NOTES ON THE GEOLOGY OF WYOMING AND COLORADO TERRITORIES.—No. 1.

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The following notes on the Geology of Wyoming Territory, along the line of the Union Pacific Rail Road, were prepared in the field after the labors of the day were completed, but the region examined presents so many features new to geologists, that I desire to have them published in the Proceedings of the American Philosophical Society in advance of my more elaborate report. The great interest which is investing all this region, will cause any remarks on the geological structure to be read with satisfaction.

My examinations properly begin at Cheyenne City, along the line of the Union Pacific Rail Road, but the connection of the geology eastward, with that of the west, will be better understood by a resumé of the structure of the country from Omaha. At Omaha, and extending above that point along the Missouri River for about forty miles, we find that the underlying formations belong to the upper or barren coal measures.

Overlapping these are the sandstones of the Cretaceous period, which first reveal themselves immediately along the Missouri River about twenty miles west of Omaha, but are found about ten miles westward, as much as eight or ten miles south of the Platte River.

Near the mouth of the Elkhorn, the rusty sandstones of the Dakota group occupy the whole country. Near Columbus, and beyond for twenty or thirty miles, traces of No. 3 Cretaceous are observed, but they are never conspicuous. Nos. 4 and 5 have not been seen along the Platte.

About two hundred miles west of the Missouri River, along the Platte, the light colored clays and marks of the Tertiary period commence, foreshadowed, however, by a thick superficial deposit of fine brown grit, which seems to be of Post Pliocene age, as it is filled with recent fresh water and land strata. *Helix*, *Planorbis*, *Pupa*, *Physa*, *&c.* The Tertiary beds extend uninterruptedly to the margin of the Laramie Range, along the line of the Union Pacific Rail Road.

For one hundred and fifty to two hundred miles west of Omaha the soil is fertile, and, in an agricultural point of view, can hardly be surpassed; but beyond that point there is an absence of wood and water, which will render it impossible to cultivate the west-

ern half of Nebraska successfully. As a grazing country, however, it will eventually prove most valuable. For sheep raising it seems especially adapted. Sheep would thrive well on the short nutritious grasses, and the dry surface strewn with drift pebbles would be admirably adapted to preserve their feet from disease. It seems to me that all this portion of the West may at some period be inhabited by a pastoral people, who will raise some of the finest flocks and herds in America. The soil itself is fertile enough, for the cuttings along the Rail Road show a depth of six to twelve inches of vegetable mould, but there are not streams enough to irrigate any great portion. Even the Platte is sometimes so dry as to have no running water below the junction of the forks. The Platte valley is very broad, averaging five to fifteen miles in width, and on the bottom a good crop of grass grown every year, so that thousands of tons of hay are made for the use of the Government and the Union Pacific Rail Road.

The rocks for building purposes are not abundant anywhere along the Platte east of the mountains, but the materials for making brick or artificial building stone occur in the greatest abundance, scarcely equaled in any part of the world. The vast superficial or Post Pliocene deposits which cover the surface, are especially adapted for these purposes. At Sidney Station and westward, there are some rather thick beds of light brown calcareous grit which seems to answer an excellent purpose for buildings, and has been much used in the erection of round houses and other buildings of the Union Pacific Rail Road. Near Cheyenne City these same Tertiary beds yield an excellent limestone, which has been much used at that place. These Tertiary rocks are rather porous, but work easily, and are sufficiently durable in the absence of more compact rocks.

Along the margin of the Laramie range, about sixteen miles west of Cheyenne City, there are beds of white limestone of Carboniferous age, which, when burned into lime, is of the finest quality. The walls of houses plastered with it are as white as snow, and it is a great favorite with masons. The supply is inexhaustible.

As soon as we reach the mountains, the building materials are as extensive as the range themselves. The sienites predominate, and are of every quality, from compact fine grained, to a coarse aggregate of quartz and feldspar, decomposing readily under atmospheric influences.

