Article XXI.—THE HUERFANO LAKE BASIN, SOUTHERN COLORADO, AND ITS WIND RIVER AND BRIDGER FAUNA.

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In this paper will be discussed Professor Hills's observations upon the Huerfano Eocene Lake Basin, also those of the writer and Dr. Wortman, including a description of the fauna.

1.—GEOLOGY OF THE BASIN.

In 1888 Professor R. C. Hills,[1] of Denver, announced his very important discovery of Tertiary Beds in the Huerfano River Basin of Southern Colorado. This basin opens towards the Plains through the Huerfano Cañon south of the Wet Mountain Range, and some distance north of the Spanish Peaks. It therefore has at present an eastern drainage into the Arkansas River, and is of exceptional interest because of its isolation from the typical Eocene exposures to the north and west. Professor Hills first described as the 'typical exposures' those occurring upon the Muddy Branch of the Huerfano River in the centre of the valley, and he named them the Poison Cañon Series (1888, p. 16). He estimated them at eight thousand feet in thickness, and as consisting of three divisions: an 'upper series' of softer red and yellow sandy clays and marls, two thousand feet; and below this sandstones, in two 'lower series,' aggregating five thousand feet.

The 'lower series,' he observed, cover a much larger area than the soft sands and marls of the 'upper series,' and extend to the southeast far beyond the limits of the Huerfano into the Cuchara Valley and to the Apishapa, or nearly north and south for a distance of fifty miles, from the base of the Spanish Peaks to the

[1] R. C. Hills. 1888. Recently discovered Tertiary Beds of the Huerfano Basin, Denver, 1888.
" 1889. Additional Notes on the Huerfano Beds. Proc. of the Colorado Scientific Society, October 7, 1889.
" 1891. Remarks on the Classification of the Huerfano Eocene. Proc. of the Colorado Scientific Society, February 2, 1891.

Wet Mountain Valley. This area, having an east and west extent of ten to fifteen miles, he mapped as the former basin of the Huerfano deposits, representing it as bounded upon the east by a distant anticlinal axis extending from the eastern flanks of the Wet Mountain Range from five to ten miles southeast of the present main axis of the range and Spanish Peaks. He thus regarded the eruption of the Spanish Peaks and of Silver Mountain as occurring within the Huerfano Lake area subsequent (1888, p. 11) to the formation of the latest Huerfano Lake deposits, possibly during the Uinta period (1889, p. 223), and considered the upturned beds upon the slopes of the Spanish Peaks and Silver Mountain as part of the Huerfano deposition. Further (1888, p. 14) he suggested that the probable outlet of the Huerfano Lake was to the northward through the Wet Mountain Valley. In his first paper also (1888, p. 16) Professor Hills identified as probably of Pliocene age, the uppermost deposits of between seven and eight hundred feet in thickness, consisting of fawn or buff colored, compact marls, clays and sandstones, between the Muddy and the Huerfano in the centre of the basin, but in his second paper these were correctly determined as Eocene, while more restricted true Pliocene or Equus Beds sands were found above. The harder beds of the 'lower series' underlying these he compared lithologically with the Wasatch of the Uinta and San Juan Basins. In fact the first fossils he procured resembled the remains of *Coryphodon.*

In his second paper (October, 1889, p. 218) Professor Hills divided the Huerfano Beds into three series, as follows:

Total thickness exposed in Poison Cañon, and approximate total at West Spanish Peak.

- Marls, clays, soft shales and sands, of red, gray, yellow, green and purple colors, red predominating. (Fully exposed in Huerfano Valley, removed by erosion in Cuchara Valley.).....3,300 ft.
- Pink and white massive sandstones (well exposed in Cuchara Valley and West Spanish Peak).....300 ft.
- Soft sandstones and fine conglomerates of a yellowish tint, with occasional bands of yellow clay or marl, 3,500 ft.

The upper marls and clays, he observed, were altered where they come in proximity to the laccolithic mass of West Spanish Peaks. In this paper he demonstrated positively that the upper

variegated marls and sands belong to the Eocene, from the occurrence in these beds of a number of characteristic Eocene genera, such as *Tillotherium*, *Hyrachyus*, *Glyptosaurus* and *Palæosyops*.[1] He also distinguished as Pliocene[2] the superficial deposits of volcanic ash found between Muddy and Turkey Creeks, which contained remains of Horses, Llamas and Elephants. No fossils were reported from the deposits of the 'lower beds,' but the characteristic Bridger fossils found in the 'upper beds' furnished important evidence of their Bridger age.

