



FIG. 1.—Scene in the Bad Lands of the White River formation in Nebraska. F



The Bad Lands of the White River formation in Nebraska. From Dr. Hayden.

THE  
AMERICAN NATURALIST.

VOL. XVI. — MARCH, 1882. — No. 3.

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THE TERTIARY FORMATIONS OF THE CENTRAL  
REGION OF THE UNITED STATES.

BY E. D. COPE.

THE principal Tertiary formations of the region between the Mississippi river and the Sierra Nevada are the following, as mainly determined by Dr. Hayden: The Puerco, the Wasatch, the Bridger, the Uinta, the White River, the Truckee, the Loup Fork and the Equus beds. Several of these are again distinctly subdivided, and in a few instances such divisions have been regarded by authors as of equal importance with those above mentioned; as, for instance, the Green River portion of the Wasatch. But the evidence of vertebrate palæontology is not as yet clearly favorable to further primary subdivision than is indicated by the above names. In the following pages I will briefly describe the character and distribution of these formations.

The general history of the succession of the Tertiary lakes of the interior of the North American continent and their deposits has been developed by the labors of various geologists, prominent among whom must be mentioned Hayden, Newberry and King. It may be synoptically stated as follows:

The Laramie Cretaceous period witnessed a great difference in the topography of the opposite sides of the Rocky Mountain range. To the east were extensive bodies of brackish and nearly fresh water, with limited ocean communication, studded with islands and bordered by forests. On the west side of the range was a broad continent, composed of mostly marine Mesozoic rocks, whose boundaries are not yet well ascertained. Towards the close of the Laramie, the bed of the great eastern sea began to emerge from the waters, and the continent of the western side of the great range descended. The relations of the two regions.

were reversed; the east became the continent, and the west became the sea. The latter, receiving the drainage of the surrounding lands, was a body of fresh water, whose connection with the ocean permitted the entrance of a few marine fishes only. This was the great Wasatch lake, whose deposits extend from the upper waters of the Yellowstone far south into New Mexico and Arizona, between the Rocky mountains on the east and the Wasatch range on the west. Its absence from the east side of the former range indicates the continental condition of that area at the time. The only locality where the Wasatch deposits are extensively deposited on the Laramie, is in the region intermediate between the two districts in Wyoming Territory. Here the sediments of the former are seen to have succeeded those of the latter, and to have been coincident with an entire cessation of brackish conditions. Elevations of the continent northward and southward contracted the area of the great Wasatch sea, and perhaps deepened it, for at this time were deposited the fine limestones and silico-calcareous shales of the Green River epoch. There is no evidence that these beds had a greater eastern extension than that of the parent Wasatch lake. King has given distinct names to these ancient lakes. I think it better to pursue the usual course of using for them the names already given to their deposits, as involving less strain on the memory; the more as the number of these lakes is being increased by numerous new discoveries. The only known region which it covered west of the Wasatch range, is represented to-day by the calcareous strata in Central Utah which I have called the Manti beds. The exact equivalency of these is, however, not quite certain. Further contraction reduced this area to perhaps two lake basins, whose deposits now form two isolated tracts in Southern Wyoming, and are known as the Bridger formation. Continued elevation and drainage caused the desiccation of these basins also, leaving only, so far as present knowledge extends, a body of water on the south of the Uinta mountains, in Northeastern Utah. The sediments of this lake form the Uinta formation, which is the latest member of the series now found in the region lying between the Rocky and Wasatch mountains.

About the time that the elevation of the present drainage basin of the Colorado river was completed, a general subsidence of level of the great region east of the Rocky mountains com-

menced. Extensive lakes were formed in the depressions of the Laramie and older beds which formed the surface, which were probably connected over a tract extending from near the Missouri river to Eastern Wyoming and Colorado. Near the same time a similar body of fresh water occupied a large part of what is now Central Oregon and certain areas in Northwestern Nevada, according to King. The sediments now deposited constitute the White River formation, and the faunal distinctions which I have discovered to characterize the eastern and western basins have led me to employ for them the subdivisive names of White River beds for the former and Truckee (King) for the latter. It may have been during the early part of this period, or during the Uinta, that there existed two contemporary bodies of water, separated by a wide interval of territory. One of these extended over a considerable tract in Northern Nevada, and deposited a coal bed near Osino. A formation probably the same, has been found by Professor Condon in Central Oregon, underlying the Truckee Miocene beds. The other lake left its sediments near Florissant, in the south park of Colorado. This formation I have named the Amyzon beds,<sup>1</sup> from a characteristic genus of fishes which is found in it. It has been referred to the Green River formation by King, but in contradiction to the present palæontological evidence, as it appears to me.