I would here call attention especially to some beds of fine grained compact sienite along the line of the Union Pacific Rail Road, near the summit of the first range, which nearly equals the best Scotch sienite, and resembles it very closely. The Union Pacific Rail Road contemplate transporting this beautiful rock to Omaha, to construct with it the piers of the bridge across the Missouri River. I regard this sienite to be as durable, and more elegant for building purposes than Quincy granite.

One of the most important problems for solution affecting the prosperity of this portion of the West, is the possibility of utilizing the vast quantities of coal and iron with which this country abounds. All the coals of Wyoming and Colorado appear to be of Tertiary age; and so extensive are they in the West, that it becomes a question whether the Tertiary might not with more propriety be called the Carboniferous or coal bearing period. I have estimated the coal area north of the Arkansas, south of Lodge Pale Creek, and east of the mountains, at five thousand square miles. It is quite possible that a more careful examination will show that it covers a still larger area.

In connection with this coal are large deposits of brown iron ore or limonite. Vide LeConte's Report, p. 60. There is *no evidence* as yet that the heat-producing power of these coals is sufficient to reduce iron. This iron ore occurs in the form of nodules or concretions, varying in size from an ounce to several hundred pounds in weight. It resembles very closely the iron ore of Maryland and Pennsylvania. It seems to be coëxtensive with the coal beds, though occurring more abundantly at some localities than at others. About twelve miles south of Cheyenne City there are large quantities, and within a few miles, beds of coal five to six feet in thickness are now worked. At South Boulder Creek it occurs again in great quantities, scattered through twelve to fifteen hundred feet of sands and clays connected with the coal. It will doubtless be found in the form of carbonate of iron beyond the reach of atmospheric influences.

The first smelting furnace erected in Colorado was established by Mr. Joseph Marshall, and he informed me that it required about three tons of ore to make one ton of pig iron. Over five hundred tons of this ore have been taken from this locality, and the area occupied by it is over fifty square miles.

There are many other localities on both sides of the mountains where this form of iron ore abounds.

At the sources of the Cherry-water, about thirty miles north

of Cheyenne City, there is a vast deposit of magnetic iron ore of the best quality. Through the kindness of my friend Dr. Latham and Mr. Whitehead, citizens of Cheyenne City, I had an opportunity to visit these iron mines, and I found them much richer and more extensive than I had previously imagined. Worn boulders of this ore have been found in the valley of the Cherry-water for many years. In the report of Capt. Stansbury the following paragraph is found: "In the bed of the Cherry-water and on the sides of the adjacent hills were found immense numbers of rounded black nodules of magnetic iron ore, which seemed of unusual richness."

In the winter of 1859 I gathered a large number of erratic specimens of this ore, which seemed to be scattered in the greatest quantity throughout the valley of the Cherry-water. The snow was so deep that I could not trace the masses to their source. This season I followed these erratic masses up the valley of the Cherry-water and in the mountains, interstratified with the metamorphic rocks, probably of Laurentian age, were literally mountains of this magnetic ore. Mr. Whitehead traced one of these beds a distance of one and a half miles. It occurs in mountain-like masses similar to the ore beds on Lake Superior.

In regard to the coal of this country the evidence seems to be clear that it is probably of Tertiary age. I have traced it over a vast area on the Upper Missouri River, and it seems probable that it extends far northward towards the Arctic Sea. I have also traced the Lignite beds from the Yellowstone valley by way of the Big Horn Mountains to the North Platte, until they pass beneath the White River Tertiary beds, about eighty miles north of Fort Laramie. These beds reappear again about ten miles south of Cheyenne City and continue uninterruptedly to the Arkansas. On the west side of the Laramie range these beds appear again a few miles east of Rock Creek, and from there continue westward to Salt Lake and perhaps farther. In Colorado these coal beds have been wrought to a considerable extent. At South Boulder Creek there are eleven beds of coal varying in thickness from five to thirteen feet. The lowest bed is thirteen feet in thickness and is of excellent quality, very much resembling anthracite in appearance, though much lighter.

An analysis of this coal by Dr. Torrey of New York, shows it to contain 59.20 per cent. of carbon — water in a state of combination or its elements 12.00 — volatile matter expelled at a red heat forming inflammable gases and vapor 26.00 — Ash of reddish color, color sometimes gray, 2.80.