In his third paper (1891) Professor Hills positively identified the 'upper beds' as equivalent to the Bridger group, and restricted the term HUERFANO to these beds, applying the terms CUCHARA to the middle division, and POISON CAÑON to the lower division. These divisions, correlated with the measurements previously assigned them, would then occur as follows:

Huerfano Series (Eocene).	Huerfano Beds.....	= Bridger Group.....	3,300
	Cuchara Beds.....	.....	300
	Poison Cañon Beds.	= Lower Eocene (Green River, Wasatch and Puerco).....	3,500

While these studies were in progress a large collection of fragmentary bones was made by Mr. Milligan, of Gardner, which is now preserved in the Museum of the Colorado Scientific Society, and which Professor Hills kindly enabled the writer to carefully examine.

The essential features of Professor Hills's conclusions may be summarized as follows:

1. The identification of the total Huerfano series of 3,300 feet with the Bridger or Middle Eocene, and the provisional identification of the Cuchara and Poison Cañon series with the Lower Eocene, in the absence of fossils, upon stratigraphical evidence.

2. The Post-Laramie formation of a great anticlinal axis, as the eastern border of the Huerfano Lake to the east and southeast of the Wet Mountain range and Spanish Peaks, and the subsequent removal of this axis by erosion.

[1] Mainly identified by Professor Marsh.
[2] If equivalent to the *Equus Beds*, these would be termed Pleistocene.

3. The eruption of the laccolithic Silver Mountain and Spanish Peaks subsequent to the deposition of upper lake deposits of Bridger age.

4. The drainage of the Huerfano Lake to the north through the Wet Mountain Valley.

It should be stated here that these opinions were expressed at a time when several geologists had identified Laramie deposits east of the Rockies as Tertiary, owing partly to Professor Marsh's identification of a Laramie Dinosaur with *Bison alticornis.*

For the sake of clearness of contrast it may be well to summarize at this point the geological conclusions formed by the writer and Dr. Wortman during their brief reconnaissance of this region :

1. That west of the Huerfano Cañon the variegated marls, clays, soft shales and sands aggregate only 800 to 1000 feet in thickness, and are nearly horizontal in position. They may be positively divided into Upper Beds, equivalent to the Bridger, and Lower Beds, equivalent to the Wind River, or Upper Wasatch. These constitute the only true Huerfano Lake deposits.

2. That the Cuchara and Poison Cañon Beds are unconformable with the Huerfano Beds and older than the Eocene, probably marine Cretaceous, as partly determined by the presence of a species of *Baculites* in the yellow sandstone of the typical Poison Cañon section.

3. That the present cañon of the Huerfano River cuts through the base of the main anticlinal axis of Post-Laramie origin, which formed the eastern boundary of the lake. This axis extended to the south so as to include the base of Silver Mountain toward the Cuchara divide ; but it lies from three to seven miles west of the anticlinal axis described by Professor Hills.

4. That the Huerfano Lake deposition did not extend as far to the east or south as the Spanish Peaks, and that the variegated beds observed there are of older origin. This would materially affect the geological age of the prominent neighboring laccoliths.

The geological features of these conclusions can hardly be dignified by the term 'a theory of the Huerfano Lake,' for they were formed during a hasty reconnaissance of this basin, while Professor Hills's theory certainly deserves the deliberate consideration of a prolonged survey. In fact this basin, with its volcanic disturbances and eruptions, presents in compact form a fascinating problem in the geology of Tertiary times.

2.—Determination of Two Horizons.

We may now proceed with an account of our reconnaissance. Attracted by the prospect of adding to our knowledge of the Bridger fauna, and especially of the little-known genus *Tillotherium*, the writer, accompanied by Dr. Wortman, entered this Basin upon May 25 last.

In transportation and outfitting we were most liberally assisted by President E. T. Jeffery and other officials of the Denver and Rio Grande Railroad, to whom we return our hearty acknowledgments.

