present, though, as a rule, they are represented by smaller and more primitive forms. The similarity between this fauna and that of the Laramie contrasts strongly with the great dissimilarity between the

vertebrates of the Judith River and those of the Atlantosaurus beds, the next older fresh-water horizon in this region, containing also a rich and varied vertebrate fauna, but quite distinct from that of the beds in question.

The Dinosauria were the predominant vertebrates in Judith River times, and they, of all the vertebrates of these beds, afford the best basis for a comparison of the fauna of these deposits with that of the Laramie above and the Jurassic below. The great group of Sauropoda, which formed so conspicuous a feature of the animal life at the close of the Jurassic and the beginning of the Cretaceous, is entirely wanting. Among the Predentata the Stegosauria, which had formed so striking a feature among the Jurassic dinosaurs, have almost or quite disappeared and are replaced entirely by the quadrupedal Ceratopsidæ and the bipedal Trachodontidæ. No unmistakable repesentative of the Stegosauria is certainly known from the Judith River beds. *Palæoscincus*, referred to this suborder chiefly on the evidence of teeth alone, may or may not pertain to the Stegosauria; while *Stereocephalus* appears to have been founded on material belonging in part to the Crocodilia and in part to the Dinosauria. No evidence has as yet been produced to show that the large pointed shields described and figured by Lambe as pertaining to this genus may not have belonged to some member of the Theropoda or to the Ceratopsidæ. That they really belonged to one or the other of these is most likely, since very similar plates have been met with in the Laramie also. No vertebræ or shield plates like those known to have belonged to *Stegosaurus* are known from the Judith River beds.

The Trachodontidæ had already attained to considerable diversity in Judith River times. Indeed, they appear to have been more abundant, as regards both numbers of individuals and genera and species, than they were in the Laramie. Judging from the rather meager material at hand for comparison they were, however, somewhat less specialized, as is evidenced by such characters as the presence of four digits in the pes of *Pteropelyx* and the complement of teeth, which in the later Laramie forms seems to have been considerably greater than in the Judith River.

It is in the Ceratopsidæ more than in any other group that we are at present able to contrast the Judith River and Laramie forms. The chief differences are noticeable in the skull, and more especially in the structure of the parietal crest and the comparative size of the supraorbital and frontal horn cores. In the Laramie the supraorbital horn cores are always much larger than the nasal and the latter are frequently rudimentary, while in the Judith River beds conditions just the reverse prevail. In the Laramie the huge parietal fontanelles so common in the forms from the Judith River beds are known only in the single rare genus *Torosaurus*. There is some evidence also that the teeth in some of the Judith River forms are only in the process of

assuming that method of replacement which is common in later representatives of the group, and by means of which the single root of the embryo tooth early becomes bifurcated. The primitive nature of the Judith River Ceratopsidæ, as compared with the Laramie, is especially seen in *the smaller size of the individuals, the less perfectly developed armature of the skull, and the imperfectly developed parietal crest.*

So little is at present actually known of the Theropoda of either the Laramie or the Judith River beds that it is quite impossible to make anything like an adequate comparison between them. The group, however, is represented in both formations by quite similar forms, though differing perhaps both generically and specifically. The Theropoda in the Judith River beds show much greater diversity than do those of the Jurassic, and judging from the remains available they represent quite different types.

Although much is desired in the way of better material before we shall be able to determine, even approximately, the character of the vertebrate fauna of the Judith River beds, enough is already known to suggest its diversity and to show that the fauna is similar to that of the Laramie and different from that of the Jurassic. The long period of time which had elapsed between the close of the deposition of the Atlantosaurus beds and the beginning of the Judith River was sufficient to accomplish a complete revolution in the vertebrate fauna of that region, though most of the later forms are clearly descended from the earlier. Scarcely a single vertebrate of strictly Jurassic type is found in this fauna, for, as mentioned above, *Stereocephalus* Lambe, referred by that author and by Osborn to the Stegosauria, appears to have been founded on a composite type containing remains pertaining both to the Crocodilia and to the Dinosauria. The Dinosauria are not distinguishable from remains from the Laramie at present referred to the Ceratopsia, and the Crocodilia represent a group of crocodiles at present only known from the Judith River beds.

Briefly, the Judith River fauna, it is clear, is descended from the Jurassic and is the direct ancestor of the Laramie. Its relations with the former are not close, and several groups are absent in the one which are present in the other. Its relations with the Laramie are much closer, as should be expected, considering the stratigraphic position. With one or two possible exceptions all the families represented in either of these two later deposits are present also in the other. Although several genera and species now appear to be common to both these formations, it is probable that when more perfect material is available they will be found, in most instances, to be quite distinct, though some pertaining to more persistent types may prove to be identical. In every case where any group of the fauna has been studied from sufficient material it has been found to be represented by distinctly older and more primitive types than the related forms from the Laramie.

INVERTEBRATE FAUNA.

By T. W. STANTON.

The invertebrate fossils of the Judith River beds have nearly all been adequately described and illustrated by Meek,[a] White,[b] and Whiteaves[c] in previous publications. For the present purpose, therefore, it will be sufficient to describe and illustrate a few new species and to give an annotated list of the others, with references to good figures. The systematic list will be followed by a brief discussion of the character and relationships of the fauna and of the evidence it affords as to the conditions under which the formation was deposited.

PELECYPODA.

OSTREA SUBTRIGONALIS Evans and Shumard.

Ostrea subtrigonalis Meek, 1876, Rept. U. S. Geol. Surv. Terr., vol. 9, p. 510, Pl. XL, figs. 1a–1d.

The species was originally described from the vicinity of Owl Butte, between Grand and Moreau rivers, South Dakota, from beds that are now supposed to belong to the Laramie. From the fact that the types have never been figured and that no one has since studied them or other material from the type area, it may be questionable whether the Judith River form which Meek described under the same name is really identical. Whatever the final decision on that point may be, the form figured by Meek is the most abundant and widely distributed of the Judith River invertebrates. In the exposures near the Missouri on Dog Creek, Birch Creek, and Cow Creek there is a bed from 1 to 2 feet in thickness, at or very near the top of the formation, almost entirely composed of the shells of this species, with local accumulations of *Corbicula cytheriformis*, and less abundant specimens of *Corbula subtrigonalis*, *Anomia gryphorhynchus*, and *Goniobasis convexa*. The

[a] Invertebrate Cretaceous and Tertiary fossils of the upper Missouri country: Rept. U. S. Geol. Surv. Terr., vol. 9, 1876, pp. 509-592, pls. 42-43.

[b] Review of the nonmarine fossil Mollusca of North America: Third Ann. Rept. U. S. Geol. Survey, 1883, pp. 411-550.

[c] Report on the Invertebrata of the Laramie and Cretaceous rocks of the vicinity of the Bow and Belly rivers and adjacent localities in the Northwest Territory: Cont. Canadian Palæont., vol. 1, pt. I, 1885. The Belly River [Judith River] species are described on pp. 55-77.

same brackish-water fauna has a similar development at this upper horizon on Milk River in the neighborhood of Havre, especially near the mouth of Beaver Creek, 2 to 3 miles west of Havre, and at the head of Supenaw Coulee, on the north side of the river, 5 or 6 miles farther west. *Ostrea subtrigonalis* is reported by Whiteaves from about the same horizon at the mouth of St. Mary River and in Milk River Ridge, Canada, where the bed is referred to the "base of the shales of the Fort Pierre group."

Ostrea subtrigonalis also occurs in the upper part of the Claggett formation, on the north side of Milk River 4 miles west of Havre, Mont., and near Pendant d'Oreille, Canada, at both places associated with *O. glabra*, with which it seems to be connected by intermediate forms. It is reported from the lower Laramie and from the "Belly River" beds at several localities in Alberta and Assiniboia.

OSTREA GLABRA Meek and Hayden.

Ostrea glabra Meek, 1876, Rept. U. S. Geol. Surv. Terr., vol. 9, p. 509, Pl. XL, figs. 2a–2d.

Ostrea glabra White, 1883, Third Ann. Rept. U. S. Geol. Survey, p. 421, Pls. IX–XI.

The types of the species came from near the mouth of Judith River, but whether they occurred there in the Judith River beds or in the Claggett formation is not certainly known. In the present collection it was obtained from the upper part of the Claggett formation on Milk River 4 miles west of Havre, Mont., and in the neighborhood of Pendant d'Oreille, Assiniboia, and at the latter locality in the basal beds of the Judith River. Whiteaves reports it from several localities in the Canadian "Belly River" beds. It is also a very common species of the Laramie at many localities in the United States as well as in Canada, and apparently the same species occurs at several horizons in the Montana group.

ANOMIA GRYPHORHYNCHUS Meek.

Anomia gryphorhynchus White, 1883, Third Ann. Rept. U. S. Geol. Survey, p. 422, Pl. XII, figs. 12–15.

The original locality is Point of Rocks, Wyoming, where the species occurs in a horizon now known to be in the Montana group, and probably not far from the horizon of the Judith River beds. It has also been recognized at Black Buttes, Wyoming; Crow Creek, Colorado, and various other localities in the Laramie. The species is not uncommon associated with *Ostrea subtrigonalis* near the top of the Judith River beds on Cow Creek, and near Havre, Mont., and at the base of the same formation or in the upper layers of the Claggett near Pendant d'Oreille, Assiniboia. It shows considerable variation in size and in the convexity of the upper valve.

ANOMIA MICRONEMA Meek.

Anomia micronema White, 1883, Third Ann. Rept. U. S. Geol. Survey, p. 422, Pl. XII, figs. 6–11.

Anomia micronema Whiteaves, 1885, Cont. Canadian Palæont., vol. 1, p. 64.

This common Laramie species has been reported by Whiteaves from the Belly River beds of South Saskatchewan, half a mile below the forks of Bow and Belly rivers.

AVICULA NEBRASCANA Evans and Shumard.

Pteria (*Oxytoma*) *nebrascana* Meek, 1876, Rept. U. S. Geol. Surv. Terr., vol. 9, p. 34, Pl. XVI, figs. 5a, 5b, and Pl. XXVIII, fig. 11.

Pteria (*Oxytoma*) *nebrascana* Whiteaves, 1885, Cont. Canadian Palæont., vol. 1, p. 56.

Whiteaves reports this species from the "Belly River" beds in Milk River Ridge, Alberta. It is a common form in both the Claggett and the Bearpaw formations, and may therefore be expected in the Judith River beds wherever a marine stratum occurs.

MYTILUS SUBARCUATUS Meek and Hayden.

Mytilus subarcuatus Meek, 1876, Rept. U. S. Geol. Surv. Terr., vol. 9, p. 69, Pl XXXVIII, figs. 2a, 2b.

Mytilus subarcuatus Whiteaves, 1885, Cont. Canadian Palæont., vol. 1, p. 56.

The type is from Dog Creek, Montana, probably in the Claggett formation. Whiteaves reports it from the "Belly River" beds on South Saskatchewan River 8 miles below Red Deer River, and our collections contain a single specimen doubtfully referred to the species from the top of the Judith River beds in Meili Coulee, 4 miles west of Havre, Mont.

MODIOLA sp.

Fragments of a species with rather coarse radiating sculpture were collected from the lower part of the formation on Milk River, near Pendant d'Oreille, Assiniboia, and from the upper brackish-water bed on Cow Creek, Montana, 13 miles above its mouth.

CRENELLA PARVULA Whiteaves.

Crenella parvula Whiteaves, 1885, Cont. Canadian Palæont., vol. 1, p. 57, Pl. IX, fig. 1.

This species is known only from strata referred to the "Belly River" beds in Milk River Ridge, Alberta.

NUCULA sp.

Imperfect specimens of an undetermined species of *Nucula* were seen in a bed of friable sandstone containing other marine fossils on Cow Creek, Montana, about 7 miles above its mouth. The horizon is about 150 feet below the top of the Judith River beds.

LEDA sp.

An imperfect specimen of a large species, probably undescribed, was collected on Cow Creek at the locality and horizon last mentioned.

ANODONTA PROPATORIS White.

Anodonta propatoris White, 1883, Third Ann. Rept. U. S. Geol. Survey, p. 429, Pl. XIX, figs. 6–9.

The types are from Judith River beds on Dog Creek and Birch Creek, Montana. This species is represented in our collections from the neighborhood of the original localities and also from Cow Creek, Willow Creek, and near Havre, Mont., and somewhat doubtfully from Sage Creek, Assiniboia. Whiteaves reports the species, with some doubt as to identification, from many Canadian localities. It seems to be confined to the Judith River beds, and ranges throughout the whole formation except the brackish-water and marine layers. It is usually preserved in the form of casts and no perfect specimens are known.

ANODONTA PARALLELA White?

Anodonta parallela White, 1883, Third Ann. Rept. U. S. Geol Survey, p. 429, Pl. XIX, fig. 5.

Whiteaves has reported one doubtful specimen of this Laramie species from the "Belly River" beds on the South Saskatchewan 1 mile below the mouth of Bow River.

UNIO SUBSPATULATUS Meek and Hayden.

Pl. XIII, fig. 1.

Unio subspatulatus Meek, 1876, Rept. U. S. Geol. Surv. Terr., vol. 9, p. 518, Pl. XLI, figs. 1*a*, 1*b*.

The type from near the mouth of Judith River has the outer surface exfoliated so that the beak sculpture is not retained and the beaks are made to appear somewhat nearer the anterior end than they actually are. On Milk River 2 miles below Pendant d'Oreille, Assiniboia, Mr. Hatcher collected many well-preserved specimens of a *Unio* that seems to be referable to this species from a stratum containing *Corbula*, *Corbicula*, and *Modiola*, near the base of the Judith River beds. Some imperfect specimens were collected at the mouth of Meili Coulee, on the north side of Milk River 4 miles west of Havre, Mont.

It is a rather slender, compressed shell, with nearly terminal, inconspicuous beaks and narrowed posterior end. The umbonal region is marked by a few distinct, undulating, concentric ridges, and the posterior umbonal slope bears two sharply elevated radiating lines that fade out about an inch from the beak. The shell is rather thin, and the teeth are correspondingly light.

Similar beak sculpture is found in several Cretaceous species of *Unio*, such as *U. vetustus*, *U. priscus*, etc., but the general form and proportions of the shell are different. It is a much lighter, less convex shell, with more nearly terminal beaks than *Unio danæ* and *U. deweyanus*, with which it has sometimes been supposed to be identical.

UNIO PRISCUS Meek and Hayden?

Pl. XII, fig 1.

Unio priscus Meek, 1876, Rept. U. S. Geol. Surv. Terr., vol. 9, p. 516, Pl. XLIII, figs. 8*a*–8*d*.

The type of this species is from the Yellowstone, 40 miles above its mouth, and presumably from beds of Laramie age. Meek also figured small specimens from Judith River, but it is somewhat doubtful whether they are really identical with the Yellowstone form which is represented in the National Museum collection by the single crushed specimen. All the specimens have an elongate form and beaks with strong concentric wrinkles, but those from Judith River and from the same formation on Milk River at Pendant d'Oreille, Assiniboia, and at a locality 5 miles south of Wild Horse Lake, on the Canadian boundary, have the posterior end somewhat broader and other slight differences in outline that may have specific or varietal importance. The specimen figured is from the locality last named.

UNIO PRISCUS var. ABBREVIATUS n. var.

Pl. XII, figs. 2–4.

This variety has the general aspect and sculpture of *U. priscus*, with the strong concentric wrinkles on the beaks and two elevated radiating lines on the posterior umbonal slope, but it differs in having the posterior end relatively much shorter and somewhat broader, and it is apparently somewhat more convex. The shell is rather thin and the hinge teeth are light. The specimens figured are from Milk River, about 5 miles south of Wild Horse Lake.

UNIO DANÆ Meek and Hayden.

Unio danæ Meek, 1876, Rept. U. S. Geol. Surv. Terr., vol. 9, p. 517, Pl. XLI, figs. 3*a*–3*c*.

Unio deweyanus Meek, 1876, Rept. U. S. Geol. Surv. Terr., vol 9, p. 519, Pl. XLI, figs. 2*a*–2*c*.

The specimens described under the two names cited above all came from near Judith, Mont., and the differences on which the two species are based are due to the state of preservation rather than actual specific characteristics. None of the types shows all of the specific features fully, but those of *U. danæ* give a better idea of the outline and general proportions, while those of *U. deweyanus* show part of the surface and details of the hinge, though giving an erroneous impression concerning the form. Our collections contain many specimens evidently belonging to one species, some of which agree with one of these types and some with the other. The species attains a much larger size than the types, and apparently Meek was right in describing the beaks as unsculptured, in this respect differing from the form

which I have identified with *Unio subspatulatus*. We collected it on Sage Creek, Assiniboia; on Milk River, near Havre; on Cow Creek, Dog Creek, and at other localities in the original Judith River area. Apparently the same species, or if not, a closely related one that can not be separated with the imperfect material at hand, occurs in the Laramie at Black Buttes and on Lance Creek, Wyoming, near the mouth of the Yellowstone, and elsewhere in Montana. It has also been reported from the Laramie of Alberta.

UNIO SUPENAWENSIS n. sp.

Pl. XIII, figs. 2 and 3.