The oscillations of the surface which brought the White River period to a close, are not well understood. Suffice it to say here, that after an interval of time another series of lakes was formed, which have left their deposits at intervals over a wider extent of the continent than have those of any other epoch. These constitute the beds of the Loup Fork period, which are found at many points between the Sierra Nevada and the Rocky mountains, from Oregon to New Mexico, and over parts of the Great Plains of Colorado, Kansas, and northward, and in the valleys of the Rocky mountains. King has shown that the beds of this epoch are slightly elevated to the westward, thus proving that the elevation of the Rocky mountains had not entirely ceased at that late day. A probably continuous succession of lakes has existed from this period to the present time in ever-diminishing numbers. The most important of these later lakes were in the Great basin in Oregon, in Washington and in Nebraska, and their

<sup>1</sup> AMERICAN NATURALIST, May, 1879.

deposits enclose the remains of a fauna entirely distinct from that

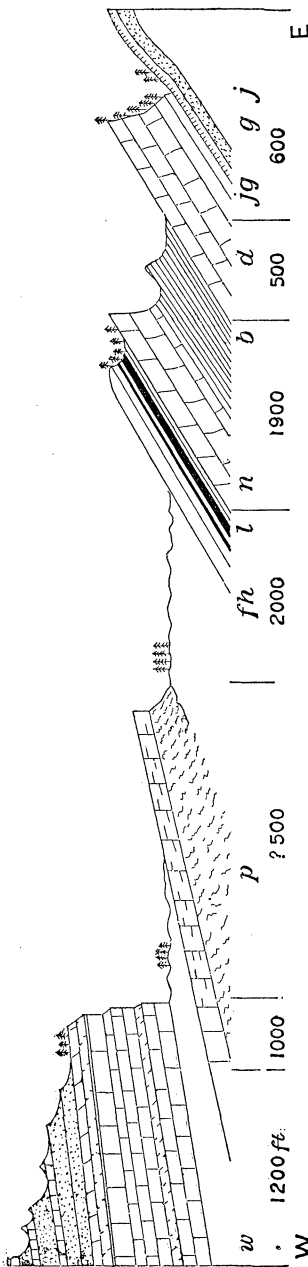


FIG. 2.—Section west of the Gallinas mountains, New Mexico, from Gallinas creek to the Eocene plateau. Letter *j*, Jurassic; *jg*, Jurassic gypsum; *g*, Gallinas creek; *d*, Dakota; *b*, Benton; *n*, Niobrara; *l*, lignite; *fh*, Fox hills, *p*, Puerco; *w*, Wasatch; from Lt. Wheeler's report.

of the Loup Fork period and of more modern character. They are known as the Equus beds. This fauna was probably contemporaneous with that which roamed through the forests of the eastern portion of the continent, whose remains are inclosed in the deposits of the caves excavated from the ancient limestones.

A more detailed account of the formations is now given, with the names of a few of the characteristic fossils.

#### THE PUERCO.

This formation, having furnished numerous mammalian fossils, is known to belong to the Tertiary rather than the Post-cretaceous series. It is regarded by Dr. Endlich as a subdivision of the Wasatch, but the characteristics of its fauna are so marked as to constitute it a distinct horizon.

The most southern locality at which it has been observed, the one from which I named it, and where its characters are distinctly displayed, is west of the Jemez and Nacimiento mountains, in New Mexico, at the sources of the Puerco river. At this place its outcrop is about 500 feet in thickness, and has an extent of several miles on both sides of the river. From this point the strike is northward, keeping at the distance of a few miles to the eastward of

an escarpment of the Wasatch formation. It contracts in depth to

the northward, and it extends to the south-west, beyond the overlying Wasatch beds.

It is well developed in Southern Colorado, where Dr. F. M. Endlich<sup>1</sup> and William H. Holmes,<sup>2</sup> of Dr. Hayden's Survey, detected it in 1876. Its mineral character is there similar to that seen in New Mexico, and its thickness is much greater. On the Animas river it is 1000 to 1200 feet; on the San Juan river, near the Great Hog Back, 700 feet. The general characters of the formation are expressed in the following description, extracted from my report to Lieut. G. M. Wheeler.<sup>3</sup>

"South of the boundary of the Wasatch, the varied green and gray marls formed the material of the country, forming bad land tracts of considerable extent and utter barrenness. They formed conical hills and flat meadows, intersected by deep arroyos, whose perpendicular walls constituted a great impediment to our progress. During the days of my examination of the region, heavy showers of rain fell, filling the arroyos with rushing torrents, and displaying a peculiar character of this marl when wet. It became slippery, resembling soap in consistence, so that the hills were climbed with difficulty, and on the levels the horses' feet sank at every step. The material is so easily transported that the drain-

<sup>1</sup> Annual Report U. S. Geol. Surv. Terrs., 1875, p. 189.

<sup>2</sup> Loc cit., 247.

<sup>3</sup> Annual Report of Chief of Engineers, 1875, p. 89. Appendix 44.

