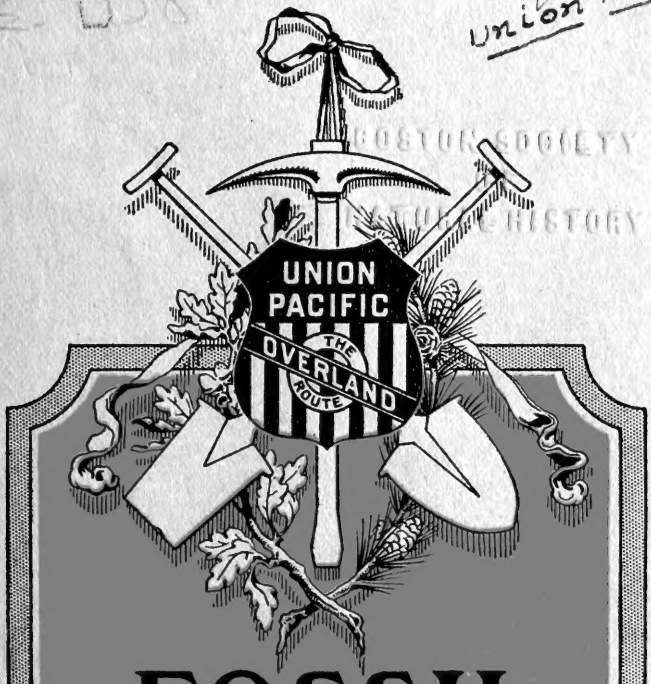
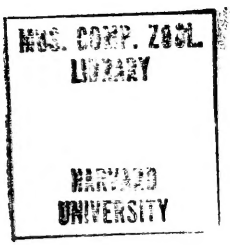


FOSSIL DISCOVERIES IN WYOMING

The Fossil Fields of Wyoming

Reports by Members
of the
Union Pacific Expedition

ISSUED BY
PASSENGER DEPARTMENT,
UNION PACIFIC RAILROAD COMPANY,
OMAHA, NEBRASKA.



FOREWORD

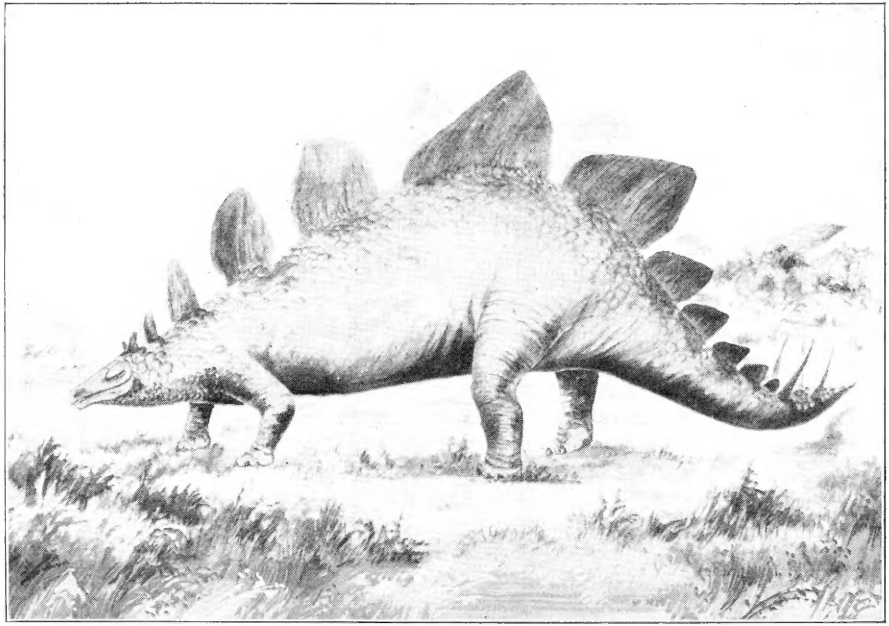
The fossil fields of Wyoming are widely known in this country among the students of paleontology, and their peculiar value to scientists has been established for many years. The general characteristics of this region, its contour and formation, fauna and flora, and the particulars of the different strata found there have been given the public by many men eminent in their profession. Professor Marsh of Yale many years ago recorded the results of his researches, and F. V. Hayden, Clarence King of the U. S. Geological Survey, Arnold Hague, J. J. Stevenson, Marvin and Endlich, and others, have described the country in detail.

In July, 1899, the passenger department of the Union Pacific Railroad sought to revive interest in the further exploration of this wonderful field, and to that end invited a number of scientific men to visit that part of Wyoming and make personal investigation of the field. They went as guests of the Union Pacific and were escorted by an official of the company.

Several of these gentlemen recorded their impressions and experiences, and in some instances embodied in their review a a critical and comprehensive account of their findings which form a valuable contribution to science; and it has been thought proper to make these papers public on account of their intrinsic worth and interest.

At the time this expedition, or excursion, was made it was given full prominence in elaborate newspaper articles and in magazine reviews, and this seemed then to meet all requirements. But, more recently, inquiries have constantly been received asking for fuller and more detailed information if it was attainable. It is to meet this demand that these personal statements by members of the excursion are published.

Passenger Department
UNION PACIFIC RAILROAD,
Omaha, 1909.



Restoration of Stegosaurus found at Como, Wyo., in 1878

STORY OF THE DISCOVERIES

HE first great fossil expedition in Wyoming was conducted in the summer of 1870 in what is now known as the Bridger Basin, near Fort Bridger. An immense amount of material was found at that time by Professor O. C. Marsh and his expedition. He obtained concessions from the Government and had an escort of two companies of United States soldiers. The material particularly searched for and found at that time was the bones of the early horses, the ancestors of the modern horse.

In the lowest horizon of the Tertiary, at the foot of the Wasatch Mountains, was found a three and a four-toed horse. Above, in a later age, were found the bones of the toes drawing up, leaving one central toe. Many examples of this were found; and, as the Professor worked toward the upper Pliocene Tertiary, he found the horse as he is to-day with the exception of the size. The earliest of the horses, the three and four toed, were about as large as a fox. Several thousand feet higher in the upper Tertiary the horse had taken his form of to-day, but the size was not much increased; he was still small, a little larger than a fox. In searching for these bones of horses in which Professor Marsh was particularly interested, the bones of many other mammals were found, particularly camels, cats, dogs, beavers, and deer. These bones were all carefully taken up and shipped to the Yale Museum from Carter Station, on the Union Pacific. Several similar expeditions were sent into this field in the years from 1870 to 1877, and many wonderful discoveries were made. Still other expeditions going into this field in later

times found something new to science; and I consider the field still exceedingly rich in this material, to anyone who wishes to investigate such things.

On March 7, 1877, I found, one and one-half miles from Como Station, on the Union Pacific, the bones of some dinosaurs. These were the first found in the Rocky Mountain region. I commenced work on this material on the date of discovery and shipped one ton of these bones to Professor Marsh in the month of June the same year. Then Professor Marsh sent out Dr. S. W. Williston, now in the University of Chicago, Chicago, Illinois, to look after the work for a short time. Dr. Williston and myself worked in this quarry about one year and took a good portion of three skeletons out of it. About this time Professor E. D. Cope of Pennsylvania put a party into the field and there was much competition between the Cope and Marsh parties for several years. Many valuable discoveries and a great addition to scientific information resulted. This material, collected from 1877 to 1888, was divided between the Smithsonian Institution, at Washington, and Yale Museum. Professor Cope's collection was shipped to Philadelphia where he investigated and made some valuable restorations. After his death the collection was sold to the American Museum, Natural History, New York, and is among its most valuable possessions to-day. Since 1888 the American Museum, the Carnegie Institute at Pittsburg, the Field Columbian Museum at Chicago, Harvard University, and Princeton University have had parties in this region nearly every year and an immense amount of fossils has been discovered and shipped to the different institutions.

Wyoming University commenced in 1895 to collect material for a museum. This has been carried on to the present time,

and we now have in this collection about eighty tons of fossil bones, mostly of the reptilian kingdom, but also a large amount of Tertiary or mammalian bones. These are being worked up and put on exhibition as fast as possible.

The field is exceedingly rich, and, to me, after nearly forty years' experience in this work, it seems just as good as before it had ever been touched. No party that makes a thorough investigation in one summer ever goes away empty-handed; usually some exceedingly rare and rich fossils are found. There is no square on the earth as rich as Wyoming in its fossil forms of ancient life. From the Permian, at the close of the Paleozoic, to modern annals, nearly all the life that has ever lived upon the earth can be found within the limits of this State. Of course it takes, first, knowledge and, second, energy to find and bring these things to light; but that is all that is necessary to equip the fossil hunter for successful work in Wyoming.

W. H. REED,
Curator, Museum, University of Wyoming,
Laramie, Wyo.

OBSERVATIONS ON THE EXPEDITION

In response to an invitation by the Union Pacific Railroad Company, a large party of scientists arrived in Laramie, one of the principal cities of Wyoming, on the 19th of July. The writer was at once impressed with the purity of the atmosphere of this country and the sparkling water trickling down the streets of this beautiful city, coming from a large spring two miles away. To fully appreciate its purity and deliciousness one must take a draught of it; no description will do it justice. Two days after arriving in Laramie, the expedition moved to the west, making a circle, the terminus of the trip to be the Grand Cañon of the Platte River. We passed over excellent collecting grounds both in plant and invertebrate fossils, and on the eighth day of the trip we arrived at Aurora, the historic dinosaur field, where Professor Marsh of Yale, more than thirty years ago, discovered the bones of these immense lizards which are fully described in the sixteenth annual report of the Geological Survey. Here quite a number of specimens were found, and after remaining a day and two nights, we started for Freezeout Mountains, going by way of Medicine Bow, a small station on the Union Pacific Railroad. In these mountains the expedition was on virgin dinosaur fields and, so far as I know, every member of the party found and shipped some specimens of these bones. The writer, in connection with Prof. S. B. Brown of West Virginia University, found five vertebrae, two large femora and quite a number of large pieces of other bones of these animals. In this region we saw the bones that are being excavated by the American Museum people, also the Field Columbian, the Wyoming University and Kansas University Museums.