Shell of medium size, obliquely subovate in outline, with relatively thick test and broad hinge plate; beaks very prominent, slightly incurved, very near the anterior end of the shell, and sculptured with distinct concentric wrinkles; the rest of the surface showing only ordinary lines of growth and very faint radiating striæ, which probably are not visible except when the actual surface is slightly exfoliated; dorsal and basal margins forming very gentle regular curves; anterior margin slightly excavated above in front of the beak and broadly rounded below; posterior end somewhat narrowly rounded; shell very gently convex in the umbonal and median portions, but abruptly descending toward the front and dorsal margins; cardinal teeth large, very irregular in form, and strongly corrugated; posterior lateral well developed, elongate.

Length of type, about 65 mm; height, about 55 mm; convexity of single valve, 22 mm.

The only Cretaceous species at all resembling this are *Unio propheticus* White and *U. proavitus* White, both of which were described from the Laramie at Black Buttes, Wyoming, and may well be considered as descendants of *U. supenawensis*. The resemblance is closer with *U. propheticus*, which is slightly smaller, with beaks nearer the anterior end, a more distinctly flattened band extending from the beak to the middle of the basal margin, more broadly rounded posterior end, and straighter basal margin.

Locality.—The types were found near the top of the Judith River beds at the head of Supenaw Coulee, about 10 miles northwest of Havre, Mont., where the species is common. Another specimen was obtained from near the same horizon on the north side of Milk River opposite Havre.

UNIO CRYPTORHYNCHUS White.

Unio cryptorhynchus White, 1883, Third Ann. Rept. U. S. Geol. Survey, p. 431, Pl. XIV, figs. 6, 7.

The types are from Dog Creek, Montana, and the species has been doubtfully identified in the Laramie at Black Buttes, Wyoming.

UNIO SENECTUS White.

Unio senectus White, 1883, Third Ann. Rept. U. S. Geol. Survey, p. 432, Pl. XIX, figs. 1, 2.

From Dog Creek, Montana, and also reported by Whiteaves from the South Saskatchewan near the mouth of Bow River.

UNIO PRIMAEVUS White.

Unio primaevus White, 1883, Third Ann. Rept. U. S. Geol. Survey, p. 432, Pl. XIV, figs. 4, 5.

From Judith River beds near Cow Island, Montana. Also reported by Whiteaves from branch of east fork of Milk River, near the Canadian boundary. It occurs in our collections from Cow Creek and from Milk River 5 miles south of Wild Horse Lake.

Some of the specimens apparently belonging to this species are very much larger and more elongate than the type. It is probable that the two specimens figured by White represent two species, and if so, the smaller one, whose outer surface is figured, should be considered the type. The exterior of the other specimen is in a very poor state of preservation, so that its specific characters are not clearly determinable. It may possibly be the same as *U. priscus* var. *abbreviatus*, described above.

UNIO CONSUETUS Whiteaves.

Unio consuetus Whiteaves, 1885, Cont. Canadian Palæont., vol. 1, p. 59, Pl. IX, figs. 4, 4*a*.

Described from the "Belly River" beds of Alberta. Somewhat doubtfully identified in our collections from the Judith River beds at Willow Creek, Montana.

UNIO SUPRAGIBBOSUS Whiteaves.

Unio supragibbosus Whiteaves, 1885, Cont. Canadian Palæont., vol. 1, p. 66, Pl. X, fig. 1.

Types from South Saskatchewan near mouth of Bow River. Represented in our collection from lower part of Judith River beds on Milk River 2 miles below Pendant d'Oreille, Assiniboia, associated with *U. subspatulatus*.

UNIO sp.

There are several other species of Unio represented in our collections by material too imperfect for satisfactory specific description. It is therefore thought better to await more complete collections. Several of the species already described, from the formation, are so imperfectly known that it is almost impossible to identify them, even by direct comparison with the types.

SPHÆRIUM PLANUM Meek and Hayden.

Sphærium planum, Meek, 1876, Rept. U. S. Geol. Surv. Terr., vol. 9, p. 526, Pl. XLIII, figs. 6*a*, 6*b*.

This is one of the most common of the Judith River fresh-water species, occurring at many localities in the original area on Dog Creek, Birch Creek, and Cow Creek, and on Milk River from Havre to the Canadian boundary. The types came from near Grand Island, on the Missouri, below the mouth of Cow Creek, but they were at first erroneously reported to have come from near Grand River, Nebraska. The species attains a size considerably larger than the figured type. A similar but not identical form occurs in the Laramie of Converse County, Wyo.

SPHÆRIUM RECTICARDINALE Meek and Hayden.

Sphærium recticardinale Meek, 1876, Rept. U. S. Geol. Surv. Terr., vol. 9, p. 527, Pl. XLIII, figs. 3*a*, 3*b*.

The types are from the same locality as the preceding, and the species, though not so abundant, also occurs sparingly at nearly all the localities where *S. planum* is found. Large specimens are nearly half an inch in length.

SPHÆRIUM FORMOSUM Meek and Hayden?

Sphærium formosum? Whiteaves, 1885, Cont. Canadian Palæont., vol. i, pp. 61 and 68, Pl. IX, fig. 3.

This form, from the Judith River beds of Alberta, is doubtfully referred to *S. formosum*, which was originally described from Laramie or Fort Union beds near the mouth of the Yellowstone. The Canadian shell may possibly be the young of one of the preceding species.

CORBICULA OCCIDENTALIS Meek and Hayden.

Corbicula occidentalis Meek, 1876, Rept. U. S. Geol. Surv. Terr., vol. 9, p. 521, Pl. XL, figs. 6*a*–6*c*.

This form originally described from the badlands of the Judith, is less abundant there than *C. cytheriformis*, with which it is associated, but on Milk River near Pendant d'Oreille, Assiniboia, it is very common near the base of the Judith River beds, where it is associated with specimens that are intermediate in character between these two nominal species. It was collected on Cow Creek and near the mouth of Birch Creek, Montana, and forms that are apparently not specifically separable occur in the Laramie of Wyoming and northwestern Colorado, as well as the "Western Laramie" of Canada.

CORBICULA CYTHERIFORMIS Meek and Hayden.

Corbicula cytheriformis Meek, 1876, Rept. U. S. Geol. Surv. Terr., vol. 9, p. 520, Pl. XL, figs. 5*a*–5*c*.

The remarks on the range and distribution of *C. occidentalis* apply to this form also. It is locally very abundant in the brackish-water

bed at the top of the Judith River on Cow Creek and near the mouth of Birch Creek, and it also occurs on Milk River 3 miles west of Havre. Forms that have been referred to the same species occur in the Montana group at Point of Rocks, Wyoming, and in the Laramie at Black Buttes, Wyoming, and at various points in Wyoming and Colorado, as well as in Alberta. The type of *Corbicula* represented by this and the preceding species may be said to range throughout the Upper Cretaceous, as similar forms are found in the Colorado group in Utah and in the Bear River formation in Wyoming.

TELLINA sp.

A single specimen of a medium sized *Tellina* was obtained from the marine stratum 150 feet below the top of the Judith River beds on Cow Creek, Montana, 7 miles above its mouth.

PANOPÆA SIMULATRIX Whiteaves.

Panopœa simulatrix Whiteaves, 1885, Cont. Canadian Palæont., vol. 1, p. 11, Pl. II fig. 2, 2*a*.

The types are reported from several localities in the "Western Laramie" area of Canada, but it is possible that some of those localities, if not all, are in the Judith River beds. We collected the species on Milk River 3 miles west of Havre, and on Cow Creek 13 miles above its mouth. In both cases it was associated with the brackish-water forms at the top of the formation.

LIOPISTHA (CYMELLA) UNDATA Meek and Hayden.

Liopistha (*Cymella*) *undata* Meek, 1876, Rept. U. S. Geol. Surv. Terr., vol. 9, p. 236, Pl. XXXIX, figs. 1*a*, 1*b*.

Originally described from beds now known to belong to the Claggett formation near the mouth of the Judith, the species is also of common occurrence in the Bearpaw shales, and it was found in the marine stratum 150 feet below the top of the Judith River beds on Cow Creek 7 miles above its mouth.

MACTRA WARRENANA Meek and Hayden?

Mactra (*Cymbophora*) *warrenana* Meek, 1876, Rept. U. S. Geol. Surv. Terr., vol. 9, p. 208, Pl. XXX, figs. 7*a*–7*d*.

A single specimen from the locality and horizon last mentioned is doubtfully referred to this Fox Hill species.

MACTRA (CYMBOPHORA) ALTA Meek and Hayden.

Mactra (*Cymbophora*) *alta* Meek, 1876, Rept. U. S. Geol. Surv. Terr., vol. 9, p. 210, Pl. XXXVII, figs. 2*a*, 2*b*; Whiteaves, 1885, Cont. Canadian Palæont., vol. 1, p. 62.

Whiteaves reports this species from the Judith River beds in the Milk River Ridge, Alberta. The occurrence may be in a local marine facies of the formation like that mentioned on Cow Creek, or it may be in the top of the Eagle formation, where it normally occurs.

CORBULA SUBTRIGONALIS Meek and Hayden.

Corbula subtrigonalis Meek, 1876, Rept. U. S. Geol. Surv. Terr., vol. 9, p. 529, Pl. XL, figs. 3*a*, 3*b*.

This species was first described from the brackish-water bed at the top of the Judith River formation in the typical area. It has since been recognized at many localities in the Western States and Canada, from the Benton formation to the Laramie. In our collections it was found most abundantly in the lower part of the Judith River near Pendant d'Oreille, Assiniboia, but it occurs sparingly wherever the brackish-water strata are found.

At the locality on Cow Creek, 13 miles above its mouth, a greatly elongated variety occurs with the typical form.

CORBULA PERUNDATA Meek and Hayden.

Corbula perundata Meek, 1876, Rept. U. S. Geol. Surv. Terr., vol. 9, p. 528, Pl. XL, figs. 4*a*–4*d*.

Originally described from the same locality as the preceding, it also occurs with it at many localities on Milk River from Havre, Mont., to Pendant d'Oreille, Assiniboia, and elsewhere in that territory and Alberta.

GASTEROPODA.

NERITINA sp.

Velatella baptista (White) Whiteaves, 1885, Cont. Canadian Palæont., vol. 1, p. 73.
Not *Neritina* (*Velatella*) *baptista* White, 1880, Twelfth Ann. Rept. U. S. Geol. and Geog. Surv. Terr., p. 89, Pl. XXIX, figs. 6*a*, 6*b*.

Specimens from Milk River near Pendant d'Oreille, in the neighborhood of some of Whiteaves's localities, on direct comparison with the types of *Neritina baptista* from the Laramie at Black Buttes, Wyoming, prove to be different in both form and color pattern, but the material in hand is not sufficient for specific description.

LUNATIA sp.

A small specimen of an undetermined species was collected with the other marine fossils 150 feet below the top of the Judith River formation on Cow Creek 7 miles above its mouth.

VIVIPARUS CONRADI Meek and Hayden.

Viviparus conradi Meek, 1876, Rept. U. S. Geol. Surv. Terr., vol. 9, p. 597, Pl. XLII, figs. 15*a*–15*d*.

This species was originally described from near the mouth of Judith River. We found it locally abundant near the top of the Judith River formation on Cow Creek, and Whiteaves reports it from a number of localities in Canada. It has been erroneously reported to occur in the Bear River formation.

VIVIPARUS sp.

Imperfect specimens representing at least two or three species were found at a number of localities on the Missouri and on Milk River, but they were too much distorted and crushed for specific description. These forms seem to be closely allied to Laramie species, but apparently not identical with them.

CAMPELOMA VETULA Meek and Hayden.

Campeloma vetula Meek, 1876, Rept. U. S. Geol. Surv. Terr., vol. 9, p. 587, Pl. XLIV, figs. 14*a*, 14*b*.

Described from the Judith River area. We found it most abundant and beautifully preserved in the upper part of the Judith River formation near the head of Supenaw Coulée, about 10 miles northwest of Havre. The specimens obtained here are clearly referable to *C. vetula*, though they are also very much like the typical form of *C. multilineata* from the Laramie. The slight differences pointed out by Meek hold good, except that some of our specimens are slightly unbilicated, and these differences are probably of specific importance in spite of the fact that specimens not in a good state of preservation may be difficult to classify. The common Laramie form of *C. multilineata* with shouldered whorls is very distinct. The Laramie specimens from Black Buttes, Wyoming, and elsewhere, that have been referred to *C. vetula*, so far as I have been able to reexamine them, are too imperfect for positive identification, and may well belong to *C. multilineata*.

At least a part of the specimens from the Canadian Judith River beds referred to *C. multilineata* by Whiteaves probably belong to *C. vetula*.

CAMPELOMA MULTILINEATA Meek and Hayden.

Campeloma multilineata Whiteaves, 1885, Cont. Canadian Palæont., vol. 1, p. 77.

See remarks under *C. vetula*, above. No specimens referable to this species have been found in the Judith River beds of Montana, but it is one of the most common Laramie species, ranging probably as high as the Fort Union.

CAMPELOMA PRODUCTA White.

Campeloma producta White, 1883, Third Ann. Rept. U. S. Geol. Surv., p. 469, Pl. XXVI, figs. 21–27; Whiteaves, 1885, Cont. Canadian Palæont., vol. 4, pp. 24, 28, 77.

This is also a Laramie species that has not been found in the Judith River beds of the United States, but has been reported by Whiteaves from both the Laramie and the Judith River of Canada.

VALVATA? MONTANAENSIS Meek.

Valvata? montanaensis Meek, 1876, Rept. U. S. Geol. Surv. Terr., vol. 9, p. 591, text figs. 81–83.

Described from mouth of Judith River. Represented in our collections from two localities on Cow Creek.

HYDROBIA SUBCONICA Meek.

Hydrobia subconica Meek, 1876, Rept. U. S. Geol. Surv. Terr., vol. 9, p. 573, text fig. 77.

Mouth of Judith River.

HYDROBIA SUBCYLINDRACEA Whiteaves.

Hydrobia subcylindracea Whiteaves, 1885, Cont. Canadian Palæont., vol. 1, p. 75, Pl. X, fig. 8.

Type from Belly River east of Driftwood Bend. Whiteaves also reports the species from Milk River near Pakowki Coulée, and we collected it at Pendant d'Oreille, near the latter locality, where it was associated with *Corbula subtrigonalis*, *C. perundata*, and *Rhytophorus glaber*, near the base of the Judith River beds.

MELANIA? WHITEAVESI n. sp.

Pl. XIII, fig. 5.

Melania insculpta (Meek) Whiteaves, 1885, Cont. Canadian Palæont., vol. 1, p. 73, Pl. X, fig. 6.

Not *Melania insculpta* Meek, 1873, Sixth Ann. Rept. U. S. Geol. Surv. Terr., p. 515.

Shell of moderate size and rather robust form; whorls moderately convex, with the suture between them deeply impressed; surface marked by rather narrow, elevated, revolving striæ, of which about six are visible on the spire, and by broader, more distant, curved ribs, which are more or less nodose at the intersections with the revolving lines. There are fifteen ribs on the last whorl of the specimen figured, which is considerably more strongly sculptured than the average.

Height, with apex restored, about 40 mm.; breadth, 13 mm.

The specimens studied show much variation in the strength of the sculpture, with every gradation from the nearly smooth forms like that figured by Whiteaves to the one illustrated here. The species differs from *M. insculpta* in the form of the whorls and in all the details of sculpture, both the ribs and the spiral lines being more distant and less regular.

Some of the more strongly sculptured specimens of *Goniobasis convexa* M. & H. approach this form rather closely, and it is probable that they are related. Both are always found associated with brackish-water or marine species. The figured specimen of *M. whiteavesi* was obtained from near the base of the Judith River beds on Milk River 6 miles

below Pendant d'Oreille, Assiniboia, and it was collected at several other localities near there, at one point ranging down into the top of the Claggett formation. Whiteaves reports it (under the name *M. insculpta*) from the same neighborhood, but his figured specimen is from the South Saskatchewan 6 miles below the mouth of Bow River.

GONIOBASIS CONVEXA Meek and Hayden.

Goniobasis convexa Meek, 1876, Rept. U. S. Geol. Surv. Terr., vol. 9, p. 562, text figs. 71, 72, and Pl. XLII, figs. 2*a*, 2*b*.

Described from mouth of Judith River. Represented in our collections from Milk River near Havre, associated with *Ostrea*, *Anomia*, and other brackish-water forms at the top of the Judith River beds.

GONIOBASIS CONVEXA var. IMPRESSA Meek and Hayden.

Goniobasis convexa var. *impressa* Meek, 1876, Rept. U. S. Geol. Surv. Terr., vol. 9, p. 563, Pl. XLII, figs. 2*c*, 2*d*.

Occurs with the preceding at the type locality and in the brackish-water bed at the top of the formation on Cow Creek.

GONIOBASIS SUBLÆVIS Meek and Hayden.

Goniobasis sublævis Meek, 1876, Rept. U. S. Geol. Surv. Terr., vol. 9, p. 567, Pl. XLII, figs. 5*a*, 5*b*.