Aided by sketches of the topography and the fullest information as to localities kindly given us by Professor Hills, we proceeded directly to the Huerfano Cañon. There we observed the base of a great anticlinal fold originally of at least 1500 feet in thickness, but now greatly eroded and cut directly through its axis by the river. This Cretaceous axis appears to have been of sufficient thickness to have held back the drainage of the basin, and to have caused the deposition of the 800–1000 feet of Eocene sediment which we found above. We followed up the Huerfano and Muddy about twenty-five miles to the entrance of Poison Cañon, and explored first, the three large Eocene buttes between the Muddy and Huerfano Rivers, as well as Monument Bluffs opposite. Subsequently Box Cañon was carefully worked over by Dr. Wortman, and the whole region west of Gardner. Unfortunately, Mr. Milligan, who went over the ground for Professor Hills, was not experienced, and his very thorough gatherings from the surface had removed most of the indications of the underlying remains, which are invaluable to the trained collector. Thus the beds appeared to be generally barren, although originally, judging by

the large number of fragments in the Museum of the Colorado Scientific Society, the indications must have been more plentiful. The surface also is naturally unfavorable to the collector, as compared with the Bridger, because the rock is much softer, the overcrust is deeper and comparatively few areas are free from trees and vegetation, whereas the Bridger buttes are absolutely bare, and the eye reaches long distances. All the remains were found in the sands, clays and marls, varying from red, purple, gray, green and yellow or whitish in color, the upper arenaceous clays containing the best deposits.

We nevertheless found very considerable portions of the skeleton of *Tillotherium*—a form which is very rare in the Bridger—besides remains of *Hyrachyus*, *Palæosyops*, *Microsyops*, *Calamodon*, *Stypolophus*, and the Bridger Horse, probably *Pachynolophus*. The region thus shown to be homotaxial with the Bridger is rendered peculiar by the scarcity of any remains of *Uintatherium*.

In the typical Poison Cañon section, described upon page 4 of Professor Hills's first paper, from Poison Cañon to Monument Bluffs, the yellow sandstones underlying the Upper Beds just south of Muddy Creek were proved to be Cretaceous by the presence of *Baculites* and other invertebrate remains in the clays immediately underlying them. These Cretaceous Beds are certainly not 800 feet below the summit of the Upper Huerfano Beds, yet they are directly in the path of the typical Poison Cañon section described by Professor Hills. This observation therefore not only affects the determination of the age of the Poison Cañon and Cuchara Beds, but it materially reduces the estimated thickness of the Upper Beds.

At all points, except close to the old northern lake border against the Wet Mountain range, where the Upper Beds partook of the mountain uplift, we observed a nearly horizontal position of the Upper Beds, and a very decided unconformity with the massive underlying pink and yellow sandstones, which at many points were sharply upturned. At distant points these Upper Beds were easily distinguished by their alternating bands of reds, grays and buffs. In fact the extensive view of the basin afforded from the uneroded buttes between the Muddy and the Huerfano —from Promontory Bluffs upon the north to the Sheep Mountains

on the south (which we were unable to visit)—gave the impression of a typical lake deposit of about 800 feet in thickness, nearly horizontal, covering what were formerly insular masses of upturned rocks, and overlying here and there, in the valleys, cleanly eroded Cretaceous Beds. In several places these Eocene Beds are intruded by laccolithic dykes[1] and by fissures of recent origin, filled with gravel conglomerates similar to those which cap the beds. As in the Bridger of Wyoming, these Upper Beds were capped with conglomerates.

In examining Professor Hills's collection in Denver the writer found part of a molar tooth of *Coryphodon*, also the distal end of a humerus and a femur, confirming Professor Hill's original identification of a portion of the beds with the Wasatch or Wind River. This was fully corroborated by our own collections.

Subsequent to the writer's departure from the Basin, Dr. Wortman explored the region east of Gardner, our previous explorations having been to the north and west, and was surprised to find an entirely different fauna, containing none of the forms characteristic of the Upper or Bridger level, but on the other hand distinguished as of Wind River or of Wasatch age by the presence of *Coryphodon*, *Lambdotherium*, *Oxyæna*, *Pantolestes* and other lower Eocene forms. "These beds of the lower division," writes Dr. Wortman, "are indistinguishable, so far as their general appearance and lithological characters are concerned, from those of the upper level. The fossils occur apparently in a single stratum not exceeding 10 or 15 feet in thickness, and not more than 30 or 40 feet from the base of the formation. They underlie the beds of the upper division with perfect conformity, and there is at present no means of determining exactly where the one ends and the other begins. That sedimentation was continuous and uninterrupted

[1] "Near Gardner is found the small laccolith known as Rattlesnake Butte. It is a small volcanic mass standing almost in the center of the basin, not exceeding 250 feet in height, and apparently unconnected with the numerous dykes which cross the basin in the direction from northeast to southwest. That this laccolith antedates the deposition of the Huerfano sediment is proved by the fact that the beds in its immediate vicinity show no evidence whatever of any disturbance of level, which must have undoubtedly occurred had it been intruded into these sediments after they had been laid down. On the other hand they preserve their horizontality and unaltered condition even to actual contact with the volcanic rock. In the same manner the Huerfano Beds lie almost horizontal against the base of Silver and Sheep Mountains, a fact which must argue strongly for their pre-Huerfano formation. It is, however, a fact that many of the dykes were formed subsequent to the deposition of the Huerfano sediments."—J. L. W.