As a fuel for domestic purposes I am convinced that this coal will rank next to anthracite and prove superior to the ordinary bituminous coals. It is as neat as anthracite, leaving no stains on the fingers. It produces no offensive gas or odor, and is superior in a sanitary point of view; and when brought into general use it will be a great favorite for culinary purposes. It contains no destructive elements, leaves very little ash, no clinkers, and produces no more erosive effects on stove grates or steam-boilers than dry wood. If exposed in the open air it is apt to crumble, but if protected it receives no special injury. Dr. Torrey thinks there is no reason why it should not be eminently useful for generating steam and for smelting ore.

In the Laramie Plain along the line of the Union Pacific Rail Road extensive beds of coal have been opened, and the coal is used for generating steam and for fuel on the cars. It cannot be long before it will come into general use throughout the West.

August 15th. Left Cheyenne City with Dr. Curtin, an assistant on the Survey, and Mr. Whitehead, a citizen of Cheyenne City, for the purpose of exploring the Cherry-water valley to its head. For the first twenty miles we passed over the light colored marls and sands of the White River Tertiary. As we approached the foot of the mountains we came into a beautiful valley, varying from three to ten miles in width, looking as though it had been scooped out as it were during the Glacial period by forces from the mountain sides. All over this country are marked proofs of a powerful erosion at the close of the Drift period, which gave to the surface of the country its present configuration. There are terraces also along the base of the mountains as well as along the stream, and the nearer we approach the mountain slopes the more conspicuous these terraces become.

We camped the night of the 15th on Horse Creek, a branch of the North Platte. This valley can hardly be surpassed for grazing purposes. The water is excellent and the grass good. Near the point where the creek issues from the foot hills of the Laramie range there is a series of upheaved ridges with a strike nearly east and west, the beds inclining from 50° to 70°. The series of strata seems to be nearly as complete as that observed southward towards Denver. The red arenaceous beds are well shown, but no gypsum was seen.

In the valley of the Cherry-water near the fount whence its branches issue, the rocks are elevated at various angles, and by their great variety of color give a most picturesque appearance

to the scenery. Inclining away from the sienite nucleus we have here, 1st, the red arenaceous beds, 1000 to 1500 feet in thickness, then, 600 to 800 feet of variegated marls and clays with layers of sandstone, all destitute of fossils or any evidence of their age. These beds incline south-west at various angles 19°, 11°, 6°, &c. Then the cretaceous beds are quite well represented. From No. 5 I gathered *Baculites ovatus* and an *Inoceramus*.

Upon the Cretaceous beds, but not conforming to them, rest the White River Tertiary beds, inclining at a small angle, as if they had partaken of the latest upward movements of the mountain ranges.

The central portions of the mountains are composed of sienite mostly. The outer beds are rotten sienite of a dull gray color, disintegrating to such an extent that the surface is covered with a thick deposit of crystals of feldspar. As we approach the dividing ridge the beds of sienite become more compact and durable. Now and then we find beds of hornblendic gneiss or white quartz. All these rocks are nearly vertical.

Intercalated among these beds of sienite we found the beds of iron ore which, though not continuous like the sienite, occur here in large quantities. The ore beds incline in the same direction with the others, with the same joints and clearage, and the surface of many of the layers has the appearance of slickensides. Thousands of tons of this ore have been detached from these beds and distributed throughout the valley of the Cherry-water in a more or less worn condition. Although the amount of iron ore which we were able to discover, was indefinite in extent, yet we had evidence of the existence of other beds in the mountains at the sources of all the branches of the Cherry-water.

The Cherry-water empties into the North Platte, and has a valley about one hundred miles long. It has been for many years a favorite locality for wintering stock, not only for the excellence of the grass and water, but also from the fact that the climate is mild throughout the Winter. Cattle and horses thrive well all Winter without hay or shelter. The soil in all the valleys of the stream that flow into the North Platte is fertile, and where the surface can be irrigated good crops of all kinds of cereals and hardy vegetables can be raised without difficulty.

While my explorations this season will be confined mostly to the plain country, yet my plans contemplate numerous side trips to interesting points in the contiguous mountains.