Types from the fresh-water beds near the mouth of Judith River. Common on Cow Creek and Willow Creek, and along Milk River from Havre, Mont., to the Canadian boundary.

GONIOBASIS INVENUSTA Meek and Hayden.

Goniobasis invenusta Meek, 1876, Rept. U. S. Geol. Surv. Terr., vol. 9, p. 564, Pl. XLII, figs. 1*a*–1*e*.

Occurs with the preceding and is somewhat more abundant, being found at most localities where fresh-water fossils occur in the Judith River beds, as far north as Pendant d'Oreille, Assiniboia.

GONIOBASIS GRACILENTA Meek.

Goniobasis gracilenta Meek, 1876, Rept. U. S. Geol. Surv. Terr., vol. 9, p. 568, text fig. 74, and Pl. XLII, fig. 3.

This species was found at the mouth of Judith River. It has also been reported from the Laramie at a number of localities in Wyoming and Colorado, but the state of preservation of all these specimens, as well as of the types, is such that their specific identity is doubtful.

GONIOBASIS? OMITTA Meek and Hayden.

Goniobasis? omitta Meek, 1876, Rept. U. S. Geol. Surv. Terr., vol. 9, p. 568, Pl. XLII, figs. 4*a*–4*c*.

Mouth of Judith River.

GONIOBASIS ? SUBTORTUOSA Meek and Hayden.

Goniobasis ? subtortuosa Meek, 1876, Rept. U. S. Geol. Surv. Terr., vol. 9, p. 569, text figs. 75, 76, and Pl. XLII, figs. 17*a*, 17*b*.

Described from near the mouth of Judith River, this is one of the most characteristic of the fresh-water species found in the formation. It has been collected at many localities in the original area, and along Milk River above Havre, Mont. Whiteaves reports it also from the South Saskatchewan, Bow, and Belly rivers in Alberta.

GONIOBASIS JUDITHENSIS n. sp.

Pl. XIII, fig. 4.

Shell of moderate size, stout, consisting of seven or eight very convex whorls; aperture very slightly produced below; surface marked by narrow, sharply elevated revolving lines, of which four to six are visible on the spire, separated by broader, flat bands which bear numerous minute revolving striæ, and crossed by very fine growth lines.

Height of an average specimen, 22 mm.; breadth, 13 mm.

This species is probably the ancestor of *Goniobasis tenuicarinata* M. & H., from which it differs in being larger, with more robust form, and with more narrow, more evenly distributed, and somewhat less prominent revolving lines or ridges.

It is common in the fresh-water beds of the Judith River on Dog Creek and at other localities near Judith, Mont., on Cow Creek, and on Milk River from Havre to the Canadian boundary. The figured specimen is from Simpson's ranch, on Milk River about 10 miles south of the boundary.

RHYTOPHORUS ? GLABER Whiteaves.

Rhytophorus? glaber Whiteaves, 1885, Cont. Canadian Palæont., vol. 1, p. 69, Pl. X, figs. 4, 4*a*–4*c*.

This peculiar little species, originally reported from a number of widely distributed points in Alberta and Assiniboia, we collected only from the brackish layers near the base of the formation on Milk River in the neighborhood of Pendant d'Oreille, Assiniboia.

HELIX VETUSTA Meek and Hayden.

Helix vetusta Meek, 1876, Rept. U. S. Geol. Surv. Terr., vol. 9, p. 552, Pl. XLII, figs. 7*a*, 7*b*.

Mouth of Judith River.

HYALINA? EVANSI Meek and Hayden.

Hyalina? evansi Meek, 1876, Rept. U. S. Geol. Surv. Terr., vol. 9, p. 548, text figs. 68–70.

Mouth of Judith River; also in our collections from Cow Creek and at various points on Milk River from Havre to the Canadian boundary.

HYALINA? OCCIDENTALIS Meek and Hayden.

Hyalina? occidentalis Meek, 1876, Rept. U. S. Geol. Surv. Terr., vol. 9, p. 547, Pl. XLII, figs. 6*a*–6*d*.

Somewhat more common than the preceding species and with the same geographic distribution.

THAUMASTUS LIMNÆIFORMIS Meek and Hayden.

Thaumastus limnæiformis Meek, 1876, Rept. U. S. Geol. Surv. Terr., vol. 9, p. 553, Pl. XLIV, figs. 8*a*–8*d*.

Thaumastus limnæiformis Whiteaves, 1885, Cont. Canadian Palæont., vol. 1, p. 72.

Originally described from Laramie or Fort Union beds near the mouth of the Yellowstone, and, so far as known, does not occur in lower horizons in the United States. Whiteaves reports the species from both the Laramie and the Judith River in Canada.

VITRINA? OBLIQUA Meek and Hayden.

Vitrina? obliqua Meek, 1876, Rept. U. S. Geol. Surv. Terr., vol. 9, p. 545, Pl. XLII, figs. 10*a*, 10*b*.

Mouth of Judith River.

PLANORBIS (BATHYOMPHALUS) AMPLEXUS Meek and Hayden.

Planorbis (*Bathyomphalus*) *amplexus* Meek, 1876, Rept. U. S. Geol. Surv. Terr., vol. 9, p. 539, Pl. XLII, figs. 16*a*–16*e*.

Near mouth of Judith River. Represented in our collections from the same region and also from Cow Creek and on Milk River near Havre.

PLANORBIS PAUCIVOLVIS Whiteaves.

Planorbis paucivolvis Whiteaves, 1885, Cont. Canadian Palæont. vol. 1, p. 71, Pl. X, fig. 5.

From Judith River localities on Belly River and South Saskatchewan, Alberta.

PHYSA COPEI White.

Physa copei White, 1883, Third Ann. Rept. U. S. Geol. Survey, p. 450, Pl. XXV, figs. 1, 2.

Described from Judith River beds near Cow Island, Montana. The species is represented in our collections from Cow Creek, Dog Creek, and from several localities on Milk River from Havre to the Canadian boundary. Whiteaves reports it from many localities in both the Judith River and the Laramie of Alberta.

BULINUS SUBELONGATUS Meek and Hayden.

Bulinus subelongatus Meek, 1876, Rept. U. S. Geol. Surv. Terr., vol. 9, p. 540, Pl. XLII, figs. 13*a*, 13*b*.

Mouth of Judith River.

BULINUS ATAVUS White.

Bulinus atavus White, 1883, Third Ann. Rept. U. S. Geol. Survey, p. 450, Pl. XXV, figs. 6, 7.

Described from Dog Creek, Montana. Found also sparingly on Milk River near Havre.

CEPHALOPODA.

PLACENTICERAS sp.

Some fragments of a *Placenticeras* were seen in the marine stratum 150 feet below the top of the Judith River beds on Cow Creek 7 miles above its mouth. Like the other purely marine fossils found here, this ammonite does not really belong to the Judith River fauna, but as it occurs within the stratigraphic limits of the formation it is worthy of mention.

INSECTA.

Associated with the plants collected on Willow Creek 10 miles north of Musselshell post-office a single wing of an insect was found which has been identified by the entomologists of the United States National Museum as belonging to a cockroach.

GENERAL COMMENTS ON THE INVERTEBRATE FAUNA.

The species enumerated in the above list fall into the three general categories of marine, brackish-water, and fresh-water forms, the latter including a few more or less doubtful land shells.

As the Judith River is essentially a nonmarine formation, strictly speaking its fauna should not be made to include the species cited belonging to *Avicula*, *Crenella*, *Nucula*, *Leda*, *Tellina*, *Liopistha*, *Mactra*, *Lunatia*, and *Placenticeras*, which were brought into the Judith River area by a local, temporary invasion of pure marine waters. In our field studies we saw only one occurrence of this kind, and that was on Cow Creek, Montana, where, as already described, the evidence seems clear that the marine beds are on the same horizon and strictly contemporaneous with fresh- and brackish-water beds in the same neighborhood. There is no mixture of nonmarine with the marine invertebrates, but in an overlying stratum marine and land vertebrates are found commingled. The marine invertebrates found here belong to the faunas of the underlying and overlying formations.

The few marine fossils reported by Whiteaves from the Judith River beds in Canada may indicate a similar occurrence there, or possibly there has been an error in identifying the formation from which they came. With these exceptions no strictly marine fossils are known from the main mass of the Judith River beds, but at the base

and the top there is ample evidence of continuity with the underlying and overlying marine formations. In many cases the lithologic change is not exactly coincident with the faunal change, so that the topmost layers containing the Claggett fauna and the lowest beds containing the Bearpaw fauna often closely resemble the Judith River beds in lithologic features.

The brackish-water fauna has a wide geographic distribution, occurring in practically every area in which the Judith River formation is found, but it is confined to thin beds intercalated in the upper and lower portions of the formation. On Milk River near Pendant d'Oreille, southern Assiniboia, these layers with brackish-water shells are unusually well developed near the base of the formation, and there are several intercalated bands extending up about 100 feet above the base. The individual beds are usually not more than 1 or 2 feet in thickness and the intervening strata contain fresh-water invertebrates. Farther south, near Havre, and in the area along the Missouri, brackish-water bands are seldom found in the lower part of the formation, but in the upper 25 feet there is a very persistent oyster bed, varying in thickness from 1 to 4 feet, closely associated with a heavy bed of lignite. In some places there are two or three of these brackish-water beds close together near the top of the formation. According to the Canadian reports, an oyster bed occurs at about this horizon in many places in Alberta.

The following species are confined to the brackish-water layers:

Species confined to brackish-water layers of Judith River formation

Ostrea subtrigonalis.	Corbula perundata.
Ostrea glabra.	Panopæa simulatrix.
Mytilus sp.	Rhytophorus glaber.
Modiola sp.	Neritina sp.
Anomia gryphorhynchus.	Melania? whiteavesi.
Corbicula occidentalis.	Goniobasis convexa.
Corbicula cytheriformis.	Goniobasis convexa var. impressa.
Corbula subtrigonalis.	

The species of *Corbula*, *Corbicula*, and a few of the others apparently ranged into nearly fresh waters, as they are sometimes found associated in the same layer with abundant specimens of *Unio* and *Campeloma*, while the oyster beds represent more nearly marine conditions which did not permit the mingling of purely fresh-water forms. The three forms of gasteropods in this list, doubtfully referred to *Melania* and *Goniobasis*, occur in the oyster beds. It is noteworthy that the Laramie species, *Melania? wyomingensis* and *M.? insculpta*, also occur with brackish-water fossils, and the former has been found with marine associates in the upper layers of the Fox Hills.

By far the most abundant of the brackish-water forms is *Ostrea subtrigonalis*, which could probably furnish more individual specimens

than all the rest of the Judith River fauna together. Next to it in abundance are the species of *Corbula*, *Corbicula*, and *Anomia*, but their distribution is much more local and irregular. *Ostrea glabra* and a variety intermediate between it and *O. subtrigonalis* are locally abundant, but the differences between these oysters are chiefly in the size, and the relationship between the different forms seems to be analogous to that between the local and commercial varieties of *Ostrea virginica*.

The five forms of Gasteropoda enumerated in our brackish-water list all appear to be confined to the Judith River beds, and the brackish-water faunule as a whole has a distinctive facies that is not exactly duplicated elsewhere, and yet when the comparison is made species by species almost all the other forms are represented in the Laramie by similar if not identical species, and some of them are represented in other formations as low as the Colorado group. In fact, they are persistent types that range throughout the Upper Cretaceous, and forms similar to some of them exist in the present seas. It is obvious that such species can not be safely used singly in correlating over great distances, but within limited areas, when comparison is made with an entire assemblage of forms and checked by stratigraphic observations, their evidence is often to be depended upon, and is as convincing as any other paleontologic evidence. When full collections are compared it will usually be easy to distinguish between Judith River and Laramie from the brackish-water fossils alone, but if the collections are meager and fragmentary it may not be practicable to do so. This remark is based on experience with the two faunas in the United States. Comparing the oysters, in the Laramie the large *Ostrea glabra* is the common form, while in the Judith River *O. subtrigonalis* is by far the most abundant and most widely distributed. *Corbicula* also has a different development in the Laramie, the type represented by *C. occidentalis* and *C. cytheriformis* being comparatively rare, while there are many other species that are much more abundant. In Canada the lists of brackish-water fossils from the "Western Laramie," as given by Whiteaves, include practically all of the Judith River forms, and indicate that the two faunules are indistinguishable. On examining the descriptions of the localities at which these fossils were collected it is found that in the majority of cases the strata have steep dips or show other evidence of much disturbance, suggesting the possibility that the fossils in question may have really come from the Judith River instead of the Laramie. Another explanation, which is perhaps as reasonable, is that the Judith River brackish-water Mollusca really persisted in the far northwest to Laramie time as a continuous and practically unchanged faunule, while in the United States the break in continuity and resultant necessary migrations caused greater modification.

After removing from our list of species the few sporadic marine forms and those that are confined to the brackish-water bands in the upper and lower portions of the formation, there still remains a much larger number of fresh-water and land species of Mollusca. These characterize probably more than nine-tenths of the total thickness of the formation, though of course they are not uniformly distributed through it. Mention has already been made of the fact that *Unios* and other fresh-water shells are occasionally found in actual association with brackish-water species such as *Corbula*, *Neritina*, and *Corbicula*, but as a rule they are in distinct beds, even in the upper and lower parts of the formation, while the middle 300 or 400 feet contain none but fresh-water and land Mollusca, associated with vertebrates of similar habitat.

A considerable number of the fresh-water and land species are not found outside of the formation. A few apparently occur in the Laramie also, and others are represented in the Laramie by similar forms that are doubtless their direct descendants. Taken as a whole, the Judith River fauna is distinguished from that of the Laramie by the presence of many characteristic species that do not occur in the higher formation and by the absence of many of the most common and striking of the Laramie forms.

This difference is sufficiently conspicuous to have been recognized by all paleontologists who have studied the faunas, even when the formations were supposed to be nearly or quite contemporaneous.

In the systematic list, under the specific headings mention has been made of the fact that certain Judith River fresh-water species apparently recur in the Laramie and that others are represented there by forms so similar that they may be considered their direct descendants. We may cite as conspicuous examples of the first class *Unio danæ*, *U. priscus*, *U. cryptorhynchus*, and *Goniobasis gracilenta*, and of the second class *U. supenawensis*, *Sphærium planum*, *Campeloma vetula*, *Goniobasis judithensis*, and *Physa copei*. These, however, form a comparatively small proportion of the fauna, and there is a much larger list of forms that have not been recognized outside of the Judith River beds, and at least one form, *Goniobasis? subtortuosa*, conspicuous on account of its peculiar specific characters and wide distribution, has no near relative in the Laramie. On the other hand, there is an absence of many of the peculiar types of *Unio* and of such conspicuous forms as *Viviparus trochiformis* and *Tulotoma thompsoni*, common in the Laramie.

Taken as a whole, the fresh-water faunas of the Judith River and the Laramie are somewhat more distinct than the brackish-water faunas of the same formations, and with fairly complete collections it should not be difficult to distinguish them in the laboratory.

From the facts that have been stated concerning the distribution of the different kinds of invertebrates within the Judith River beds, we

may reach some conclusions as to the conditions under which the deposits were found, for these animals were inhabitants of the waters in which the sediments were laid down, and they give clear testimony concerning the character of the waters and their relations with the sea. It is evident that after the deposition of the Claggett formation a considerable area in north central Montana and in Alberta and Assiniboia emerged from the sea and became the habitat of land and fresh-water animals. Since there was no obvious break in the sedimentation, it is probable that the larger part of the area was covered by low-lying swamps and lagoons. For some time there were slight oscillations that occasionally for brief intervals brought large parts of the area down to sea level and gave the lagoons sufficient connection with the ocean to allow the growth of oysters and other brackish-water forms over areas that had been occupied by fresh waters. Then for a longer period, during which 300 or 400 feet of sediments were formed, there was no connection with marine waters, though it is not probable that the area was ever very many feet above tide. During this epoch the general upward movement was reversed, and when the subsidence progressed more rapidly than deposition connection with the sea was soon again established, bringing in, first, brackish waters with their oyster beds, over nearly the entire area, with probably local bays and straits having more open and direct oceanic connections, such as is indicated by the occurrence of marine fossils in the Judith River on Cow Creek. Finally marine conditions were fully established over the entire area, so far as known, and continued during the deposition of the Bearpaw shales.

PLATE XII.

PLATE XII.

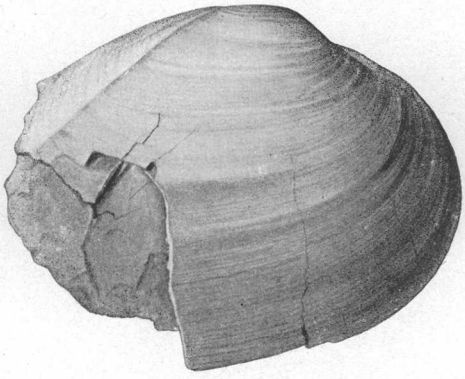
Page.