In discussing this paper at the Detroit meeting of the American Association, Mr. G. K. Gilbert, of the U. S. Geological Survey, observed that laccoliths make a very slight disturbance of local strata.

from the beginning to the close of the whole deposit, I do not think there can be the slightest question. The exact locality from which the greater number of the fossils of the Lower Beds were obtained is Garcias Cañon, about one and one-half miles south of Talpa or the mouth of Turkey Creek."

He traced the distribution of the sediment southward around the base of Silver Mountains, but was unable to find it to the south of the Cuchara-Huerfano divide, nor to the east of the Huerfano Cañon. To the south of the Silver Mountains the Upper Bed formation thins out rapidly, giving the impression that the Huerfano-Cuchara divide is a continuation of the axis of the southern boundary of the Lake first observed at the Cañon. No traces could be found of the Upper Beds at Spanish Peaks, after careful search, but it is possible that the especial localities described by Professor Hills as exhibiting the Upper Bed formation were not met with.

The faunal division between the Upper and Lower Beds is therefore very clearly marked by fossils in the Museum of the Colorado Scientific Society (indicated by C.), and by those collected for the American Museum of Natural History (indicated by A.), as follows :

3. Huerfano Lake Fauna.

	I. Lower Beds. *Wind River.*	II. Upper Beds. *Bridger.*
Creodonta	Oxyæna huerfanensis (A.). Didymictis protenus (A.). " dawkinsianus (A.).	Patriofelis ulta (A.).
Ganodonta		Calamodon[1] (C.).
Rodentia	Plesiarctomys delicatior (A.).	Paramys (C.).
Tillodontia		Tillotherium fodiens (C. A.).
Primates	Hyopsodus powellianus (A.).	Microsyops (C.).
Amblypoda	Coryphodon, sp. indet. (C. A.).	Uintatherium, sp. indet. (C. A.).
Perissodactyla	Lambdotherium popoagicum (A.).	Hyrachyus (C.).
Artiodactyla	Pantolestes secans (A.).	Palæosyops paludosus (C.).

[1] This determination rests upon a tooth sent to Professor Marsh for identification in 1889, and described to the writer by Professor Hills. It is possibly *Stylinodon*, in which case it belongs to the Upper Beds.

I. LOWER BEDS.—WIND RIVER AGE.

Among the Creodonts is a small lower jaw (No. 2681) which belongs either to *Stypolophus* or *Didelphodus.*

Oxyæna huerfanensis, sp. nov.

Specific characters.—Reduced second superior molar, posterior nares partially enclosed by convergence of pterygoids in median line.

Oxyæna is represented by a fragmentary skull and jaws (No. 2683) of an animal differing from *O. forcipata* in its smaller size, and especially in the marked reduction of the transversely placed second superior molar, the proportions being:

	M^1.	M^2.
O. forcipata	.021	.023
O. huerfanensis	.018	.013

This reduction indicates that this is a distinct species, a successor probably of *O. forcipata* which is found in the Wasatch, and possibly transitional to *Patriofelis* of the Bridger, in which, according to Wortman, the second superior molar has disappeared entirely. The palate of this valuable new type is entire, and is of importance because it shows that the pterygoids bend over and unite in the median line as in certain species of *Mesonyx* and *Hyænodon.*

Didymictis protenus v. altidens *Cope.*

Didymictis is represented by several lower teeth (No. 2677, canine, fourth premolar, first and second molars) which nearly agree in size with those of *D. altidens* belonging to the Wind River period, but the form of the second lower molar is closer to that of the smaller *D. protenus* of the Wasatch. The reference of this specimen is therefore somewhat uncertain.

Didymictis dawkinsianus *Cope.*

This species is represented by two lower jaws (Nos. 2678, 2679) and a few limb bones. It is common to the Wasatch and Wind River levels.

Plesiarctomys? delicatior *Cope.*

This rodent is represented by several individuals. The most complete animal (No. 2682) consists of limb and foot bones of great value, namely: humeri, ulnæ and radius, femora, tibiæ and a distinct fibula, calcanea, astragali, cuboid, navicular, metapodials, many vertebræ, and other less perfect parts.