Within a few weeks a great excitement has been created at

Fort Sanders and Laramie City, by the reported discovery of rich gold diggings near the sources of Little Laramie River. This district has a regular organization, hundreds of claims have been staked out and the name of "Last Chance" diggings given to it. Some very large and valuable nuggets of gold have been taken from these mines, and the usual exaggerated reports of their richness have been circulated everywhere.

August 20th. I started from Fort Sanders to make an examination of this district under the auspices of Maj. Gen'l Gibbon, U. S. A., the commander of the Rocky Mountain District. We were so fortunate also as to have the company of Prof. James Hall, State Geologist of New York. Our course was nearly south-west up the valley of the Little Laramie River to its sources in the Snowy Mountains. From Fort Sanders to the Little Laramie River the distance is eighteen miles over a very nearly level country, underlaid by Cretaceous beds holding a horizontal position nearly. Nos. 2 and 3 are quite well shown. No. 2 with its dark plastic clays is first observed at the Big Laramie Stage Station, six miles west of Fort Sanders.

In the broad, level plain country, west of this point No. 3 attains a thickness of fifty to one hundred feet, sometimes exhibiting its usual chalky character, but mostly composed of thinly laminated calcareous shale. All through it are thin layers of fibrous carbonate of lime, the fibres at right angles to the plane surface, and attached to these masses or layers are myriads of the little oyster *O. Congesta.* I also found a number of the vertebræ of a saurian animal.

From the Stage Station we passed directly up the valley of the Little Laramie. On either side were long ridges covered with grass and water-worn rocks, but from their sides projected a bed of rusty sandstone which contained *Inoceramus* and other marine fossils, which indicate the upper Cretaceous or No. 5. These beds continue for about fifteen miles, to a point where the river issues from the foot hills of the mountains, and thence to its source we follow its windings through some most beautiful and rugged scenery. The river itself has wrought its way through a synclinal valley caused by two separate minor ranges projecting out from the main range of mountains, and the trend of the minor ranges is nearly north and south.

One of these small ranges is quite peculiar in its character. On its east base, which fronts the Laramie Plains, the upper Cretaceous beds jut up against its side, and no unchanged rocks

of older date are seen, while on the west side, about five miles distant in a straight line, the entire series from the Carboniferous to the summit of No. 3 Cretaceous are visible, inclining at greater or less angles from the slope. The nucleus of the mountains is sienite of various degrees of fineness and compactness, inclining from 50° to 70° towards the south-east or nearly east.

It is an important question to determine the exact relation of these metamorphic rocks, which form the central portion of all the mountain ranges, to the unchanged beds which usually incline from their sides. Do they conform to each other or not? Did the metamorphic rocks lie in a more or less inclined position prior to the deposition of the Silurian or Carboniferous beds upon them? We have thus far found it difficult to determine the conformability or nonconformability west of the Laramie range; but on the east side of the mountains, especially near Fort Laramie and along the eastern slope of the Big Horn and Wind River Mountains, the discordant relation of the two series of rocks is very apparent. These questions will have a most important bearing when we attempt to reconstruct the history of the physical revolutions which have occurred in the West during past geological epochs. The sienite beds which form the nucleus of the small range of mountains between the Big and Little Laramie Rivers inclining eastward, were pushed up in such a way that the east front is almost vertical, and the Cretaceous beds at the base, which must have been borne upward in part during the elevation, have fallen abruptly down, so that in some instances they have passed the vertical position 20° to 30°. East of the Big Laramie and all along the western slope of the Laramie range, the entire series of unchanged rocks are visible, inclining at moderate angles from the mountain sides. On the west of this range the slope is more gentle, and the Carboniferous, Triassic and Jurassic and Cretaceous beds present their upturned edges clearly to the scrutiny of the geologist. The synclinal valley here through which the Little Laramie flows is about five miles wide, and crossing this stream west we find the full series inclining from the mountain slope eastward. The dip of the red beds is from 40° to 60°, that of the Cretaceous 40°.