Fig. 1. Unio priscus Meek and Hayden? 108

Figs. 2, 3, 4. Unio priscus var. abbreviatus n. var 108

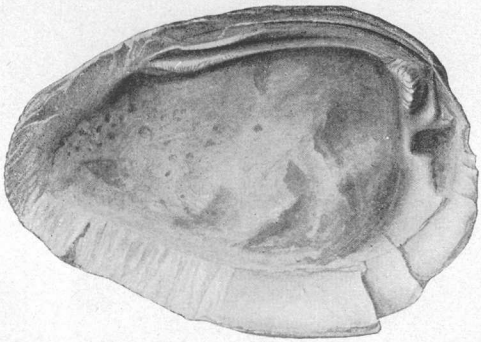
126

1



2

3



4

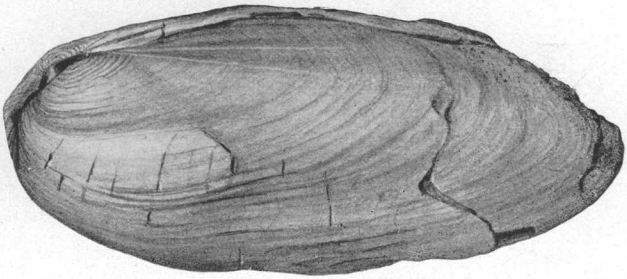
JUDITH RIVER MOLLUSCA.

PLATE XIII.

PLATE XIII.

Page.

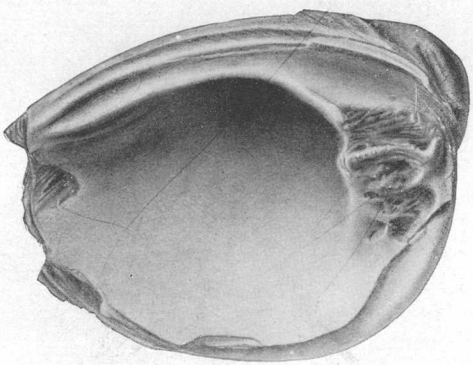
Fig. 1. Unio subspatulatus Meek and Hayden 107
Figs. 2, 3. Unio supenawensis n. sp..... 109
Fig. 4. Goniobasis judithensis n. sp..... 117
Fig. 5. Melania whiteavesi n. sp..... 115



1

2

4



3

5

JUDITH RIVER MOLLUSCA.

FOSSIL PLANTS OF THE JUDITH RIVER BEDS.

By F. H. KNOWLTON.

DESCRIPTIONS OF SPECIES.

FERNS.

Pl. XIV, fig. 1; Pl. XV, fig. 7.

Aside from the species below described as *Osmunda montanensis*, the collection contains minute fragments of two other evidently quite distinct ferns, upon which I have not ventured to bestow even generic names. The first of these, shown on Pl. XIV, fig. 1, is a fragment of what appears to be the extreme tip of a pinnule of an apparently very delicate fern. It is cut into several rounded lobes which are slightly decurrent along the stem or rachis. One of these, together with the terminal lobe, appears to have been toothed, but this is obscure. The frond seems to have been thick, and is apparently covered with minute papillæ. The nervation can not be made out satisfactorily. This fragment suggests the terminal portion of a pinnule of some of the lip ferns, *Cheilanthes*, but the material is not sufficient to warrant even generic determination, and it is only mentioned in the hope of calling attention to it in future.

On the same piece of matrix there are fragments of the terminal portions of several small pinnules, each being cut into several relatively strong lobes. The nervation is obscurely preserved, but appears to be only once forked. Its relationship is not apparent. It is shown on Pl. XV, fig. 7.

OSMUNDA MONTANENSIS n. sp.

Pl. XIV, fig. 6.

Shape of frond unknown; pinnule linear-lanceolate, obtusely wedge-shaped at base, rounded at apex; margin obscure, but apparently finely and sharply serrate; midrib strong, straight; nervation strong, arising at an acute angle, forking in an almost dichotomous manner three or exceptionally four times, the ultimate branches entering the sinuses between the marginal teeth.

Unfortunately this species is represented by a single pinnule only, which is linear or slightly linear-lanceolate in shape, with a very obtusely wedge-shaped base and a somewhat narrowed and rounded apex. The length is 22 mm. and the width about 7 mm. The margin is not very well preserved, but so far as can be made out it is finely and sharply serrate. The nervation as described above is well shown in the figure.

Among the few known living species this pinnule agrees most closely with those of *Osmunda regalis*, the well-known and widely spread Royal fern; in fact, the agreement is so close that with the limited material available it is impossible to note any essential difference in size, shape, marginal dentation, and nervation, the resemblance extending even to the ending of the ultimate nerve branches in the sinuses. But as we have no knowledge as to the shape of the whole frond, and, moreover, as the geologic horizon whence this comes is so remote from the present time, I have hesitated, even though the resemblance is so close, to regard it as a fossil representative of the living species. It is hardly to be presumed that a species could come down from the Cretaceous to the present without change. Additional material is much to be desired.

Some half a dozen fossil species of *Osmunda* have been described from North America, ranging in age from the Potomac to the Eocene. The Potomac species described by Fontaine[a] may be dismissed at once, as they do not suggest the present form in the least. The species approaching it most closely in size is *Osmunda öbergiana* Heer[b] from the lower Atanekerdluk beds of Greenland, but this differs in having entire margins and only once-forked nerves; in nervation ours is nearest to *O. doroschkiana* Göpp.[c] (the *O. torrelli* of Heer and Lesquereux), from the Miocene of Sachalin, but the size and margin are not in accord. *Osmundites skidegatensis* of Penhallow,[d] from the Lower Cretaceous of Skidegate Inlet, Queen Charlotte Islands, has the pinnules too fragmentary to admit of satisfactory comparison.

Locality.—Willow Creek, Fergus County, Mont., about 12 miles north of Musselshell post-office and 1 mile east of road from Junction City to Fort Maginnis.

CYPERACITES sp.

On several pieces of matrix there are fragments of narrow grass-like or sedge-like leaves that require at least to be mentioned, although they are not of sufficient size or well enough preserved to be of any value. The longest fragments are under 6 cm. in length and show a width of 3 or 4 mm., and are provided with numerous close, parallel

[a] Potomac flora: Mon. U. S. Geol. Survey, vol. 15, 1889, pp. 145–147.
[b] Fl. Foss. Arct., vol. 3, pt. 2, Pl. XXVI, figs. 9–9*b*.
[c] Op. cit., vol. 5, pt. 3, Pl. I, fig. 4.
[d] Trans. Roy. Soc. Canada, vol. 8, sec. 4, pp. 3–29.

veins. They have not been figured, as they are too characterless to be of value.

Locality.—Willow Creek, Fergus County, Mont., about 12 miles north of Musselshell post-office and 1 mile east of road from Junction City to Fort Maginnis.

SEQUOIA REICHENBACHI (Geinitz) Heer.

Pl. XIV, figs. 3–5.

This is by far the most abundant form in the collection, there being hundreds of specimens, while there is hardly a piece of matrix that does not show it in greater or less profusion. It is present from large branches nearly 2 cm. in thickness, from which nearly all the leaves have fallen, to great clusters of branchlets and even those just unfolding, and in one or two instances there are branchlets showing the male aments in a good state of preservation. I have selected for illustration a few to show the range of size and appearance.

Unfortunately this species is of little value in fixing age within narrow limits, as it is of almost world-wide distribution within the Cretaceous. In this country it occurs very abundantly in the Potomac, and has been reported in greater or less abundance and with greater or less degree of certainty in the Kootenai of Great Falls, Mont., the Dakota group at Fort Harker, Kans., the Belly River series at Belly River, Canada, the clay marl at Cliffwood, N. J., the Amboy clay at Woodbridge, N. J., the Montana formation at Point of Rocks, Wyoming, the Livingston beds in the Bozeman coal field of Montana, etc.

I have very carefully compared these specimens with the illustrations of *Sequoia reichenbachi* in all the literature available, and I am not able to separate them from this form. As would be expected from such a mass of material, there are differences in size and to some extent in appearance, but these are connected by all possible gradations and are undoubtedly to be explained on the ground of robust and perfect development and the completeness of the suite of specimens.

Locality.—Willow Creek, Fergus County, Mont., about 12 miles north of Musselshell post-office and 1 mile east of road from Junction City to Fort Maginnis.

SEQUOIA sp.? (cone).

Pl. XIV, fig. 2.

From the Judith River beds 10 miles northwest of Wild Horse Lake, Alberta, Mr. Stanton obtained a single, much-broken cone that appears to belong to *Sequoia*. It is globular in shape, being about 3 cm. long and nearly the same in width, but it is somewhat flattened and the exact dimensions can not be ascertained with certainty. The

scales were very large and thick, apparently not more than five showing in a vertical view. No attachment for the cone is observable.

This cone appears to be very similar, except as regards size, to *Sequoia heerii* Lesq.,[a] from the western Tertiary. This, however, does not exceed 1.5 cm. in long diameter, while the one in hand exceeds 3 cm., which is too great a difference for reasonable specific variation. This also suggests certain cones of *S. reichenbachi* as figured by Heer[b] from the Kome and Pattorfik beds of Greenland, but it is too much broken to be positive.

Locality.—Judith River beds 10 miles northwest of Wild Horse Lake, Assiniboia.

SEQUOIA HETEROPHYLLA? Velenovsky.

Pl. XVI, fig. 5.

Sequoia heterophylla Velenovsky, Gymnosp. d. Bohm. Kreidf., p. 22, Pl. XII, fig. 12; Pl. XIII, figs. 2–4, 6–9.

Among the hundreds of coniferous branches in this collection there is but a single one, together with its counterpart, that appears to belong to this species. It is a small piece, about 5 cm. in length, of the upper portion of a branchlet, and bears rather small, relatively broad and abruptly pointed leaves, which, in the lower part of the branchlet, are remote and approximately opposite. The leaves are slightly narrowed at the base and are decurrent for a considerable distance down the stem—in fact, reaching down to and apparently overlapped by the leaves next below. In the lower portion of the branchlet the leaves are open and spreading, but they become closer and more erect at the tip.

The marked characteristics of this species as defined by its author, and as interpreted by Newberry from the Amboy clays, is the heterophyllous form of the leaves, those at the base of the branchlets being shorter, smaller, and more appressed; while above, the leaves are more scattered and spreading, though ordinarily not to the extent shown in the lower portion of the Willow Creek specimens. This, however, compares very closely with figs. 2–4 of Velenovsky's Pl. XIII (op. cit.), as it does with Newberry's Pl. VI (op. cit.), figs. 3, 5, and 13. In the upper part of the branchlet, where the leaves become more erect, it is not possible to distinguish our specimen from the ordinary branchlets of *S. heterophyllus*. The lowest leaves preserved in the Willow Creek specimens are slightly smaller than those a little above, which is an indication that, had the whole branchlet been preserved, they would show a still further reduction. Thus I am convinced that the specimens in hand are correctly referred to the above species; yet, as there is but

[a] Tert. Flora: Rept. U. S. Geol. Surv. Terr., vol. 7, Pl. VII, fig. 13. Also Newberry, Later extinct floras of North America: Mon. U. S. Geol. Survey, vol. 35, 1898, Pl. XLVII, fig. 7.

[b] Fl. Foss. Arct., vol. 3, pt. 2, Pl. XX, figs. 1, 2.

a single example, and this not a complete branchlet, I have hesitated to record the identification as absolutely certain.

Sequoia heterophylla was described by Velenovsky from the Upper Cretaceous (Cenomanian and Senonian) of Bohemia, and in this country has been found abundantly in the Amboy clays by Newberry and sparingly in the Upper Cretaceous of Staten Island (Kreischerville) by Hollick,[a] in the Tuscaloosa of Alabama by Smith,[b] and by Ward[c] in the so-called Lower and Upper Albirupean (Later Potomac) of Virginia. In some of the localities above enumerated, except in the Amboy clays, it is not present in numbers sufficient to remove all suspicion as to the correctness of the determination, although the material was perhaps as satisfactory in some cases as that now in hand.

Locality.—Willow Creek, Fergus County, Mont., about 12 miles north of Musselshell post-office and 1 mile east of road from Junction City to Fort Maginnis.

THUJA CRETACEA? (Heer) Newberry.

Pl. XVI, figs. 3, 3*a*.

Thuja cretacea (Heer) Newberry, Flora Amboy Clays, p. 53, Pl. X, figs. 1, 1*a*.
Libocedrus cretacea Heer, Fl. Foss. Arct., vol. 6, pt. 2, p. 49, Pl. XXIX, figs. 1, 2; Pl. XLIII, fig. 1*d*.

The collection contains four small pieces which I am unable to distinguish from *Thuja cretacea*. These specimens show very well the size and arrangement of the branchlets, but unfortunately they are not sufficiently well preserved to show clearly the shape of the leaves, though in one small area their outline can be faintly made out. I can see no difference in the size and disposition of the branchlets, nor for that matter in the leaves, between them and *Thuja cretacea*, yet as there is a slight doubt, I have questioned the specific determination.

Heer described his *Libocedrus cretacea* from the Ataneschichten of Greenland, and apparently the same form was identified by Newberry from the Amboy clays of South Amboy, N. J. The latter author changed the generic name to *Thuja* on what seems good grounds.

These specimens have some resemblance to *Thuja interrupta* Newb.,[d] from the Fort Union beds near the mouth of the Yellowstone, but are distinguished at once by their more slender, graceful habit, and by not being enlarged at the extremity of the branchlets.

Locality.—Willow Creek, Fergus County, Mont., about 12 miles north of Musselshell post-office and 1 mile east of road from Junction City to Fort Maginnis.

---

[a] Trans. New York Acad. Sci., vol. 12, p. 30, Pl. I, fig. 21.
[b] Geol. Surv. Alabama, 1894, p. 348.
[c] Potomac formation: Fifteenth Ann. Rept. U. S. Geol. Survey, p. 378 et seq.
[d] Later extinct floras of North America: Mon. U. S. Geol. Survey, vol. 35, Pl. XXVI, figs. 5-5*d*.

DAMMARA ACICULARIS n. sp.

Pl. XV, figs. 2–5.

Cone scales broad and very thick at apex, narrowed below into a broad, thick basal portion; apex broadly rounded, provided in the center with a long, slender, acute, apparently depressed awn; body of scale with several (8 to 10) strong apparently concentric ribs, which are pressed close together and pass down the narrowed basal portion as thin striæ.

The collection contains a large number of these scales, evidently from a large cone, all of them detached and most of them widely separated, though occasionally several of them are found near together or even overlapping. The smallest one observed has a width of 11 mm. at the distal end, while the broadest one noted is 16 or 17 mm.; the majority of them are 14 or 15 mm. broad. The slender, awl-shaped awn shows an extreme length of 5 mm., but the usual length is 3 or 4 mm.; it appears to have been directed downward in the perfect cone. The length of the scales is about 18 mm., exclusive of the awn, and the width of the narrowed basal portion 3 or 4 mm.

This species shows unmistakable affinity with forms described by Heer from the Ataneschichten and Patootschichten of Greenland, but may be distinguished from them at once by the long, sharp awn. In size it is perhaps nearest to *Dammara microlepis* Heer,[a] which shows a width of 14 mm., but it is described by its author as having an obtuse, rounded apex and an attenuated base. In shape and the disposition of the ribs or striæ it is more like *D. borealis* Heer,[b] but this is 22 mm. broad and has a shorter, thicker basal portion.

Both the Greenland species are without the awn so characteristic of the specimens under consideration, though *D. borealis* is stated by Heer to have the apex apiculate. Doctor Newberry identified[c] this latter species in the Amboy clays, where he states it to be abundant, but the only specimen he figures is as small as, or even smaller than, the smallest one observed from Willow Creek. The figure shows a short apiculate apex and is not unlike some of ours from which the awn has been broken, but as he has "found numbers of them sometimes associated together, often scattered," and makes no mention of the presence of an awn, it was probably not a character of the Amboy clay form. What is probably the same species, though mentioned under the name of *Eucalyptus geinitzi* Heer,[d] was found by Mr. David White in the Cretaceous of Marthas Vineyard, but the figured specimen shows no evidence of the awn, nor is it mentioned, although Mr. White states that this species is one of the commonest forms present

a Fl. Foss. Arct. vol. 6, pt. 2, p. 55, Pl. XL, fig. 5.
b Op. cit., p. 54, Pl. XXVII, fig. 5.
c Flora Amboy clays: Mon. U. S. Geol. Survey, vol. 26, p. 47, Pl. X, fig. 8.
d Am. Jour. Sci., 3d ser., vol. 39, 1890, p. 98, Pl. II, fig. 10.

at that place. The reasons for regarding Heer's *Eucalyptus geinitzi* as at least generically similar to Dammara are well set forth by Newberry in his monograph on the Amboy clay flora (p. 47).

The same form, or at least a form very closely allied to it, is described and figured by Velenovsky [a] from the Upper Cretaceous of Bohemia, also under the name of *Eucalyptus geinitzi*, and it is also reported from the Cenomanian of Moravia. It would seem that these must all belong to one genus, and that a conifer.

Locality.—Willow Creek, Fergus County, Mont., about 12 miles north of Musselshell post-office, and 1 mile east of road from Junction City to Fort Maginnis.

CUNNINGHAMITES ELEGANS (Corda) Endlicher.

Pl. XV, fig. 1.