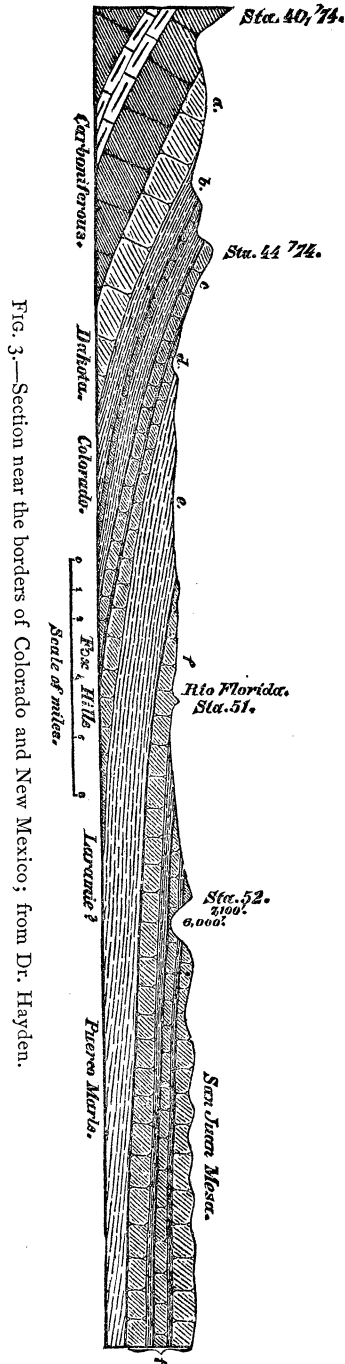


FIG. 3.—Section near the borders of Colorado and New Mexico; from Dr. Hayden.



age channels are cut to a great depth, and the Puerco river becomes the receptacle of great quantities of slimy looking mud. Its unctuous appearance resembles strongly soft soap, hence the name *Puerco*, greasy. These soft marls cover a belt of some miles in width, and continue at the foot of another line of sandstone bluffs, which bound the immediate valley of the Puerco to a point eighteen miles below Nacimiento.

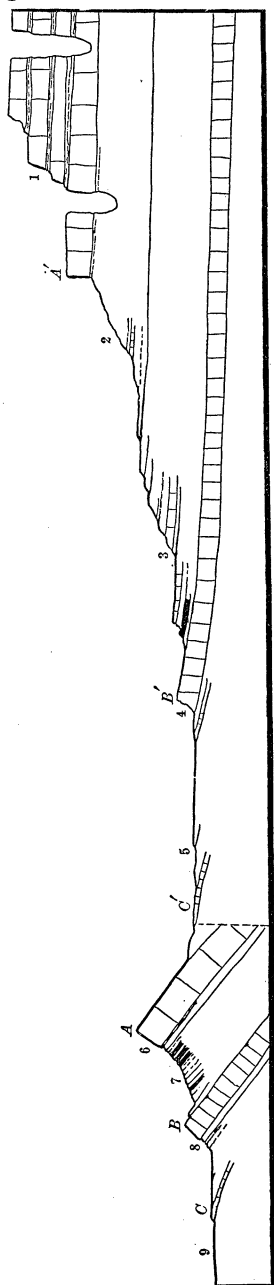


FIG. 4.—Section in southern Colorado, showing apparent duplication of strata and location of the supposed fault, by which *A* would be the same as *A'*, *B* the same as *B'*, and *C* the same as *C'*. Figures are the same as in Fig. 5; from Dr. Hayden's ann. report.

“The Puerco marls have their principal development at this locality. I examined them throughout the forty miles of cutcrop which I observed for fossil remains, but succeeded in finding nothing but fossil wood. This is abundant in the region of the Gallinas, and includes silicified fragments of dicotyledonous and palm trees. On the Puerco, portions of trunks and limbs are strewn on the hills and ravines, in some localities the mass of fragments indicating the place where some large tree had broken up. At one point east of the river I found the stump of a dicotyledonous tree which measured five feet in diameter.”

The fauna of this formation is different from that of the other Eocenes in the presence of a saurian, *Champsosaurus*, which is characteristic of the Laramie Cretaceous, and a marsupial Mammal (*Ptilodus*) which is a remnant of a type only known otherwise from the Jurassic. Its characteristic genera are *Catathlæus*, a many-toed hooped animal, *Psittacotherium*, a gnawing Tillodont, and various flesh-eaters with primitive teeth. *Coryphodon* is, so far, unknown.

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## THE WASATCH.

In lithological character, the Wasatch consists of a mixed arenaceous-calcareous marl, alternating with beds of white or rusty sandstone. The more massive beds of sandstone are in New Mexico, Colorado and Wyoming, at the base of the formation. The marls readily weather into the fantastic forms and cañon labyrinths of bad-land scenery. The marls often contain concretionary masses of a highly silicious limestone, which cover the banks and slopes of the bluffs with thousands of angular fragments. It is characteristic of this formation that the marls contain brightly colored, usually red strata; and in many localities the colors are various, giving the escarpments a brilliantly banded appearance.

Petrographically this formation has two divisions, the Wasatch proper and the Green River beds; the latter name having sometimes been given to the entire formation as well as the former.

Of the few vertebrate fossils known from the Green River division, some are identical with those of the Wasatch, while at least one genus of fishes is common to the Bridger.