No fossils have been found in any of the unchanged rocks below No. 3 Cretaceous west of Fort Sanders, nor does the nature of the beds indicate that the physical conditions during their their deposition were favorable for the existence of animal or vegetable life, certainly not for the preservation of its remains.

Between the well marked Cretaceous beds and the metamorphic rocks nearly all the rocks are brick-red, or tinged more or less with red from the presence of the peroxide of iron, and diffused through them there is a certain amount of gypsum; hence they have been called gypsiferous deposits. In the Black Hills, Big Horn and Wind River Mountains these red beds are largely developed, and there they contain beds of beautiful white amorphous gypsum, varying in thickness from five to sixty feet. Along the east slope of Pike's Peak in Colorado these formations contain valuable beds of gypsum, but in the Laramie Plains I have as yet observed no regular beds. The thickness of these deposits was estimated by Prof. Hall to be about 3000 feet, while the Cretaceous beds were 500 to 800 feet thick.

Camping with our wagons at the base of the main range of mountains near the source of the Little Laramie, we prepared to ascend the mountains on horse-back to the gold mines; the distance was about ten miles before we came in view of the "diggings," and to reach them made an ascent of about 2000 feet above the bed of the creek. We were then between 10,000 and 11,000 feet above the sea, very near the elevation of perpetual snow and where frost occurs every night of the year. On the summits of these lofty mountains are some most beautiful open spots without a tree, and covered with grass and flowers. After passing through dense pine forests for nearly ten miles, we suddenly emerged into one of these park-like areas. Just in the edge of the forest which skirted it were banks of snow six feet deep, compact like a glacier, and within a few feet were multitudes of flowers, and even the common wild strawberry seemed to flourish. These mountains are full of little streams of the purest water, and for six months of the year good pasturage for stock could be found.

The gold is sought after in the gulches that are formed by the little streams that flow from the Medicine Bow and other snowy mountains, most of which flow into the North Platte. We labored for two days to discover the quartz seams which we supposed to be the source of the stray lumps of gold, but the great thickness of superficial drift which covers all these mountains, concealed them from our view. The gold as far as known in this district seems to be confined to the lower glacial drift. That valuable mines will be found in these mountains at no distant day seems very probable. The geological evidence is quite conclusive, and the mountains are a continuation northward of

the same range in which the rich mines of Colorado are located.

Not only in the more lofty ranges, but also in the lower mountains, are large forests of pine timber which will eventually become of great value to this country. Vast quantities of this pine in the form of rail road ties is floated down the various streams to the Union Pacific Rail Road. One gentleman alone, has a contract for 550,000 ties, all of which he floats down from the mountains along the southern side of the Laramie Plains. The Big and Little Laramie, Rock Creek, and Medicine Bow River, with their branches are literally filled with ties at this time, and I was informed that in time of high water they can be taken down to the railroad from the mountains after being cut and placed in the water, at the rate of from one to three cents each. These are important facts, inasmuch as they show the ease with which these vast bodies of timber may be brought down into the plains below and converted into lumber, should the future settlement of the country demand it. I am inclined to believe that a peculiar class of people, like the lumbermen of Maine and Michigan, will some day fill these mountain regions.

There are several species of pine wood and one spruce or balsam of fir, *Abies Douglassi*. The latter is a beautiful and symmetrical tree, rising to the height of 100 to 150 feet and as straight as an arrow. The ties that are made from this spruce are of the best quality.

On the morning of *August 25th*, I left Fort Sanders on a third side trip to the North Park, in company with a hunting party composed of Gen'l F. P. Blair, Col. Dodge, U. S. A., and Capt. Proctor, U. S. A. Messrs. Smith and Carson, assistants, accompanied me. The examination of the North Park forming a part of my plan of operations, I regarded this as the most favorable opportunity that was likely to present itself, affording adequate protection. I was the more desirous of visiting that interesting locality from the fact that the geological character is entirely unknown.