The hundreds of square miles of these beds containing thousands of tons of the bones of these huge vertebrates, some of which are exposed by erosion each year, impresses one with the vastness of the burying ground over which we were traveling and the history of its formation and inhabitants while it was a low marshy plain. These bones are imbedded in a pale bluish-green stratum of clay varying in thickness from twenty to fifty feet. This stratum is easily found and recognized, being immediately above the shale overlying the Triassic red sandstones, under which is a layer where the belemnites are found very abundantly. Above the dinosaur stratum is a thick layer of sandstone, and boulders from this often tumble down dragging the bones among the talus, often making it difficult to determine the exact point from which the bones came.

From our camp at Freezeout Mountains by three marches we arrived at the Grand Cañon of the Platte. Here the Platte River has cut a channel with almost vertical sides a thousand feet deep, through the strata for a distance of nine miles. Owing to the arduous task of entering the cañon, at many places this being impossible, the study of the exposed strata at close range, becomes somewhat difficult. The writer, in company with Lieutenant Murphy of Wyoming University, entered the cañon and drank from the rushing river. None of our company were daring enough to attempt to go through the cañon, although we were told that only one man had ever succeeded who attempted it. On approaching the cañon it was seen that we were on a rolling plain, indented here and there with small streams that had made rather deep channels for this country. However, I am sure it would never occur to a stranger that only two or three hundred yards in front of him was a chasm a thousand feet deep. Almost instantly you perceive there is a great cañon in front

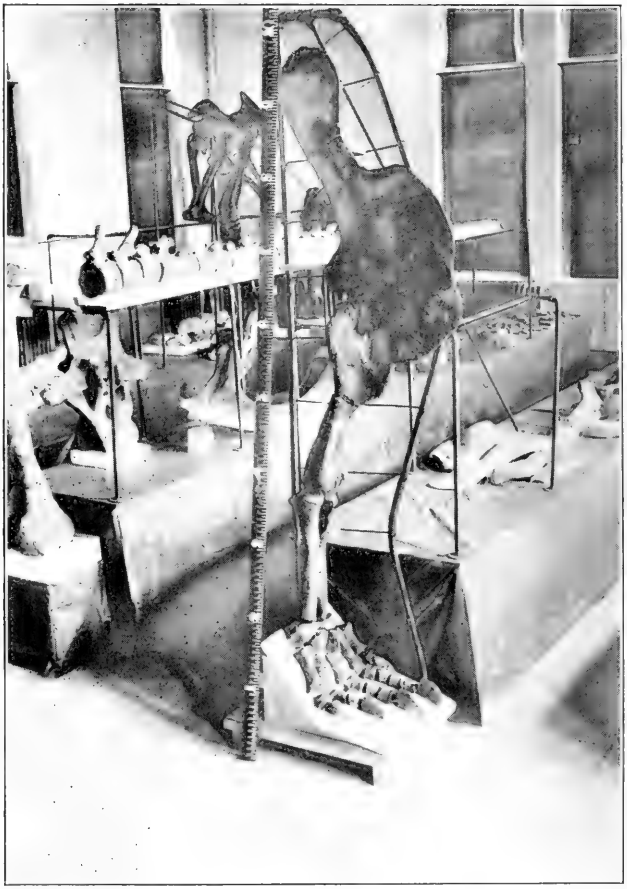
Right hind leg of largest Dinosaurus known, mounted in the museum, University of Wyoming. Found five miles south of Medicine Bow on Union Pacific Railroad

where a moment ago you thought it was a perfect plain. Then you undertake to enter it through a ravine and travel many times the distance it was supposed to be, and of a sudden you find yourself standing on an immense strata of rock, a step more would land you six or seven hundred feet below in a stream which rushes madly, as it were, past the boulders that have fallen from the cliffs. If one has imagined that he would like to go through the cañon his slightest wish quickly leaves him on seeing the danger of such an undertaking. The most sublime sight I ever beheld was to stand on the edge of this cañon and see the tilted strata, the Archean to the left and below, and look to the right and see the great number of strata through the series to the characteristic red beds of the Triassic and above these the Jurassic. The scene impresses one in a way that words meagerly describe, but the feeling comes that here is an epitome of Nature's records inviting one to read the history of these formations, see the principles of structural geology here unfolded, and conceive the great length of time necessary for their consummation.

The noted Fremont fault is about three miles north of the cañon. Here the carboniferous lime and sandstones are faulted and lying on the Jurassic, apparently, almost conformable. Here are five hot springs, the temperature of the largest being 140 degrees. The entire route through Wyoming afforded a most excellent opportunity for studying geology. The great amount of tilted and eroded strata, and the sparse vegetation, enabled one often to follow for miles, with greatest ease, a single formation, or to cross a great many different ones in traveling only a short distance.

In conclusion I wish to say I am very grateful to our leader, Prof. Wilbur C. Knight, for his able and efficient service and his many valuable suggestions, also to the Union Pacific Railroad Company for its many courtesies.

J. A. YATES,
Professor of Natural Sciences, Ottawa University,
Ottawa, Kansas.



Front limb of Diplodocus in the museum, University of Wyoming, Laramie, Wyo.
Found in Freezeout Hills, fourteen miles north of Medicine Bow, on
Union Pacific Railroad

PRACTICAL VALUE OF THE EXCURSION

Learning that the Union Pacific is to publish some of the results of the recent Fossil Field Expedition, so admirably planned and so successfully carried out by the railroad and Prof. W. C. Knight of the University of Wyoming, I hasten to add my testimony to its benefits. They may be briefly enumerated as follows:

1. It enlarged greatly the stock of knowledge of every geologist enlisted, and of that sort best calculated to improve his teaching capacity. It substituted clear typical object lessons for the meager illustrations and halting descriptions of textbooks. Even those familiar with typical examples in the eastern part of our country were greatly impressed with the great advantage of the absence of vegetation and clearness of atmosphere in Wyoming. Views were more comprehensive and details more distinctly exhibited. This was true particularly of folds, faults, wind work and stream work, stratification and concretions. It afforded opportunities for excellent acquaintance with most interesting formations and fossils not accessible in the east.

The erosion forms, the work of untold ages on the granite axis of the continent; the carboniferous rocks without coal; the glowing red beds; the Jurassic, with its various horizons, including probably the oldest great fresh water lakes, with their huge dinosaurs; the stretches of Cretaceous with its sandstone ridges and mesas, its gumbo plains and slopes, its chalk cliffs glaring across the waste, its swarms of fossil shells, its gigantic globular concretions, its coal beds with fossil palms and deciduous trees; the Tertiary lake beds, with their mon-

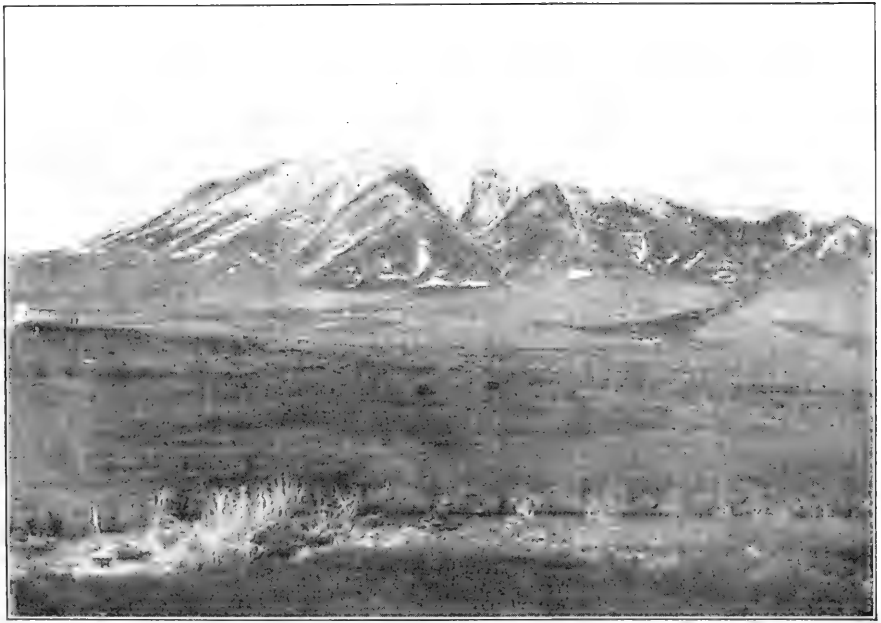
Baptannodon Reedi bones found in a quarry north of Union Pacific Railroad

strous mammalian bones, remnants of Nature's efforts in preparing the various beasts of the present time; the gravel-spread and boulder-dotted terraces of the Pleistocene age, records of the former floods which worked so faithfully to humble the pride of the rising Rockies, and convey their grandeur to beautify and enrich the plains of the Mississippi—all these are now vivid realities in the minds of all who rode over them and worked about them with this expedition.

2. It will furnish substantial contributions to science. It is not yet time to sum up results in this line. Months and perhaps years may pass before we know what new species have been found, what conclusions are reached by many minds brought face to face with that wonderful region. It was not an unknown region. Many bright minds had already traversed it. Yet some new discoveries may be, at least, hinted. Numerous deciduous leaves were found mixed with abundant marine forms in the Fox Hills beds. A considerable fauna of fresh-water invertebrates was found in the dinosaur beds of the Jurassic. This will no doubt be fully presented by those more closely identified with the discovery. The opinion that the Fox Hills group is but a sandy local development of the Fort Pierre will be strengthened by the work of the expedition, and furthermore it may appear that the Laramie is but a local fresh water stage of the same.

Several additional new features have been revealed in the dinosaur bones unearthed by this expedition.

3. It has and will promote popular interest in science and education. This is not only by the public press and the pictures and fossils scattered by the members of the expedition throughout the country, but by the individual articles and lectures and by the proposed illustrated history.



Elk Mountain, which can be seen at many points between Rawlins and Laramie. This mountain is about 11,000 feet high and is the termination of Medicine Bow Range

PRACTICAL VALUE OF THE EXCURSION

It calls fresh attention to the conclusions of geology concerning the building of the earth and the development of life-forms. It reveals to many a new world of the imagination. Science has swept into oblivion the whole brood of mythological monsters, centaurs, griffons, chimeras and dragons, that once delighted the lovers of the terrible and strange, but now it is substituting the monsters of geological lore. It arouses new interest in

"The fairy tales of Science and the long result of Time."

It will stimulate a more healthy interest in science for its own sake.

4. Let us hope that this expedition may arouse such lasting interest in scientists and the patrons of public museums in the wonders of the West that it may be but the first of a long series of similar vacation excursions which may prove of mutual advantage to all engaging in them and to the public at large.

J. E. TODD,
Professor of Geology and Mineralogy,
University of South Dakota.

ITS WORTH TO THE STUDENT

It has become a proverb that for a geologist there are three requisites for success: The first is travel, the second is travel and the third is travel.