The Wasatch beds proper are much more widely distributed than those of the Green River. They appear first in the south in Northwestern New Mexico, and extend thence into the adjacent parts of Colorado. They are exposed over extensive areas of Colorado west of the Rocky mountains, and reappear in Southwestern Wyoming. They extend along the western portion of the Green River valley, whose northern portion they entirely occupy. On the eastern side of the Wind River mountains it has, according to Hayden, an exposure of from one to five miles in width for a distance of one hundred miles, from the source of the Wind river to the Sweet Water river. North of this point it fills the extensive basin of the Big Horn river to the borders of Montana. It does not occur east of the Rocky Mountain range. The thicknesses given by geologists are the following:

<i>Northwestern New Mexico</i> (Cope).	
Red-striped marls .....	Fet. 1500
Reddish-brown sandstone.....	1000
	<hr style="width: 10%; margin-left: auto; margin-right: 0;"/> 2500
<i>Rio San Juan, Colorado</i> (Holmes).	
Coarse yellowish sandstones, alternating with variegated marls..	1200
<i>White and Yampa Reservations</i> (Endlich and White).	
Chiefly yellow and reddish sandstones, alternating with shales...	1500

*Bear River, Wyoming* (Hayden).

Red banded marls .....	700
Sandstones and shales .....	800
	<hr/>
	1500

*Wind River Valley* (Hayden).

Variegated marls and sandstones.....	5000
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The Green River division of the Wasatch is much less extensively distributed than the Wasatch proper. Its exposures are confined to the valley of Green river, particularly the regions between its affluents both north and south of the Uinta mountains. In the Bridger basin it forms a wide rim around the Bridger formation, and is especially developed on Fontanelle creek and on Bitter creek, and the region to the south of it. I here found its thickness to be 1200 feet.<sup>1</sup> Farther south, in Western Colorado near the Yampa river, Dr. White gives its depth at 1400 feet.<sup>2</sup> South of this, in Western Colorado, Dr. A. C. Peale<sup>3</sup> gives the united thickness of this formation and the Wasatch at 7670 feet; but how much of this is to be referred to the Green River proper we are not informed. It does not appear to exist on the San Juan, according to Endlich and Holmes, and I did not find it in New Mexico.

According to King, the deposits of the Green River formation rest unconformably on those of the Wasatch.<sup>4</sup> He also believes that it has a considerable extent west of the Wasatch mountains, over parts of Utah and Nevada. I have shown that the palæontological evidence is opposed to the identification of these "Amyzon" beds with the Green River, and that they are probably of later origin. There is, however, a series of calcareous and silico-calcareous beds in Central Utah, in Sevier and San Pete counties, which contain the remains of different species of vertebrates from those which have been derived from either the Green River or *Amyzon* beds. These are *Crocodylus* sp., *Clastes* sp., and a fish provisionally referred to *Priscacara* under the name of *P. testudinaria*. There is nothing to determine to which of the Eocenes this formations should be referred,

<sup>1</sup>Annual Report U. S. Geol. Surv., 1873, pp. 436, 437.

<sup>2</sup>Annual Report U. S. Geol. Surv., 1876, p. 36.

<sup>3</sup>Annual Report, 1874, p. 156.

<sup>4</sup>U. . Survey of the Fortieth Parallel, I, p. 377.

