ANNUAL REPORT

—OF THE—

TERRITORIAL GEOLOGIST,

—TO THE—

GOVERNOR OF WYOMING.

—JANUARY, 1888.—

LOUIS D. RICKETTS, D. Sc.

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CHEYENNE, WYO.,
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CHEYENNE, Wyoming, January 1888.

SIR: In accordance with the Statutes of the Territory of Wyoming, I have the honor to transmit herewith a report of the results of examinations and observations made by me upon the Economic Geology and Mineral Resources of this Territory since my appointment to office in April last.

Very respectfully, your obedient servant,

LOUIS D. RICKETTS,
Territorial Geologist and Mining Engineer.

To His Excellency, THOMAS MOONLIGHT,
Governor of the Territory of Wyoming.

INTRODUCTORY.

In order to prepare a report reflecting the greatest credit to Wyoming and to myself, it is necessary to have a personal knowledge of the resources of the Territory, and also to pursue a course of reading and to make chemical analyses in the office and in the laboratory. In spite of the importance of the two latter subjects, previous personal inspection is necessary.

Owing to the recentness of my appointment in the latter part of April, 1887, it was found impossible to give proper attention to all of these subjects. It was decided, therefore, to give all possible time to field work, and to depend for analyses showing the quality of materials upon information that could be gathered by limited reading, or that could be furnished by citizens of the Territory. The entire season, from early in May to late in December was spent in the field, and the time reserved for writing this report, doing the collateral reading and making the few original analyses, has been but little more than two weeks.

The portion of the Territory examined has been large, but very important areas have not been visited for the simple reason that the ground could not be covered in the time allowed.

The examinations made enabled the following chapter embracing the subjects mentioned to be written:

Chapter I..Coal.
Chapter II...Petroleum.
Chapter III ....Natural Soda.
Chapter IV...................................Mining Districts.
Chapter V...............................Descriptive Geology.

In the first chapters it has been endeavored to render the subject treated as intelligible as possible but at the same time there was no hesitation, in some cases in giving somewhat technical descriptions which those not interested in the particular district described may not care to follow. I do this because otherwise the description would be of no great value to those interested in that particular place and the latter, familiar with the ground, will be easily able to understand the subject.

In Chapter V. I have endeavored to unite, together with a description of the various rocks of Wyoming, an account of the general elements and philosophy of geology that may enable the reader who has never considered these subjects to gain some idea of them. I am aware that such a task is one of the most difficult and should be prepared with great care but notwithstanding I have written the chapter and let it stand, hoping that however faulty, it may prove of some use.

NEEDS OF THE OFFICE.

Some trips have been made in wagons, others on horseback. The expenses for traveling, fuel, office rent, and the chemical apparatus and supplies imperative to the office have clearly shown that if the course proposed be carried out the contingent fund will be scarcely large enough as it stands, and that it either should be increased or else offices should be provided free of rent. In many instances I have been obliged to refrain from hiring help to make measurement and to do other work necessary to the construction of maps and sections, and I earnestly call attention to these facts. Such a change would enable all the plans for future work to be carried out, including an examination of the coal measures for coking coal, the collection of data for a geological map of the Territory, and the collection of museum specimens that will be a credit to Wyoming.

In conclusion, I wish to express my appreciation and thanks for the universal kindness and hospitality shown me everywhere on my travels. So universal was this kindness and hospitality that to make separate mention of it were to mention every place at which I have stopped.

CHAPTER I.

THE COAL FIELDS.

The area of Wyoming is about 87,000 square miles and of this area it has been roughly estimated that fully 20,000 square miles are underlaid by coal. That is to say, the area underlaid by the Laramie group of rocks, which bears the coal of the west and which usually contains workable seams where it exists in any large thickness, is that large. My trips through the Territory during the past summer and fall were necessarily hasty and the whole ground has not been covered, but I am convinced that this estimate is too low and that the coal area, thus estimated is nearly or quite 30,000 square miles. In this estimate I include all ground on which the Laramine rocks would be struck by sinking regardless of the depth at which they would be reached. My opinion is based upon the large coal area of the northern and central portions of the Territory. I will give roughly the limits of these areas as far as I know them. One great coal field lies in northeastern Wyoming and is bounded on the south approximately by a right line passing from the point on the Platte River where it is cut by the Carbon county line to the mouth of Shawnee Creek. On the west the boundary is about as follows: From the first named point along the Carbon county line to the head of Salt Creek, thence a few miles east of Salt Creek along Pine Ridge (sometimes even west of the creek itself,) all the way to its mouth. From the latter point the boundary follows approximately a line running N. 18° W. through Buffalo to the Montana line I am not familiar with the eastern limit. Mr. Tom Hooper of Crook County, tells me that the coal area extends continuously from the western boundary of the county to near the west side of Bear Lodge Mts. and that the eastern boundary of this great coal field passes southeast from the northern part of the county to the eastern line of the Territory. If these limits are correct the area of this field is even larger than estimated. Nor do I know that they have been determined but that the belt is broad is certain, and Powder River after it turns and takes it northerly course seems to lie in the heart of the coal field. Consequently the field is very wide and cannot be much less than 10,000 square miles in area.

North of the Rattlesnake Mountains there is another coal area which extends from Oil Mt., in township 33, N. Range 82, W. on the east to within four miles of Lander on the west, a distance of about 110 miles. North and south it averages 30 to 35 miles in width lying as it does from the foot of the Rattlesnake mountains, nearly to the foot of the Big Horn and Owl Creek mountains. This area then contains over 3,000 square miles. A third area lies in the Big Horn Basin, north of the Owl Creek mountains. Of its limits I know absolutely nothing, but I believe, from what I have heard and from what information I could gather, that it is an area of considerable size. With these three great coal fields then we come from the north of the Territory to the Sweetwater and Platte River with a total area covered with the coal bearing rocks of probably 15,000 square miles, and to this must be added the great coal fields of Uinta County, the area east of the Laramie Mountains, as for instance the ground beneath Cheyenne and all the large areas lying along the Union Pacific railway between the Colorado line and the Sweetwater and Plate Rivers, and the Sherman and Aspen divides. The latter includes the coal fields of the Laramie Plains, about Carbon, about the Seminole mountains and about Rock Springs and will bring the total, I think to at least 30,000 square miles.

CHARACTER OF COAL OF THE LARAMIE GROUP AS COMPARED WITH COALS OF OLDER FORMATIONS.

In the concluding chapter of this report some remarks are made at the outset concerning the change of sediments into sedimentary rocks, and of the soft stratified rocks into harder rocks, finally into semi-crystalline and crystalline rocks through metamorphism. Such changes are produced by pressure, and either a low degree of heat through a great geological time, or a higher degree of heat through a shorter geological time. Thus the oldest sedimentary rocks are usually more or less altered, while while the younger are not, except when they have been cut through by eruptive rocks, or had eruptive rock intruded into them in layers parallel to the strata, or have been through other agencies abnormally heated. In such cases these rocks are likewise changed or metamorphosed. A notable example of such a change is shown at Aspen, Colorado, where a mass of porphyry, coming in contact with the carboniferous limestone, changed it locally from its normal, fine-grained texture and gray-blue color, to a white and coarse crystalline marble. In the east the great dykes of doleryte which lie in the red sandstone strata, likewise alter and harden that rock, and so through innumerable examples.

As it is with ordinary rocks, so it is with coal. As the sedimentary rocks are first formed of mud, sand, gravel, etc., so coal is formed of dead vegetation. And as the rock sediments change into soft rocks, then into harder, and finally become firm, hard, and even crystalline rocks, so the peat swamps are covered up and change through all the grades into lignite, bituminous coal, semi-bituminous coal, anthracite, and like the sedimentary rocks, change slowly if under low degrees of metamorphic action, rapidly if under high.

The coals of the east belong with one exception to the middle series of the carboniferous rocks, and have laid under the pressure of superincumbent strata for countless ages. As a rule they have been subjected to feeble metamorphic agencies, and as a result are now in the shape of bituminous coals. But wherever the metamorphism has been greater they more closely approach the anthracites, and finally in northeastern Pennsylvania they are anthracites altogether. In the West the coals occur in a much younger formation, namely in the Upper Cretaceous rocks. Frequently they have been subjected to great pressure, but the low metamorphic action similar to that exerted on the bituminous coals of the East has not lasted long enough to convert them into coal of the same grade. As a consequence, although it was recognized that the Western coals were excellent for domestic and steam making purposes, it was thought that nothing comparable to the eastern coking-coals would be found, and that the production of such coals in the Rocky Mountains was out of the question.

The progress of gold, silver and lead mining in Colorado caused the necessity of smelting plants, and these required coke for the reduction of the ores. Such coke was imported from Pennsylvania at great expense, and rendered the discovery of coking coal a matter of great importance. Searching revealed the fact that coking coal existed in the state, and in 1885 Colorado stood fifth in the list of the seventeen coke producing States and Territories, with a production of nearly 132,000 tons of coke. Further, not only was coking coal discovered, but anthracite coal has now been found in several localities. With these discoveries a great growth of railroad construction has come, and special lines of road have been built for the coal trade. Thus the Midland road of Colorado, whatever its ultimate aim may be, would not have been begun now had it not been for the coal deposits of western Colorado.

While all this development has been carried out in Colorado, Wyoming has until the past year stood still as far as the development of new fields is concerned. Last year some prospecting for coal was begun and now the Territory is on the eve of a great advance in this direction. It is true that with one exception, thus far not proved to be of great importance, no coking coal has as yet been found within the Territory. Excellent coal, like that of Rock Springs, for domestic and steam making purposes and of Carbon, well adopted to locomotive use, is abundant but no coking coal. The question arises, will such coals be found? .The answer is, yes—almost as certainly as if it was known to occur to-day. *

It will take trouble, much searching, perhaps much disappointment but that it will be found there is hardly a question.

When we discuss the general occurrence of coal in Colorado and Wyoming the reason for this deduction is plain enough. In Colorado the coal occurs in the upper cretaceous as it does in Wyoming and as a rule is very similar to the Wyoming coal. It has as much moisture, volatile matter, and no more fixed carbon. But in the localties where the coking coals are found the conditions are different from the known localities in Wyoming. Sometimes such coal to all appearances simply occurs low down in the Upper Cretaceous, namely in the Fox Hill's group, but usually they occur in the Laramie beds in conjunction with eruptive rocks. In other words in the neighborhood of localities where dikes of eruptive rocks have cut through the coal measures, or spread out between their strata as intrusive sheets. The coal in this way subjected to a degree of heat higher than the normal and all the time covered with heavy rock strata has been through suchmetamorphic action changed to bituminous coal or even to anthracite, and in this manner what time has failed to yield intensity has accomplished. The coal thus heated has become more dense, has less water in it and while the volatile matter has decreased the fixed carbon has become greater, and bituminous matter is produced which render the coals more liable to coke.

In Wyoming the coal occurs in the same formation as it does in Colorado, but no systematic search has been made for coking coal. Of all the mines, none are off the main line of the railroads excepting those at Almy, and they are only two miles distant. One of the mines at Carbon, now abandoned, was four miles distant, while the mines now worked are alongside the main track. At Rock Springs the mines are alongside the main line. At Deer Creek, on the Northwestern, it is the same way.

*Since writing the above I have been informed that there is coking coal in Crook County. This coal lies in a separate area from the great coal field first described, and the banks being worked lie south of Sundance about thirty miles. Two ovens are completed and coke is being made from them, while a third oven is in course of construction. The coke is shipped by wagon to the Iron Hill smelter in the Black Hills. It is hauled in wagons the entire distance of 75 miles.