Hyopsodus? powellianus *Cope.*

Doubtfully referred to this species, which Cope has recorded only from the Wasatch, are remains of two individuals (Nos. 2675, 2676) represented by two molar teeth each.

Coryphodon.

Portions of the lower jaw and teeth of a *Coryphodon* (No. 2690) in our collection correspond with the *Coryphodon* of larger size found in the Wind River Beds, but cannot be specifically determined. An upper molar is preserved in Professor Hills's Collection.

Lambdotherium popoagicum *Cope.*

This species is represented by the upper molars and fourth premolar of one side (No. 2688), and by other fragments of one animal. The presence of this type seems to afford the best evidence that the 'Lower Beds' are of Wind River rather than of Wasatch age.

II. Upper Beds.—Bridger Age.

Patriofelis ulta *Leidy.*

This very rare animal is represented by portions of the lower jaws of one individual (No. 2691), the right ramus being nearly complete, including the canines, three premolars and the second molar, being the first teeth of *Patriofelis* secured for the American Museum Collection.

This individual, although an aged animal, is much smaller than Leidy's type of *P. ulta*, the canines and last molar being extremely worn. The linear measurements of the lower teeth are as follows:

	P_2–M_2.	P_2–P_4.
Leidy's type of *P. ulta* (approximate)	.074	
Huerfano specimen, No. 2691	.060	.034

The premolars exhibit rather blunt, conical cusps. The diastema between $P_{\frac{2}{2}}$ and the canine is wanting, and it is possible there existed a small $P_{\frac{1}{1}}$.

Tillotherium fodiens *Marsh.*

This animal was abundant in the Huerfano basin, leaving many remains.

The first fragments found of a skeleton representing this species (No. 2692) gave rise to hopes of the discovery of valuable material, but these were not realized. The specimen includes the upper incisor, last upper premolar, three lower molars, and fragments of other teeth which resemble in size the *T. fodiens* of Marsh. The animal is about the size of *Pachyæna ossifraga* or of the modern black bear. The associated skeletal remains afford several characters in addition to those given by Marsh.[1] The shaft of the femur is broad and flat proximally (partly owing to pressure), supporting an elevated great trochanter. The distal face of the tibia is very oblique, as in the Creodonts. The radius proximally gives evidence of some power of rotation, although not very extensive. The left cuneiform shows proximally a large pisiform facet, a slightly divided ulna facet, and distally a single facet for the unciform only. Metacarpal III is proximally wedge-shaped, abutting by an oblique outer face sharply against the unciform, as in many Creodonts. The first and second phalanges are rather short, and the numerous segments preserved indicate that the *fore foot was short, spreading and strongly clawed.*

With the exception of the flattened proximal shaft of the femur the resemblances throughout are with the Creodonta rather than with the Edentata-Ganodonta.

[1] Amer. Jour. Science, March, 1876, p. 251.

Uintatherium *Leidy.*

Uintatherium is certainly very rare in these beds, but its presence seems to be demonstrated by the proximal portion of a very small tibia, smaller even than that of *Palæosyops paludosus* (No. 2693), for which it was at first mistaken. It does not belong to any Perissodactyl, but is distinguished as an Amblypod tibia by the absence of a spine between the condylar facets; these facets being continuous over a low intermediate ridge; the internal facet being much larger than the external, as in many *Uintatherium* tibiæ in our collection.

Uncertainty as to this reference arises only from the diminutive size of this animal, the transverse diameter of the articular end of the bone being only .085.

Protorohippus *Wortman.*

There are several remains of *Hyracotheriinæ*, or primitive Horses, in the collection, the most perfect (No. 2685) being a lower jaw which agrees exactly in size with the small *Hyracotherium index* of the Wasatch, but has the developed postero-internal cusp on $P_{\frac{4}{4}}$ characteristic of the subgenus *Pliolophus*. The total molar-premolar series, including the estimated $P_{\frac{1}{1}}$, measures approximately, only .051.

In conclusion the writer desires to express his hearty appreciation of the assistance rendered by Prof. R. C. Hills, of Denver, who first made the existence of this interesting deposit known to the world. To Dr. J. L. Wortman the writer's thanks are due for valuable suggestions and coöperation in the field. Dr. W. D. Matthew has been of great service in the Museum in restoring and aiding in the determination of the types in this collection.