Cunhinghamites elegans (Corda) Endlicher, Synop. Conif., p. 270.
Cunninghamia elegans (Corda) in Reuss, Verstein. Bohm. Kreidef., pt. 2, p. 93, Pl. XLIX, figs. 29–31.

The collection contains portions of three or four thick branches, rather closely beset with long narrow leaves that I think must be referred without doubt to this species. The longest and best of these, shown on Pl. XV, fig. 1, is about 15 cm. in length and shows a thickness of 1 cm. While the leaves are not very well preserved, they are at least 3 cm. long and 3 mm. or more in width, and the scars left on the branch by their fall are 5 mm. or more long and about 3 mm. broad; they are apparently 1-nerved.

The specimen here figured, together with another smaller one, is not to be distinguished from figures of this species given by Newberry [b] from the upper part of the Amboy clay at Keyport, N. J. It is of about the same size, and has the same large leaves and scars.

Cunninghamites elegans, first described from Moletein in Moravia and from Mseno in Bohemia, was also found by Heer [c] in the Patoot beds of Greenland, and according to him the forms from the lower Senonian of Westphalia referred by Hosius and von der Marck [d] to *Cunninghamites squamasus* should belong here also.

Locality.—Willow Creek, Fergus County, Mont., about 12 miles north of Musselshell post-office and 1 mile east of road from Junction City to Fort Maginnis.

---

[a] Foss. Fl. böhm. Kreidef., vol. 4, Pl. II (XXV), figs. 8–11.
[b] Flora Amboy clays: Mon. U. S. Geol. Survey, vol. 26, p. 48, Pl. V, fig. 1.
[c] Fl. Foss. Arct., vol. 7, Pl. LIII, fig. 1*a*.
[d] Fl. d. Westf. Kreidef.: Palæontogr., vol. 26, Pl. XXXVII.

CUNNINGHAMITES RECURVATUS? Hosius and von der Marck.

Pl. XVI, fig. 6.

Cunninghamites recurvatus Hosius and von der Marck, Fl. d. Westf. Kreidef.: Palæontogr., vol. 26, p. 179 (55), Pl. XXXVII, figs. 143, 144.

Associated with the last is the specimen here figured, which seems to belong to this species. It is a fragment from the middle of a branch; is between 8 and 9 cm. in length, and 3 or 4 mm. in thickness. The leaves are not very well preserved, but they are over 2 cm. in length, and, so far as can be made out, about 2 mm. in width at or near the base, and taper from near the middle to a narrow, acute point. They arise at a low angle and are somewhat decurved. The scars left on the branch by their fall can not be determined, as the specimen is too poorly preserved at this point.

In view of the fact that this species is not only found in the same beds with the last-mentioned species, but has a fragment of it on the same piece of matrix, it is entirely possible that this example is incorrectly determined. It may possibly be a smaller branchlet of *C. elegans* with the leaves slightly recurved, but it agrees almost perfectly with the figures given of *C. recurvatus*, and I have referred it provisionally to this species. The type locality of *C. recurvatus* is the *Scaphites binodosus* zone of the lower Senonian of Westphalia.

Locality.—Willow Creek, Fungus County, Mont., about 12 miles north of Musselshell post-office and 1 mile east of road from Junction City to Fort Maginnis.

CUNNINGHAMITES PULCHELLUS n. sp.

Pl. XVI, fig. 1.

Branches apparently slender, leaves alternate, somewhat remote, broad and thick at base, turning abruptly at right angles to the stem, very long, narrow, sharp-pointed at apex, thick in texture and apparently deeply channeled above; leaf-bases large, oblong, obtusely acute, keeled and provided in the lower part with several fine striæ.

This form is represented by several very well-preserved branches, the best of which is here figured. The greatest thickness observed in a branch is 6 or 7 mm., and the least about 3 mm. Lateral branches slender, arising at intervals of some 2 or 3 cm., alternate and nearly at right angles to the main branch. Leaves persistent for at least two seasons, disposed spirally, with enlarged bases closely appressed to the branch, just above which they turn abruptly at right angles and are then straight or sometimes slightly depressed. Length of the leaves from 2 to 3 cm., and their width 2 mm. or less. As stated above, the leaves appear very narrow and stiff, their upper surface apparently being deeply channeled.

The specimen shown in Pl. XVI, fig. 1, evidently represents portions of two seasons' growth, the lower segment, showing the origin

of three lateral spurs, being clothed with shorter, more slender leaves, which are closer together, while the upper portion shows a period of more active growth, in which the leaves are slightly more scattered and larger and decidedly longer than those below. In all cases, however, the leaves just above their thickened base turn abruptly at right angles to the branch. By taking an impression of the branch with modeling clay or wax the original shape of the branch is approximately restored and the size and shape of the leaf bases become clear. It appears that the leaves are distributed on all sides of the branch in a regular spiral manner, a fact which is also shown in a fortunate fracture across the branch, showing the leaves going down into the matrix on what is now the underside of the stem. The thickened and ribbed base of a leaf is closely appressed to the branch, being overlapped at base by the leaves below and itself in turn partially overlapping the one next above. While there is no positive evidence to show how the leaves separated from the branch, it is probable that they were cut off at or near the point where the right-angled turn of the blade is made, which would leave behind the thick base. But, as already pointed out, it is certain that the leaves were persistent for some time, probably several seasons.

This fossil form has been very carefully compared with the only living species of *Cunninghamia* (*C. sinensis*) of China and Japan, and the points of agreement are so many as to leave no doubt regarding their generic identity. In the living species the leaves are distributed in a spiral manner and have the same thickened bases, which overlap and are in turn overlapped by others, as in the fossil. By taking an impression in clay of a branch of about the same size as some of the fossil branches, a mold is obtained which agrees in essential particulars with the fossil impression. By the strong curving of the leaves on the lower side of a branch they are made to assume a flat, more or less two-ranked disposition, and it is quite possible that a similar condition may have existed in the fossil. The leaves are evidently persistent for several years, as there is no evidence in any of the specimens available for study of a disposition to fall. The leaves in the living species, while of about the same size and shape as in the fossil, differ in having finely serrate margins and several faint parallel ribs, instead of what appears to be a channel in the middle.

So far as I have been able to find, the nearest approach among fossil forms to the one under consideration is the one which was called *Abietites setigera* by Lesquereux,[a] but which has been later regarded as merely rootlets, a view I have myself held; but since seeing the material from Willow Creek I am decidedly of the opinion that Lesquereux's specimens actually represent a conifer. It seems quite impossible, however, that they could belong to *Abietites* on the ground of analogy

[a] Ter. Flora: Rept. U. S. Geol. Surv. Terr., vol. 7, p. 82, Pl. VII, figs. 17, 18.

with the living *Abies* or *Picea*, since in both these the leaves fall with the greatest ease. In discussing his *Abietites setigera*, Lesquereux states that he had submitted it to Saporta, who informed him that he had an undoubtedly identical form from the Upper Cretaceous of St. Paulet, Gard, France. Saporta disagreed with Lesquereux as to the affinity of the fossil in question, but the latter does not mention what Saporta proposed to call it, nor have I thus far been able to find any mention of such a plant in Saporta's works, or of an account of the plants of St. Paulet.

Among species of *Cunninghamites* the one in hand appears to approach most closely to *C. recurvatus* Hos. and v. d. Marck,[a] from the Lower Senonian of Westphalia; in other words, to the preceding species. In that species the leaves, while somewhat recurved, arise at a considerable angle, whereas in this the leaves are at a decided right angle. This difference is really not great, yet the appearance of the two is very different, but it is possible that with a larger series of specimens of the former this apparent distinction might disappear. I have hesitated to think that there could be three well-marked species of so rare a genus in the same beds, yet this is by no means without precedent.

Locality.—Willow Creek, Fergus County, Mont., about 12 miles north of Musselshell post-office and 1 mile east of road from Junction City to Fort Maginnis.

POPULUS CRETACEA n. sp.

Pl. XVII, figs. 1–5.

Leaves coriaceous in texture, ovate or elliptical-ovate in shape, very obtusely wedge-shaped, sometimes almost truncate, at base; rather obtuse or somewhat rounded at apex; margin entire at base, becoming coarsely undulate-toothed above, the teeth usually very much rounded, sometimes more nearly acute, occasionally with a small tooth between the larger ones; petiole slender, not fully preserved; midrib strong, passing straight to the apex; secondaries strong, 4 or 5 pairs, alternate, remote, lower pair arising at or a little above the top of the petiole, with several (3 or 4) branches on the outer or lower side, some of which pass directly to the margin, while others unite into broad loops and send small branches to the teeth; upper secondaries straight, or more frequently curved upward, often forked, the branches passing to the teeth, or, especially in the upper part of the blade, with the secondaries uniting by broad bow well inside the margin and sending slender branches into the teeth; nervilles rather obscure, apparently irregular and mainly percurrent; finer nervation obscure.

This species, if I am correct in supposing that all here included actually belong to one form, is a very polymorphous one and

[a] Fl. d. westf. Kreidef.: Palæontogr. vol. 26, p. 179, Pl. XXXVII, figs. 143, 144.

shows considerable variation in size, shape, marginal teeth, and nervation, and yet with the ample material in hand it seems impossible to draw any satisfactory line between them. What is assumed to be the typical form is shown in Pl. XVII, fig. 1. It is elliptical-ovate in general outline, with an abruptly and very obtusely wedge-shaped base and rather few, low, mostly rounded teeth, and has the lower pair of secondaries arising above the top of the petiole; its length is 6.5 cm. and its width about 4 cm. Agreeing with this in size and in the marginal teeth, but with a more nearly truncate base and the lower secondaries arising at the extreme base of the blade, is the form shown in fig. 5. Its length can not be ascertained, but the width is the same as that of the form first described. Of a smaller size and a more nearly elliptical outline is the leaf shown in fig. 3, in which the teeth are relatively larger and the lower secondaries apparently take their origin above the base of the blade. Its length is 4 cm. and its width 3 cm., and a little more than 1 cm. of the petiole is preserved. The smallest leaf regarded as belonging here is that shown in fig. 16*d*. It is only 2.5 cm. in length and a little over 2 cm. in width. The extreme in another direction is exhibited in fig. 2, which is more nearly ovate in outline and has an abruptly rounded base with a small deltoid extension down the petiole. Its marginal teeth are obscure, but so far as can made out the margin is merely undulate in the lower portion, but becomes regularly toothed in the upper part. The lowest pair of secondaries arise some distance above the base of the blade. The length of this example is about 6.5 cm. and the width 5.5 cm. It is possible that this last may not belong with the others, but I have several specimens which seem to connect it with them, and it may at least provisionally be regarded as the same.

I have been much puzzled as to the correct generic reference of these leaves, and had at first supposed that they belonged to *Quercus*, but a somewhat extended search among living and fossil forms has not disclosed anything that can be regarded as especially close. Thus at first sight they seem to suggest certain of the forms of *Quercus westfalica* Hos. and v. d. Marck,[a] from the Upper Senonian of Westphalia, but in these the secondaries are much more numerous and in no case do the lower pairs arise at the top of the petiole, nor are they branched on the lower side as in the Willow Creek leaves. I have finally concluded, on the ground of their obvious and close resemblance to the leaves of the living *Populus grandidentata* Michx., that they are best referred to *Populus*. In looking through the specimens of the living species in the National Herbarium it is easy to select examples from many parts of the country in which the resemblance is really striking.

[a] Fl. d. Westf. Kreidef.: Palæontogr, vol. 26, Pl. XXIX and XXX.

They have the same ovate shape, with the rounded or obtusely wedge-shape base, and while the teeth vary somewhat in character, in many cases they are low and rounded, as in the fossil. The apex of the leaf is always pointed, but is more or less rounded in the fossil. The lowest pair of secondaries always arise at the very base of the blade, whereas in the fossil they may or may not do so. The other nervation is also quite like that in the Willow Creek specimens, but it is more inclined to be camptodrome, though not infrequently the secondaries enter the teeth directly.

Locality.—Willow Creek, Fergus County, Mont., about 12 miles north of Musselshell post-office and 1 mile east of road from Junction City to Fort Maginnis.

POPULUS sp.

Pl. XIX, fig. 1.

The collection contains a single fragment that appears to belong to *Populus*, but it is, unfortunately, not well preserved. It is a small leaf, apparently almost circular in shape, being about 3 cm. broad and possibly a little less in length. The margin is uncertain, but appears to be undulate. The petiole is very long and slender, over 2.5 cm. of it being preserved. The nervation consists of 5 ribs arising from the top of the petiole, the three middle ones being strong and once forked, the branches often uniting before reaching the margin, while the lateral ones on each side are slenderer and apparently unbranched. At the base of each of these outside ribs is a small secondary branch which has much the appearance of another rib. The nervilles, so far as can be made out, seem to be irregularly reticulated.

In size, shape, and the long petiole this fragment suggests *Populus rotundifolia* Newb.,[a] from the Fort Union beds of Montana, but the nervation, as well as can be determined, appears different, and the margin can not be compared. In size and shape, also, it is like *P. flabellum* Newb.,[b] from the supposed Upper Cretaceous of Puget Sound, but the nervation is quite different. The status can not be fixed until more and better material is forthcoming.

Lacality.—Willow Creek, Fergus County, Mont., about 12 miles north of Musselshell post-office and 1 mile east of road from Junction City to Fort Maginnis.

POPULITES AMPLUS n. sp.

Pl. XVIII, fig. 1.

Leaf coriaceous in texture, apparently very broadly ovate in shape; base destroyed, but apparently truncate; apex very obtuse and

[a] Later extinct floras of North America: Mon. U. S. Geol. Survey, vol. 35, Pl. XXIX, figs. 1–4.
[b] Op. cit., Pl. XX, fig. 4,

rounded; margin with apparently one large, obtuse, lateral lobe, but others provided with obscure, faint, remote teeth; midrib of moderate strength, somewhat zigzag in the upper portion; secondaries four pairs, craspedodrome, the lowest pair straight, apparently opposite, and arising at or near the top of the petiole, provided with several branches on the lower side; upper secondaries remote, alternate, much arched upward, usually with two or three strong forks, all branches entering the margin in very slight marginal dentations; nervilles few, strong, and irregular.

The example figured is the only one contained in the collection, and unfortunately this is imperfect in that it lacks the basal portion. It is a large leaf of thick texture, and so far as can be made out is very broadly and obtusely ovate in outline, with a single rather large lobe on one side and faint indications of scattered marginal teeth. The length is about 9 cm. and the width nearly the same; possibly the length may have been a little more when the leaf was in perfect shape. From the appearance of the larger, lower pair of secondaries it would seem that they were opposite and at or near the top of the petiole, giving rise to an obscurely 3-nerved condition.

This form seems to find its closest relationship with the genus *Populites*, as described by Lesquereux, from the Dakota group. For instance, it suggests in a general way *P. letigiosus* (Heer) Lesq.,[a] being of approximately the same shape and with the same type of nervation, but it differs specifically in its much larger size and fewer, more arched, secondaries. In shape and disposition of the nerves it also suggests *Populus? cordifolia* Newb.,[b] from the Dakota at Blackbird Hill, Nebraska, which is figured as having a serrate margin.

Locality.—Willow Creek, Fergus County, Mont., about 12 miles north of Musselshell post-office and 1 mile east of road from Junction City to Fort Maginnis.

BETULITES? HATCHERI n. sp.

Pl. XVIII, fig. 3.

Leaf small, apparently of firm texture, approximately circular in outline, slightly heart-shaped at base, rounded at apex; margin rather coarsely toothed, the teeth broad and obtuse (petiole not preserved); midrib strong, irregular or zigzag; secondaries, about five pairs, strong, especially the basal ones, which arise at a nearly right angle, the others being at an angle of 30° or 40°; lower pair of secondaries with four or five slender tertiary branches on the lower side, which unite in a broad bow some distance inside the margin; upper secondaries forked at about two-thirds the distance between the midrib and

[a] Flora Dakota group: Mon. U. S. Geol. Survey, vol. 17, Pl. VII, fig. 7; Pl. VIII, fig. 5, etc.
[b] Later extinct floras of North America: Mon. U. S. Geol. Survey, vol. 35, Pl. III, fig. 7.

margin, the branches uniting and sending slender slips from the outside of the bows to the marginal teeth; nervilles numerous, very strong, mostly unbroken and at right angles to the secondaries.

This is another form represented by a single specimen, but it is well characterized by its small size, nearly circular or very broadly ovate outline, coarsely toothed margin, and peculiar strong nervation. The length is 2.5 cm. and the width about 3 cm. It is well shown in the figure.