Apart from these mines a few others have been opened up near Lander, Buffalo, Douglas and Shawnee to supply—excepting the latter——only the local demand, and these are necessarily locations of convenience. All of the latter produce a small amount of coal in the aggregate, but they complete the list of the working mines in the Territory. All of these mines then are worked, either because they are convenient to the railroads or convenient to the towns. They have been opened up because coal was wanted and these localities were the best or the only localities known to be near at hand and ready to be worked without much expense, and not because the coal was searched for over the whole Territory, independent of the railroads. Whenever such an active and intelligent search is made for coal with a view to its coking qualities, and not especially with a view of its location, I believe that coal will be found; and at such places, if they are at all accessible, I believe the railroads will be glad to build.

DEVELOPMENT.

Up to the present time the only largely producing coal mines have been along the line of the Union Pacific railroad. The extension of the Northwestern system into central Wyoming is now causing activity in the coal industry in that portion of Wyoming, and mines that will probably prove of great importance as future coal producers are now being opened up at the mouth of Deer Creek, on the Platte River.

The coal produced throughout the Territory is, as a rule, excellent for the purposes for which it is used, and aside from locomotive consumption it is largely used in stoves and in manufactories. The Rock Springs coal is shipped in large quantities eastward into Nebraska as far as Omaha, and south even to Kansas City. To the west it is largely used in Utah, and at Butte, Montana. The Carbon coal is finely suited for locomotive fuel and steam making, besides being used for domestic purposes, and is largely shipped. The Almy coal is only adapted for locomotives, and is used for this purpose by the Union and Central Pacific railroads. The newly developed mines on Deer Creek also produce excellent coal, both for stoves and boilers, and though it is somewhat light when compared with the Rock Springs coal it is not so dusty. From all the mines, excepting those last named, coal has been taken for the last twenty years, and with fluctuations the production has steadily increased.

The past year (1887) has been an exceptionally active one in coal mining, and will largely exceed the output of any previous year. The following table taken from the works of the Geological Survey (Mineral Resources of the United States, calendar year 1885, p. 73), will show the statistics of coal production from 1868 to 1885 inclusive:

Year	Carbon.	Rock Springs.	Almy U. P.	Almy C. P.	Twin Creek.	Total.
1868	6,560	365				6,925
1869	30,482	16,933	1,967			49,382
1870	54,915	20,945	12,454	16,981		105,295
1871	31,748	40,566	21,171	53,843		147,328
1872	59,237	34,677	22,713	105,118		221,475
1873	61,164	44,700	22,847	130,989		259,700
1874	55,880	58,476	23,006	81,699		219,061
1875	61,750	104,664	41,805	92,589		300,808
1876	69,060	134,952	60,756	69,782		334,550
1877	74,343	146,494	54,643	77,373		342,853
1878	62,418	154,282	59,096	57,404		333,200
1879	75,424	193,252	71,576	60,739		409,991
1880	100,433	244,460	100,234	82,684		527,811
1881	156,820	270,425	110,156	90,779		628,181
1882	200,123	287,510	117,211	94,065	8,855	707,764
1883	248,380	304,495	111,713	78,450	36,651	779,689
1884	319,833	318,197	150,880	68,471	45,189	902,620
1885	226,863	328,601	164,441	70,216	17,207	807,328

The production for the year 1886, and the first half of 1887, according to the figures furnished by the Union Pacific Railway and published in the recent report of the Governor to the Secretary of the Interior was as follows:

	1886.	1887 to July 1.
Carbon	214,235	147,028
Rock Spring	359,338	250,660
Almy	119,118	108,478

The above does not include the production of the Central Pacific mines at Almy. It will be seen that the production for the first half of 1887, is over half a million tons and as the coal trade has been exceptionally brisk this fall, there can be little doubt but that the production for the whole year will be considerably over one million tons. One of the Deer Creek mines was just opened last fall and small shipments were begun in November. I am informed on good authority that in the last 45 days of the year 6,800 tons of coal were produced, and that they are about to put in hoisting machinery and make a very large output during 1888. As the market will compete but little with the Union Pacific mines this will tend to largely increase the production.

It is not my purpose in this report to attempt any description of the well developed mines. A few remarks upon the size of the veins and the quality of the coal will be given.

CARBON.

The coal area immediately about Carbon is limited. On the south it plays out against the foothills of the Medicine Bow mountains, and on the east there are none of the Laramie Rocks at

Wilcox. On the southeast, I think it connects with the area bordering the Medicine Bow mountains. On the west I am unfamiliar with the limits, but on the north the formation becomes much broken and folded a few miles from the railroad, and ceases altogether some fifteen miles out at the Medicine Bow River. About Carbon the coal is broken by a series of faults running in a northwesterly and southeasterly direction into a series of steps.

The coal outcrops at the old mine north of town, and dipping in a southerly direction toward the town it is broken by a fault, either simple or compound, which brings the coal to the surface again along the line of the railroad. The stopes on this outcrop follow it for several thousand feet (over two thousand), where there is another slip which brings the coal to the surface a third time—and other mines are located on this outcrop. Besides these faults, which are over a hundred feet in throw, there are numerous other smaller faults which seldom exceed ten or fifteen feet in displacement. There are two known veins at Carbon, of which only one, the upper, is worked. The latter is seven feet in thickness while the other is but four. They lie within 40 feet of each other. The roof of the main Carbon vein is a slate which swells on contact with the air and as a consequence a scale of coal is left in the roof to prevent the air affecting it. More rarely the roof is pure sandstone with no slate whatever. The floor is an old soil as usual. The Carbon coal is as a rule free from "woody" structure though specimens showing the grain of wood, a knot, etc., are not uncommon. The composition of the Carbon coal is shown by the following analyses: *

	No 1.	No. 2.
Water	8.10	6.10
Volatile matter	34.70	38.80
Fixed Carbon	51.65	49.30
Ash	5.55	5.80

Rock Springs. The Rock Springs coal is celebrated as a fine stove and steam coal as already mentioned. It occurs in an area entirely surrounded by heavy Tertiary deposits, the Laramie Beds here out cropping as a sort of an island. The coal is mined from a vein from 9 to 10 feet in thickness and is very clear and homogeneous in character. It shows scarcely any signs of woody structure. The shale roof is strong and easily held up. The coal dips at an angle of about 8° to the northeast and is opened both by inclines and shafts. The water is low and the fixed carbon high. The sulphur contents, which are not shown

*Mineral Resources of the United States, 1883-4, p. 101.

is low. The following analyses taken from the same article with the Carbon analyses shows the composition of the Rock Spring coal.

Water	7.00
Volatile matter	36.81
Fixed carbon	54.46
Ash	1.73

The lowness of moisture and the high fixed carbon of the Rock Springs coal together with its want of tendency to slack may be accounted for by the presence the Leucite rocks which occur cutting through the surface some twenty miles northeast of the Springs.

The Almy Mines. I have never visited these mines. Analyses of the coal show it to be fit for locomotive use only. It contains a high percentage of moisture. There is, however, coal in the vicinity of Hilliard station and less than a mile from the railroad which seems to be of better quality than the Almy coal. The workings, which were sunk through morainal material was unsecurely held and had caved in covering up the croppings. I was informed, however, that the vein was 20 feet in thickness. A sample of this coal was collected and an analysis made, and the result given in No. 1 No. 2. (Mineral Resources of the United States 1883-4, p. 102.) is an analysis of the Almy coal:

	No. 1.	No. 2.
Water	9.83	15.575
Volatile matter	40.97	33.905
Fixed carbon	43.65	44.785
Ash	5.55	5.928

It will be seen that the Hilliard coal contains much less moisture than the Almy sample, while the ash and fixed carbon are about the same. From the looks of the pieces which I took for analysis and which had been lying in a heap of slack for eight years, I would judge that it would not slack badly but that the tendency would be in breaking to check up into blocks, the smaller of which would still have considerable size.

The mines at Twin Creek, on the Oregon Short Line, are now closed down, and no active mining is now carried on along that branch of the Union Pacific. I understand, however, that active and intelligent prospecting work has been inaugurated in Uinta county, near Twin Creek and that that locality will probably become an important shipper of coal in the near future.

The remaining coal fields to be described belong to the coal areas at present but little known, and lie almost altogether north of the northern boundary of township 32. The Deer Creek

mines lie on the North Platte River at the mouth of Deer Creek, and between that point and Fort Fetterman. Owing to the hight of the river I could not ford it when I was in that part of the Territory, and have not visited those mines, but the information given is authentic. The coal outcrops in a line approximately east and west, some three-fourths of a mile from the river, and dips toward the river at an angle of about 8°. The Northwestern railroad runs parallel to and alongside the croppings. The coal lies in two veins, the upper seven feet in thickness and the lower about four to four and one-half feet thick. From specimens furnished me from the mines of the Deer Creek coal company, I find it to be bright and clear, and unquestionably an excellent coal for fuel—especially for stove fuel. The coal was analyzed by myself and gave the following result:

Water	13.33
Vol. matter	32.69
Fixed	49.93
Ash	4.05
	100.00

This analysis shows that this coal, though somewhat high in its percentage of water, is low in volatile matter and high in fixed carbon, and that aside from the water contents it compares favorably with the Rock Springs coal. A main slope, now over 700 feet, has been driven on this vein of coal, and entries have been started from this, and on the 17th of November last they began to break coal for the market. The coal was raised in the slope by mules, and only 150 tons per day (6,800 tons in forty-five days) could be taken out up to January 1. Machinery is being obtained for a hoisting plant now, however, and the output, for which there is now a large demand, will soon be very largely increased. In all probability these mines will have produced 150,000 tons by the first of January next, and will compare favorably as producers with the mines along the line of the Union Pacific.

Another company called the Wyoming Fuel Company own coal lands at the mouth of Box Elder, on the Platte River, above Old Fort Fetterman. The coal is reported to be of similar quality to the Deer Creek company's coal, and some work in the shape of tunnels has been run on the veins, one of the tunnels being over 200 feet in length. The croppings show many veins of coal which vary from one to nine feet in thickness, and the larger ones which have been opened up show the coal to be clean and free from slate. It is proposed to open these mines and to make extensive developments during the coming year.

Across the river from Deer Creek, near the mouth of Coal Creek, coal again outcrops. At this point the sandstones dip at an angle of from 20° to 25°. On going up Coal Creek four or five veins of coal may be seen outcropping in the steep bluffs which border the narrow valley. They are all over one foot in thickness. Two of them are over four feet in thickness. The first seam is about four feet in thickness, and another further up is about five feet thick. The first has a narrow streak of fire clay in it which renders the amount of clear coal less than four feet. This coal looks much like the Deer Creek coal across the river. It is black and shiny, and shows little or no remains of vegetable fibre. It lies where mined, in great lumps, which do not break up into slack, and contain fewer water cracks after exposure than the Deer Creek coal. I cannot decide without further examination whether these veins are the same as those at Deer Creek or not. If they are there must be a fault which has lifted up the rocks on the Coal Creek side, relatively to the Deer Creek mines, in a manner similar to the faulting at Carbon.

Coal also outcrops along the Platte River at Douglas, in a vein four feet or more in thickness. This coal is, however, inferior to the Deer Creek coal, and contains more sulphur—the latter seeming to be almost free from it. The Douglas coal also shows more woody fibre. A careful study of the coal formations between Douglas and Cottonwood Creek would probably reveal the relations between the Douglas and Deer Creek coals, and I am inclined to believe that the Deer Creek coal veins will be found underlying the Douglas veins.