but it is tolerably certain that it is to be distinguished from the

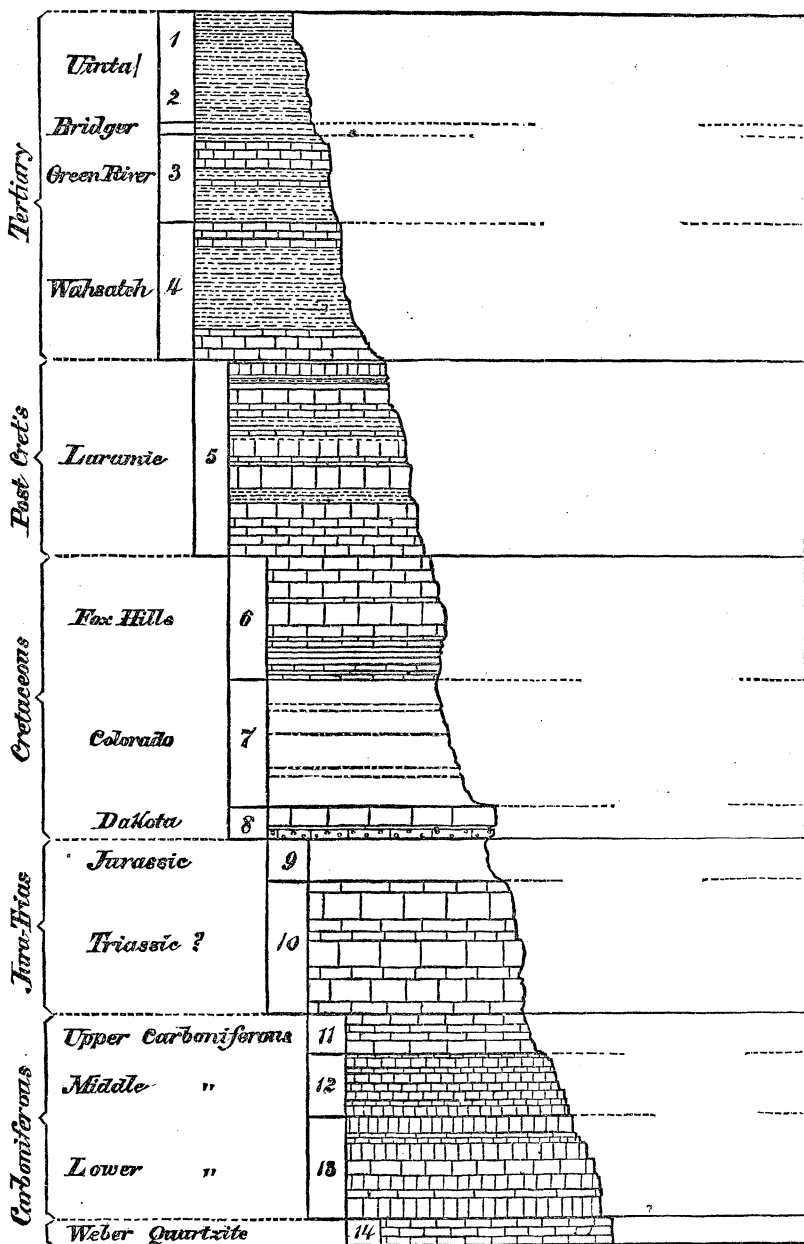


FIG. 5.—General section in the Yampa district.

Amyzon beds. In its petrographic characters it is most like the Green River.<sup>1</sup>

The writer first referred the Wasatch to the Eocene division of the Tertiary, it having been previously regarded as Miocene. (Proceedings American Philosophical Society, February, 1872.)

The vertebrate fauna of the Wasatch is rich, and presents many peculiarities. Prominent among these is the presence of the strange *Coryphodontidæ*, which reached a great development at this time. Also the *Phenacodontidæ*, and the genus *Hyrachtherium*. These are the ancestral types of the hoofed mammals, and they were associated with numerous flesh-eaters of partly marsupial character. It is nearly identical with that of the Suessonian of Western Europe, which is at the base of the Eocene series. The fullest account of it is that which I have given in the Report of Captain Wheeler of Explorations and Surveys west of the 100th meridian, Vol. iv.

#### THE BRIDGER.

“ This is one of the more important of the groups among those that, in Western North America, are referred to the Tertiary period, especially as regards the vertebrate remains that have been obtained from its strata. It is most fully and characteristically developed in the region known as the Green River basin, north of the Uinta mountains, only the south-eastern portion of the formation, so far as is now known, extending into North-western Colorado. In its typical localities it is found resting conformably upon the Green River group, into which it passes without a distinct plane of demarkation among the strata.

“ Its molluscan fossil remains correspond closely with those of the Green River group, some of the species being common to both, all indicating a purely fresh condition of the waters in which the strata of both groups were deposited. At the typical localities the group is composed in great part of soft, variegated, badland sandstones, a peculiar greenish color often predominating over the others, which are reddish, purple, bluish and gray. Limestone strata, marly and clayey beds, and cherty layers are not uncommon, and grits and gravelly layers sometimes occur.”

To the above general remarks of Dr. C. A. White I add, that the material of this formation consists of indurated clays more or less arenaceous, which display various degrees of hardness. The harder beds are, however, thin, and the intervening strata yield readily to meteoric influences. They are frequently quite arena-

<sup>1</sup> See AMERICAN NATURALIST, April, 1880.

ceous, and rather thin beds of conglomerate are not uncommon. The colors that predominate are greenish-gray and brownish-green, with frequent ash-colored beds. The peculiar condition of hardness of most of the strata, render it one of the formations which most generally present the bad-land scenery; it permits the erosive action of the elements without general breaking down, great numbers of fragments of the strata remaining in spaces between the lines of destructive action. The result is the extraordinary scenery of Black's Fork, Church Buttes and Mammoth Buttes, of which mention has been made in various recent publications.

The distribution of the Bridger formation is limited, and is, so far as I am aware, restricted to three areas, whose mutual connection is as yet uncertain. Its principal mass is in the Bridger basin, which extends from the northern base of the Uinta mountains to the latitude of the mouth of the Big Sandy river northward. In this area it reaches a depth, according to King, of 2000 or 2500 feet. A second district is also in Wyoming, and lies east of Green river, between Bitter creek and the northern boundary of Colorado, in what is called by King the Washakie basin. The depth of the formation there reaches 1200 feet.<sup>1</sup> The third region is in Western Colorado, where it loses much of its importance. Dr. C. A. White found it only 100 feet in thickness near the White river.<sup>2</sup> Dr. Peale found it near the Gunnison river, as he discovered vertebræ of *Pappichthys*, a genus which belongs to this horizon only; but he did not distinguish it from the underlying formations, so that I do not know its thickness at that point. South of this locality it is unknown.

As pointed out by Leidy, this period is especially characterized by a peculiar and rich vertebrate fauna. This is of truly Eocene character, as I first showed, but it is distinguished from the Wasatch by various subordinate peculiarities. These are the presence of Dinocerata, and of the leading Perissodactyle genera, *Palæosyops* and *Hyrachyus*, together with the absence of many types, as *Coryphodon*, *Tæniodonta*, etc.

#### THE UINTA.

"Resting directly, but by unconformity of sequence, upon all the Tertiary and Cretaceous groups in the region surrounding the

<sup>1</sup> Annual Report U. S. Geol. Surv. Terrs., 1873 (1874), pp. 436-437.