I am uncertain as to the proper generic reference for this little leaf. Although differing greatly in size, the shape and general character of the nervation are strongly suggestive of certain species of *Viburnites* from the Dakota group of Kansas. Thus *V. crassus* Lesq.[a] has a heart-shaped base and coarse-toothed margin as well as a strong nervation, but the teeth are lower and more acute and the secondaries after forking do not unite so distinctly, but pass directly to the margin. A similar criticism applies to *Viburnites masoni* Lesq.,[b] though with less force. Certain of Lesquereux's species of *Protophyllum*, which, by the way, are hardly to be separated from some forms of *Viburnites*, agree very well in shape, but have a more or less peltate base and distinctly forking secondaries, while in *Populites* the margin is somewhat different and the secondary nervation is strongly forked. Altogether this leaf seems to approach more closely to some of the forms of the highly polymorphous *Betulites westii* Lesq.,[c] of the Dakota group. In size and shape it agrees very well with *B. westii subintegrifolius*, and in shape, size, and marginal teeth with *B. westii reniformis*. But in these forms, as well as in all but one of the other varieties, the secondaries usually fork and pass to the margin without uniting. In *B. westii grewiopsideus*,[d] however, the upper secondaries unite in exactly the same manner as in the leaf under consideration, and it is consequently referred to the same genus, although with a mark of interrogation. I do not think this leaf is sufficiently close to any of the forms of *Betulites westii* to warrant placing it with them, but, as above indicated, it does not seem generically distinct from them. In any event it is a well-marked leaf and can easily be identified if found in future.

Locality.—Willow Creek, Fergus County, Mont., about 12 miles north of Musselshell post-office and 1 mile east of road from Junction City to Fort Maginnis.

---

[a] Flora Dakota group: Mon. U. S. Geol. Survey, vol. 17, Pl. XLV, figs. 1-4.
[b] Op. cit., Pl. XLV, fig. 5.
[c] Op. cit., Pls. IV and V.
[d] Op. cit., Pl. LXIV, fig. 10.

QUERCUS MONTANA n. sp.

Pl. XVII, fig. 6.

Leaf of firm texture, ovate in shape, with a very obtusely wedge-shaped base and an obtuse apex; margin perfectly entire below along the wedge-shaped portion of the base, regularly and coarsely undulate-toothed above, the teeth obtuse and rounded; petiole slender, of moderate length; midrib of moderate strength, straight; secondaries, four or five pairs, rather slender, alternate or subopposite, remote, passing directly to marginal teeth or forking and the branches entering the teeth; nervilles numerous, mostly unbroken.

The example figured is all that can with certainty be referred to this form. It is ovate in shape, with a peculiarly straight and obtusely wedge-shaped base and coarse-toothed margin. The length is about 6 cm. and the width about 5 cm., while the petiole, which seems to be entirely preserved, has a length of a little more than 1 cm. The nervation is well shown in the figure.

I am uncertain as to the generic reference of this leaf, and it may possibly be an extremely aberrant form of what has been described as *Populus cretacea* (p. 138), but I do not think so. It has the peculiar base described above, very regularly toothed margins, and the lowest pair of secondaries arising at a distance above the top of the petiole, although at the extreme base of the blade is a pair of very thin secondary branches, which only proceed for a short distance.

Among fossil forms this seems to find its greatest affinity with *Quercus suspecta* Lesq.,[a] from the Dakota group of Ellsworth County, Kans. The latter, however, is broader, being elliptical rather than ovate, more obtuse at apex, and has more numerous secondaries, which all seem to enter the larger marginal teeth. The finer nervation is not preserved in the Kansas leaf mentioned.

Lesquereux regards his species as being most closely related to *Q. wilmsii* Hos., and *Q. latissima* Hos.,[b] from the Upper Cretaceous of Westphalia, but neither one seems to approach very closely to the form in hand.

Locality.—Willow Creek, Fergus County, Mont., about 12 miles north of Musselshell post-office and 1 mile east of road from Junction City to Fort Maginnis.

QUERCUS JUDITHÆ n. sp.

Pl. XVIII, fig. 2.

Leaf rather membranaceous in texture; apparently obovate in shape, truncate at base, and broadly rounded at apex; margin undulate-toothed, the teeth largest near the middle and becoming more shal-

[a] Flora Dakota group: Mon. U. S. Geol. Survey, vol. 17, Pl. XLVII, fig. 7.
[b] Dicotyl. Westf. Kreidef.: Palæontogr., vol. 17, Pls. XII and XIII.

lowly undulate at the apex; midrib rather slender, zigzag, especially above; secondaries slender, five or six pairs, alternate, remote, forking, and sometimes ending in the marginal teeth, but usually joining the one above and sending thinner branches to the margin; finer nervation obscure, but apparently forming irregular meshes.

The specimen figured is all that was found in the collection, and unfortunately this is quite imperfect, lacking most of the sides below. As nearly as can be made out it was obovate in outline, being about 9 cm. in length and about 7 cm. in width. It seems to be allied to the preceding species and even to that described as *Populus cretacea*, but its obovate outline and somewhat different nervation are perhaps sufficient to characterize it.

Locality.—Willow Creek, Fergus County, Mont., about 12 miles north of Musselshell post-office and 1 mile east of road from Junction City to Fort Maginnis.

SAPINDUS INEXPECTANS n. sp.?

Pl. XVII, fig. 7

Leaf small, membranaceous in texture, elliptical-ovate in shape, apparently rounded at base, obtuse at apex; midrib slender, straight; secondaries stout, about six pairs, subopposite, at an angle of about 45°, much curved upward, camptodrome, each joining the one next above; nervilles numerous, thin, mainly broken, and forming large, irregular areas.

This little leaf, the only one contained in the collection, is elliptical-ovate in outline, about 3.5 cm. in length and 2.25 cm. in width. The nervation is shown in the drawing.

I have not attempted much search for the close relatives of this species, as the single specimen available is of such a nondescript character that it would be difficult to work out satisfactorily its relationship.

Locality.—Willow Creek, Fergus County, Mont., about 12 miles north of Musselshell post-office and 1 mile east of road from Junction City to Fort Maginnis.

TRAPA? MICROPHYLLA Lesquereux.

From the base of the Judith River beds, at a point on Cow Creek about 13 miles above its mouth, Mr. Stanton has obtained about fifteen specimens of small detached leaves or leaflets that I am not able to distinguish from this species. While they are all smaller than the usual examples from the type locality (Point of Rocks, Wyoming), they agree well in shape and the marginal dentation, but unfortunately have not retained the nervation, or at most but slight traces of it. This species, or, at least, what has been so identified, has been figured by Dawson, in Tyrrell's collections from Bad Lands, Red Deer, and

Rosebud rivers, and Pincher Creek, Canada, the age of which he regards as "Lower Laramie," and also a single doubtful example "from the Upper Laramie of Great Valley."[a]

Professor Ward found this species abundantly at Burns ranch, on lower Yellowstone River, Montana, in beds supposed to be of Fort Union age; but, as I have shown in the Flora of the Montana Formation (p. 63 et seq.), I can not believe that these should be referred to *T. microphylla*, for the reason that they are clearly compound leaves, rarely detached, whereas at the type locality and at all the points mentioned by Dawson they are always separated and show no evidence of having been compound. I found examples that are not to be distinguished, apparently, from the Burns ranch forms, on Wolverine Creek, in the Yellowstone National Park, in beds regarded as of true Laramie age,[b] and in 1896 Mr. Stanton and myself found a large number of detached leaves in Converse County, Wyo., in clay beds in the lower portion of the true Laramie.[c] It may be that my presumption of two forms being mixed under this name is not valid, but it is certainly remarkable that at two localities they should always give evidence of being compound and at all the other localities appear as detached leaves, with no indication of being compound, especially as the material is ample in most cases. It must be confessed, however, that when dealing with isolated leaves or leaflets it is impossible to draw any satisfactory line between them.

Locality.—Cow Creek, Montana, 13 miles above its mouth.

TRAPA? CUNEATA Knowlton.

Trapa? cuneata Knowlton, Flora Montana formation: Bull. U. S. Geol. Survey No. 163, 1900, p. 64, Pl. V, fig. 6.

The Willow Creek material contains a single, somewhat imperfect example, which is practically indistinguishable from my *T. cuneata* from Point of Rocks, Wyoming. It has the same obovate-cuneate outline, being broad and obtuse above and wedge-shaped below, and shows the same obtuse teeth confined to the upper third of the blade. It is slightly larger, being about 2.5 cm. long and a little over 1.5 cm. wide, while the Point of Rocks species is 2 cm. long and slightly over 1 cm. wide. The only point of difference is a very slight one in the midrib, this in the type specimen being "slender, somewhat flexuous, with several very slender, flexuous, often forking, branches," and in the one under discussion it is even less pronounced; in fact, hardly to be made out at all. But this character is perhaps not of much importance when considered in relation to the condition prevailing in *Trapa? microphylla* Lesq., of which a great many speci-

[a] Cf. Trans. Roy. Soc. Canada, vol. 4, p. 31 (1886).
[b] Mon. U. S. Geol. Survey, vol. 32, pt. 2, p. 661, Pl. LXXVII, figs. 3, 4.
[c] Flora Montana formation: Bull. U. S. Geol. Survey No. 163, p. 63.

mens have been found, and in which the midrib is sometimes quite distinct and at others very faint or almost obsolete. The general nervation, however, is identical in the two specimens, and it seems safe to regard the Willow Creek example as the same as *T. cuneata*. It is not necessary to go into the question of the generic reference of these curious little leaves, as this has been done several times before.[a]

Locality.—Willow Creek, Fergus County, Mont., about 12 miles north of Musselshell post-office and 1 mile east of road from Junction City to Fort Maginnis.

DIOSPYROS JUDITHÆ n. sp.

Pl. XVIII, figs. 4, 5; Pl. XIX, fig. 3.

Leaves membranaceous in texture, elliptical-lanceolate in shape, broadest at or near the middle, from which they narrow about equally to the acute base and acuminate apex; margin entire; petiole short; midrib of medium strength for the size of the blade, straight; secondaries five or six pairs, thin, alternate, irregular, camptodrome, arching well inside the margin and joining the one next above; lower secondaries very thin and forming a series of bows just inside the margin; nervilles numerous, very thin, mainly percurrent, and approximately at right angles to the secondaries.

This form is represented by about half a dozen examples, which show such a range in size as to suggest the possibility of two species being confused, but there seems no other line except that of size to be drawn between them. They all have the elliptical-lanceolate outline and are all about equally narrowed to both base and apex. The largest, shown in Pl. XVIII, fig. 5, is about 6 cm. long and 3.5 cm. wide; it is quite imperfect, lacking the apex and most of one side. The next in size, shown in fig. 3, is 4.5 cm. long and 2.25 cm. wide; its petiole, seemingly entire, is 4 mm. in length. In fig. 4 is shown the smallest leaf, this being 3 cm. long and about 14 mm. wide.

These leaves are referred to the genus *Diospyros* from their agreement with certain leaves from the Dakota group of Kansas so referred by Lesquereux. For example, it is similar to some of the leaves referred to *D. kansaseana* Lesq.,[b] but more particularly with *D. primæva* Heer,[c] which was originally from the Dakota group of Nebraska, but also since found in Kansas. In both of these species, however, the secondaries are more numerous than in the Willow Creek specimens, and the petiole and midrib are much stronger.

It was at first supposed that these leaves should belong to the Celastraceæ on account of their resemblance to certain forms of *Celastrus*,

[a] Cf. Flora Montana formation: Bull. U. S. Geol. Survey No. 163, pp. 62–64.
[b] Flora Dakota group: Mon. U. S. Geol. Survey, vol. 17, Pl. XVII, figs. 1, 2, etc.
[c] Op. cit., Pl. XX, figs. 1, 2.

Euonymus, etc., but the resemblance is perhaps closer with *Diospyros*, as above pointed out.

Locality.—Willow Creek, Fergus County, Mont., about 12 miles north of Musselshell post-office and 1 mile east of road from Junction City to Fort Maginnis.

CASTALIA STANTONI n. sp.

Pl. XIX, fig. 4.

Leaf large, evidently thick and of firm texture, approximately circular in outline; deeply cordate at base, the sinus rather broad and the lower lobes rounded; apex very obtuse and rounded; margins very faintly and obscurely toothed; petiole evidently thick and strong; nervation pinnate, the midrib relatively thin, straight; secondaries, five or six pairs, strong, subopposite, arising at an angle of about 45°, lowest secondaries with several (four or five) branches on the lower side, which fork two or three times and supply the lateral lobes, the branches passing to the minute marginal teeth; upper secondaries with one to three, occasionally uniting forks, the ultimate branches entering the marginal teeth; nervilles numerous, strong, mainly broken.

This splendid leaf, which is preserved practically entire, is the only one of its kind in the collection. It is nearly circular, the length from the top of the petiole to the apex being about 11 cm., and the width at the broadest point a little more than 12 cm.; the lateral lobes extend downward below the top of the petiole for a distance of about 2.5 cm. While the central or midrib is not particularly strong, the remainder of the nervation is abundantly so for the size of the leaf.

There seems to be little or no doubt as to the propriety of referring this leaf to the genus *Castalia*, since, for example, it agrees very closely in size and shape with many leaves of *C. odorata* of eastern North America or *C. alba* of the Old World. It has, however, a shallower, broader basal sinus than is usual in most leaves of these species, and the lobes are more obtuse and rounded, yet in this respect it is not greatly unlike other species, such, for instance, as what has been called *C. elegans* (Hook.) from Guatemala. In most species of *Castalia* the margin is perfectly entire, yet there are notable exceptions, as in *C. ampla* (Salsb.) of Mexico and the West Indies, *C. lotus* and *C. thermalis* of the Old World, and *C. gigantea* (Hook.) of Australia. In the fossil form under consideration the margin is very slightly but unmistakably toothed. As regards nervation, in most living species of *Castalia* the secondaries after forking are more or less united, thus inclosing a large and one or two series of smaller areas, while in some—e. g. *C. ampla*—the secondaries are practically united from near the midrib into numerous series of large aerolæ. In

the splendid *C. gigantea* of Australia, however, the secondaries are little or not at all joined, but fork several times and send the ultimate branches to the margin. Thus, as regards marginal dentation and nervation, our fossil leaf seems to agree most closely with the Australian species mentioned.

The only other species of the genus thus far detected in this country is the doubtful *Castalia? duttoniana* Knowlton[a] from the Montana formation at Dutton Creek, Laramie Plains, Wyo. This latter form, however, is a very different leaf, being hardly half the size of the one before us, broadly elliptical, very slightly heart-shaped at base and entire-margined; the nervation is also different, and it may not be correctly referred to *Castalia*.

Locality.—Willow Creek, Fergus County, Mont., about 12 miles north of Musselshell post-office and 1 mile east of road from Junction City to Fort Maginnis.

PHYLLITES DENTICULATUS n. sp.

Pl. XIX, fig. 2.

Leaf of small size and very thick texture; shape ovate, being apparently rounded at base and obtusely pointed at apex; margin entire at base, becoming strongly toothed above, the teeth being slender, sharp-pointed, and upward or outward turning; midrib rather slender, apparently zigzag; secondaries, three or four pairs, alternate, arising at a low angle and much curving upward, craspedodrome, entering the teeth, or forked and the branches entering the marginal teeth; finer nervation not observable.

This little leaf, the only one of its kind found in the collection, is evidently of thick texture, as the nervation can be made out with difficulty. It lacks both base and apex, but as nearly as can be determined its length was about 2 cm. and the width 1.5 cm.

I am uncertain as to the generic relations of this leaf, and moreover the single example is hardly well enough preserved to warrant speculation on this point.

Locality.—Willow Creek, Fergus County, Mont., about 12 miles north of Musselshell post-office and 1 mile east of road from Junction City to Fort Maginnis.

PHYLLITES INTRICATA n. sp.

Pl. XVIII, fig. 6.

The collection contains also another fragmentary example of a small leaf of doubtful affinity. It appears to have been rather membranaceous in texture, regularly ovate in shape with an apparently truncate or slightly cordate base and an acute apex. The margin is provided

[a] Flora Montana formation: Bull. U. S. Geol. Survey No. 163, p. 55, Pl. XIII, fig. 7.

with a few relatively large, coarse teeth. The nervation is very thin, consisting of a slender, straight midrib, and two or three pairs of very thin secondaries which arise at an acute angle and are greatly curved upward, ending apparently in or just below the sinuses. The length of this little leaf was 2 cm. and the width about 1.25 cm.

This leaf suggests in a way certain herbaceous plants, but I am wholly at a loss as to its probable affinities, and simply present it in the hope that more material may subsequently be secured.

Locality.—Willow Creek, Fergus County, Mont., about 12 miles north of Musselshell post-office and 1 mile east of road from Junction City to Fort Maginnis.

CARPITES JUDITHÆ n. sp

Pl. XVI, fig. 4.

Fruit evidently of firm texture, possibly a stone fruit; broadly obovate in shape, with a rather broad point of attachment and a regularly and obtusely rounded apex; fruit marked with numerous fine striæ which arise at the apparent base, at which point they are slightly stronger, and after spreading slightly in the middle converge toward the apparent apex.

The fruit here figured is all of its kind in the collection. It is perfectly preserved. It is rounded obovate, 14 mm. long and 11 mm. broad. It is provided with numerous fine striæ which converge at what is assumed to be the apex. The smaller end is presumed to be the point at which it was attached, as the striæ or ribs are thicker at this place. Its affinity is unrecognized.

Locality.—Willow Creek, Fergus County, Mont., about 12 miles north of Musselshell post-office and 1 mile east of road from Junction City to Fort Maginnis.

CARPITES PRUNI n. sp.