This describes the coal of the southern portion of the coal field with the exception of that at Shawnee, which I have not seen and concerning which I have no authentic information, further than coal has been mined there and shipped on the Northwestern for locomotive use, I think. Continuing north the Laramie sandstones are found in a belt extending all the way to the Montana line, a distance of over 150 miles in an air line. Sage Creek and the streams which lie on the sides of Pine Ridge, all show the Laramie Rocks, and along the sides of Pine Ridge and high up where the gulches are deep and bare coal croppings. Here however, the land is much broken and folded and too rough and limited in area for coal mining. Further down however, on the eastern slope of Pine mountain, coal will probably be found in large quantities and in veins excellently adapted for

the economic extraction of coal. Pine Ridge is a long anticlinal fold exposing the lower cretaceous rocks towards Salt Creek, and in the districts between Salt Creek and the South Fork of Powder River. Due west to southwest the dip changes to the same direction and the coal measures of the Rattlesnake coal field come in. Along Pine Ridge I have been informed that coal occurs along the west side in one locality, namely on the head of Sherwood creek, but as a rule it is found chiefly on the east side.

Near the northern terminus of Pine Ridge and about twelve miles south of the Powder River crossing, there is an out crop of coal which shows very well for a prospect but which is not sufficiently developed to show the exact thickness of the vein. The store-keeper at Powder River, who owns a claim on the cropping of this vein took me to it and showed it to me. There is a large cropping of coal and slate which runs along the base of the ridge, here in a direction nearly east and west, which may be traced for many hundred feet very easily and then it is gradually covered up with the soil. A gulch cuts the croppings at one point and with the small amount of work that has been done upon it partially exposes the vein. The top rock is a yellowish sandstone which overlies the slates which forms the top of the vein. The vein itself is very thick and the bottom is not exposed. The top shows just two feet of clean coal and then about one foot of slate, coal again appearing beneath the latter. This lower seam is seen to be over three feet in thickness and how much thicker could not determined but there can scarcely be a doubt but that it is plenty thick enough to work. This coal at the croppings dips to the north at an angle of from 22° to 25° with a strike of east and west. From the nature of the country however, it will greatly decrease in dip within a few hundred feet of the croppings. This coal is shiney and black and has a low percentage of ash (under 5 per cent.) and seems to be very similar in all respects to the Deer Creek coal. Above these croppings and further up on the hill other small coal areas, far too small to work, are found and with it but always occurring in the sandstones there is much carbonate of iron which I do not regard as being of great economic value. Continuing northward over the coal field we enter the great stretch of agricultural land for which Johnson county is celebrated. This country and the belt on the west, parallel to it, is all underlaid by coal, and is only divided by the topography of the country into two such belts.

From Crazy Woman Creek to the Montana line there is the most beautiful strip of agricultural land I have ever seen. The

Big Horn Mountains from the head of Crazy Woman to Buffalo run nearly due north, and from the latter point somewhat west of north, out of the Territory. The mountain system presents a first steep slope which takes its contour from the great uplift which has formed it. The upper part of this slope is composed of the Palæozoic sandstones and limestones, and the younger rocks come in successively to the Laramie Group, which closely approaches the foot of the mountains. On the mountain side the rocks dip steeply eastward, but this dip rapidly decreases, and the Laramie rocks are almost flat. The surface of the country out from the base of the mountains is gently rolling near the mountains, and consists for the most part of flat, low hills, with broad, flat valleys between them. Further to the east the hills become more abrupt and the valleys narrower, and the country runs gradually into hilly country, excellent for grazing purposes but too rough for agricultural purposes in most places. This level belt of country next the mountains and the hilly country further east are the two belts referred to. They extend from Crazy Woman Creek to the Montana line—a distance of over 70 miles—one of them smooth or gently rolling, the other rough and hilly. At intervals of from five to fifteen miles both of these belts are intersected by large mountain streams which are often formed by a number of smaller streams uniting a short distance away from the mountains. These larger streams are Crazy Woman, Clear Creek, Piney, Big Goose, Little Goose, Wolf Creek and Tongue River. With these there are also a large number of smaller streams, like Prairie Dog, Soldier, and Five Mile Creeks. All these streams hold an abundance of water and, the mountains holding the snow, they are the highest when most wanted—namely, in June and July. In the fall, even, they must contain much water, and there is no doubt that the streams afford far more water than is required for irrigating purposes. The first strip of country is peculiarly adapted to irrigating, from the fact that the higher lands run out in long, slowly descending ridges from the mountains, and renders it possible to cover almost all of the belt with water. As a consequence there is a large farming community, and all the vegetables and cereals of the corresponding latitude in the East—New York, for instance—are raised in profusion. Over this agricultural portion of the Territory the soil is very deep, and though many coal croppings are known they are frequently covered up, and it is only when we reach the steeper and barren hills further to the east that the coal seems to be outcropping almost everywhere.

Immediately about Buffalo coal is abundant, and it is mined for use in the town at several different points. The main outcrop on which this coal is obtained lies east and northeast from the town. Westman's mine lies between a mile and a mile and a half west of Buffalo. Here as elsewhere, the coal lies almost flat—so flat that no definite dip could be observed. A small creek, tributary to Clear Creek on the south, has cut away a broad, flat course with a bluff on the west side and here the coal is exposed. The improvements consist of a shaft 75 feet deep, a tunnel running into the bluff and an incline which slopes with an angle of 30° and consequently cuts down through the flat lying strata. The tunnel could not be entered on account of the water backed up in it, but appeared to develop coal of an inferior quality only. The shaft starts in the black slate which lies below the level of the tunnel. About 20 feet down and just above the water which fills it there is a streak of coal showing which is 3½ feet thick. The same streak is shown in the incline and is a much better coal than the tunnel streak. The incline passes down through slate and connects with the shaft along the above streak. It then passes down still further and cuts several smaller streaks and at the face where I was there was still slate and a streak of fire clay. It is reported that a very large streak of coal is developed in the shaft, and that it is very solid and clean. This streak is said to be fourteen feet in thickness, with only one break at a point eight feet from the top where there is a streak of fire clay about five inches in thickness. The incline, on which they were working last May is intended to cut the vein of coal last mentioned. All of these workings together with a few pits sunk in the immediate neighborhood develop the fact that all the coal at this point belongs to one very large coal bank and that the aggregate thickness of the coal and slate together is over 100 feet.

The Foote mine lies about two and a half miles north from Buffalo, across Rock Creek. It has been worked for several years, and during the year 1886-7 about 3,600 tons of coal were shipped from it. There is scarcely a question that this mine is upon the same coal bank with the Westman property.

Three seams of coal are known to exist. They are separated from each other by slate, and a little sandstone and fire clay. Two of these seams have been worked. The upper vein is about fifty feet above the gulch bottom. The hill side does not here slope very steeply, and the vein has been stripped at places and a few thousand tons of coal mined. At present this seam is on fire and is not being worked. The seam upon which the most work has been done and from which the most coal has been taken, outcrops along the bottom of the gulch already mentioned. A tunnel which quickly branches into a number of drifts has been made from the croppings. From the several drifts a number of rooms have been made which now all unite with each other, forming a large chamber with no pillars to support the roof. Notwithstanding the fact that this large space is but poorly timbered, it has not caved or even begun to creep, showing that the ground stands excellently.

The coal in both seams is about five feet thick. Every piece of it shows the original grain of wood. It breaks up in large rectangular blocks and frequently splits parallel to the grain. On exposure to the air it looses moisture and surface cracks appear abundantly, but it does not appear to break up into fine slack as coal with a like amount of moisture, but without the woody structure, usually does. The coal burns with a smoky flame and produces a good heat, and is highly satisfactory for all the purposes for which it is used. Although the moisture is high the ash is low, and this coal will unquestionably be used for steam making purposes when the demand for such fuel arises. Coal is also mined at one or two other points about Buffalo, but these localities were not visited.

To sum up, I think that all the ground to the east of Buffalo is underlaid with coal, and that there is coal beneath the town itself. These seams, as shown at various points, are from five to six feet or more in thickness. It is to be regretted that no analyses of these coals can be given at this time, but it was found impossible to do so on account of pressure of time.

Between Clear Creek and the Powder River many other veins of coal occur, some of them answering the description of the Buffalo coals and others showing but feeble signs of the woody structure so characteristic of the former. Such a vein outcrops on the eastern bank of Powder River above the mouth of Clear Creek. Although brighter looking than the coal near Buffalo, it is not sure that it is better for steam making or domestic use.

Besides the localities mentioned, coal is known to occur at almost innumerable points over eastern Johnson and northern Crook counties, and that there is a large number of separate coal banks over this area. The Laramie Group, which covers the entire area, is very thick. It lies flat, or nearly so, seldom dipping more than 5° to the southwest. The total thickness of the coal bearing rocks, as exposed from Buffalo to the mouth of Clear Creek, cannot be less than 1,500 feet, and as already described, this thickness of rock shows many workable seams of coal, besides almost innumerable seams of less than three feet in thickness. The numerous workable veins in conjunction with the great coal area of northeastern Wyoming, show that the coal in this portion of Wyoming is practically inexhaustible, even if the whole world were using it.

THE COAL FIELDS NORTH OF THE RATTLESNAKE MOUNTAINS.

This area, as already estimated, probably covers over 3,000 square miles. The coal occurs all along the southern edge of the belt outcropping plainly in many instances, exposed only by the black soil brought up by the prairie dogs in others, and again completely covered with a heavy drift or with Tertiary deposits. At different points along the outcrop it has been opened up by short inclines and coal has been taken out and used for fuel at ranches or where wells have been drilled for oil. Near Lander several claims have been taken up and mines opened upon them. In all about six openings have been made in this area, and from only two, have more than a hundred tons of coal been taken.

In going from the "Goose Egg" Ranch at the mouth of Poison Spider Creek to Rattlesnake Mountain, the coal bearing rocks are first struck at the western edge of T. 33 N. R. 83 W. They here stand almost vertically, the dip being to the southwest. Although no work has been done here the presence of the coal is plainly shown by the burrows of small animals. To the southeast where the old "Mormon Trail" crosses this outcrop the same conditions are present. Upon passing beyond this line of outcrop and going further west the Laramie rocks disappear beneath Tertiary deposits, and it is only at the western portion of T. 33 N., R. 86 W. that they again occupy the surface, now dipping northeast and showing one or two narrow streaks of coal. From this point the Laramie rocks may be traced westward all the way to the Little Popoagie River, with only a few breaks when Tertiary rocks cover up the croppings for short distances. At points where I have been on the northern side of this coal area the Tertiary rocks cover the croppings of the entire Mesozoic series of rocks and abut against the Carboniferous sandstones of the Owl Creek Mountains. Consequently it is only inferred that the coal bearing rock cease somewhere north of the channel of the Badwater.

The easternmost opening on the Rattlesnake coal area is on the line between sections 27 and 28, T. 33 N., R. 86 W. The tunnel, which runs S. 80° E. follows the strike of the vein. The dip, which is here about 20° is consequently N. 10° E. The coal is a lignite somewhat woody in structure and breaks into angular blocks which do not dry to slack, but on which weather cracks appear. The seam on which the tunnel is run is fully six feet in thickness of clear coal. Besides this there are several other seams of coal alternating with sandstones and shales. Starting from below the larger seam the following is the sequence of strata for the first 50 feet or more.

1. Coal—two feet.
2. Fire clay—four to five inches.
3. Coal—six feet.
4. Shale—four feet.
5. Coal—three feet and one-half.
6. Sandstone—twenty feet.
7. Shale and fire clay—five feet.
8. Coal—five feet.
9. Shale—two feet.
10. Sandstone—indefinite thickness.

The coal seam marked No. 8, resembles the larger in quality and appearance. The following is an analysis of a sample of this coal taken from the six foot vein:

Water	14.80
Volatile matter	35.70
Fixed carbon	43.28
Ash	6.22
	100.00

Below the above group of coal seams there are a number of smaller or impure seams, seldom or never exceeding one foot, or at most, two feet in thickness.