<sup>2</sup> Annual Report, 1876, p. 36.

Annual Report U. S. Geol. Surv. Terrs., 1874, pp. 157, 158.

eastern end of the Uinta Mountain range is another Tertiary group that has received the name of "Uinta group" from Mr. King, and "Brown's Park group" from Major Powell. It is possible that this group was deposited continuously, at least in part, with the Bridger group, but at the places where the junction between the two groups has been seen in this region, there is an evident unconformity, both of displacement and erosion.

"The group consists of fine and coarse sandstones, with frequent layers of gravel, and occasionally both cherty and calcareous layers occur. The sandstones are sometimes firm and regularly bedded, and sometimes soft and partaking of the character of bad-land material. The color varies from gray to dull reddish-brown, the former prevailing north of the Uinta mountains and the latter south of them.

"The only invertebrate fossils that are known to have been discovered in the strata of this group are some specimens of a *Physa*, very like a recent species. Therefore, invertebrate palæontology has furnished no evidence of its assumed Tertiary age and lacustrine conditions of its deposition. Its fresh-water origin, however, seems unquestionable, because of its intra-continental position, its limited extent, and the fact that none but fresh-water deposits are known in this part of the continent that are of later date than the close of the Laramie period."

To these remarks of Dr. White I add, that several species of *Vertebrata* have been obtained from this formation by Professor Marsh, who has determined from it a few genera of Tertiary and Upper Eocene character. Such are, of *Mesodonta*, the genus *Hyopsodus* and of *Ungulata*, the Perissodactyle form *Amynodon*.

#### THE WHITE RIVER.

The material of which the beds of this formation are composed in their eastern division, are calcareous clays and marls, alternating with a few unimportant strata of light-colored sandstone. They are white and gray, with occasionally a pink and red, and sometimes greenish tinges. The beds of the western deposit in Oregon, consist of a more or less indurated mud, which is, according to King, of trachytic origin, which is rarely hard, and frequently rather soft. Its predominating color is light green, but is frequently olive and light brown. The depth of the formation on the White river of Nebraska is, according to Hayden,<sup>1</sup> about 150 feet; and on Crow creek, Colorado according to King,<sup>2</sup> 300 feet. Sixty miles east of Crow creek I estimate its thickness as some-

<sup>1</sup> Proceedings Academy, Philada., 1857, p. 153.

<sup>2</sup> Report of Geol. Survey of 40th Parallel, 1, 410.



Fig. 6.—Scene in the Bad Lands of the White River formation, in Nebraska. From Dr. Hayden.



what greater. The Truckee beds of Oregon have, according to Marsh, a depth of from 3000 to 4000 feet, and King estimates the

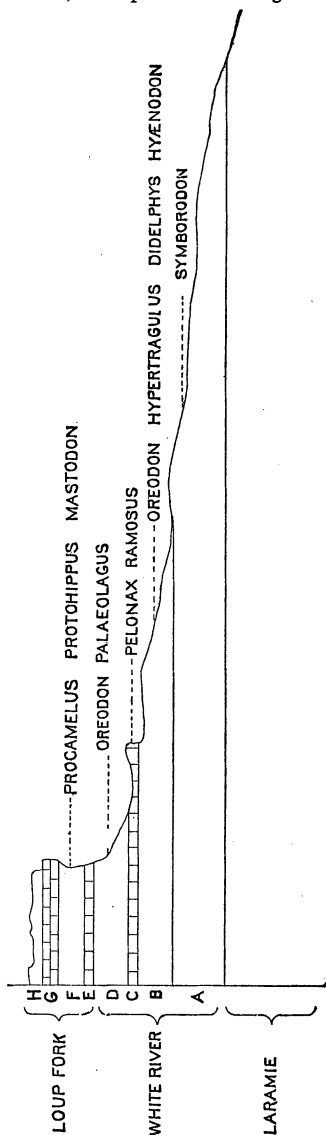


Fig 7.—N. and S. section on Horse-Tail creek, Northeastern Colorado.

deposit exposed in the Hawsoh mountains, Nevada, at 2300 feet.<sup>1</sup> An extensive deposit exposed in the region of the Cajon pass, Southern California, is suspected, by King, to belong to the same horizon.

The fauna of this epoch is widely different from that of the Eocene in its more modern characteristics. These are the presence of various types of Rodentia, of true Carnivora, of Dicotylidæ, *Elotherium*, *Oreodontidæ*, *Pœbrotherium* and *Rhinocerotidæ*. All the especially Eocene groups are absent, except *Leptictidæ* and a few *Hyænodontidæ*. These give it a more ancient character than the Miocenes generally, so that it is frequently referred to as "Oligocene."

The following diagram represents without much detail, the section in Eastern Colorado, along the Horse Tail creek, from the Chalk bluffs southward.