The Union Pacific Railroad Company was thus contributing to the success of a large number of geologists, when it made accessible to them that open book on geology, the Wyoming plains and mountains; and those who were so fortunate as to be able to accept the invitation gained results the value of which it would be hard to estimate.

All forms of geological phenomena were so well presented in Wyoming as to be well nigh diagrammatic and it would be difficult to say in which department of the science the greatest interest was felt and the greatest profit attained.

Students of structural geology, who were acquainted with Appalachian and Alpine mountain architecture alone, beheld such monoclines, synclines and anticlines as they had never seen before.

Students of physiographic geology observed peneplanation on a world-wide scale, and had presented to their view splendid examples of erosion that varied from the cuttings of rivulets through non-resistant regolith to the powerful carving of the Grand Platte through tenacious Mesozoic sandstones and limestones, through Paleozoic rocks of similar character and through Archean quartzites and granite.

The student of economic geology had opportunity to become acquainted with Wyoming coal deposits, gypsum beds, various building stones, railroad ballast and road material, and

saw possible sources of carbonate of soda, magnesium sulphate and asphalt for commercial use.

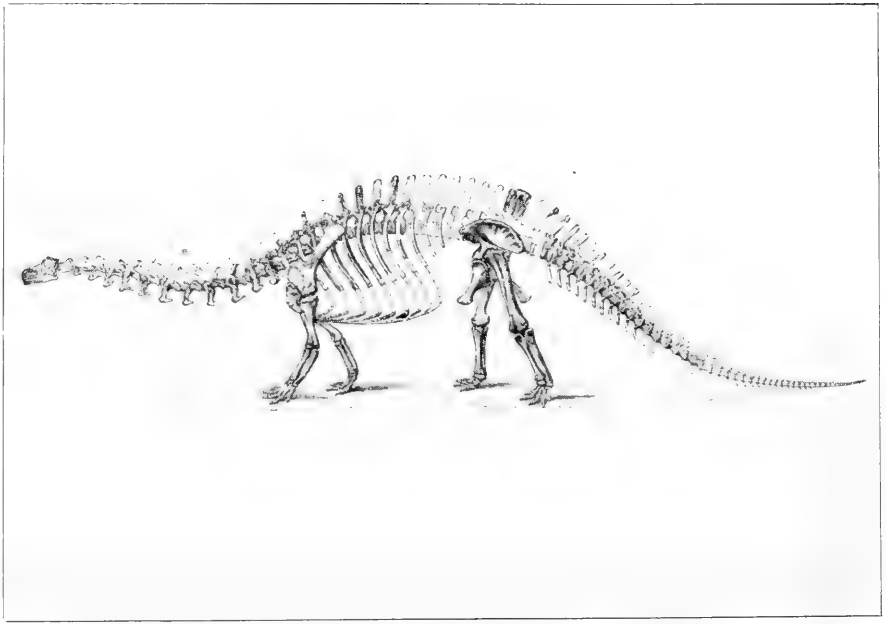
An excellent chance was afforded petrographers for collecting sedimentary rocks, representing geological periods all the way from Tertiary to Ordovician, and crystallines from the Paleozoic and Archean.

The region traversed was not especially rich in mineral wealth, yet there was opportunity to collect fine quartz of many varieties, calcites and aragonites, graphite, gypsum and various iron-bearing minerals.

Invertebrate paleontologists fared even better than the petrographers and mineralogists and the variety and quantity of their collections were among the chief rewards of the expedition.

The chief interest of the general public in the expedition was in the vertebrate remains that were known to exist in the various geological horizons. These the excursionists hoped to see exhibited in position in bed rock and to have opportunity to carry away with them to be used later for the convincing of the incredulous.

Jurassic dinosaurs were looked for with the greatest enthusiasm and nearly every member of the party carried home some trophy, even though it may not have been more than a small fragment; and some members secured desirable material. The Northwestern University party sent home about two tons of specimens, the greater part of which consisted of the spinal column, ribs and pelvic arch of a dinosaur that is probably the form known as ceratosaurus. It was found in the Freezeout Hills, in the region of the Platte Cañon. The same party located reptilian remains. But the absence of plaster and other means of saving the materials, as well as the remoteness of the region, made work in that locality appear undesirable.



Restoration of Brontosaurus in Yale Museum, New Haven, Conn. Found at Como, Wyo., on Union Pacific Railroad, in 1878

ITS WORTH TO THE STUDENT

Great credit is due Prof. Wilbur C. Knight for his untiring efforts and skill in conducting the expedition, and all members of the party appreciate his work and feel under great obligation to him.

The thought was indeed most happy which led the Union Pacific Railroad to organize the expedition as it did. Every member of the party returned to his work invigorated in body, enthusiastic in spirit and furnished with an increased fund of illustration for teaching and material for investigation. So that every student who comes in contact with these tourists—and they number thousands—will profit by the generosity of the Union Pacific. Further than this some contributions to scientific knowledge will result. Consequently the Union Pacific Railroad is to be congratulated upon having contributed to the progresss of civilization in this regard also, and to it is due the heartfelt thanks of others than those who were the most immediate and evident gainers in this generous and well planned expedition.

A. R. COOK,
Professor of Mineralogy, Northwestern University,
Evanston, Ill.

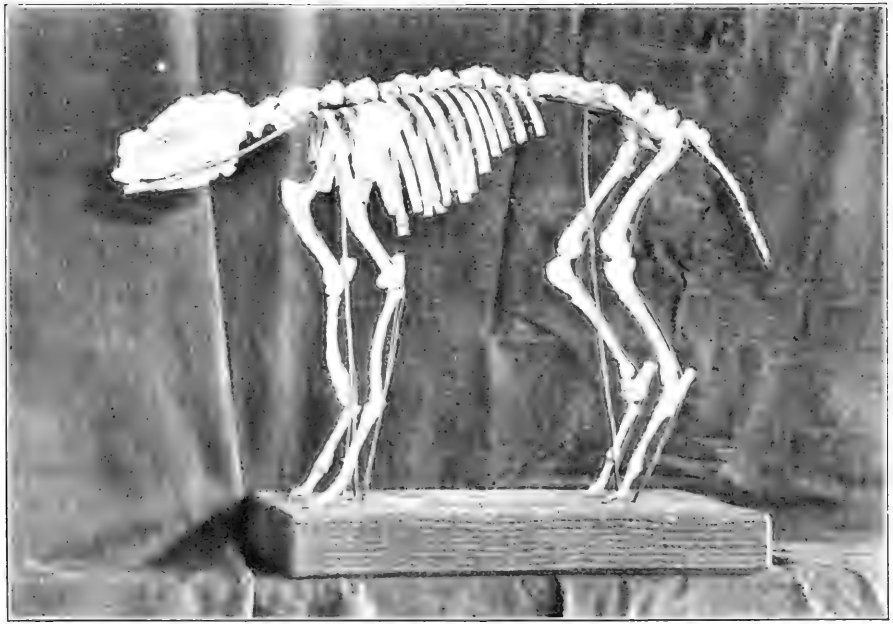
AN ENJOYABLE OUTING

When the Union Pacific Railroad proffered an invitation to the geologists of various colleges and universities in the United States to visit what are now considered the most prolific fossil fields of the world, it rendered an undoubted service to science. On July 19th we reached Laramie City via Denver, where we were pleasantly quartered and on the night of our arrival were given an enjoyable reception by the citizens of Laramie. As outlined in the letter of invitation sent us, we were to travel by wagon from Laramie. Prof. Wilbur C. Knight had with keen foresight secured twenty or more farm wagons and drivers who were well acquainted with the territory over which we were to travel. We divided up into messes of ten, with drivers, cooks, tents, bedding, etc., and on the morning of July 21st, we left Laramie, with about eighty people in the company, there being about sixty geologists and students from colleges in all parts of the United States: California, Minnesota, Texas, Alabama, New York, etc. The National Museum, Washington, D. C., was ably represented by Prof. Schuchart. At Fox Creek, in the adjacent mountains, were found thousands of gastropoda, mollusca and concretions, also beautiful specimens of quartz in all colors; many fine amethysts were picked up. We lingered here until Monday morning; again we moved to the north. About noon we reached the coal fields of Carbon County. The entire party halted and we were soon busy collecting leaf impressions which overlay the coal to a thickness of at least four feet; the impressions are so perfect that the most minute markings of the leaves are as clear as the dried leaves of the various trees would show. We next went

into camp at Rock Creek, a most beautiful grassy valley. Rock Creek might well be called a river, as a large volume of clear water is constantly flowing through its channel. Beautiful snow-capped Elk Mountain was ever to our left, and Laramie Peak to our east. From Rock Creek camp, side trips were made to the great chalk cliffs and the ammonite and gastropod fields nearby. Many hundreds of pounds were collected, carefully packed in boxes and shipped from Rock Creek station, by the various college representatives. The writer was so fortunate as to find a mollusk, twelve inches in diameter, showing all the colors as bright as it could have been in the Tertiary. After a three days' halt at Rock Creek camp, we traveled directly north and at the end of the day reached the great dinosaur beds, or fields, of Wyoming, and went into camp not over two thousand feet from where Professor Marsh, of Yale College, discovered and successfully removed one of the largest dinosaurs discovered in the world. Professor Knight of Wyoming University and Professor Williston of Kansas University have recently made some valuable finds at this place. Several of our party secured some valuable specimens of femora and vertebra. Professor Yates of Ottawa, Kan., University and Professor Brown of Virginia, also Professor Charlton of Texas, were highly successful in securing specimens for their colleges. This section of the Freezeout Mountains shows many wonders in the various folds and unconformities. Lake Como and Como Station were near our camp. After a two days' extremely interesting stop, we moved northwest and, at Medicine Bow, I, through press of other business, was reluctantly compelled to leave the party and return to "Sunny Kansas," much benefited in health and knowledge.

H. L. T. SKINNER,

Ottawa, Kansas.