There are also coal seams outcropping in sections 14 and 25, T. 34 N., R. 88 W., and some work has been done upon the coal. The largest vein was opened to supply fuel for boilers used in drilling for oil at a point two miles or more to the south. The chief vein, which has sandstone both above and below it, is very similar to the coal last described. The seam shows twelve feet of solid coal. It has a dip of 30°, N. 25° E. The sandstone above it shows the same dip for a distance of at least two miles to the north. Below the large seam there is another less than a quarter of a mile distant which is about six feet thick, but which is less pure, and in which there is a streak of fire clay about three inches in thickness two feet from the top of the vein. Between these two large seams there are several very thin, impure seams of coal. A third seam was reported to me but was not visited. A sample given me gave the following analysis:

Water	13.57
Volatile matter	36.74
Fixed carbon	44.80
Ash	4.89
	100.00

I regret that the sample from the largest vein, which was to be forwarded for analysis, did not arrive, as I regard this coal as the best in the eastern portion of the field.

The Lander coal is obtained from the Laramie Beds, about seven miles east from the town, near the mouth of the Little Popoagie River. The coal occurs in a seam seven feet in thickness, and appears to be of a good quality. It is black and shiny and does not appear to slack. It burns finely and freely in a stove. The sample given me for analysis had some slate in it, and does not fairly represent the coal, which is actually low in ash. The analysis, however, shows, comparatively speaking, a low percentage of water and a high percentage of fixed carbon. The result was as follows:

Water	9.24
Volatile matter	33.83
Fixed carbon	44.69
Ash	12.24
	100.00

There can be but little doubt that a fair sample of this coal would yield less than five per cent of ash.

Such is a brief description of a few of the localities from which coal is taken for use as fuel. The analyses represent, as far as possible, average samples, and the localities described have been selected without regard to quality, but from every point which has been visited where coal is mined.

I wish to again emphasize the fact that in all these localities the coal has been developed merely because it is convenient to consumption, and not because it was, after careful search, independent of locality and regarding only quality, found to be the best of any occurring in Wyoming. As it is, the coal is in many cases of superior quality; but, notwithstanding, it is believed that far better coals will be found. In fact, such coals are now being reported. From veins near Rawlins, analyses show the samples to rival the Rock Springs coal, while samples from Crook county give superior results. Several analyses made some time after the body of this report was written show the nature of these coals. I give two analyses. The first is from the Dillon mine at Rawlins, the second from Crook county. The latter sample swells in the crucible and forms a light and hard coke.

	No. 1	No. 2
Water	7.47	5.25
Volatile matter	36.05	41.70
Fixed carbon	51.66	44.98
Ash	4.82	8.07
	100.00	100.00

So little indeed have the Wyoming coal fields been developed that it is difficult to describe them with any fairness. In the coming season it is expected that very important developments will be made along the line of the newly surveyed railroads.

CHAPTER II.

THE PETROLEUM FIELDS OF WYOMING.

In the report of the Territorial Geologist published early in 1886, Samuel Aughey, Ph. D., gives a large portion of his space to the oil fields and to a description of the springs. He there describes fully the oil phenomena observed at the springs, the nature and quality of the oil and the amount of it escaping, and in many cases the geology of the country about the springs. As a consequence it is deemed useless to repeat such descriptions in this report, and only new facts will be stated together with only the repititions necessary to give the reader a proper understanding of the subject.

HISTORICAL.

The occurrence of petroleum in Wyoming has been known for nearly a quarter of a century, and twenty years have elapsed since it was first collected, in a small way it is true, and sold on the market. According to Prof. Aughey, oil was first discovered in 1864 at a point on Little Wind River, evidently at the oil spring just below Fort Washakie. But it seems probable that the spring at Oil Mountain in Township 33 N. R., 82 W. was discovered several years before this, and as early as 1863, Seminole collected the oil and sold it for axle grease to the immigrants who passed over the old Mormon Trail which crosses the Poison Spider a few miles from the Spring. I do not know the date of discovery of the oil spring, near the mouth of Sulphur Creek in Uinta county, but in 1867 the oil was collected at this point and sold by Judge C. M. White who owned the

spring, and who had pits dug and the oil collected during the years 1867-8-9. In 1868 Mr. J. G. Fiero dug a shaft fifty feet in depth and collected the oil which seeped into it at the point now known as the Carter Oil Wells, located between nine and ten miles from the former springs and he collected oil for two years. The oil from both these places had a gravity of about 28° Baume, and were alike in changing from an olive to a black color on exposure to the air. But little "hardened oil" is to be seen on Sulphur Creek, however, while at the Carter Wells there is a bed of it, of small area but several feet in thickness. This oil was sold for lubricating purposes to the Union Pacific Railway, then in course of construction, to the contractors at work on the grade and to various coal mines including the Carbon mines. In all, over $5,000 worth was sold at prices ranging from forty cents to one dollar a gallon.

These early discoveries excited but little attention, however, and no active prospecting for oil was prosecuted systematically for years. But as the Territory was gradually opened up for settlement and became better known, many new oil springs were discovered and, at first regarded only as curiosities, remained unclaimed. At last, when the springs were recognized as indicators of reservoirs of oil stored in the rocks below, people began to take up the land around them and an active and intelligent search for other springs and oil indictions was inaugurated. As a result many new localities were found where there were springs and croppings of rock showing the presence of oil in them. Thousands of locations (I speak advisedly) have since been made on what was considered land apt to produce petroleum and now there are oil claims located in all or nearly all of the eight counties of the Territory. Owing to the fact that all or nearly all of these locations are located at great distances from the railroads very little actual development has been done in the way of boring for oil, but notwithstanding three wells, all sunk near one spring, have proved productive and, more than this, would be considered good flowing wells in any oil district. Besides these wells some sixteen or eighteen others have been started at other points, namely, seven in Uinta county, one on Powder River, four along the northern foothills of the Rattlesnake Mountains and a number in Crook county. Most of these wells, excepting the Crook county wells with which I am not familiar, have proved unproductive and for the excellent reason that they have never reached the main oil bearing stratum for which they were started when the drilling was begun. As a consequence they cannot be regarded as of value one way or the other on the question of the power of the rocks beneath to yield petroleum. During the present season three more wells have to my knowledge, been started, one at Twin Creek, near the Oregon Short Line, one at the head of South Fork of Powder River and the third about three and a half miles northwest of the Goose Egg Ranch on the Platte River. These wells will be duly described further on.

DISTRIBUTION OF THE OIL DISTRICTS.

I know of no oil springs, thus far, developed in either Albany, Laramie or Sweetwater counties, but in all the other counties of the Territory oil is known to exist. It is found in Uinta within ten to fifteen miles of Evanston, as already mentioned, and also at frequent springs on and about Twin Creek, on the Oregon Short Line. I have understood that there are oil indications in the Eocene rocks along the Union Pacific Railway in Sweetwater county. In Carbon county there are many springs along the base of the north side of the Rattlesnake Mountains, and in the extreme northern part of the county, on Salt Creek and Powder River. In Fremont county the most promising field lies between the Rattlesnake Mountains and the Big Wind River along a line drawn through the Shoshone Oil Wells, and through points about three miles east of Lander and Washakie. Promising oil prospects also occur along the base of the Rattlesnake Mountains, and adjoining the fields similarly situated in Carbon county. I also understand that there are oil springs, at present but little known, that lie on the Stinking Water, or near it. In Johnson county oil is known to occur on the Nowood River, opposite the mouth of Paint Rock Creek; and also, I believe, at a point along the southeastern foothills of the Big Horn Mountains. In Crook county oil occurs over quite a large area near the central portion of the county. The most prominent localities are on the Belle Fourche River, or near it, and thirty to thirty-five miles west of Sundance. There are also a number of springs at other points, both north and south of the above localities.

DESCRIPTION OF SOME OF THE OIL DISTRICTS—THE RATTLESNAKE DISTRICT.

I include under this title all the territory which contains the oil springs, and croppings of rock showing oil from Beaver Spring, in T. 33 N., R. 94 W. on the west, to Oil Mountain and the spring at its base in T. 33 N., R. 82 W. In other words, I include all that belt of ground extending from the Beaver oil springs to the North Platte River at the mouth of Poison Spider Creek. In doing this I separate from the great belt, described by Professor Aughey in his last report, the western portion in the vicinity of the Shoshone Wells and Fort Washakie. The reasons for such a division will appear later. In this description I shall avoid as much as possible a repetition of the matter contained in the report referred to, and those wishing a detailed description of each of the various springs are referred to that report.

GENERAL GEOLOGY OF THE RATTLESNAKE DISTRICT.

The thickness of most of the rocks of the various ages, as exposed on the north side of the Rattlesnake Range is given in the last chapter, together with their nature and more prominent characteristics. Notwithstanding, it is thought best to give a very short description of them in this chapter, as it will render the subject more intelligible.

The summit of the Rattlesnake Mountains is either granite or Tertiary rock. There are none of the intermediate strata, and on the south side of the range nothing but such granite and Tertiary rocks occur. It is only upon the north side of the range that the conformable strata from the Silurian to the top of the Cretaceous are found. The Silurian rocks lie directly upon the granite upon this side. They consist of coarse sandstones and do not aggregate more than 200 feet in thickness. Near the base they usually consist of a fine conglomerate strangely unaltered. The finer rock, higher up, is often altered to a hard, dense quartzite. In other cases it remains unchanged as a soft sandstone.

The limestone which lies upon the Silurian sandstones is pure and is from white to gray in color. Usually it is quite massive and heavily bedded. Frequently it shows fossils characteristic of the Lower Carboniferous to which age they are referred. A body of sandstone, also of the Carboniferous Age, overlies this limestone. This sandstone is likewise about 200 feet thick. It is a gray, coarse-grained rock usually very firm but with occasional strata of soft sandstone in it. Overlying the sandstone and completing the carboniferous series there is a thin stratum of limestone which contains numerous flint concretions. No fossils were found in this limestone. In thickness it varies between the limits of twenty-five and forty feet. The Triassic and Jurassic rocks which overlie the above described Palæozoic rocks have an aggregate thickness of about 1,500 feet. The Triassic rocks consist, almost entirely, of deep red, more or less coarse-grained sandstones with several strata, usually not more than twenty feet in thickness, of impure magnesian limestones. The Jurassic rocks are lighter in color, and although they contain a number of finely bedded deep red sandstones they consist, for the most part, of very pure white sandstones and of some impure limestone similar to that occurring in the Triassic. Gypsum in comparatively small deposits occurs in both formations, but chiefly near the top of the Triassic.

All of these rocks are well defined and exposed along the base of the Rattlesnake Mountains and outcrop, one after the other on the side of the range. They are cut by innumerable streams and gulches and are exposed from the top to the bottom. In this district however no oil springs or indications of oil have been found in them from the top of the Jurassic to the bottom of the Silurian. This statement is made after a careful personal inspection of the ground and after inquiry among all who are familiar with the district.

We now come to the Cretaceous series of rocks which extend from near the base of the Rattlesnake Mountains far to the north and follow it in general trend. It is from these rocks that all the oil spings of the district flow and every one of the various groups of the Cretaceous have oil springs or contain strata whose croppings are saturated with oil.

The Dakota Group forms the bottom of the Cretaceous series. It is by far the most promising rock, as far as yielding oil is concerned. Along Rattlesnake Mountain it is at least 500 feet thick, and consists of conglomerates and some coarse, porous sandstones. At the exposures in the vicinity of Oil Mountain the conglomerate is fine, and there is more sandstone in proportion, and the thickness of the entire group is less than 250 feet. The Benton Shales and other members of the Colorado Group lie upon the Dakota, and have a total thickness of nearly, or quite, 1,000 feet. They consist chiefly of shales, for the most part argillaceous shales; near the top they are more or less calcareous. As far as observed no limestones occur. Strata, of sandstone usually coarse grained, occur with these shales. They are twenty feet or more in thickness, but usually less. They are coarse grained and porous, and frequently contain more or less oil at the croppings.