At both localities the lower beds carry the bones of the gigantic *Menodontidæ*, *Menodus* in Nebraska, and *Symborodon* with *Menodus* in Colorado. But few other types occur in this bed in Colorado, the great number of genera and species being found in bed B, in which I did not discover any fragments of *Chalicotheriidæ* among a large

<sup>1</sup> L. c. p. 423; l. c., p. 415.

quantity of remains of *Ungulata*, *Carnivora*, *Rodentia*, etc. The lithology is as follows: Bed A is a white calcareous soft clay rock, breaking into angular fragments. Bed B has a similar mineral character, with frequently a red color of different obscure shades. Bed C is a sandstone of varying persistence. Bed D is a white argillaceous rock like that of bed A. Fossils are less numerous than in bed B, and included no *Symborodons* nor other *Menodontidæ*.

The eastern area of this formation is the true White River epoch of Hayden; the western deposits form the Truckee epoch of King. I named this formation the Oregon, but Mr. King's name is the older and must be retained.<sup>1</sup>

According to Professor Condon, the Truckee formation of Oregon, on the John Day river, rests unconformably on the laminated beds, containing *Toxodium* and fish remains, which, as I have suggested on a previous page, may be an extension of the Amyzon shales. These in turn rest on a formation of hard laminated beds, which contain an abundance of *Calamites*, which doubtless belong to the Triassic or Jurassic period. The Truckee beds are, like the true White River, overlaid by the Loup Fork, and this in turn by heavy beds of basalt.

The fauna of the Truckee presents some characters which distinguish it from that of the White River. These are, the absence of *Hyænodon*, *Leptictidæ* and *Ischyromys*, and most of the *Menodontidæ*, and the presence of several genera of *Canidæ*, *Nimravindæ* and *Rodentia*. Many genera, and apparently several species, were common to the two epochs.

#### THE LOUP FORK.

This formation has now been studied in many widely-separated localities in the region west of the Mississippi river. It was discovered by Dr. Hayden, whose collections furnished the basis of Dr. Leidy's determination in 1858.<sup>2</sup> It was next observed by myself in Colorado in 1873,<sup>3</sup> and twenty-one species were determined; and in the following year I identified the Santa Fé marls of New Mexico, already observed by Dr. Hayden, with the same

<sup>1</sup> Bulletin U. S. Geol. Surv. Terrs., v, p. 52.

<sup>2</sup> See Proc. Acad. Nat. Sci. Phila., 1858, p. 20, and Extinct Mammalia of Dakota and Nebraska.

<sup>3</sup> Bulletin of the U. S. Geol. Surv. Terrs., No. 1, Jan., 1874.

horizon.<sup>1</sup> Messrs. Hayden and King have discovered it west of the Wasatch range in Utah and Nevada, and Marsh has observed it in Oregon. Messrs. Dana and Grinnell found it occupying the valley of Deep river in Montana, and Professor Mudge and myself have seen it in Northern and Western Kansas. There is a near lithological resemblance between the strata at these localities, and the fauna presents a common character as distinguished from those which preceded and followed it; but sufficient care has not always been exercised to distinguish its upper members from the *Equus* beds above them. The latter contain a distinct fauna.<sup>2</sup>

According to King, about 1500 feet of beds are included in this formation.

The water-shed between the South Platte river and the Lodge Pole creek, Colorado, is composed superficially of formations of the Loup Fork epoch, of Hayden. On its southern side is an abrupt descent in the level of the country, which generally presents the character of a line of bluffs varying from 200 to 900 feet in height. This line bends to the eastward, and extends in a nearly east and west direction for at least sixty miles.

The upper portion of this line of bluffs and buttes is composed of the Loup Fork sandstone in alternating strata of harder and softer consistency. It is usually of medium hardness, and such beds, where exposed, on both the Lodge Pole and South Platte slopes of the water-shed, appear to be penetrated by numerous tortuous friable silicious rods and stem-like bodies. They resemble the roots of the vegetation of a swamp, and such they may have been, as the stratum is frequently filled with remains of animals which have been buried while it was in a soft state. No better preserved remains of plants were seen.

This formation rests on a stratum of white friable argillaceous rock of the White River epoch, as represented in Fig. 7.

The lithological characters above described are precisely those presented by the same formation in New Mexico.<sup>3</sup>

Mr. King employs the name Niobrara for this formation, but Dr. Hayden's name<sup>4</sup> was introduced many years previously. The

<sup>1</sup> Ann. Rep. Chief of Engineers, 1874, II, p. 603.

<sup>2</sup> See Bulletin U. S. Geol. Surv. Terrs., IV, p. 389, and V, p. 47.

<sup>3</sup> See Report Lieut. G. M. Wheeler's Explorations west of 100th Meridian, Vol. IV, p. 283.

<sup>4</sup> See Dana's Manual of Geology, edit. 1864, p. 511.

new name has also the disadvantage of being already in use for a horizon of the Cretaceous, which is well distinguished palæontologically.

Some genera of Rodentia are common to this formation and the White River (*Steneofiber*, *Palæolagus*), but its fauna is well distinguished by the presence of *Camelidæ* with a cannon bone, three-toed horses with cementum in the molars, Antelope with a burr of the horns (*Cosoryx*) and *Mastodon*.