The skeleton of one of the early Camels. A type in the museum, University of Wyoming, Laramie, Wyo.
Found north of Union Pacific Railroad

GEOLOGY OF THE LARAMIE PLAINS

Traveling westward along the Union Pacific Railroad, we reach Cheyenne and find that we are 6,050 feet above the sea. Thirty-three miles farther west, we are at Sherman, on the summit of the Laramie Mountains, a little over 8,000 feet above sea level. Twenty-four miles farther on, we descend upon the Laramie Plains and are 7,149 feet above the sea. Then, for 270 miles farther, our route over the railroad will pass along the valleys scalloped out of the plains and undulating between 7,100 and 6,740 feet, until, on descending the valley of Green River, we are 6,077 feet above tide. For 100 miles of this distance the road traverses the well-known Laramie Plains. The Laramie Plains are bounded on the east and north by the Laramie Hills, on the south and west by the Medicine Bow Mountains and their extensions. The plains may be 25 to 40 miles wide, and, beginning near the line of Colorado and Wyoming, they extend northwardly for 100 miles, thence northwestwardly for 50 miles. On the west, the Medicine Bow Range forms a prominent barrier as far north as Elk Mountain, thence it drops off into valleys continued beyond in the Seminole, Shirley and Indian Grove Mountains to the Grand Cañon of the North Platte. These mountains are all granitic; Elk Mountain is 11,000 feet altitude. The granite of the Seminole, and similar ranges north, is a coarse, red feldspathic and would undoubtedly afford an excellent quarry rock.

The plains near Laramie City are from 7,100 to 7,500 feet above the sea, but northwardly they are from 6,500 to 7,000

feet elevation. The hills just south of Como rise 400 feet above the plain, caused by uptilting of strata. Within ten miles north of Medicine Bow, hills appear on the left and twenty miles north we are in the Freezeout Mountains; a few miles farther are the Freezeout Hills. By quaquaversal upthrusts this region has been thrown up and tilted so as to form beautiful anticlinals, bringing to view the Triassic and Jurassic, capped by Dakota Cretaceous. Viewed from several miles east, the Freezeout Mountains present an interesting panorama, the strata toward the southeast end dipping southeast, while that south a few miles off dips south, with the central portion very much eroded, the whole a beautiful illustration of an anticlinal valley. The eroded hills, formed of Jurassic beds capped by Dakota sandstone, afford picturesque scenery near Rock Creek, Little Medicine and the Freezeout Hills northwardly to the Seminole Mountains. In this region are beautiful exhibitions of anticlines, synclines, faults and erosion. The plains are mostly underlaid by later cretaceous. The Dakota group consists chiefly of sandstone. The Fort Benton group is chiefly clay shales with fish scales and teeth. The Niobrara crops out in the lower hills of the plains. The Fox Hills group consists chiefly of sandstone and shales with some hard concretionary masses of calcareous sandstone, often containing fossil mollusca.

The Laramie Plains are traversed by tributaries of the North Platte, including Laramie, Rock Creek and Medicine Bow, all swiftly flowing streams, with an abundant supply of clear, cool water. These streams all originate in the Medicine Bow Range. Occasional small lakes occur on the plains; Cooper's Lake is the largest. Como is also a pretty body of water. Some of the lakes contain valuable deposits of soda.

The surface of the plains generally consists of two to three terraces, the higher one often flat on summit and with scant grass.

Most of the terraces are sandy and frequently are strewn with water-worn pebbles. The valleys along the streams are wide and often slope up gently to the terraces above. Grass abounds on the valleys, and, with judicious irrigation, can furnish plenty of hay and also good grazing. Most of the valleys of the tributaries of both the Platte and the Laramie may be considered as valuable for grazing purposes.

The "sagebrush" is common, growing on good soil. The "grease wood" is rather common on alkali soils. Cactus abounds on the dry slopes. Along the running streams are willows, cottonwood and birch. Pines abound on the mountains and also occur in the valleys of the hills.

The Medicine Bow Mountains are clothed with a dense growth of pines, chiefly *P. Contorla.* In many places the ground may be covered with a dense mass of fallen logs, often apparently one-fourth as many as are standing. High up on the mountains the pine gives place to the spruce, growing large and very straight. In wet mountain valleys, the quaking aspen abounds. Cedar is also common.

The Dakota sandstone, along the Front Range in Colorado and New Mexico, forms the prominent "hog-back" ridge. On Rock Creek it affords excellent beds for building purposes. The other Cretaceous groups above are mostly shaly; the Fox Hills everywhere is easily recognized.

The following named fossils were collected, all of them mollusca: *Helicoceras vespeieones, Ancylocevas uncum, A. annulatum, A. Jenneyi, Scaphiits nodosus var. plenus, Baculites ovatus, B. compressus, Hammea minor, H. occidentalis, Pseudobuccinum Nebrascense, Fasciolaria cretacea,*

Bones of Diplodocus as found in the quarry in Six Mile Gulch, two miles north of Wilcox, Wyo., on Union Pacific Railroad

F. buccinoides, F. Culbertsoni, Anisomya borealis, Limatia occidentalis, Chemnitzia centhiformis, Limopsis paraoul, Axinea subimbricata, Cardium speciosum, Pteria (oxytomia) erecta, P. perpleura, P. linguiformus, Mactra nitidula, Nucula subplana, Pteria gastrodes, Yoldia scitula, Y. evansi, Pteria fibrosa, Trigouarcar obliqua, Endocostea typica, Inoceranus altus, I. Howelli, I. crispii, Itenuilineatus, I. Balchii, I. tenuirostratus, I. Vanuxemi, I. problematicus, I. deformis, I. Sagensis, I. proxinus, I. Simpsoni, I. barabini.

The indurated Fox Hills strata are often entirely made up of *Inocerami,* some very large.

The following is a section of strata seen in the Como anticlinal:

1. 45 feet of mostly brown sandstone forming the crest of the hill—Dakota.
2. 55 feet of shales, may also be Dakota.
3. 2 feet gray sandstone.
4. 60 feet marine Jurassic. Soft gray and chiefly a sandy clay.
5. 5 feet of red shales.
6. 10 feet of yellow sandstone.
7. 5 feet of red shales.
8. 10 feet of yellow sandy layers.
9. 44 feet of red banded beds.
   Contains thin calcite plates.
10. 18 feet of blue laminated clay.
11. 5 feet, one bed of gray sandstone.
12. 18 feet of blue shales, with occasional solid layers.
    Contains plates of calcite.
13. 6 feet of yellow sandstone.
14. 250 feet of dark, soft laminated shales.

The Paddles of a Megalneusaurus, nine feet long, mounted in the museum, University of Wyoming.
Found north of Union Pacific Railroad. This swimmer was larger than any whale

15. Gray sandstone.
16. 16 feet of shales.
17. 4 feet of gray shales.
18. 75 feet of red beds.
19. 1 foot of gray beds.
20. 11 feet of red beds.
21. 5 feet of gray ripple-marked sandstone.
22. 12 feet of soft red shales.
23. 11 feet of gray sandstone.
24. 22 feet slope to railroad station.

In above sections 1 and 2, Dakota..... 100 feet
Nos. 3 to 17, inclusive, are Jurassic.....2,201 feet
Nos. 18 to 24 are Triassic..... 77 feet

Although no fossils have been found as yet in the Triassic of the West, yet its thickness, well developed, and its uniform red beds cause it to be easily recognized. I have seen it on the Colorado River in Texas, in New Mexico, and at the Garden of the Gods in Colorado, where it forms such curious figures and stands on edge, forming spires over 200 feet high. Here it is largely pebbly. It is often beautifully ripple-marked and often contains beds of gypsum. On the southern border of the Laramie Plains, I observed 36 feet of white gypsum with about 1,000 feet of red beds above and yellow beds below. Near the Grand Cañon of the North Platte, there are undoubtedly several hundred feet of Triassic, including the bright brick-red strata, some of it beautifully ripple-marked. At its base are shaly beds with numerous chalcedonic concretions. Some of these, if cut and polished, would form beautiful, agate-like ornaments. Below this was observed about 40 feet of drab and buff limestone, containing in the upper part numerous minute geodes.

View of quarry, Six Mile Gulch, two miles north of old Wilcox, Wyo., on Union Pacific Railroad. Bones now in American Museum of Natural History, New York

The Jurassic beds are well exposed in the Como anticlinal, in the Freezeout Mountains, and the Freezeout Hills, and on Little Medicine. In the upper portion chest layers are occasionally present. Lower down are found mollusca of the following species, viz: *Camptonectes extenuatus, C. bellistriata, Ostrea strigilicula, Pecten Newberryi, Belemnites densus, Belemnites Mucronata, Trapezium subaequalis.*

But it is the upper Jurassic that has made this formation pre-eminently interesting, that has attracted people from every direction to Wyoming, to dig out and view the wonderful fossil treasures, the saurians small and large, and dinosaurs over 100 feet long. The world wonders at the discoveries. I only saw portions of the skeletons, including a femur of a brontosaur, at Laramie University, 69 inches long. I obtained the vertebral joint of a dinosaur one foot in diameter. The leg bones of the brontosaur would indicate a height of at least 15 feet.

Fifty species of saurians have been taken from these beds. Some of the dinosaurs were reptile-footed, some were bird-footed, some were beast-footed. Some were related to the crocodile, others presented the characteristics of birds. Some were carniverous, others herbiverous. Some were covered with bony plates, others had horns. The stegosaur had a series of pointed plates rising as spines three feet high along the dorsal ridge. The atlantosaur of Marsh had a thigh-bone over six feet long.

Twenty-five years ago Prof. O. C. Marsh of Yale University quarried from the beds at Como bones of larger animals than had yet been found. They were chiefly saurians and varied from the size of a small animal to that of the atlantosaur, 130 feet long. After that for ten years Professor Marsh worked more or less at these beds.

THE FOSSIL FIELDS OF WYOMING

The various Government surveys have at some period within the last thirty-five years examined the geology in part of the Laramie Plains and vicinity. In 1842, Captain (afterward General) John C. Fremont and party passed down the North Platte Cañon and barely came out with their lives, losing nearly all their outfit.

Fremont in his report speaks of passing through North Park and the Laramie Plains, and of the wonderful variety and beauty of the flora.

In the following pages I quote from the reports of Clarence King, Arnold Hague, F. V. Hayden, J. J. Stevenson, Marvin and Endlich.

Arnold Hague, in "Geology of 40th Parallel," speaking of the Laramie Plains, says: "They may be 80 by 30 miles and are limited on the north by the hills at Como. On the south they are shut in by the coming together of the Medicine Bow and Laramie Ranges near the 41st parallel. The plains are elevated from 6,800 to 7,300 feet above the sea and the surface is so undulating that in the distance it seems to be apparently level, with ridges 100 to 200 feet high.