The Fox Hill and Laramie Groups of the Cretaceous merge into one another, and I have been unable to locate the boundary between them. Suffice to say, that taken together they consist of strata of sandstones more or less argillaceous near the top, and and strata of sandstone and sandy shales near the bottom, and in aggregate thickness they are certainly over 6,000 feet. Both the Fox Hill and Laramie rocks show sandstone stained or saturated with oil. With these few remarks on the general character of the rocks the reader will be able to follow me. The concluding chapter deals more fully with this subject.

The most prominent mountain in the Rattlesnake Range, Garfield Peak, stands on the extreme northern side of the mountains, its summit being in section 4, T. 32. N., R. 87 W. The descent on the southern side is gradual, though rough and broken, while to the north it is very steep, often precipitous. From the northwest side of Garfield Peak a long, flat-topped mountain, called Rattlesnake Mountain, runs out with an almost level top to a point about eight miles distant, and in section 6, T. 33, R. 88, it descends a few hundred feet to a low, rolling divide, running northward to the Big Horn Mountains, and separating the waters of the Wind and Powder Rivers. East of Garfield Peak the mountains spread out into a broad plateau, so that it is difficult to distinguish the true axis of the range, but actually it runs in a southeasterly direction across the heads of Horse and Fish Creeks to the point where it is cut by the Platte River. To the west of Garfield Peak the divide between the Sweetwater and Wind River observes a more rugged character, and is marked by a series of rugged granite hills which rise above the Tertiary deposits which here lie even upon the top of the divide. This divide leaves the long, flat-topped Rattlesnake Mountain to the north, and passing near the centre of T. 33 N., R. 87 W., it extends in a generally western direction to the Wind River Mountains.

At the end of Rattlesnake Mountain at the N. W. corner, T. 33, R. 88, where the mountain has descended to a low divide the deep red Triassic strata outcrop with a strike almost due east and west and with a dip to the north of about 30°. Toward the east the strike changes rapidily and in less than half a mile it is nearly southeast. On following the outcrop, it is seen to take this general direction all the way along the sides of Rattlesnake Mountain and Garfield Peak, to the center of the north line of T. 32, R. 87 and from thence onward with only a short break, where it is covered up by Tertiary rocks, it maintains the same general courses across the head of Horse Creek, until it again finally disappears under the heavy Tertiary deposits near the southeast corner of T. 32, R. 86. From the end of Rattlesnake Mountain west, on the other hand, the strike of the Triassic strata changes to the southwest and follows the other side of the Mountain (the northwest side) until it comes near the main divide and here it swings with a broad bend to the west again and continues towards the Continental Divide. The rocks younger than the Triassic, including the whole of the Jurassic and the Cretaceous are found in the order of their succession out cropping, one after the other, as the hill is descended all dipping away from it, and all following the same general course of strike with the same variations as the Triassic sandstones already described. So also do the rocks older than the Triassic but these, instead of passing around the end of Rattlesnake mountain, pass over the end of it in a fold and from the end dip to the northeast and northwest, corresponding with the slope on the three sides of the mountain.

We now leave the Rattlesnake Mountains entirely and go to Oil Mountain and the country in the vicinity of the mouth of Poison Spider Creek. At the western end of Caspar Mountain opposite the mouth of the latter stream, the Triassic sandstone may be seen overlying the white Carboniferous rocks. This contact rapidly descends the mountain to the valley of the Platte River. On the north side a hill again rises, here an anticlinal fold running in a northwesterly direction (N. 60° W.) The top of this anticlinal is not level, but dips at an angle of 6° to 8° to the northwest. Hence, near the Platte, its crest is composed of red sandstones, a mile further northwest of Jurassic rock and then successively the Dakota conglomerates and Benton Shales form the crest. Upon the northeast side of this anticlinal the rocks all dip gently away from the crest into the valley of Caspar Creek while on the southwestern side they dip very abruptly (at an angle of from 65° to 70°) toward the valley of the Poison Spider. In the latter valley the dip decreases and the strata gradually approached a horizontal position; then take the reverse dip and assume the form of a somewhat similar anticlinal which forms an abrupt rough hill shaped in general outline like a loaf of bread. This hill, which is called Oil Mountain, is but a few miles long. It lies chiefly in the southeastern quarter of T. 33, R. 82. The top of that mountain, the crest of the antlicinal, exposes the Jurassic rocks with the fine conglomerate of the Dakota encircling it. Both to the northwest and southeast the crest of the anticlinal dips below a level line, and is then occupied by the Dakota, Colorado and Fox Hill successively. Several miles to the southeast the anticlinal seems to change to a fault which throws the Triassic on the southwest side into a bluff far above the Fox Hill on the opposite side of the fault line. I say what appears to be a fault because I have never been directly at the Triassic bluff in question and the parallax observed of rock which appears to be directly against red sandstone from one point of view and far from it from others leads to the suggestion that on close examination this may prove to be no fault but only

an anticlinal. This fault then, if fault it be, extends towards the mountain and is upon the same axis of uplift, but does not reach it as a fault but as an anticlinal fold.

From the Oil Mountain Anticlinal the rocks dip regularly to the southwest and in this direction we pass over the Benton Shales, Fox Hill and Laramie Cretaceous in their order of succession and finally come to the Tertiary rocks which cover them from view. Taking a due west course from Oil Mountain we pass over the same rocks, all dipping to the southwest till we reach the Tertiary rocks below the "F. L." Ranch and, continuing up the Poison Spider in the same westerly direction, we finally pass out of the flat Tertiary rocks and strike the Laramie sandstones now dipping to the northeast instead of the southwest as on the Oil Mountain side. Continuing across T. 33, R. 86, where we first strike the Laramie with its northwest dip we again come to the Fox Hill and Benton Cretaceous and to the Triassic red sandstone flanking Garfield Peak as already described.

From the southwestern corner of T. 34, R. 88 due north to the Owl Creek Mountains the section would be similar, namely: the Cretaceous rocks dipping to the north from the Rattlesnake, to the south from the Owl Creek Mountains, but here these rocks are much more heavily covered with Tertiary rocks and the structure is not so easily seen.

This description will develop the fact that the area north of the Rattlesnake Mountains is a great synclinal. From Beaver Creek (about T. 32, R. 96) to the point of Rattlesnake Mountain (T. 34, R. 88) this great synclinal runs nearly east and west, but at the latter point it veers towards the southwest and passes in the direction of the Platte River, which it probably crosses between the mouth of the Poison Spider and the mouth of the Sweetwater River. Also it will be seen that the uplift forming the Rattlesnake Mountains forms the southern side of this synclinical and as far as could be inferred, the Owl Creek Mountains, Pine Mountain and Oil Mountain form the northern and northwestern limits. I am aware that it is difficult to follow this long and technical description without a map but the map could not be prepared. The importance of the structure of the formation will become apparent when we arrive at the discussion of the depths required at various points for wells which are required to penetrate a given oil bearing stratum and this description, written especially for those directly interested in these important oil fields may be easily understood by referring to a map of the Territory and by re-reading if necessary.

The district will now be divided into five areas and a short description of each will be given. They will be named as follows: The Oil Mountain, Arago, Rattlesnake, Dutton and Beaver areas. Such a division is necessary on account of the size of the district under discussion and although it is somewhat arbitrary and artificial, yet each area will be found to have some pecularities.

THE OIL MOUNTAIN AREA.

The structure of Oil Mountain and vicinity has been already generally described. It will be remembered that on top of Oil Mountain there is a small area of Jurassic rocks surrounded by a ring of the Dakota conglomerates. The top of the anticlinal dips both to the northwest and southeast from this point, at an angle not exceeding 15°, and to the northwest not more than 5°. In this direction the gently dipping Dakota is gradually covered with a thin covering of the Benton Shales before the foot of the mountain is reached. Here in section 23, T. 33, R. 82, the oil spring which lies in this field is located. The surface of the ground consists of the soil arising from the decomposition of the Benton Shales, and the latter lie below it. At a depth of fifteen to twenty feet shafts sunk at this point have reached the Dakota, and the oil was found coming from the latter into the shaft. These shafts have now caved in, and the mud and dried oil has largely stopped the flow of oil. The oil that does rise is olive green in color, and has a gravity of 31½° to 32° Baume. (Annual Report of the Territorial Geologist, 1886, p. 71.) On exposure to the air for any length of time it changes to a black color. There is always a coating of oil half an inch thick over the water in one of the shafts, and the soil all about the shaft is saturated with oil.

That the oil comes from Dakota rock at this point there is no question, and according to the last report of the Territorial Geologist there are also other places where strata of Fox Hill sandstone are stained with oil. The Jura-Trias show no oil whatever, consequently in sinking there is a possibility of striking oil above the Dakota, but the latter certainly offers the best chances, and in drilling the estimates would have to be made for striking that rock. The following observations are made on the depth of the Dakota at various points in this area.

We have seen that the Dakota dips very steeply from the top of the Oil Mountain anticlinal to the southwest and northeast, and that from the anticlinal across the valley of the Poison Spider it dips steeply to the southwest. Descending these hills, on either side of the valley, we pass from the Dakota over the Colorado rocks to the bottom of the Fox Hill sandstones, which are the last rocks visible at the foot of either hill, the dip in both cases being from 65° to 75° from the horizontal. The valley bottom proper, which is nearly or quite six miles in width, is covered with a thick soil, and all the rocks occurring above the bottom of the Fox Hill are covered up. It is probable that the steep dip of the hill side rapidly flattens, however, and that the rock at the centre of the valley lies flat and does not run higher than the bottom of the Laramie. If this is the case, the depth from the surface at which the Dakota would be struck would be over 2,000 feet.

At the southeast end of Oil Mountain the top of the Oil Mountain Anticlinal passes southeast toward the mouth of the Platte Canon and along this line, and also along a similar line beyond the other end of the mountain, the Dakota lies nearer the surface than at any other points in the area. Thus, where the old Mormon Trail crosses this line about one mile from the base of the mountain, the depth of the Dakota beneath the surface cannot be more than 1,200 feet, and northwest of the mountain at a similar distance it would probably be less.

In my opinion the strips of ground along these two lines are the most favorably located of any in the Oil Mountain area. On the southwest side of Oil Mountain the rocks all dip steeply to the southwest, and the Dakota rapidly gains depth below the surface, and I am of the opinion that a well located one mile from the base of the mountain on this side would have to sink considerably over 3,000 feet. If, however, this portion is broken by a series of faults passing northwest and southeast the depth is over estimated, but there is little evidence, as yet, that any such condition exists. In the Poison Spider valley, from where the road crosses the creek below the "F. L." Ranch to within two miles of Aggers' Ranch, the surface is covered with a heavy deposit of Tertiary rock which overlies the Laramie, and here, in the centre of the great synclinal, the depth to the Dakota rocks beneath the surface must closely approach 8,000 feet.

THE ARAGO AREA.

This area includes all of Township 32 N., Range 86 W., and the sections adjoining it. Besides a number of croppings of oil saturated rock, there are two springs in sections seven and twenty-two respectively. In section seven the spring comes from the face of the Dakota reef near the western side of the section, and a shaft sunk back of the reef cuts a stratum of sandstone from which the oil—very thick and black, and so heavy that it sinks in water—gradually oozes. This oil is so thick that it will not pour. In section 22 the oil is thinner, and much resembles the Rattlesnake oils. The output, however, is smaller, and the oil does not collect about the spring, so that a sample could not be collected. The oil from both springs is black and has a sweetish taste. Besides these two springs there are a numoer of places where the Dakota shows oil saturated rocks, and in one place there is a large amount of Tertiary rock which cover the Dakota, that contains much oil.