Our course from Fort Sanders was nearly south-east up the Big Laramie River towards its source in the mountains. The geology of the plain country through which the Big Laramie flows is very similar to that of the Little Laramie — about fifteen miles to the westward. There are comparatively few exposures of the basis rocks on account of the superficial drift which covers all this country. Still we find along the banks of the river, near the Stage Station, the same black plastic clay of

No. 2 with *Ostrea congesta* and a few remains of fishes; also the chalky marls of No. 3; and about two miles above, the long high ridges, on either side, extending up for several miles, composed of the rusty yellow sands and sandstone of No. 5. The dip of these beds is very gentle, hardly perceptible to the eye.

The Big Laramie is a very clear stream, about fifty yards in width and averaging about two feet in depth, easily forded in most places. Like most of the western streams, the difference between high and low water mark is very great. In Spring and early Summer, when the snows of the mountains melt, these streams become formidable rivers. The soil along the bottoms appears to be very good, the grass grows quite heavily and hundreds of tons of hay are cut here by the settlers for Winter use. The grazing is excellent, and numerous ranches have been started all through the valley for the purpose of raising stock. Even at this season of the year a great variety of flowers covers the surface. The *Compositae* and *Leguminosae* prevail in numbers, and yellow is the dominant color. As we approached the foot hills of the mountains the transition beds or No. 1 (?) appeared on the ridge, rocks of more recent date having been swept away by erosion. Fragments of pudding stone and rusty colored masses of sandstone were scattered here and there; then beneath them were exposed about 400 feet of variegated arenaceous layers of uncertain age, perhaps Jurassic; then a little higher up the side of the mountains were revealed the red beds 1500 feet or more in thickness, presenting wonderfully picturesque scenery. All these beds seemed to have been lifted up in a nearly horizontal position, so that they present lofty escarpments, sometimes cone-like or pyramidal in shape, revealing each layer in the order of succession. The harder layers yielding less readily to atmospheric influence, project out from the sides adding much to the novelty of the view. Most of the beds incline from the flanks of the mountains at various angles, 3°, 8°, 15°, and then continue along the river winding for twenty-five miles among the mountains almost to the foot of the snow covered peaks.

On either side can be seen a number of sienitic nuclei, but I could not find the unchanged rocks so clearly in contact with them that I could define their relation to each other.

Before reaching the mountains we passed a series of alkaline lakes which are simply shallow depressions, receiving the drainage of a small area without any outlet. From these shallow

lakes the water is evaporated, so that in the Autumn the bottoms are dry and covered with a white incrustation which looks much like water in the distance. One of these lakes still contained water and seems to have a fair supply at all seasons. It is almost a mile in length and half a mile in width. In the Spring these lakes are quite large and are filled by the overflow of the branches of the Big Laramie, which are greatly swollen by the melting snows. Great quantities of fish are swept into these lakes from the neighboring streams, and in the Autumn the water becomes so alkaline by evaporation that the fish die in great numbers along the shore. It is a curious fact that not a single trout has ever been taken in any of the branches of the North Platte unless a few have been caught in the Sweet-water, while the branches of the South Platte are filled with them.

After entering the foot hills of the mountains the Big Laramie and its branches wind their way through the narrow valleys or gorges formed by the anticlinals and synclinals produced by the upheaval of the unchanged rocks.

All the lower beds are more or less arenaceous and of a brick-red color, with only three layers of a light gray sandstone. No fossils can be found in any of the rocks, so that it is difficult to determine their age with certainty. We believe that the lower beds are Carboniferous, and have received their red color from the fact that the sediments were doubtless derived from the disintegration of the red sienitic rocks upon which they rest. It is also quite possible that a portion of the red beds are Triassic, and also that the yellow, gray and rusty sands and sandstones above are Jurassic.

Lying above the supposed Jurassic and beneath the well defined Cretaceous there is a large thickness of sandstone which I have called Transition beds or No. 1 (?), because they occupy the position of the lower Cretaceous No. 1, as shown on the Missouri River and in Middle Kansas. These beds are well developed and quite uniform in their lithological character all along the mountain sides from latitude 49° to the Arkansas, yet they have never yielded a single characteristic fossil that would determine their age. I have therefore called them provisionally Lower Cretaceous or beds of transition from one great period of geological history to another, and the characters of the sediments which compose them justify the name.