"The Laramie Hills on the east are a continuation of the Colorado Range and are scarcely 1,500 feet above the plains. The Medicine Bow on the west rises 3,000 to 4,000 feet higher."

Clarence King, in the "Geology of the 40th Parallel," says: "The Laramie Plain is essentially a broad, level upland of the Colorado cretaceous."

Hague further says: "The Laramie Hills lie chiefly between 41° and 42° north latitude, extending to Laramie River on the north and Cache la Poudre on the south, having

a broad summit and an altitude of 7,800 to 8,300 feet above the sea, with only one peak as high as 9,000 feet.

"The drainage from the Laramie Hills is all eastward and no streams flow west, with a few springs at the base of the hills that afford a small supply of water."

"There are but few trees on the summits, with some pines in the valleys and on the slopes.

"The Laramie Hills form a single anticlinal range, its central mass a heavy body of metamorphic granites of Archean age, with Paleozoic rocks on the flanks resting at 4° to 10° against the west side of the slopes."

Hayden in his report, 1867–1869, says that the Laramie Range forms one of the most complete and beautiful anticlinals seen in the Rocky Mountains. It extends from a point near the Sweetwater, southeastwardly, curving around until lost in the main range near Long's Peak, but Hayden considers the Laramie Plains to be not over 100 miles long. The nucleus of the Laramie Hills is red syenite, flanked on each side by Paleozoic and Mesozoic, with Tertiary in some places, inclining at different angles. A vast deposit of Cretaceous and Tertiary was formed in this region with a small percentage of calcareous material. The Cretaceous amounted to 5,000 feet.

Clarence King in the "Geology of the 40th Parallel" considers the Medicine Bow granite later than that of the Colorado and Laramie. The extension of the Medicine Bow south of Wyoming is overflowed by a rhyolite mass. Medicine Peak consists chiefly of white quartzite nearly 2,000 feet thick, trending north 20° to 25° east and dipping east, the quartz being cut by a dioryte dyke. In the rocks of the Laramie and Medicine Bow are found quartz, orthoclase, plagioclase, hornblende, mica, chlorite and calcite. In other respects the ranges differ.

Skulls of Titanotheriums in the museum, University of Wyoming, Laramie, Wyo.
Found forty miles north of Rawlins, Wyo., on Union Pacific Railroad

Graphite occurs in the Laramie Hills. Among the western foothills near Brush and Cottonwood creeks are quartz veins which carry small quantities of gold, also magnetite and red and brown garnets. At several points along the Laramie Range the Upper Carboniferous is found resting directly on the Archean. This has been mentioned also by Hague.

Arnold Hague's general section of the Jurassic and Cretaceous as published in "Geology of the 40th Parallel" is as follows:

Section southern part of Laramie plains,

Jurassic—

1.	Friable white sandstone	
2.	Reddish brown sandstone with thin layers of variegated clays and marls	100 feet.
3.	Cream-colored sandstone and marls	
4.	Bluish gray cherty limestone	25 feet.
5.	Grayish white sandstone	75 feet.

Triassic—

6.	Yellowish red sandstone	375 feet.
7.	Fine deep red sandstone	
8.	Argillaceous sand and shales with interstratified gypsum, one gypsum bed of 22 feet	150 feet.
9.	Red compact sandstone.	250 feet.
10.	Reddish gray sandstone.	
11.	Thin bed of gray cherty limestone.	
12.	Coarse friable ash colored sandstone with pebble of angular chert and Archean fragments	225 feet.

The Como anticlinal consists of a steep mural face on the north, sloping to the south, the main axis trending east and west. Ridge bears north 60°; east dip 20° to 25°. Hague section shows:

Jurassic—

1. Compact yellowish brown sandstone, Dakota, with some conglomerate layers.
2. Gray sandy marl.
3. Cream colored marls with thin sandy layers.
4. Bluish drab cherty limestone.

Jurassic (Continued)—

5. Fine ash-colored marls with thin beds of light colored cherty limestone.
6. Gray and orange-colored marls with intercalations of coarse sandy layers.
7. Reddish yellow sandstone.

Triassic—

8. Brick-red compact sandstone, Triassic.

Como Lake occupies an anticlinal valley.

In the marls both above and below the sandstone, a little above the middle of the series, are Jurassic fossils, as *Pentacrinus astericus, Belemnites densus, Tancredia Warrenana, Trigonia quadrangularis.*

The Trias is included in the belt of conformable strata wrapped around Elk Mountain, with Carboniferous beneath and Jurassic above.

The west side of Rawlins quaquaversal uplift is marked by concentric monoclinal ridges, the Trias showing above 700 feet thickness, with pink sandstone at base and deep red above.

Clarence King further says that nearly up to the 41st parallel the red beds lie directly on the Archean from 300 to 800 feet thickness. They are also often seen resting conformably on the Paleozoic.

"The Trias is essentially sandstone and includes both clays and shales, and is of a prevailing brick red color. Next to color the most noticeable feature is cross-bedding, which is marked in the upper beds, but not seen near contact with the Archean. Conglomerate zones appear in the lower part. No organic remains have been found, but a few obscure pieces of half-petrified and half-carbonized wood.

"On the east side of the valley of Laramie River, near the Wyoming and Colorado line, are seen 1,200 feet of beds dipping slightly north and west, and presenting a high, abrupt wall of

nearly 1,000 feet, with some gypsum outcrops in front. Gypsum occurs in the Jurassic, but not so abundantly as in the Trias, and only in thin layers, the thickest being two feet.

"The Jura beds are more shaly, with some limestone layers, while the Trias is essentially sandy."

Hayden, in his report for 1870, speaks of a fine exhibition of Mesozoic resting on the red syenite on Big Laramie River, 35 miles southwest of Fort Sanders, and for 20 to 30 miles from its source the Laramie flows in a synclinal valley, the red beds dipping on each side.

In Hayden's report, 1873, A. R. Marvin, U. S. Geological Survey, speaks of the Trias as coarse grits and moderately coarse sandstone with sometimes fine examples of cross-bedding, and with conglomerates near the base. A dark red color prevails. When uptilted and eroded they form curious forms, as in the Garden of the Gods and Red Buttes. The Jurassic forms a narrow zone in Colorado; northwardly it increases in width.

In the "Geology of the 40th Parallel," all the Cretaceous, from the Dakota to the Fox Hills inclusive, are spoken as of being well developed near the mountains, and are thus estimated:

Laramie—1,500 feet.

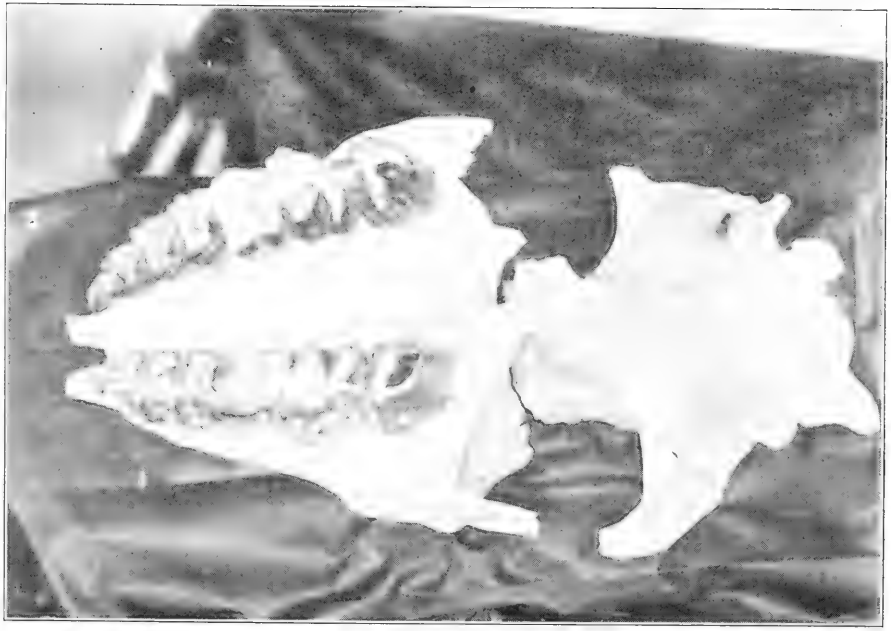
Fox Hills—1,500 feet.

Colorado, including Fort Benton, Niobrara and Pierre - 1,000 feet.

Dakota—300 feet.

The base of the Dakota is fine grained, passing into a brown sandstone.

In Hayden's report for 1874, he states that the Dakota forms the "hog-back" of the front range and is from 200 to 400



Skull of Rhinoceros in the museum, University of Wyoming, Laramie, Wyo. Found twenty miles north of Medicine Bow, Wyo., on Union Pacific Railroad

feet thick. Along the margin of the mountains east of the Wasatch it is generally present. Hayden says that it is doubtful if any geologist would ever make three divisions of Nos. 2, 3 and 4 if he had first studied them in the mountains. Hence the name "Colorado" used to include them seems appropriate.

After passing Cooper Station, five miles due east, black clays of the Lower Cretaceous appear and six miles southeast of Como on the railroad are excellent sandstone quarries, and numerous vegetable impressions occur.

Clarence King, in his 40th Parallel Report, gives a generalized section of Cretaceous east of the Colorado range, from the base up.

Number II. Fort Benton. 1st—Dark plastic ferruginous and argillaceous clays.

2d. Grayish blue clays, becoming dark calcareous near the top, 200 to 500 feet.

No. III. Niobrara. 1st—Argillaceous limestone, sometimes merging into the dark Benton shales.

2d—Light variegated marls; yellow color prevails.

3d—Yellow, white and cream colored marls with gypsum.

4th—Whitish gray marls.

5th—Yellow marls, with intercalated limestone.

6th—Bluish gray, soft, earthy beds, calcareous and argillaceous of variable thickness, 100 to 200 feet.

No. IV. Fort Pierre. 1st—Black, carbonaceous, shales and marls.

2d—Marly black arenaceous shales.

3d—Interstratified clay and sand, 250 to 300 feet.

Total, Colorado, 600 to 1,000 feet.

King, in 40th Parallel Survey, says that the Fort Benton Cretaceous occurs as dark plastic clays and thin shales. The

Niobrara is yellowish white chalky marls and impure limestone. The Fort Pierre consists chiefly of clay beds. The Fox Hills Cretaceous is a coarse argillaceous sandstone. Fish scales occur in the Colorado clay beds.