The Jurassic and Triassic rocks in this area pass through sections 18 and 25, and those lying between in T. 32 N., R. 86 W. The Dakota follows a belt one-quarter of a mile or less in width, and outcrops in sections 7, 8, 16, 17, 18, 21, 22, 26, 27, 35 and 36, but in many places it is entirely covered with Tertiary rocks.

At the spring in section 26 the Tertiary covers all rock younger than the Dakota except the Benton Shales, the latter outcropping for less than half a mile, and showing a dip of about 25°. But at the spring in section 7 there is no Tertiary to the northeast. The soil, however, covers it up completely most of the time, so that it is difficult to find the various Cretaceous rocks cropping until the coal veins are reached.

Two years ago the Colorado and Wyoming Land and Oil company started a well on section four, and the following data were given me as to the rocks passed through by Mr. George L. Aggers, of Douglas, who is interested in the property and manages the affairs of the company.

RECORD OF THE WELL AT THE HEAD OF POISON SPIDER.

Depth of Stratum.	Kind of Rock.	Thickness of Stratum.
0— 10 feet	Clay	10 feet
10— 15 "	Boulders	5 "
15—260 "	Slate	245 "
260—265 "	Sandstone	5 "
265—325 "	Slate	60 "
325—400 "	Sandstone	75 "
400—500 "	Slate	100 "
500—630 "	Sandstone	130 "
630—700 "	Slate	70 "
700—705 "	Sandstone	5 "
705-1130 "	Slate	425 "

At a depth of 1,130 feet work was stopped still in the slate which was not pierced. I was told by the same gentleman that the 130 foot sandstone first struck at a depth of 500 feet, carried much oil and that oil came up with tne water but that it was cased off without testing. Also it was judged, from the angle of shear with the layers in the small pieces of slate brought up

by the sand pump, that, at a depth of 1,000 feet and over, the rock lay almost horizontally.

There can be scarcely a question that the last 500 feet of the well is in rock belonging to the Colorado group and it is believed that if this well were carried down 500 feet further it would reach the top of the Dakota. From the drilling it is believed that the rock decreases in dip between the oil spring and the well and that a well sunk within a mile and a half of the outcrop of the Dakota would reach that rock at a depth of less than 2,000 feet.

THE RATTLESNAKE AREA.

In this area all the numerous oil springs occurring along the Rattlesnake Mountain at the heads of Caspar Creek and the South Fork of Powder River are included. The Silurian rocks outcrop at or near the top of the mountain and the Dakota, near the base, with the rest of the Cretaceous rocks extend far to the north. In consequence of the varying hardness of the various strata and their parallelism to the axis of the mountain, the topography of the mountain slope is peculiar. The hard strata withstand the erosive agencies and protect the softer strata under them while the softer strata where unprotected are more rapidly worn away. As a result the lower portion of Rattlesnake Mountain consists of a series of alternate reefs and troughs and in climbing up it from along any line not followed by a stream you pass successively up a series of long steep hills and down a series of hills shorter and almost precipitous. The bottom of the Fox Hill, the top of Benton Shales, and the Dakota all form these reefs. In the Jura-Trias series there are a number of them, the latter being usually capped by the impure strata of magnesian limestone. In five or six places the small streams forming the Caspar and Powder cut almost straight down through these reefs, in channels with steep high sides. The majority of the oil springs came from the Dakota rocks along the channels thus cut through them or near the streams from the tops of the Dakota in the troughs that have been scored out of the soft shales that formerly overlaid them. The more important of these springs, which generally occur in groups of from three to more than half a dozen, come from the Dakota on Graff, Wallace, Rogers and Lovett Creeks. Besides the present active springs there are also many other points where the Dakota shows much oil saturated rock and quantities of "hardened" oil. There are two other springs flowing small quantities of oil from the bottom of the Fox Hills and the Colorado rocks. The Fox Hill and the bottom of the Laramie all show oil indications in many places in the shape of sandstone impregnated with oil.

The Wallace, Graff and Rogers Creek springs lie respectively in Sections 29, 19 and 20, and 18, in T. 33 N., R. 87 W. The two Fox Hill springs lie in Sections 33 and 34 of the same Township, and the many other croppings of oil rock I have not carefully located.

From this description it will be seen that the whole area from the Arago spring to Township 34, R. 88, abounds in springs and other oil indications. There now remains to be discussed the question of which are the most important of these oil bearing strata, and at what rate do they gain depth along the dip to the northeast? The former question is easy to answer. There can be no doubt but that the Dakota rocks offer far the greatest promise as oil producers, and that the bottom stratum of the Fox Hill offers the next. It is by no means improbable, also, that various irregular strata both in the Benton shales and even in the bottom of the Laramie, will prove capable of yielding oil in considerable quantity.

The second question is much more difficult to answer. The ground northeast of the Dakota in the basin occupied by the rest of the Lower and a part of the Upper Cretaceous is largely covered with glacial drift, often to very considerable depth, and as northwest and southeast they are covered with Tertiary rock it is hard to obtain data. One of three conditions may exist: 1st. The whole Cretaceous series may retain a dip of 25° or more all the way across the basin. 2d. The rocks in the basin may be broken by a series of faults which throw up the rocks on the northeast side relatively to the southwest side, and at the same time the same general dip may be retained. 3d. The dip may decrease out in the basin for a mile or more, and then again increase when the coal measures are reached, as it seems to do in the case of the Cretaceous strata at Arago. If the first of these suppositions be correct, the thickness of the Cretaceous from the bottom to the first coal veins will be over 7,500 feet, and with the Laramie that overlies the coal the entire Cretaceous would have a thickness of nearly or quite 13,000 feet, of which the Fox Hill and Laramie would aggregate about 11,500—a thickness for these rocks unprecedented in the Territory. The second supposition is scarcely plausible, for there is absolutely no evidence of it yet shown. The third supposition requires a longer discussion. The general dip of the Triassic rocks is from 28° to 34° northeast, with maxima and minima above and below. The Dakota dips at about the same angle, and the Benton seems to have a dip a few degrees less. The bottom of the

Fox Hill, which is often exposed, has a dip varying from 20° to 30° to the northeast, and in Township 33, R. 87, it averages between 22° and 25°. This shows on the whole a considerable decrease in dip on going northeast, but wherever croppings were found above the drift still further out, it was fully as great as this, and at the coal veins the dip is from 30° to 34°. Notwithstanding this, the few wells that have been drilled here seem to indicate a decrease in depth. Two wells were put down, 700 and 900 feet respectively, by the Central Association of Wyoming and then abandoned. These struck and passed through the bottom strata of the Fox Hill some 200 feet sooner than the dip of those rocks call for. Both wells are sunk down in the shales below, and would have penetrated the Dakota in less than 1,000 feet more. They were abandoned several years ago, however, and no further work has been done upon them. They both struck sandstones which yielded some oil, but no attempt was made to case off the water or see how much there was. I was unable to obtain figures of the amount of oil they yielded. The third and only other well that has been put down at Rattlesnake Mountain was started by the Northwestern Oil Company in September, 1887. It was started at a point at which it was estimated that the bottom of the Fox Hills would be reached at 1,000 feet, and in a letter recently received from Mr. Geo. L. Aggers, the manager, I am told that he has struck this horizon, and that light oil is flowing out with the water. He proposed to case off this water and determine the amount of oil he has. The oil was struck at 480 feet, and the well was down to 510 feet when the letter was written (Nov. 25). If these sandstones struck in the three wells are the same that outcrop half a mile to the northeast, it is certainly true that the dip of the Cretaceous rocks decreases for a distance from the outcrop and then increases again toward the coal veins, and the evidence seems to be with this theory. More development is necessary before the question can be satisfactorily determined. Such development is very sure to come in the near future, for the district is now worthily attracting much attention, and many are investing in oil lands there. It seems justifiable to predict that the Dakota will be struck at a depth not exceeding 2,000 feet anywhere within less than a mile of the outcrop of that rock.

THE DUTTON AND BEAVER AREAS.

The Dutton area is drained by various tributaries of the Wind River including Deer and Muskrat Creeks. Both of these streams flow south at their sources but finally turn westward and flow into the Wind River independently at points less than forty-five miles below Lander and do not, as the maps indicate, flow into the Badwater. The oil claims of the Dutton area are located upon unsurveyed ground, chiefly in what would be T. 33, R. 89 and T. 33 R. 90 if surveyed. Much of this area is covered with shallow deposits of Tertiary rock. The oil occurs in most places in the Dakota conglomerates as oil saturated rock and some dried oil. North of the Benton Shale reefs there are certain mud springs that constantly give off bubbles of gas and shafts sunk about these show small quantities of a light oil which seeps into them through the soil. At another point a shaft ten feet deep and partially filled with water has been dug on the top of the Dakota and through the water there are large quantities of inflammable gases escaping which keep the water in a constant and active commotion. Many oil claims have been located here during the present season, but no active development in the way of boring has yet been started. I have not been able to study this field as carefully as I would wish and can give no estimates as to the position of the Dakota at various points north of its outcrop.

The Beaver area is also on unsurveyed ground but would be in T. 33, R. 94, if it were surveyed. I will not enter into a description of it here as it has been described in a former report and no new developments have been made since that report was written.

THE SHOSHONE OIL DISTRICT.

This district was included in a former report in one great field with the Rattlesnake district. It is here separated from the latter because the oil occurs in an entirely different rock, namely at or near the bottom of the Triassic, or the top of the Carboniferous formation. *In the Shoshone district no oil whatever occurs in the Cretaceous formation, whereas, in the Rattlesnake district no oil occurs in any other.*

GENERAL GEOLOGY OF THE SHOSHONE DISTRICT.

The rocks joining the base of the Wind River Mountains are the Carboniferous white or gray sandstones described in the concluding chapter. These rock all dip to the northeast and form the side of a synclinal which I name the Lander Synclinal. Passing from the white sandstones in the direction of the dip, the Triassic, Jurassic and Lower Cretaceous rocks are encountered. At the same time the dip decreases and about four miles from the first mentioned rocks, the strata lies horizontally. The dip then reverses and rapidly increases and forms the southwest side of the Shoshone Anticlinal. The axis of the Shoshone Anticlinal extends from the Rattlesnake Mountains northwest through a point about three miles east of Lander, and one and a half miles east of Fort Washakie. From the latter point I understand, it may be easily traced as far as the Big Wind River. Erosion has worn away all the Cretaceous formation and exposed at least the Jurassic, generally, I think always, the Triassic sandstones all the way along the top of the anticlinal and, where the streams have cut through it, the upper half of the Triassic is scored away but at no point are any rocks lower than the middle of the Triassic exposed. Toward the south end the top of the Shoshone Anticlinal is very narrow, but further north, towards Fort Washakie it has a broad flat top on which the strata lie nearly or quite flat for a width of nearly or quite a mile.