Near our camp on the Big Laramie, which was about thirty-five miles south-west of Fort Sanders and about fifteen miles

above the foot of the hills, were some singular illustrations of the dynamics of geology. On the south-west side of the stream and inclining eastward or south-eastward the entire series of red and variegated beds are shown in their order of succession 1500 to 2000 feet in height. At the foot of this escarpment is a low ridge of the red material, which is so grassed over that the connection cannot be seen with the sienite nucleus. This covers a belt of sienite, about two hundred yards wide and three to five miles long, the jagged masses of rock reaching a height of one thousand feet or more, and standing nearly vertical or dipping slightly to the south-east. Between the sienitic beds and the river are the two low ridges of Cretaceous No. 2 and 3 which seem to have been lifted up with the sienite, but to have fallen back past a vertical position, so that they now incline from the sienite ridge, while on the opposite side the beds have a regular dip from the ridge. This peculiarity seems to be common in various localities, owing to the fact that the metamorphic beds which composed the central portion of all the mountains had suffered upheaval prior to the deposition of the unchanged beds. Therefore in the quiet elevation of the mountain ranges the beds are merely lifted up in the direction of the dip of the older rocks, while they are as it were pushed away from the opposite side, forming what may be called an abrupt or incomplete anticlinal.

On the opposite or south side of the river there is a gradual slope of 2000 feet above the bed of the stream, the strata inclining 5° until we reach the nucleus of another mountain range; so that we have here as it were two huge monoclinals. These monoclinals form local anticlinals, inasmuch as, in some places, all the beds incline for a short distance from a common axis.

On the north side of the river, and east for ten to twenty miles, the flanks of the mountain ranges are covered with the unchanged rocks, which give comparatively gentle grassy slopes, owing to the readiness with which they yield to atmospheric agencies. Through these slopes many little streams cut their way, forming huge cañons, which exhibit along their sides the series of beds in their order of succession.

From a point near the source, for twenty or thirty miles, the river flows through a synclinal valley, the conspicuous red beds dipping from either side. Along the valley of the river are marked deposits of drift, the result of glacial action; but the most beautiful feature is the well defined terraces, about fifty feet high and smoothed off like a lawn. These terraces are

covered with a considerable deposit of drift; but when they are cut through by streams the basis rocks are shown.

The scenery on either side of this valley is beautiful beyond description. On the west side are the snow-clad peaks of the Medicine Bow range in the distance, with numerous intervening lower ranges ascending like steps. The snowy mountains are mostly destitute of vegetation and are covered with eternal snow, but the lower mountain ridges are covered mostly with what may be called groves of pine. Indeed the pine groves and grassy openings are so arranged and proportioned that the whole scene appears as if it might have been partially the work of art, and the traveler imagines himself in a sparsely settled mountainous district instead of the unexplored Rocky Mountain Region. These openings and grassy slopes will make excellent pasture grounds, for the grass is good, and they are watered with the finest of mountain streams and springs. I would again remark that the pine forests of these mountains must at some period be an object of earnest pursuit. Even now the mountain sides are full of tie cutters, who cut and float hundreds of thousands of ties down the mountain streams fifty to one hundred miles to the Union Pacific Rail Road, whence they can be transported by rail road to any desired point.

In the moist ravines of the mountain sides are patches of the aspen *Populus tremuloides*, which from their peculiar mode of growth, form a striking feature in the landscape. They grow very thickly, seldom attaining a height of more than forty or fifty feet, and not more than twelve to eighteen inches in diameter. The bodies are very smooth and nearly white, and their tops form a rounded cone shaped mass of foliage. These aspen groves are the favorite resort of deer, elk, grouse, and all kinds of game.

On the east side also is the snow clad range, which in its southward extension includes Long's Peak and numerous other peaks in the vicinity. On either side of these lofty ranges, which often rise above the limit of vegetation, are a number of successive lower ridges which descend like steps. There is such a wonderful uniformity in the structure of the mountains that a detailed description of a portion applies for the most part to all.