In Hayden's report, for 1874, he says that a few species of plants probably began their existence in the Fox Hills and continued on up into the Lignitic where they reached their highest development. Remarkable concretionary masses often characterize the upper Fox Hills beds, weathering so as to leave caps at top. The Fox Hills is important in a biologic view, for no animal and but few vegetables pass above. A few plants began in the Fox Hills and continued up into the Laramie.

King, in 40th Parallel Survey, says that the valleys of Big Laramie, Little Laramie, Dutton and Rock Creeks are eroded through Colorado shales and marls. North of the 41st parallel, the Fort Pierre is the uppermost Cretaceous. South of it, the Fox Hills sandstones form a broad belt extending southwardly beyond the 40th parallel. On Laramie Plains, the Fox Hills lie north and east of the Medicine Bow Range, chiefly on Rock Creek and Mill Creek. South of Mill Creek, the brownish gray sandstones carry carbonaceous shales with seams of coal and impressions of deciduous leaves. On the north side of Cooper Creek are thin seams of lignite. On Cache la Poudre Creek, the Fox Hills attains a thickness of 1,200 to 1,500 feet, consisting of friable sandstone, rendered impure by the presence of clay. From Medicine Bow to Carbon the Fox Hills forms the surface rock. Near Separation Peak, the Fox Hills Cretaceous may be 3,500 feet thick to 4,000 feet south of Fort Steele. Four miles northeast the Fox

Hills is quite ferruginous and nearby the Platte River cuts through nearly horizontal beds of Fox Hills.

The Fox Hills sandstones imperceptibly pass into the Laramie above, which is largely of sandstone but contains more clay and frequent carbonaceous shales.

East of the Rocky Mountains, the Fox Hills contains one coal bed near its eastern limit. On Cooper and Rock Creek are several coal seams. At Coalville, the workable coal is Fox Hills. The upper limit of the Fox Hills is known by the cessation of true Pelagic forms.

King says: "From the west, eastwardly, the Cretaceous series rests with absolute conformity upon the Jura."

At the Dutton coal bank the coal is overlaid by a very friable, somewhat carbonaceous shale, full of dicotyledonous leaves. This is again overlaid by a soft yellowish brown sandstone with fossil leaves in the lower beds. I did not have an opportunity of examining the Laramie beds at any other place.

Lesquereux divided the Laramie into three sub groups.

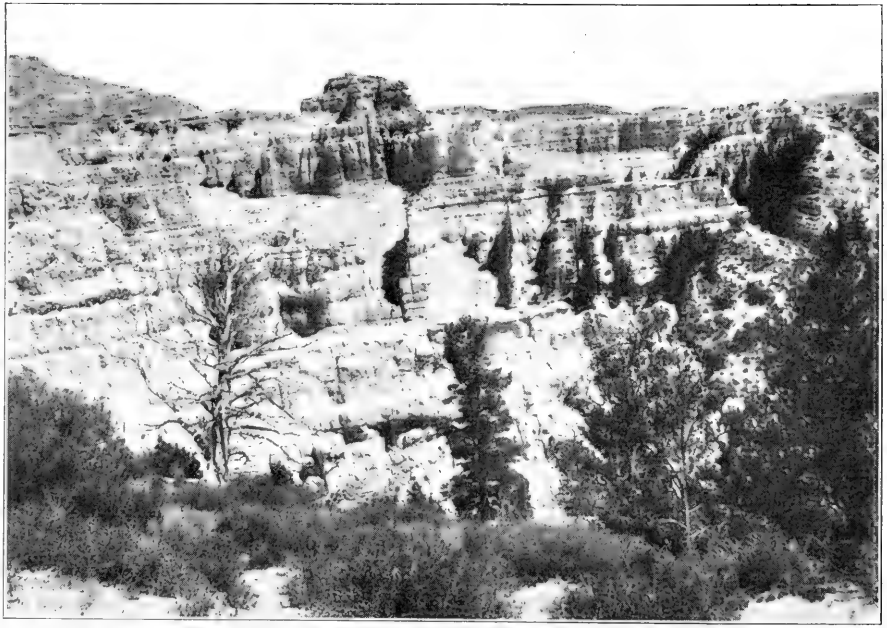
1st—Bitter Creek, or lower group, flora Eocene.

2d—Evanston, or second group, flora Miocene.

3d Carbon, the third group, upper Middle Miocene. Dinosaurs have been reported from the uppermost Laramie.

All the various geologists, who have spoken of the Laramie group, assign its position at the top of the Cretaceous, with the exception of Hayden and Lesquereux. They consider it to be basal Tertiary, considered so by Lesquereux on account of the fossil plants found therein.

In Wyoming and on the plains east of the Rocky Mountains and south of the 41st parallel, the Laramie rests conformably upon the Fox Hills Cretaceous.



Escarpment five miles west of Lone Tree Creek, Wyo.

Lesquereux, in Hayden's Report for 1872, tells how peat bogs are formed and discusses, in a full and interesting manner, their formation, and also the Lignitic formations of the Rocky Mountains. In this article he speaks of the coals of New Mexico, Colorado and Wyoming. He says that the Cretaceous, four miles west of Medicine Bow, passes under the barren Lignitic sandstone. From this to Carbon the strata is continuous in repeated undulations, forming basins, which contain the Upper Lignitic, with remarkably thick beds of combustible material. The shaft at Carbon shows:

1st—Clay shale and sandstone at top, 35 feet.
2d—Ferruginous shale with dicotyledonous leaves, 3 feet.
3d—Clay shale and sandstone, plants at top, 18 feet.
4th—Main coal, 9 feet.
5th—Fire clay, shale and dicotyledonous plants, 20 feet.
6th—Coal, 4 feet.
7th—Fire clay and shale, 8 feet.
8th—Coal, 4 feet.

In the above there are included 17 feet of coal in 101 feet of depth. One mile west of Carbon, the upper coal is seen in a cut under a thick layer of compact gritty sandstone with fossil wood and streaks of coal near the base. Over the sandstones are beds of fire-clay with silicified wood, and fossil dicotyledonous leaves occur in the overlying shale.

At Point of Rocks the Lignitic series overlies Cretaceous No. 4, these constituting the axis of an anticlinal. Dipping west the Upper Lignite strata is brought to the surface at Rock Springs. At Point of Rocks, 80 feet of the Cretaceous below the Lignitic is exposed and this is conformably overlaid by 185 feet of Lignitic sandstone, bearing fucoidal remains. Twenty-five feet above the base of this sandstone there is a bed of coal 8 feet thick.

Half a mile east of Black Buttes we see at top:

1st—Shaly sandstone, 10 feet.

2d—Argillaceous shales and clay, 7 feet.

3d—Coal streak, 3 inches.

4th—Argillaceous and sandy shale, yellowish, with many dicotyledonous leaves, 10 feet 9 inches.

5th—Main coal, 8 feet.

6th—Chocolate colored fire clay, 5 feet.

7th—Black laminated shale, 10 feet.

8th—Coal, 4 feet.

9th—Shales and fire clay, 16 feet.

10th—White concretionary sandstone with many fucoids, also is somewhat cavernous, 118 feet. Twelve feet of coal is here included.

The section at Rock Spring shows:

1st—Main coal		4 ft.
At 117 feet depth after passing hard sandstone, shaly sandstone and clay.		
2d —Coal worked two miles east		4 ft.
3d —at 149 feet, coal		3 ft. 4 in.
4th—at 268 " "		5 ft. 5 in.
5th—at 324 " "		3 ft.
6th—at 353 " "		2 ft. 6 in.
7th —at 377 " "		2 ft. 1 in.
8th—at 420 " "		3 ft.
9th—at 447 " "		1 ft. 8 in.
10th—at 476 " "		2 ft. 6 in.
11th —at 485 " "		2 ft.
12th—at 577 " "		2 ft. 6 in.
13th—at 606 " "		3 ft.
14th—at 640 " "		1 ft. 8 in.
15th—at 668 " "		1 ft. 8 in.
16th—at 728 " "		2 ft.
Total coal		48 ft. 4 in.

Soapstone and sandstone between all the coals.

Below to 1,180 feet all sandstone. The record shows an extraordinary development of coal strata, sixteen beds of coal aggregating 48 feet. Some of this coal I saw last summer in coal bins at Medicine Bow station and it certainly is a beautiful and pure looking coal.

Lesquereux considers the Laramie of carbon to be Miocene at Evanston; Upper Eocene at Raton, and Golden, Lower Eocene. The vegetation he considers Oligocene; at Black Butte and Rock Springs, Lower Eocene; at Point of Rocks, Rock Creek and Evanston, Upper Eocene and Lower Miocene form the flora.

These coals are often termed lignitic. Some even have over 12 per cent of water in their composition, which would show a relation to the English brown coals. The percentage of ash is low, being from 2 to 6 per cent. Marvin, in Hayden's report for 1873, speaks of this, and also of their remarkable purity. Iron pyrites occur in exceedingly small quantity. A mineral resin is sometimes found. The following analyses are from Hayden's report, 1873:

Sp. Grav.	Water	Vol.	Fix. Carb.	Ash	Locality
1.38	9.18	39	47	4.5	Cooper, Wyo.
1.33	6 to 11	37 to 38	49 to 51	6 to 8	Carbon U. P.
1.31		46	50	3.22	Bl. Butte
1.34	8.5	30 to 50	46 to 50	3 to 8	Pt. of Rocks
1.29	7	36	54	1.73	Rock
1.23	6.25	32	52	9.55	Springs

Much more could be said descriptive of the various coals but the above is probably sufficient.

G. C. BROADHEAD,
Columbia, Mo.

Looking up Bear Gulch at foot of Laramie Peak, in Wyoming

TOPOGRAPHY OF CENTRAL WYOMING

Few regions of the United States are so well fitted for topographical study as that of southern and central Wyoming, through which the "Fossil Fields Expedition" passed. The scenery is constructed on a generous scale; the immensity of the high plains and the great size of the terraces are notable features. There is little vegetation to obscure the details of the topography; the semi-arid climate tends at once to develop and preserve these details, so that all of them stand out in clearest definition.

Taking up the prominent types of topography in turn, we may discuss each briefly:

MOUNTAINS: These features are the most conspicuous in the state, the frontal range of the Rocky Mountains and the central portion of many other ranges are granitic; these are ordinarily characterized by their rounded summits, forming the well known dome type of topography, so marked a trait of granitic regions. Their general appearance recalls the mountains of Scotland or of Norway. Long slopes of waste cover the flanks well up toward the top, and often only the summits are composed of solid rock, and even here the process of weathering is so rapid that they are destined soon to be wholly buried in their own debris. The exfoliation of the granite is noticeable in many cases and this accounts for the rounded summits already mentioned. Because the mountains have become thus weathered, they have lost many of the sharper features of youth and have taken on the softer and block-like topography of old age. This feature of the mountains dominates all of the Wyoming scenery.