On the southwest side of the anticlinal the rocks all dip very steeply, often being nearly vertical and then they almost as rapidly flatten out. No rocks higher than the very bottom of the Laramie occur in the Lander Synclinal. On the northeast side the dip is much more gradual and seldom exceeds 15°. The various members of the Cretaceous appear in the order of their sequence and finally the Laramie in great strength. The latter is continuous with the coal measures of the Rattlesnake region. All of the various streams coming from the Wind River Mountains, including Beaver, Twin Creek, the Little and Big Popoagie and Little Wind River cut across the anticlinal. Twin Creek coming from towards South Pass cuts through it once, and turning again cuts back almost through it and then cutting its way down along the axis of the uplift it runs in a canon through the Triassic to where it enters the Little Popoagie. The Little Popoagie coming from the mountains from the southwest strikes the anticlinal and cuts into it to the mouth of Twin Creek and then flowing west of north it also follows the axis of uplift for two or three miles and then bearing northward it passes through the northeastern side and enters the Big Popoagie. Although all of these streams cut the anticlinal, there are only oil springs at one point south of the reservation, namely on the Little Popoagie opposite the mouth of Twin Creek. This location is known as the Shoshone Basin, or better the Shoshone Oil Wells. The oil springs have already been described in the last report of the Territorial Geologist and it only need be said that the soil of the Little Popoagie bottom, here only a few hundred yards wide, and walled in with red sandstone bluffs, is practically underlaid by oil and that on sinking down over an area of several acres, oil in large quantity seeps in as soon as the water level of the Little Popoagie is reached. Three wells have been put down upon this small bottom. They are about a thousand feet apart and form, approximately the apexes of an equilateral triangle. All three of these wells struck oil and yield a large flow. They are kept plugged because the oil would foul the river and also because oil escaping is oil wasted. One of the wells was turned on in my presence. A less active one was selected as there is some danger of blowing out the packing in the largest well on account of the great gas pressure. An inch pipe bent into the shape of an L was attached to the valve at the top of the casing and the oil was turned on slowly. It spurted out in a stream which flew to pieces owing to escaping gases and only touched the ground some thirty feet away. A fifty gallon iron barrel was then filled in less than six minutes. Of course this great pressure does not last when the well is turned loose, but the gas escaping when the pressure is relieved throws out all the oil in the casing with great force and then a steady flow begins. At the well across the river which flows the most oil, this pressure is so great that the oil is thrown over seventy-five feet into the air and the derrick at this well, which is sixty-eight feet high, is covered from top to bottom with stains of oil thrown over it in this way.

These three wells are all of different depths, the deepest being over 700 feet, and the shallowest only between 300 and 400 feet, yet they all seem to start at nearly the same stratum in the red sandstones. The deepest well is the largest, and it seems not improbable that if the other two were carried down to the same depth, they would be equally as large. The capacity of the three wells for producing oil is variously estimated, and I believe some of the owners estimate the aggregate flow at over 1,000 barrels per day. My opinion, based entirely upon what was told me by those who have every reason to know and in whom I place the greatest confidence, is that the three wells will certainly flow 600 barrels or over at a minimum.

It may be imagined that it is not difficult to collect samples of oil from the Shoshone Wells. Oil continually escapes outside the casing and through the packing, and up through the casing, and there are hundreds of barrels of oil thus wasted collected in sloughs which once formed the river channel, and which are now dammed up at either end to store the oil and prevent it from fouling the water

The Shoshone oil is very fluid and the gas in it has a pungent smell. It is black in color, even when it comes fresh from the well. The fresh oil has a gravity of 23½° Baume, or nearly 4° lighter than the oil tested by Professor Aughey and taken from the spring. This fact is significant, for it shows that we may look for lighter oils than the springs show in wells drilled in the Rattlesnake and other districts.

I understand that there are a number of oil springs along the Shoshone Anticlinal on the Indian Reservation, but I have seen but one of these. This spring, often miscalled the "Tar Spring," lies in a great flat on the north side of the Little Wind River. The oil spreads out from the spring in an oval some two hundred yards or more in circumference. The spring has gradually built itself up till the point where it is located is two feet or more above the general level of the flat. The material is the dried oil so common about the oil springs. The oil slowly seeps to the surface with small quantities of tepid water, and suggests that the source of the heat from which the great hot spring on the south side of the river is derived also affects the waters of the oil spring. I could collect no sample of oil from the Washakie spring because there were no pools in which it gathered, and it consequently spread out in thin layers. I do not regard it as being a remarkably heavy oil, though a lubricating oil it certainly is.

The depth at which the oil rock from which the Washakie Spring comes is not over 1,000 feet, and probably less. The strata lie perfectly level, and there is here almost an ideal position for a well. I mean by this that in sinking, the drill would pass straight through the strata and would not cut them at an angle. In fact, anywhere along the axis of the Shoshone Anticlinal, as far as it has been traced, seems to me to be an excellent place for drilling for oil, and at every point along this axis the strata in which the oil occurs at the Shoshone wells will be struck at not exceeding 2,000, and in many places not over 1,000 feet. To both the northeast and southwest of the axis the depth will be greater, and in the bottom of the Lander Synclinal from the Little Popoagie the depth cannot be much less than 4,000 feet, and may be even greater.

THE NOWOOD OIL SPRING.

It was my intention to give with this description a general description of the geology of the country drained by the Nowood River. But as my trip was made in October and storms were threatening, I had to hurry through and was unable to go off the line of the main road. In consequence I defer such a description and will only describe the country immediately about the spring.

At Hyatt's store on Paint Rock, the main county road strikes Paint Rock Creek at its junction with the Medicine Lodge. The road then follows Paint Rock in its southwesterly course to the Nowood. The Triassic outcrops well up on the sides of the mountains and dips down with the mountain slope to the southwest. At Hyatt's store the rock is probably Fox Hill and lies flat, this being the bottom of a synclinal. Going down the stream the hills on the southern side give an excellent natural section, and show that the strata between Hyatt's store and the Nowood are bent into a series of anticlinals and synclinals. There are two such anticlinals in this distance, and the red sandstones are exposed on the top of each, while in the synclinals the Cretaceous series as high as the Fox Hill appear. The Nowood, here a very large stream, follows the bottom of a third synclinal and flows over Fox Hill rocks—and beyond the river a third anticlinal, here only exposing the Benton shales, lies parallel with those already described. The Triassic rocks need no especial mention, as they are much the same here as elsewhere. The Dakota rocks are very thin and contain no conglomerates. They appear to consist of a single stratum of coarse soft sandstone not more than 60 feet thick. The Colorado Group consists generally of soft, dark blue, argillaceous shales which are very heavy, and these contain a number of strata of coarse sandstone of all sizes up to strata twenty-five feet in thickness. The amount of vegetable matter in the group from top to bottom is very great, and there appears to be thin seams of coal in it in some places.

The most prominent oil escape occurs at the center of Section 23, T. 49 N., R. 91 W., in a gulch which cuts the side of the anticlinal mentioned. The oil escapes for over a hundred yards along the bottom of this gulch. It saturates the soil and appears on the surface of the little water escaping. It does not appear that the stratum in which the oil is stored outcrops, but rather as if the oil seeped up along some joint or fracture from a limited distance below. The strata of sandstone in the Benton Shales, of which there are many, do not show oil.

Two pits have been dug into which oil and water slowly collect. If both pits were freshly cleaned out the oil would probably gather at the rate of two or three quarts in twenty-four hours. Oil is also shown in several other gulches along this anticlinical, but not so prominently.

There can scarcely be a doubt that the oil comes from some Cretaceous stratum in the lower half of the Benton Shales, or perhaps from the Dakota. In this locality the latter group of rocks is not over 60 feet in thickness, and is a coarse, porous sandstone well adapted for an oil reservoir. It is a somewhat curious fact that in all the Cretaceous croppings on the other anticlinals

toward the mountains no oil indications have been revealed.

The Nowood oil is light green in color by reflected light and a sherry red by transmitted light. It is but slightly viscous and pours like milk. Its gravity as taken by myself is 31½° Baume. The following is the result of a fractional distillation of a sample of this oil by Walter H. Kent, Ph. D., of Brooklyn, N. Y., Chemist of the Department of Health:

	per cent.	specific gravity.	Baume.	Temp.
Gasoline	2.05	.7967	46.7	(26°–100°)
Naptha	3.02	.8109	43.5	(100°–130°)
Benzine	3.89	.8189	41.8	(130°–160°)
Kerosene	28.47	.8461	30.1	(160°–210°)
Mineral sperm oil	42.97	.8439	36.6	(210°–260°)

Specific gravity 29.2° Baume=0.8822.

In concluding I would say that the chances for obtaining producing wells seems to me to be good, but the present distance from transportation is a difficulty which time and progress only can overcome.

UNITA COUNTY OIL SPRINGS.

The oil on Sulphur Creek and at "Carter's Oil Wells," all comes from the Upper Cretaceous. On Sulphur Creek there is at present but little showing of oil because the pits sunk in the gulch bottom in early days have given an escape to the oil along with the water which runs through the gravel in the bed of the gulch.

About two miles south of White's Hollow there is a small spring coming from a stratum of sandstone. The oil which seeps out is, after exposure to the air, black in color. It has a sweetish taste and much resembles the oil of Rattlesnake District. Adjacent to this oil escape there is a stratum of shale, gray-blue in color, soft and but poorly bedded, which very commonly occurs in the Laramie. This and other facts in connection with Laramie fossils occurring on one side and a large vein of coal on the other cause me to place the rock in the Laramie group. Returning again to White's Hollow the rock from which the oil comes is a sandstone which has a trend of north and south (nearly) and a dip of from 75° to 80°. Consequently, although the two wells at this point have been started within a few hundred feet of the sandstone croppings, they have never reached it and will have to be sunk many hundred feet to do so. The first of these wells was sunk in 1869 and is 250 feet deep, the second sunk in 1884 reached a depth of 484 feet. Both wells stopped in the light blue shale overlying the sandstone, probably the same shale that is exposed at the spring to the south.

At Carter's wells, located across the Aspen divide, between Bear and Green Rivers, I think but am not sure that the rock from which the oil comes is the Laramie. The main oil spring had much hardened oil about it, but no oil was coming from it, nor has there been an escape since 1868, when a shaft sunk near it drained it. The sandstones here dip 35° to 40° to the East. In 1868 a tunnel was run into the hill about 200 yards from the oil spring to strike a vein of coal. At a distance of 240 feet it struck the coal and oil at about the same time, and Mr. J. G. Fiero, who ran the tunnel and owned the ground, tells me that he obtained from eight to ten gallons of oil a day from it through a period of several months. East of the oil spring and from 150 to 200 yards up the gulch the strata are almost vertical. The latter rock is unquestionably Benton Shales. A tunnel, run I understand with the hope of striking coal, shows this shale and shows it to be like the normal Benton Shale.* If the rock from which the oil comes is Laramie, there must be a fault between the spring and the borings which have been drilled in the almost vertically dipping shales.

I have been unable to visit the important oil fields near Twin Creek on the Oregon Short Line in Uinta County. Mr. C. D. Clark of Evanston, tells me that there are, in all, some fifteen oil springs found in this region and that the oil is a lubricating oil which has been used, as collected, on engines of Union and Kansas Pacific Railroads with satisfaction. The following information was obtained from Mr. D. V. Bell, who is only familiar with one point in the district.

The Twin Creek Land and Oil Company let a contract for a well in 1886. This well caved in, the ground being soft, and a new one was started the present season and has been drilled to a depth of 185 feet. The rock for the first 129 feet was very soft and resembled a light colored, hardened mud. At 129 feet very hard rock was penetrated and pierced at 131 feet. From the latter point to 165 feet the former soft rock was passed through. From 165 to 175 feet a hard sandstone was encountered which gave off so much gas that when ignited it burnt in a flame from eight to ten feet high. The last ten feet was in soft rock again and yielded much water and oil mixed with it. The water caused the clay to run and work was stopped temporarily. It was estimated that fully one barrel of oil per 24 hours came up with this water. Another well situated about one hundred feet trom the

*Through the kindness of Mr. F. W. Stanton and Mr. R. C. Hills, of Denver, to whom I subjected fossils found in this and other localities, I find that the fossils found in the Blue Shales are chiefly Cardium pauperculum (?) Meek.

last is said to have produced twenty barrels per day,, but it has since clogged up with the soft clay. An oil spring is very near these two wells and flows fully one gallon per day. It is black in color and thin, and, my informant tells me, it much resembles the oil of Powder River, near Willow Creek. It is probable that the oil here comes from the Eocene Tertiary.

CROOK COUNTY AND OTHER OIL DISTRICTS.