Pl. XV, fig. 6, 6*a*.

Fruit apparently of shelly or bony texture, broadly and obtusely ovate in shape, basal part rounded and apparently truncate; apex obtusely rounded; body of fruit marked with a marginal rib or thickened rim, and two or three longitudinal ribs.

This fruit is also the only one of its form contained in the collection. It is broad or elliptical-ovate in shape, with a very broad base and an obtuse apex. The length is 13 mm. and the width 11 mm. It suggests in a remote way the stone of a *Prunus*, but its affinity is a matter of question.

Locality.—Willow Creek, Fergus County, Mont., about 12 miles north of Musselshell post-office and 1 mile east of road from Junction City to Fort Maginnis.

CARPITES ALATUS n. sp.

Pl. XVI, fig. 2.

The collection contains two specimens of a very peculiar winged fruit that I am unable to determine satisfactorily. The best example, shown in Pl. XVI, fig. 2, is two-winged, the wings being broad and rounded, and separated by a deep, rounded sinus. The portion containing the nucleus extends as a long point, wingless (?) at the apex, but with the wings apparently arising below the apex and extending backward. The length over all is about 12 mm. and the greatest width about the same, the nuclear portion from the rounded sinus between the wings to its apex has a length of 6 mm., and the greatest width of the individual wings about 5 mm. In another example, which is presumed to be the same species, there is shown just one-half of the fruit, with the sharp-pointed nuclear portion and large rounded backward-extending wing. The dimensions are about the same as in the other. Neither shows any apparent point of attachment.

The other specimen, which has not been figured, is not unlike a single-winged coniferous fruit, such as *Pinus*, *Abies*, etc., while the figured one suggests the same, except that there is no evidence of a line of division between them, as should be the case if it is a double fruit. There seems to be only one nucleus or seed provided with a double wing in this specimen, but if the other example really belongs with it, it is probable that the division line is too obscure to be made out.

It is to be presumed that these are the fruits of a cone-bearing tree, possibly *Pinus* or something not greatly different, but in view of the anomalous features presented it is deemed best, as the material is so scanty, to present it here under the name of *Carpites* and wait for future material to settle the question.

Locality.—Willow Creek, Fergus County, Mont., about 12 miles north of Musselshell post-office and 1 mile east of road from Junction City to Fort Maginnis.

DISCUSSION OF THE FLORA.

In 1900, when I published my paper entitled "Flora of the Montana Formation," I took occasion to describe a small collection of fossil plants from a point on the right bank of Missouri River about 7 miles below the Coal Banks, just below the Great Bend of the Missouri. The beds whence these plants came were at the time supposed to be of Belly River age, as they appeared to be essentially in the position occupied by beds so called by the Canadian geologists, beyond the international boundary.

After setting forth briefly the then current though somewhat conflicting opinions regarding the areal extent and stratigraphic position

of the Belly River beds, I offered as an excuse for including the plants in the Montana flora the contention of some writers, notably Dr. C. A. White, that these beds were synchronous in part at least with the Montana formation, instead of being wholly below it, as held by others. Subsequent events have proved that it was correct to include them in the Montana flora, though not within the Belly River beds as at present understood.

At the time my bulletin was in press Mr. W. H. Weed had in course of publication his Benton folio,[a] in which he separated the plant-bearing beds in the vicinity of the Coal Banks under the name of the Eagle formation. He placed it between the Colorado and Montana groups, as separating them, but the subsequent investigations of Messrs. Hatcher and Stanton,[b] as already set forth in this bulletin, make it the lowest member of the Montana group, and separated by the Claggett formation from the Judith River beds, which are now regarded as the complete equivalent of the Belly River beds.

The beds below the Coal Banks have afforded the following forms of plants:[c]

Thinnfeldia montana Knowlton.
Quercus? montanensis Knowlton.
Ficus missouriensis Knowlton.
Juglans? missouriensis Knowlton.
Laurus? sp.
Liriodendron alatum Newberry MSS. Hollick.
Platanus? wardii Knowlton.

As these plants were supposed at that time to belong to the Belly River beds, I assembled for purposes of comparison a list of all the known forms that have been found in beds regarded as of this age in the Canadian Belly River. The result was disappointing, for not one of the Coal Banks species was found to be identical with or to have special affinity with the Canadian Belly River, but on the other hand they did show an unmistakable affinity with the Dakota group, and two species (*Thinnfeldia montana* and *Liriodendron alatum*) were regarded as belonging to the true Laramie. The species of *Liriodendron*, with which the Coal Banks form seems identical, was described originally from very rich plant deposits at Florence, Colo., and while this material has not yet been worked up, I am of the opinion that it may prove to be older than the true Laramie, and on this point Doctor Hollick now agrees with me.

The other species (*Thinnfeldia montana*) I was not able to separate from examples found in the Laramie of the Bozeman coal field.

As regards the affinity of the Coal Banks leaves with Dakota group forms, I probably underestimate rather than overestimate it; in fact, I should incline to regard what I then called *Platanus? wardii* as a

[a] Geologic Atlas of United States, folio 55.
[b] Cf. Science, Aug. 14, 1903, Vol. XVIII, pp. 211, 212.
[c] Flora Montana Formation, pp. 11–15, Pls. I, II.

species of *Populites*, possibly the same as Lesquereux's *P. elegans*[a] from the Dakota group at Fort Harker, Kans.; and further, it would not have done great violence to the facts had I identified my *Ficus missouriensis* with *Ficus glascœana* Lesq., and *Laurus* sp. with *Laurus knowltoni* Lesq., both from the Dakota of Kansas. There are slight differences, however, as I pointed out at the time, and it is perhaps best to regard them as distinct, at least until further material can be obtained.

So far as it seems possible to ascertain at the present time, it is more than likely that the Eagle formation will be found to be identical with the Dunvegan group of Dr. G. M. Dawson,[b] for the stratigraphic position, lithologic character, and fossil plants are similar.

From the Dunvegan group Sir William Dawson described[c] 19 species of plants, of which number six or seven were regarded as identical with Dakota group species, and a number of others were quite close to forms well known in the Dakota. Although none of the species from the Dunvegan group are regarded as actually identical with those of the Eagle formation, there are several that are not distantly related.

Since the delimitation of the Eagle formation, which carried with it the only fossil flora supposed to belong to the Belly River beds south of the international boundary, there have been no known plant-bearing beds of this age in the United States. The fortunate discovery by Messrs. Hatcher and Stanton of rich plant deposits in the Judith River beds on Willow Creek, Fergus County, Mont., about 12 miles north of Musselshell post-office and 1 mile east of the road from Junction City to Fort Maginnis, has now furnished a flora of at least 28 forms, as follows:

Fossil plants found in Judith River formation.

Fern, indeterminable.
Fern, indeterminable.
Osmunda montanensis n. sp.
Cyperacites? sp.
Sequoia reichenbachi (Gein.) Heer.
Sequoia heterophylla? Vel.
Sequoia sp.?
Thuja cretacea? (Heer) Newb.
Dammara acicularis n. sp.
Cunninghamites elegans (Corda) Endl.
Cunninghamites recurvatus Hos. and v. d. M
Cunninghamites pulchellus n. sp.
Populus cretacea n. sp.
Populus sp.
Populites amplus n. sp.
Betulites? hatcheri n. sp.
Quercus montana n. sp.
Quercus judithæ n. sp.
Sapindus inexpectans n. sp.
Trapa? microphylla Lesq.
Trapa? cuneata Knowlton.
Diospyros judithæ n. sp.
Castalia stantoni n. sp.
Phyllites denticulatus n. sp.
Phyllites intricata n. sp.
Carpites judithæ n. sp.
Carpites pruni n. sp.
Carpites alatus n. sp.

[a] Flora Dakota Group, Pl. XLVII, fig. 3.
[b] Geol. Surv. Canada, Rept. of Progress, 1879–80 (1881), p. 115B.
[c] Trans. Roy. Soc. Canada, Vol. I, Sec. IV, pp. 20–23.

In order that this flora may be compared with that from the beds north of the international boundary, it will be desirable to first present a complete list of the latter as left by Sir William Dawson. The fol lowing enumeration is from Bulletin No. 163 (p. 15) and is believed to be complete:

Fossil plants found in Canada.

Pistia corrugata Lesq. (leaves).
Pinus or Abies, type of Pityoxylon (Wood).
Sequoia, type of S. gigantea (Wood).
Sequoia, type of S. sempervirens (Wood).
Sequoia reichenbachi (Gein) Heer (leaves and branches).
Thuja, type of T. occidentalis (Wood).
Taxites, type of Taxus baccata (Wood).
Ginkgo, type of G. biloba (Wood).
Ginkgo? (fruit).
Lemna scutata Dawson (leaves).
Populus acerifolia Newb.? (leaf).
Populus latidentata Dawson (leaves).
Populus sp. (Wood).
Betula sp. (Wood).
Ulmus sp. (Wood).
Carya sp. (Wood).
Nelumbo dawsoni Hollick (Brasenia antiqua Dawson) (leaves).
Trapa cf. T. borealis Heer (fruit).
Platanus nobilis Newb.
Platanus? sp. (Wood).
Acer saskatchewense Dawson (leaf).

Much of this material is in the form of wood that has never been completely studied and is consequently of little value in an attempt to fix the age. If all of the remaining forms were correctly determined it would show the presence of a very remarkable association of species, but, as I have before suggested, it is more than likely that more than one horizon is represented. A reexamination of the evidence offered by Dawson leads me to place even less confidence in the determinations, since it shows how meager and uncertain much of the evidence was. Thus, of the presence of *Platanus nobilis* in the same beds (near Medicine Hat) with *Nelumbo dawsoni*, *Pistia corrugata*, *Lemna scutata*, *Trapa*, etc., he says:[a] "There are also fragments of the great leaves of *Platanus nobilis* and the *Populus* and *Acer* described below." So far as I can find, this is the only mention of material referred to this species, yet in subsequent mention it takes its place in lists and elsewhere with unquestioned value. So also with *Populus acerifolia* Newb., the only mention of which is under his *P. latidentata*,[b] where he states that "in the same matrix with the above are fragments of leaves of another *Populus*, of the type of *P. acerifolia* Newberry." Both of these species are typically Fort Union, and have never, so far as I know, been authentically identified in older beds, and I am consequently of the opinion that the present evidence is not sufficient to warrant regarding them as species of the Belly River or Judith River beds.

After dropping *Platanus nobilis* and *Populus acerifolia*, as seems warranted, we have left but three duly authenticated species in the Canadian Belly River beds that enjoy an outside distribution, viz:

[a] Trans. Roy. Soc. Canada, Vol. III, Sec. IV, p. 16, 1885.
[b] Op. cit., p. 16.

Pistia corrugata, which occurs in the Montana at Point of Rocks, Wyoming; *Sequoia reichenbachi*, which occurs widely throughout the Cretaceous of nearly all parts of the world, and *Lemna scutata*, which was described originally from the "Lignite Tertiary" near the forty-ninth parallel, and subsequently detected by Professor Ward in the Fort Union at Burns ranch, Montana, and by Dawson in the Laramie at Wood Mountain and Pincher Creek, British Columbia. Lesquereux reported it from Point of Rocks, Wyoming, but, as I have shown in Bulletin No. 163,[a] one of the examples he so identified is a small leaf of *Pistia corrugata* and the other a *Nelumbo* (*N. intermedia* Knowlton).

As to the affinities of the other named species, it may be mentioned that *Nelumbo dawsoni* is very closely allied to my *N. intermedia* from Point of Rocks, Wyoming, while the other two species (*Populus latidentata* and *Acer saskatchewense*) are not figured, nor are they described with sufficient fullness to permit of satisfactory comparison with other forms.

Turning now to the species described in this paper, mainly from Willow Creek, Montana, the reader will observe that the most striking feature of the list is the preponderance of conifers shown, since 8 of the 28 forms, or nearly one-third, belong to this group, and when the actual number of individual specimens is considered it is safe to say that fully nine-tenths belong to these species; and it may be added that the only species common to the Willow Creek locality and the Judith River beds north of the international boundary is *Sequoia reichenbachi*. This species, as already pointed out, is exceedingly abundant at the Montana locality, and Dawson speaks[b] of it as being abundant also at Medicine Hat in the Canadian beds of this age. It is possible that if the dicotyledons described by Dawson were illustrated they would show affinity with some of those I have described from Willow Creek, but this can not be determined now.

Of the 28 forms enumerated in this paper the following species enjoy an outside dispersal:

Sequoia reichenbachi.
Sequoia heterophylla?
Thuja cretacea?
Cunninghamites recurvatus.
Cunninghamites elegans.
Trapa? microphylla.
Trapa? cuneata.

As already mentioned, the first species (*Sequoia reichenbachi*) is very widely dispersed throughout the Cretaceous, occurring more or less abundantly in this country from the Potomac to the Livingston beds. *Sequoia heterophylla*, described originally from the Cenomanian and Senonian of Bohemia, has been found abundantly in the Amboy clays and sparingly at a number of other Upper Cretaceous localities. *Thuja cretacea* was first known from the Ataneschichten of Greenland,

[a] Flora Montana formation, p. 31.
[b] Trans. Roy. Soc. Canada, Vol. III, Sec. IV, p. 17 (under *Salisburia*).

and has been found by Newberry in the Amboy clays, while *Cunninghamites elegans* occurs in the upper part of the Amboy clays, in the Patoot beds of Greenland, and in the Upper Cretaceous of Moravia, Bohemia, and Westphalia. Of the two species of *Trapa*, *T. cuneata* is known only from, and *T. microphylla* originally from, the Montana at Point of Rocks, Wyoming. As set forth under *T. microphylla* (p. 145), it has been found also in the true Laramie and in the Fort Union.

Of the species that I have described as new, *Dammara acicularis* is perhaps nearest to *D. microlepis* Heer, from the Atane and Patoot beds of Greenland, and also under the name of *Eucalyptus geinitzi* from the Cenomanian of Moravia and the Upper Cretaceous of Bohemia and Marthas Vineyard. *Cunninghamites pulchellus* seems to be nearest to *C. recurvatus*, the distribution of which has already been given. The affinities of *Populus cretacea* are uncertain, but are perhaps closest with certain forms of *Quercus* described by Hoseus and von d. Marck from the Upper Senonian of Westphalia, while *Populus* sp. is very suggestive of forms of this genus, such as *P. rotundifolia*, from the Fort Union beds. The single large leaf that I have described as *Populites amplus* is quite closely related to certain species of this genus from the Dakota group, and *Betulites hatcheri* is close to *B. westii reniformis* Lesq., and *Quercus montana* approaches *Q. suspecta* Lesq., both from the Dakota. *Sapindus inexpectans*, based on a single small leaflet, has no very definite relationship, while the species of *Phyllites* and *Carpites* are in much the same state. *Diospyros judithæ* is very suggestive of *D. kansaseana* Lesq., or more particularly *D. primæva* Heer, from the Dakota of Kansas and Nebraska, while the large leaf described as *Castalia stantoni* is quite unlike anything thus far obtained in this country.

From this review it appears that the flora of the Judith River beds that has thus far come to light shows very little affinity with the true Laramie or the Fort Union, but does exhibit an undoubted relationship with that of the Dakota group or with the Cenomanian and Senonian of the Old World, or, in broad terms, with the lower and middle portions of the Upper Cretaceous.

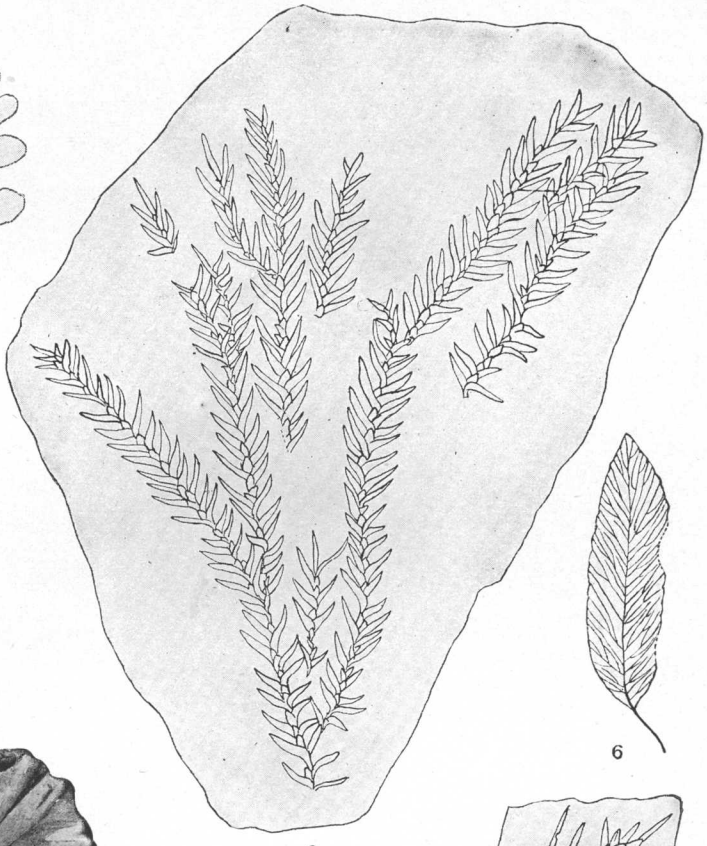
PLATE XIV.