The flanks of the range are frequently bedded rocks; in such cases their topography is much more rugged than that of the central portion.

The variation so noticeable in the topography of the mountains, as one range after another is visited, is due to differences in the composition and the hardness of the rocks; differences also in dip often make sharp contrasts in the topography of closely associated areas.

Some of the ranges visited were well dissected anticlines without a granitic core. The Freezeout Hills is a fine example of this—it is well worthy of the visit of every geologist; nothing in the country is more impressive than this magnificent arch, opened up by subsequent erosion until the whole structure is plainly seen on the lofty cliffs that wall in the subsequent valley. Not only is the extent of the erosion shown but the successive steps of its history are plainly indicated.

Toward the west the anticline that forms the Freezeouts is barely notched—just a beginning has been made in the great arch of red sandstone—but toward the east the anticline is more and more deeply dissected as one approaches the older portions of the streams that have accomplished the erosion. A panorama of age-long activities lies before the observer as he looks along the axis of this great anticline.

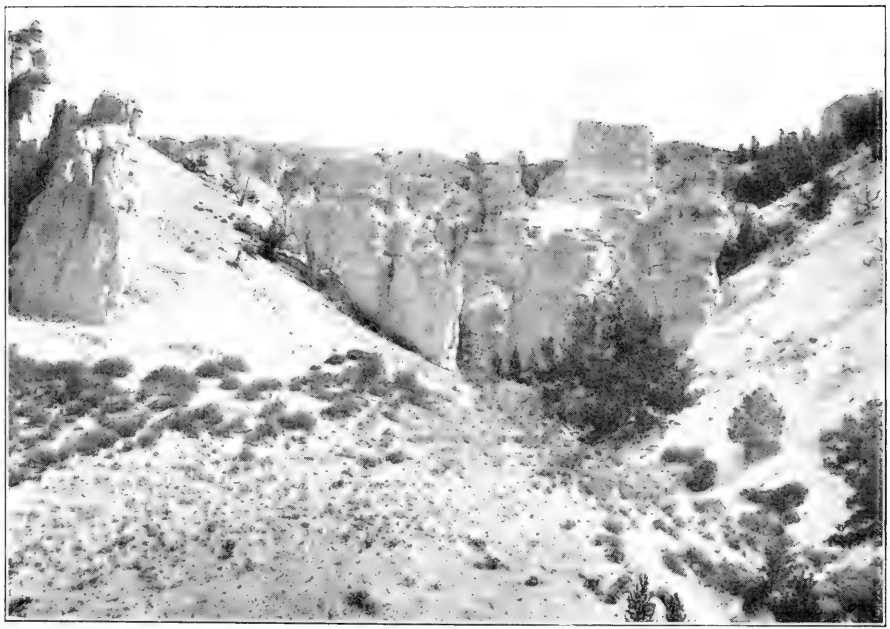
Passing away from the major folds which form the more conspicuous elevations, one meets with numerous lesser folds, which gradually die out as the distance from the mountains increases. These minor folds are generally opened up by erosion, so that the anticlines are well dissected. The hard rocks have not been reduced to the general level of the country, but stand up as rampart-like walls which sweep about as they pass from anticline to syncline, in great curves, forming

the most conspicuous topography to be seen on the Piedmont plains. No vegetation obscures them; there is nothing in this country of magnificent distances to hide the sweep of these natural ramparts as they wind back and forth across the country. The softer rocks are quite fully removed as a rule, leaving the depressions characteristically found where hard and soft rocks alternate. The classic area of anticlines and synclines in the Appalachian system of mountains is not only equaled but excelled by those of Wyoming. There is a general tendency in these smaller folds to be unsymmetrical; ordinarily the steepest side is most completely removed, leaving the gentler slopes standing as escarpments.

A fine example of this feature is seen at Aurora, where a plunging anticline has had its steepest side removed, while the less abrupt slope stands as an escarpment, several feet high, in which lie the dinosaur beds made famous by the researches of Marsh and others.

So well dissected is this particular anticline that a subsequent lake lies in its axis.

THE PLAINS: On passing away from the mountains the folds gradually disappear, and the strata assume either a horizontal position or they are inclined in some definite direction, ordinarily away from the mountains. As a rule the strata are monoclinal in this section of Wyoming, and as is usual in such conditions the region is characterized by escarpments and dip slopes. These features are especially prominent in the neighborhood of streams, where subsequent erosion has had an opportunity to work back along the strike of the rocks and develop the escarpment feature. Away from the drainage lines the plains are characterized by simplicity of topography, though this depends largely on the nature of the underlying



A gulch, Bates Hole, in Wyoming

rocks. In some localities as on the rim of Bates Hole, complex bad-land topography is found in the soft Tertiary rocks in close association with the simple and smooth topography of the harder Mesozoic rocks.

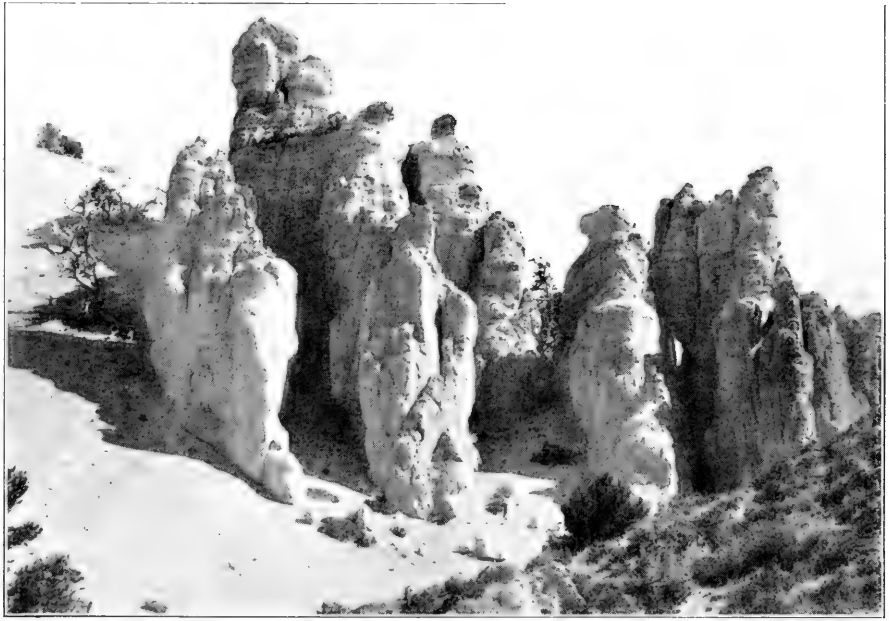
The present surface of the plains as a whole is discordant with the underlying rock structure, that is the surface of the plains does not agree with the dip of the rocks but rather bevels off the dip. This feature indicates, beyond question, that the region has been base-leveled.

Inasmuch as the Tertiaries are unconformable with the Cretaceous rocks and are laid down upon these inclined Mesozoics in a horizontal position, it would appear that the base leveling must have been post-Cretaceous.

The plains are covered by a thin, but effectual, layer of gravel, which is largely siliceous in character, and largely local in origin, as similar types are abundantly found in the still unweathered rocks.

This is especially well shown in the neighborhood of the Fox Hills formation, where the great nodules, which characterize that formation, are found scattered about the surface of the ground, left behind in the decay of the rocks. As the mountains are approached, the character of the gravel changes, there is a great accession of rocks which form the mass of the mountains themselves; in such cases the gravel is of drift origin in whole or in part.

TERRACES: The terraces are another of the important topographic features of the region. The streams in most instances are bordered by them, In many instances, as at Cooper's Creek, there are three terraces lining the stream. They are usually broad and reach heights of from fifty to one hundred feet. The valleys in which these terraces are found are also



The Witches. A formation found in Echo Valley, Utah

broad as a rule; even in the case of small streams they may be several miles wide. In these broad valleys the streams are almost lost and they meander back and forth in the most devious way, indicating that the streams have well nigh reached local base level. The broad undissected terraces contribute much to form the block-like topography of the plains region. In addition to the stream terraces, there is also a series of terraces at the foot of the mountains. In most cases these are made up of confluent fans, which stretch along at the base of the mountains for miles, parallel to their trend and only occasionally sending out a tongue of gravel into the plain beyond. The terraces of this sort are composed of coarse gravel where they join the mountains, but this becomes finer as the plain is approached.

The fronts of these terraces are often modified by stream action. In such cases they possess steeper slopes than is otherwise the case, for unless stream action has been present they pass by gradual degrees into the plain. All of the terraces are modified more or less by subsequent drainage. It is interesting to note how many of these drainage lines have originated. In most instances they have been located by the old-time buffalo trails and by the more modern cattle trails. These animals passed from their grazing grounds on the higher lands down to the streams by fixed trails which became deeper and deeper with constant use. It was not long before a deep trail became a passageway for water and soon grew into a regular water way, which soon developed into a permanent stream, or at least became a draw or gully. These draws can be seen in all stages of development, from the slightly eroded cattle trail to the well-developed ravine.