Our course along the Cherokee Trail was about south-west from the Big Laramie River, over ridge after ridge, and after traveling twenty-five miles, we entered the North Park through some of the most beautiful scenery of that interesting region. From the summit of the high ridges on the north we looked to

the southward over a series of lofty cones or pyramids, as it were, all clothed with a dense growth of pine. The metamorphic rocks of which these mountains are composed disintegrate so easily that the surface is covered with a deposit of loose material, as fine earth and fragments of rock. The hills have therefore been so smoothed down that it is difficult to see the basin rocks in continuous lines. We saw enough however to show us that red sienite in its various forms constitute the principal rocks, while now and then a bed of hornblendic gneiss, white quartz or greenstone, occurs. All through the mountain region are small open areas, sometimes on the hills and sometimes on the lower ground, forming meadow like spots which the various kinds of animals love to frequent to feed on the abundant grass. The Old Cherokee Trail derives its name from the fact that a party of those Indians cut their way through the thick pines about thirty years ago with a train of three hundred wagons.

The traveling was difficult at this time, owing to the ruggedness of the surface and the obstruction from the fallen pines.

So far as I could ascertain it, the trend of the upland mountain ridges of sienite was nearly east and west, and the dip nearly north. The North Park is oval or nearly quadrangular in shape, is about fifty miles in extent from east to west, and thirty from north to south, occupying an area of about fifteen hundred square miles. Viewing it from one of the high mountains on its border, it appears to be a vast depression which might once have formed the bed of a lake. Its surface is rather rugged, yet there are broad bottoms along the streams, especially the North Platte and its branches. Scarcely a tree is to be seen over the whole area, while the mountains which wall it in on every side are dotted with a dense growth of pine. The grass grows in the park quite luxuriantly, often yielding at least two tons of hay to the acre. Streams of the purest water flow through the Park, and there are some of the purest springs I have yet seen, a few of them forming good sized streams where they issue from the ground. I am quite confident that this entire Park would make an excellent grazing region for at least six or eight months of the year. Myriads of Antelope were quietly feeding in this great pasture ground like flocks of sheep. The soil is very rich, but the seasons must be too brief for successful cultivation of any crops. Indeed there is frost there nearly every night, and snow falls every month of the year.

As I have before stated, the Park is surrounded with lofty ranges of mountains as by gigantic walls. On the north and

east side may be seen the snow covered ranges rising far above all the rest, their summits touching the clouds. On the west side there is also a short snowy range. The snowy ranges on the east border of the Park have their north sides abrupt and south sides less so as seen from a distance, as if the massive rocky hills inclined southward. All along the north side of the Park the lower hills incline south-westward, while the higher ranges are quite steep, and correspond in the apparent dip of the beds to the lofty snow clad mountains on the east which incline south or south-westward. The inclination of the metamorphic beds composing the higher ranges is from 60° to 80°. On the west side of the Park long ridges seem to slope gradually down, so that they die out in the plain, forming a sort of "en echelon" arrangement. It is due to this fact that the area enclosed receives its oval shape.

The general trend of all the continuous mountain ranges is nearly north-west and south-east on all sides, but there are many local dips and variations from this direction.

I was much interested to know whether any of the unchanged rocks which are so well developed in the Laramie Plain occur in the North Park. I found that the entire series of red and variegated beds, including a portion of the Cretaceous strata, were fully represented, all inclining from the flanks of the mountains, and gradually assuming a horizontal position or nearly so toward the central portion of the Park. The transition beds or Lower Cretaceous, No. 1 (?), form quite conspicuous ridges inclining 19° to the south-west. They are composed of a very beautiful pudding stone of small rounded pebbles, most of them flint, cemented together with a siliceous paste. On the north side are quite large areas covered with loose sand which is blown about by the wind, resembling the sand hills on the Niobrara River. A close examination of the sand shows that it is composed mostly of worn particles of quartz and feldspar. The surface contains little or no vegetation presenting a peculiar barren appearance, the sand moving readily with the wind.

Hitherto it has been impossible to color on any geological map the geological formation of any part of this mountain region, and no information has ever been given in regard to the structure of the North Park. It will be impossible even now, with the imperfect topography of any of the maps, to color the geology in detail, but these explorations will enable me to fix the outline of the formation in a general way with a good degree of accuracy.