I have divided the Loup River formation into two divisions on palæontological grounds,<sup>1</sup> under the names of the *Ticholeptus* bed, and the *Procamelus* bed. The former occurs in the valley of Deep river, Montana, on the White river in Northern Nebraska, and in Western Nebraska, where it has been found by Mr. Hill. Its fauna presents, in Montana, a mixture of fossils of the *Procamelus* horizon; while in Nebraska, according to Hayden, its typical genera are accompanied by White river Mammalia. In the former region, *Hippotherium*, *Protohippus* and *Blastomeryx* are mingled with genera allied to *Leptauchenia* and with *Merycochærus*. In Nebraska, *Leptauchenia* is said to be accompanied by *Ischyromys*, *Palæolagus*, *Hyracodon* and even *Oreodon*, genera which do not extend to the *Procamelus* bed. There is, however, a question in my mind whether this collocation is entirely correct. It is bed D of Hayden's section in Leidy's Extinct Fauna, Dakota and Nebraska, p. 20.

The material of the *Ticholeptus* horizon is a more or less friable argillaceous sand; not so coarse and gritty as the *Procamelus* bed, nor so calcareo-argillaceous as the White River.

The *Procamelus* bed is extensively distributed. It is found in Kansas, Nebraska, Colorado, New Mexico, Utah, Nevada and Oregon.

#### THE EQUUS BEDS.

I can give little information respecting the depth and stratigraphy of the beds of this period as they occur on the plains west of the Mississippi river, for although sections of them as they occur in Nebraska and elsewhere have doubtless been published by authors, their palæontological status has not been determined for the localities described. My own knowledge of the deposits is based on localities in California and Oregon. In Nebraska they have probably been confounded with the Loup Fork beds. They

<sup>1</sup> Bull. U. S. Geol. Surv. Terrs., v, pp. 50-52.

represent the latest of all the Tertiary lakes, and include a fauna which consists of a mixture of extinct and living species, with a few extinct genera.

I have received fossils of this age from Idaho, Washington, Oregon and California. The most important locality in Central Oregon is from thirty to forty miles east of Silver lake.<sup>1</sup> The depth of the formation is unknown, but it is probably not great. It consists, first, of loose sand above, which is moved and piled into dunes by the wind; second, of a soft clay bed a few inches in thickness; third, by a bed of sand of one or two feet in depth; then a bed of clay mixed with sand of unknown depth. The middle bed of sand is fossiliferous. In Northern and Middle California the formation is chiefly gravel, and reaches a depth, in



FIG. 8.—Sand hills, Northwestern Nebraska, from Hayden.

some localities, of several hundred feet. Here, as has been proven by Whitney, it contains human remains, associated with *Mastodon*, *Equus*, *Auchenia*, etc. I have obtained *Mylodon* from the same gravel.

Traces of this fauna are found over the Eastern United States, and occur in deposits in the caverns excavated in the Lower Silurian and Carboniferous limestones, wherever the conditions are suitable. This deposit is a red or orange calcareous mud, varied with strata of stalagmite and gypsum. Remains of the fauna are found in clay deposits along several of the Atlantic rivers, as the Delaware and Potomac,

<sup>1</sup> See AMERICAN NATURALIST, 1878, p. 125.

It is probable that the formation in the western localities mentioned is mostly sand. Near Carson City, Nevada, it consists of a light-buff friable calcareous sandstone.

This is the Upper Pliocene of King and the Post-pliocene of various writers,

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## A PATHOGENIC SCHIZOPHYTE OF THE HOG.<sup>1</sup>

BY PROFESSOR H. J. DETMERS.

ABOUT twenty-five years ago Professors Brauell and Pollender in Dorpat, Russia, made an important discovery, which, though at first not considered as of much significance, soon led to investigations, the results of which have already revolutionized the ætiology of contagious and infectious diseases. Brauell and Pollender, and soon afterwards also Dr. Leisering in Dresden, discovered in the blood of man and beast, affected with anthrax or splenic fever, an infinite number of exceedingly fine, apparently solid, almost transparent, straight and motionless, rod-shaped bodies (cf. Virchow's *Archiv. für Pathol., Anat. und Physiol., und für Klinische Medicin*, XI, 2). They called them *staebchenfoermige Koerper* (Bacilli), but left it undecided whether the same bear a casual connection with the morbid process, constitute a product of the same, or are merely accidental. Still, finding these Bacilli in every fatal case of anthrax, Brauell and Pollender considered their presence as something characteristic, and as of great diagnostic and prognostic value. As early as 1860 the relation of these Bacilli to anthrax formed a topic of discussion in the annual meeting of the Veterinary Society of the Grand Duchy of Oldenburg. Later investigations, but especially those by Davaine, Koch, Cohn, Pasteur, Toussaint, and more recently by Dr. Hans Buchner, in Munich, have demonstrated beyond a doubt that these Bacilli, first discovered by Brauell and Pollender of the Imperial Veterinary School of Russia at Dorpat, and first known as Brauell and Pollender's *staebchenfoermige Koerper*, constitute the real and sole cause, and also the infectious principle, of that terrible disease known as anthrax or *Milsbrand* to the Germans, charbon to the French, and anthrax or splenic fever to the English. About the same time, or soon after Brauell and Pollender published their discovery, other simi-

<sup>1</sup> Read before the Chicago Academy of Sciences.