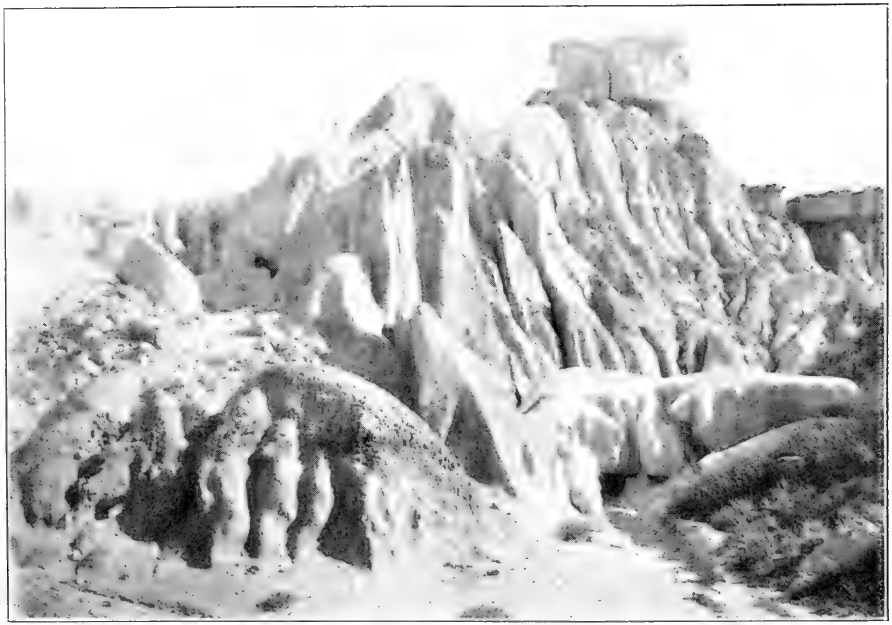
BASINS: Perhaps no feature attracts the attention of the geologist to a greater degree than the basins which abound on

Cañon in the sedimentary rocks. Vertical wall 1,000 feet high

every hand and are the most characteristic thing to be seen in the region. They are usually oval in form; frequently they have no outlet. They may or may not be occupied by water; in the former case there is usually a wide belt of alkali surrounding the pond. These basins owe their origin to a number of causes. Usually the basins occur in drainage channels and are formed by the ponding of the streams by the debris carried in by tributaries.

As is often the case, the tributaries work back along the strike of the soft rocks and thus are enabled to carry down great quantities of detritus, which the parent stream is unable to handle. Under such circumstances a basin will result sooner or later. In a few localities there was evidence of basins being formed by tectonic agencies. The best example of this was a basin in the neighborhood of Cooper's Creek, which had been formed by the uplift of a small fold across the stream.

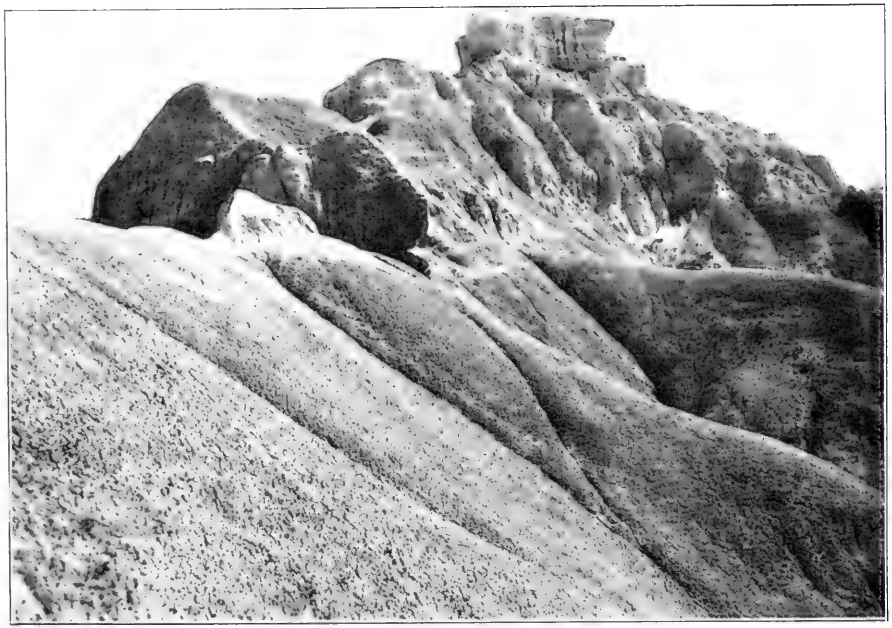
In the neighborhood of Harper, there were a few basins that had been formed by wind action; indeed, the process of construction could be seen going on in the strong wind which swept the region a good share of the time. A characteristic of such basins is that the coarse gravel is left behind, while the fine debris, such as sand and fine pebbles, is swept away; hence the bottoms of such basins are distinguished by the coarse character of the gravel. In a few instances, solution basins were observed; these were the round or oval-shaped basins which occurred in limestone regions; they had no apparent outlet. Such basins are not numerous, and they are not a special feature of the region. No basins were observed that could be attributed to glacial action; local glaciers have doubtless occurred in the region, but they have left no well-defined basins behind them as an evidence of their occupation.



Castle erosion, Bates Hole, Wyo.

VALLEYS: None of the valleys calls for special attention except that portion of the Platte Valley known as the Grand Cañon of the Platte.

Here, unknown to most, is one of the masterpieces of cañon topography in America. Not only is the scenery of the highest order, but the structural features revealed are of extreme interest. Here, in magnificent vertical section, the whole range of rocks, from the Archean up, can be studied in almost unbroken series. In the region of the cañon, the rocks dip quite uniformly in a northerly direction. The river crosses the strike as a whole, though it meanders more or less as it passes through the cañon. From a topographical point of view there are two especially interesting points to be observed. First is the contrast of the topography between the granite portion of the cañon and the sedimentary rock portion. In the former case the river is narrow and confined between vertical walls of granite a thousand or more feet high. The cañon resembles a vertical cleft in the ground, recalling in some of its features the well-known Cañon Diabolo of Arizona. On the other hand, as the river enters the region of bedded rocks, the cañon takes on an entirely different aspect; the walls recede from the stream in relatively gentle slopes; the river itself has worn a broader channel; the topography of the walls in this portion is also much more varied than in the granite portion, since the clastics vary greatly among themselves in regard to composition and character of bedding, as well as in hardness. Here are brought out in great variety and detail that common feature in cañons, namely, the combination of platform, cliff and talus slope. The topographic beauty of the cañon is greatly enhanced by the gorgeous colors of the rocks, especially those of the Triassic, with their brilliant reds and browns. The second noticeable feature is the meandering



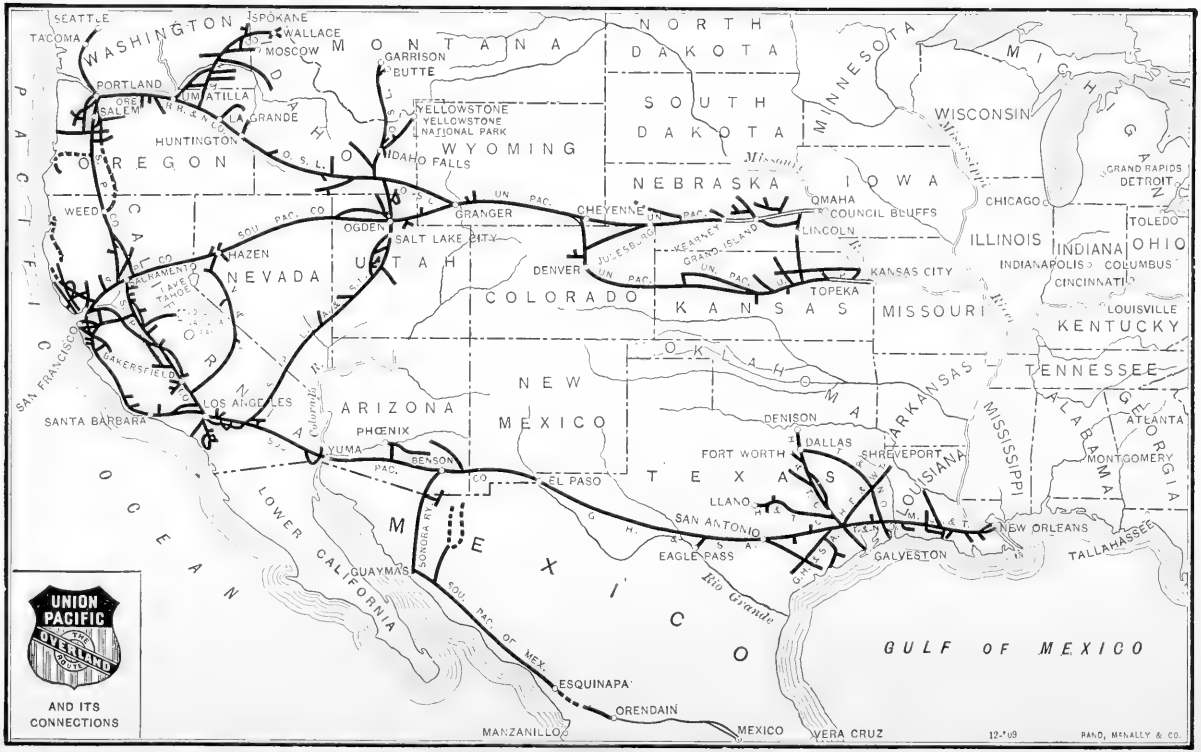
Temple erosion, Bates Hole, Wyo.

character of the stream, pointing to its superimposed origin. The Tertiary rocks lie horizontally upon the inclined Paleozoics and Mesozoics. The topography of the country indicates that the river has been superimposed upon the earlier rocks through the overlying Tertiaries. The unconformity indicates this, the fact that the Tertiary rocks have been more extensively eroded on one side than the other, and that, on the side in which the monocline plunges toward the river, the erosive forces have been much more active down the pitch of the plunging strata.

The two points mentioned above are, perhaps, most noticeable, though there are many others of interest.

No attempt has been made in this bare outline of the topography of southern Wyoming to give a scientific account of the surface features of the region; its only object is to call attention to some of its salient characteristics with the hope that it will influence others to study in detail the features, which the members of the Union Pacific expedition were enabled to study only in the most hasty and imperfect way.

GEORGE L. COLLIE,
Referee in Topography, Logan Museum,
Beloit, Wis.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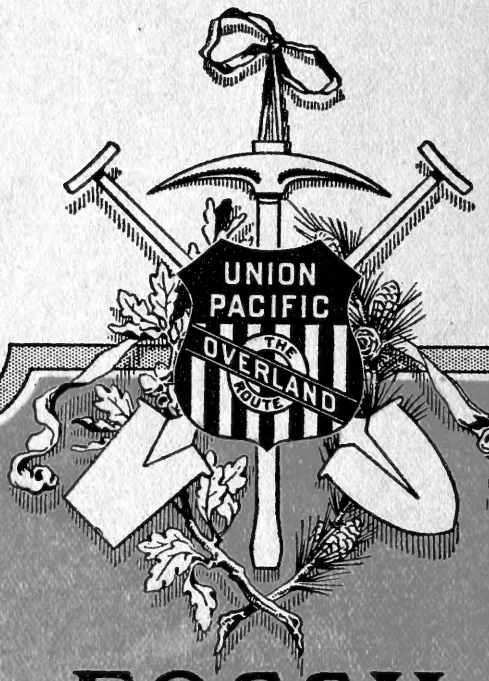

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