PLATE XIV.

Page.

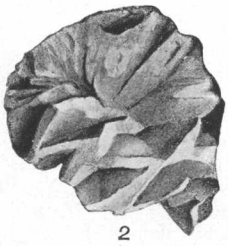
Fig. 1. Fern, indeterminable, enlarged 3 times 129
Fig. 2. Sequoia sp.?..... 131
Figs. 3, 4, 5. Sequoia reichenbachi (Gein.) Heer..... 131
Fig. 6. Osmunda montanensis n. sp., enlarged 2 times 129

1

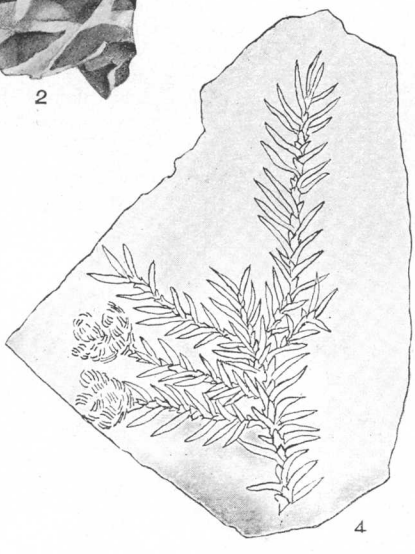


3

6



2



4

5

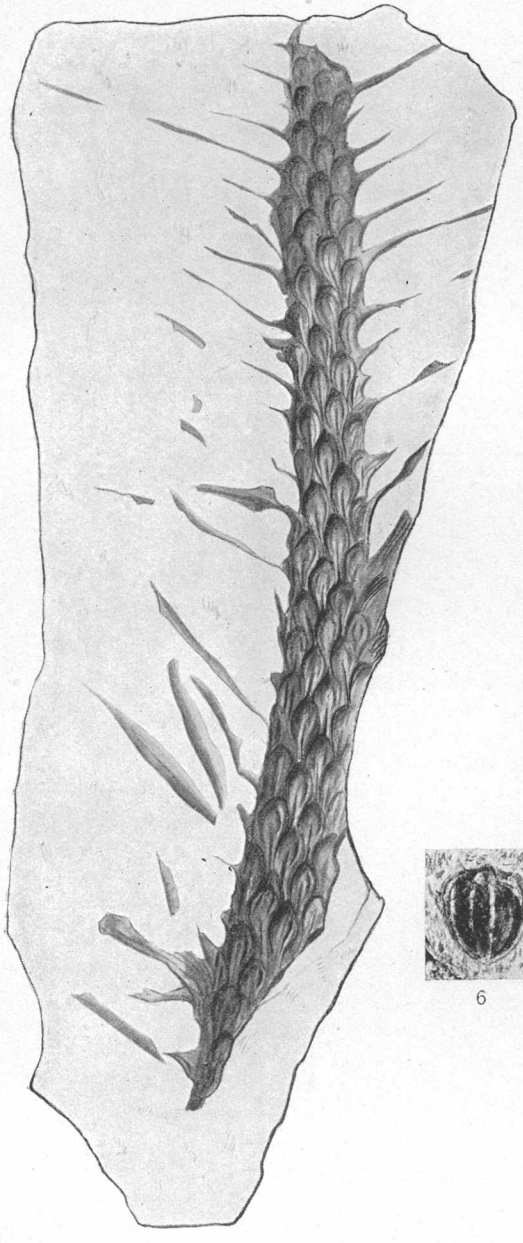
JUDITH RIVER PLANTS.

PLATE XV.

PLATE XV.

Page.

Fig. 1. Cunninghamites elegans (Corda) Endlicher 135
Figs. 2–5. Dammara acicularis n. sp 134
Fig. 6. Carpites pruni n. sp 149
Fig. 6*a*. Carpites pruni n. sp., enlarged 3¼ times 149
Fig. 7. Fern, indeterminable, enlarged 3 times 129

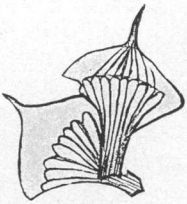


1

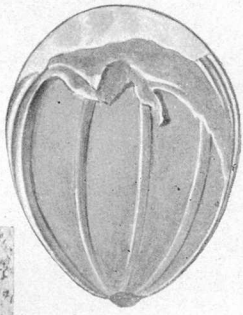
2

3

4

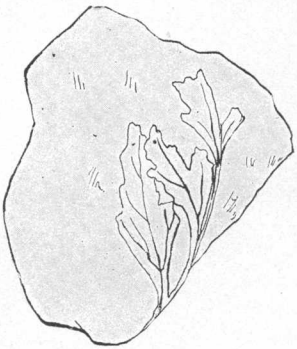


5



6a

6

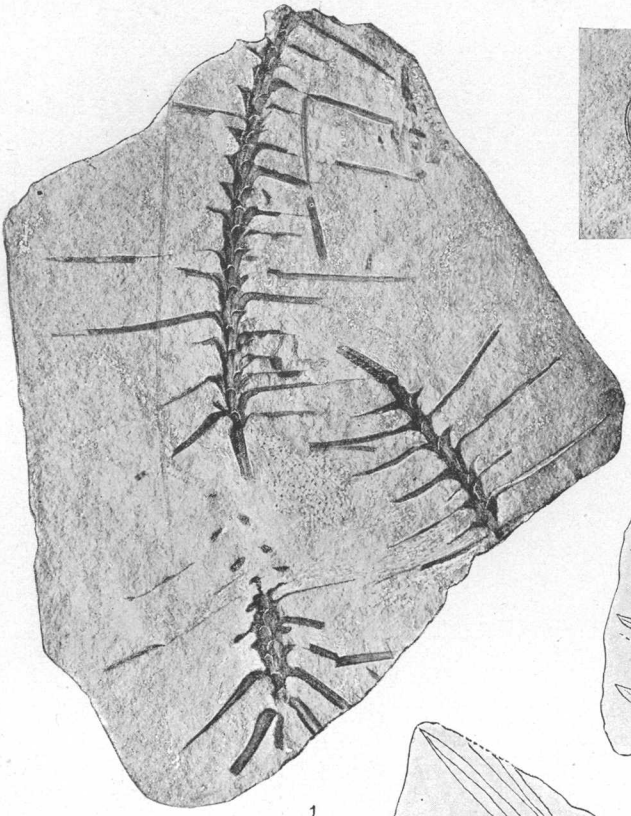


7

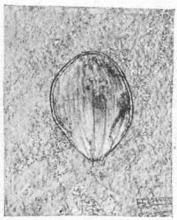
JUDITH RIVER PLANTS.

PLATE XVI.

PLATE XVI.

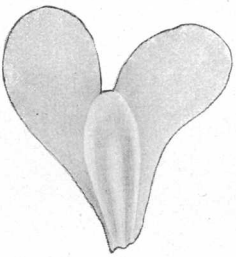


1



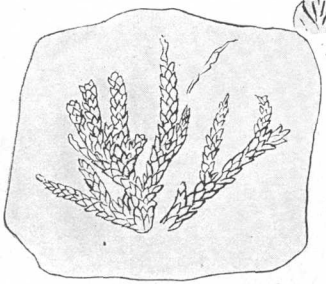
4

5

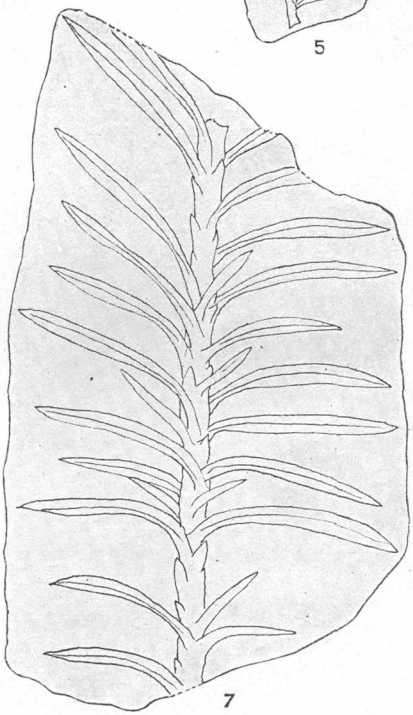


2

3a



3

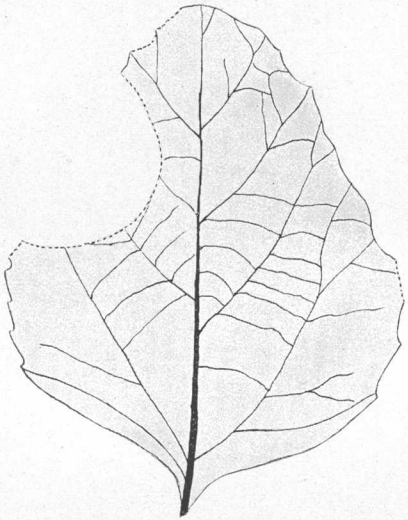


7

JUDITH RIVER PLANTS.

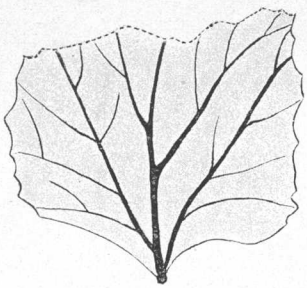
PLATE XVII.

PLATE XVII.

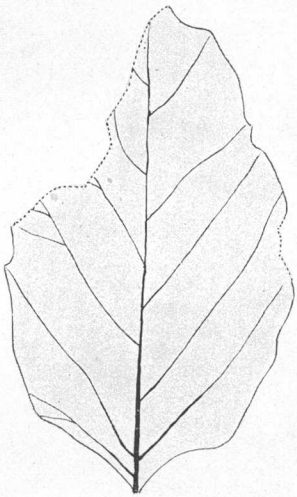


1

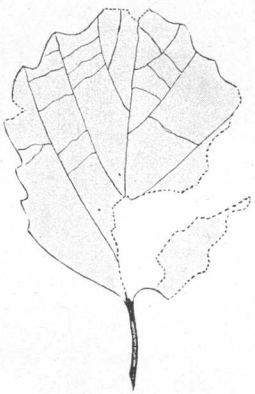
6



2



5



3

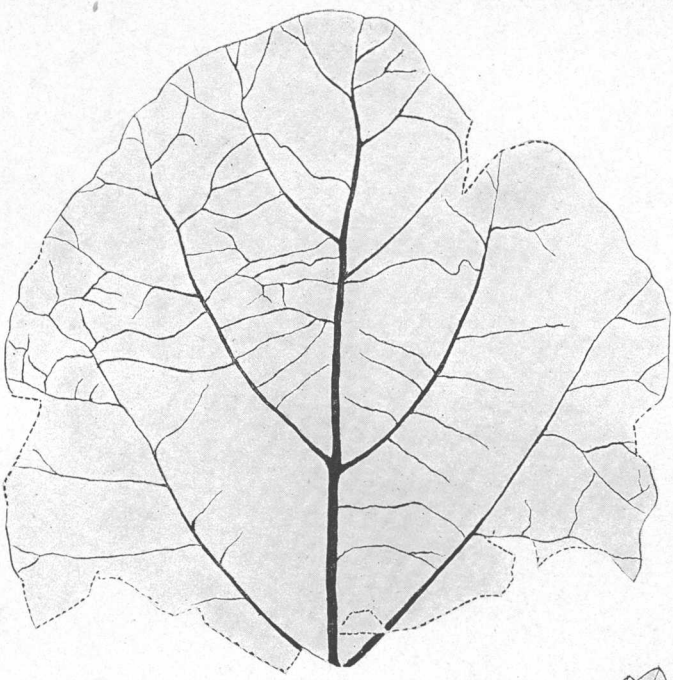
4

7

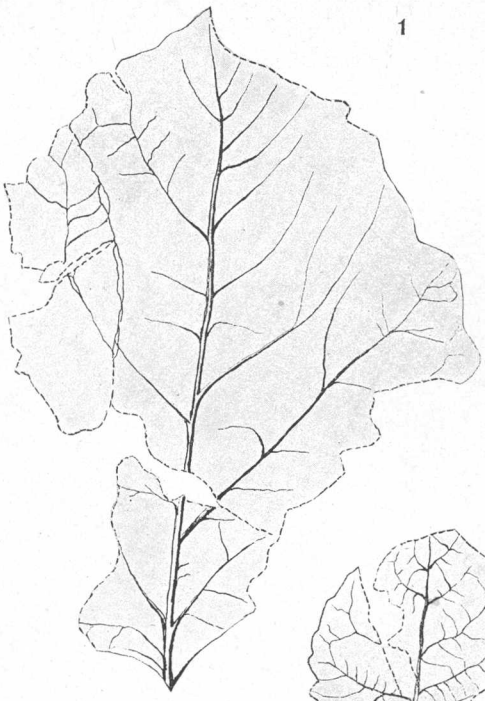
JUDITH RIVER PLANTS.

PLATE XVIII.

PLATE XVIII.



1



2

3

4

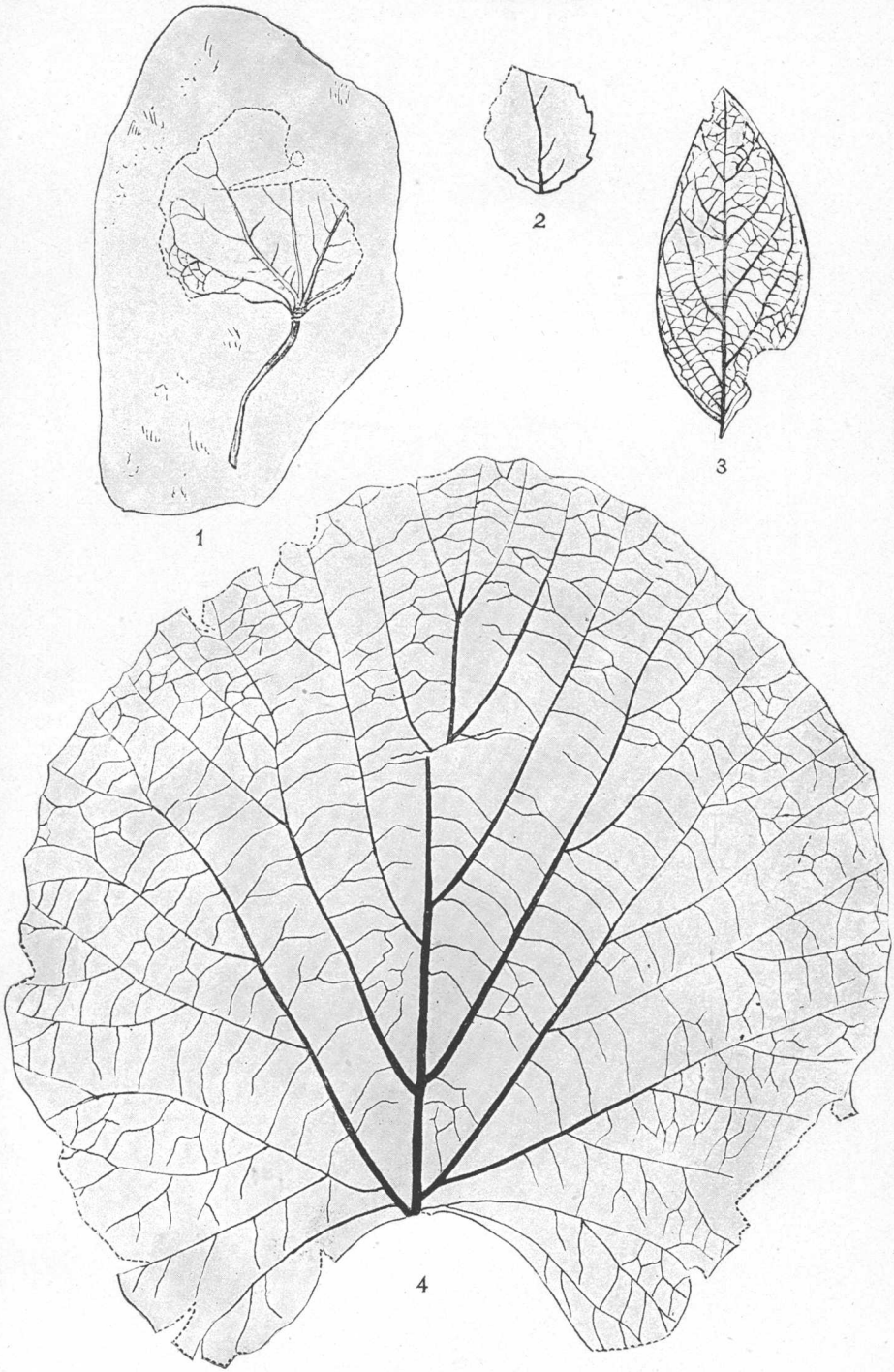
5

6

JUDITH RIVER PLANTS.

PLATE XIX.

PLATE XIX.



JUDITH RIVER PLANTS.

INDEX.

Names in italic are synonyms; figures in black-face type denote pages on which descriptions are given; italic figures refer to illustrations.

O