Although I have visited both the springs on Salt Creek and on Powder River in northern Carbon County, there has been no work done on them recently and there is little for me to say regarding them. I believe, however, that the oil, in both cases, comes from the Dakota, and this rock is the reservoir for the oil and that it is the rock in which it may be expected to be found. In Crook County, Mr. Tom Hooper informs me, some activity has been displayed in the oil fields and that several wells have been drilled. The Wyoming Standard Oil Company have a well drilled 300 feet and are pumping oil at the rate of 5 barrels per day. The Great Northwestern Company also are drilling another well but have not yet reached the oil bearing stratum. The oil pumped by the former company and that collected from various springs is transported to the mining towns of the Black Hills and commands a ready sale as a lubricating oil at a price of $28 per barrel. At over a dozen springs the oil is regularly collected, and it is reported that some of these springs yield as much as twenty gallons of oil in twenty-four hours.

CONCLUSIONS.

Nearly all of the oil districts of Wyoming at present known have been described, where they have been visited by the writer, mentioned where he has thus far been unable to visit them. In conclusion there need be made only a few remarks, equally applying to all the oil fields.

It will be seen that as far as the writer has been able to determine, nineteen wells have been drilled for oil in Wyoming up to the present date. Of these, five produce from five to several hundred barrels in twenty-four hours. (*) Four are in the course of construction, but have not yet reached the Dakota rocks. (†) Four have started below the level of the rocks that are known to contain oil in the vicinity. (‡) And the remaining six have been

(*) These wells are Shoshone wells, Fremont County, (3), the Wyoming Standard, Crook County (1). One of the Twin Creek wells, included because it produced more than five barrels when first struck. It is now choked up and the casing is full of stiff clay.

(†) Rattlesnake District at Oil Mt., (1), at head of Powder River, (1), Crook County, Great Northwestern, (1), Uinta County, Twin Creek, (1).

(‡) North Carbon County, near South Fork, Powder River, (1), Uinta County, "Carter's Oil Wells," (3).

(§) Uinta County, Sulphur Creek, (2), Rattlesnake, head of Powder River, (2), at Arago, (1), Crook County, Great Northwestern, (1).

started above the level of the chief oil bearing strata but have never reached it.

In other words all of the fourteen wells, that have been drilled or are drilling, that have not struck oil in quantity amounting to five barrels or more, have never reached what evidently is the chief oil bearing rock, either from the fact that they have never gone deep enough or that they have started too low down, and the oil bearing rock exposed in the vicinity is not beneath them.

Of course it is not to be supposed because the five productive wells are the only ones that have reached the chief oil bearing strata that all wells reaching such strata will prove productive but the fact remains that the showing is a fine one and should be generally made known.

BEST METHODS OF PROSPECTING FOR OILS.

Oil occurs in the pores of rocks whose mechanical structure is such that they can provide storage space. To this condition, which is extremely common, there must be added a position favorable to the reception of the oil, absence of overmastering forces that can prevent the storage, a source from which the oil is obtained after the storage rock is formed and finally a covering sufficient to prevent the entire escape of the oil from its reservoir. As a consequence there are many laws governing the occurrence of oils that depend upon the above conditions and although the strata in which oil occurs is generally easily determined and well known, the areas in these strata that actually contain oil in sufficient quantity for and under conditions favorable to production can scarcely ever be accurately defined and bounded. Even a partial understanding of such oil reservoirs is obtained only after much active prospecting and development.

In Wyoming the croppings of strata, the existence of springs and the few borings that have been made throw much light upon the chief oil horizons. But beyond showing this and also the presence of productive oil reservoirs, it does nothing more. And it seems certain that the only way to search for other such reservoirs and to thus develop the oil resources is to aim at striking all of the most promising oil bearing strata independent of the occurrence of oil springs wherever they manifest themselves throughout the Territory, at first attempting to strike them only at shallow depths and later as reservoirs are found to venture deeper. Certainly no producing areas can be located by any other means. Such prospecting carried on systematically would certainly result in the finding of large quantities of oil.

Attention has been called to the wells which have proved of so little service in the development of the oil fields, partially because the work has been done blindly and with but little regard to the position of the more important oil bearing strata and its depth below the surface at the point selected for drilling, or to the tools, casing etc. needed, according to the nature of the ground. It is to be hoped that in the future more attention will be given to these considerations, for far greater success will then accompany the enterprise. It is also suggested as a matter of extreme importance that a careful record should be kept at all wells of the nature of the strata pierced, and that typical samples of the drillings from such strata should be saved.

USE OF THE OILS.

The Wyoming oils thus far actually known are all more or less heavy or viscous oils. That is, such oils contain, as a rule, a high percentage of thick oils unsurpassable among all natural oils as a lubricants for machinery. But they also contain much illuminating oil, the Shoshone oil showing by analysis 47 per cent.

When the railroads come near the oil fields, as they will when development warrants it, Wyoming will become an active producer. The oil will then be refined. Besides the illuminating oil there will be a large amount of heavy oil remaining. This amount, if the Territory becomes a heavy producer, will far exceed the consumption of the market for lubricating oils, and consequently only a comparatively limited amount of such oils will be prepared. The remainder, consisting of very heavy oils—viscous, perhaps solid—will unquestionably find a market as a fuel. In fact, such products now find a market, and in places where manufactories have to import coal and pay high freights upon it such fuel would be more desirable than coal. Besides these articles the crude product would of course furnish the many ordinary by-products and the substances made from them.

CHAPTER III.

SODA DEPOSITS.

The term "soda" is here used to designate all of the sodium salts exclusive of common salt. There will also be included in this chapter mention of some very large deposits of magnesium sulphate, which in their mode of occurrence are similar to the soda deposits. Common salt is also known to exist in quantity, especially in Crook county, but no mention of it will be made.

It is now quite generally known within the Territory and is becoming known without, that Wyoming has, at various places within her borders, large and practically inexhaustible bodies of very pure soda. This soda is found as heavy deposits in the beds of lakes which vary from four to over two hundred acres in area, and which are always situated in basins that have no outlet.

It was at first generally supposed that the soda arose simply by the evaporation of surface waters that had drained through the soil into the lakes and in this way dissolved the sodium salts. For many reasons this supposition was doubted, and it is now proved to be incorrect. While it is true that the soda deposits occur in basins with no visible outlet, there are also a great number of such basins with lakes or ponds in them which contain only alkali waters, or when dry, but a thin crust of the alkalis or alkaline earths. The true soda deposits, on the other hand, though the basins in which they occur are not of abnormal area, always contain exceedingly large quantities of the salts peculiar to them, and these are pure and are not, as a rule, a mixture of sodium, magnesium and calcium salts which would be present if they were the result of the evaporation of surface waters. Mr. Arthur L. Stone, of Laramie City, has found that the "Union Pacific Lakes" near Laramie are fed by springs whose waters are highly charged with sodium sulphate. Finally at Rock Creek there are in one and the same basin some lakes containing pure sulphate of magnesium, others which contain with the latter also large quantities of sulphate of sodium, and still others which contain no deposits whatever. For these reasons it seems very certain that all of the large deposits of soda in Wyoming arise from the evaporation of the waters of springs which feed the lakes, and which are highly charged with soda.

The number of separate soda deposits, or rather, the number of separate basins containing such deposits is not, as far as known, very large. The ones to be described are those which are better known and about which reliable data could be collected. The difficulties of making personal investigations are very great as the lakes are covered with water during the Spring and Summer, and to see how extensive the deposits are and to gain other information, it is necessary to dig down or to bore with a suitable drilling machine.

THE UNION PACIFIC LAKES.

These lakes have not been visited by the writer, who has only seen the soda from them at the Laramie Chemical Works, because Mr. Stone, the chemist at these works, who is thoroughly familiar with the deposits and who has seen and noted all the developments made upon them, kindly consented to give the benefit of his analyses and observations. The following extract is from his letter:

"Replying to your letter of the 5th instant, concerning the Union Pacific Soda Lakes, I would say that the lakes are situated southwest of Laramie about thirteen miles. They are four in number, varying in size from four to forty acres, and usually (always, until within three years) are dry after the middle of August. The water which floods them in the Spring comes principally from the melting snow in the small basin which drains into the lakes. They are, however, fed by numerous springs, all of which, with two exceptions, send forth a strong solution of sulphate of sodium. This solution, evaporating under the influence of our dry, windy Summer, deposits the salt which it holds in clear crystals, having the composition indicated in the formula: $Na_2SO_4, 10H_2O$.

"Various soundings have been made into the deposits and measurements obtained, showing that the soda beds are, in some places, forty feet deep. Taking these measurements as a basis, calculations have been made which show the lakes to contain an aggregate of about fifty-two million tons.*

In speaking of the springs mention was made of two exceptions to the soda springs. These two are very remarkable inasmuch as they flow within a few feet of the soda and are of pure sweet water.

The soil surrounding the lakes, as shown by excavations made at various points near the lakes, is made up in the fifteen feet next to the surface, of 1st, a thin stratum of fine sandy gravel, 2nd, a stratum of hard clay which occasionally assumes a shaly appearance. This clay varies (to) from ten to twelve feet in thickness. Below the clay is found a coarse gravel.

The composition of the soda deposits found in these lakes is remarkably uniform, the average composition being shown by the following results made in our laboratory.

Sodium sulphate	44.5
Water	54.9
Insoluble matter	0.5
	99.9

The remaining 0.1 per cent is made of a mixture of Calcium and Magnesium salts. The insoluble matter is principally organic, but usually contains silica and alumina which have been blown upon the lakes. The water also varies in amount, but is seldom found less than 44 per cent.

*It is probable that there has been a mistake in this calculation which I have seen elsewhere. It is probable that the estimate was 52,000,000 cubic feet instead of 52,000,000 tons. (R.)

A black mud is found in the soda beds in layers of from one half inch to six inches in thickness. The composition of this mud we have never determined."

From the position of these soda deposits it is judged that the rocks forming the surface are probably Lower Cretaceous in age.

The following analyses from these deposits are taken from the "Mineral Resources of the United States."*

	(1)	(2)	(3)
Sulphate of soda	41.55	41.41	39.78
Water	54.98	54.79	59.66
Insoluble matter	.47	3.80	.56

From the same page the following analysis is obtained. It is probably of a sample of the "Black Mud" referred to by Mr. Stone.

Iron, lime, magnesia	22.33
Alumina, soda, hydrochloric and sulphuric acids	40.82
Silica	36.85
Organic matter	trace.

THE DOWNEY LAKES.

These lakes are three in number. They are located on Sections 15, 22 and 21, Township 13, N. Range 75 W. They are between eight and nine miles nearly due south of the Union Pacific Lakes, and are separated from the latter by the Big Laramie River. On the west there is a stream called Sandy Creek not more than one quarter of a mile distant. The divide between this creek and the lakes is very low—probably not over ten feet. The area of the claims, including the lakes, aggregate 320 acres, of which over one hundred acres are occupied by the soda deposits. The rock composing the major portion of the basin in which the lakes lie is Triassic Red sandstone.

The following is an extract written by the Hon. Stephen W. Downey to the Superintendent of the Tenth Census:

"The deposit whence the sample mentioned was taken covers an area of more than one hundred acres, being a solid bed of crystallized sulphate of soda about nine feet thick. The deposit is supplied from the bottom by springs, whose water holds the salts in solution. The water rising to the surface rapidly evaporates, and the salts with which it is impregnated readily crystallize into the form mentioned. Upon removing any of the material, the water rising from the bottom, fills the excavation made, and the salts crystallizing, replace in a few days, the material removed. Hence the deposit is practically inexhaustible, and it

*Calender year 1885, p. 551.

now contains about about 50,000,000 cubic feet of chemically pure crystallized sulphate of soda ready to be utilized."

These lakes have plank walks out on them, and pits have been sunk in them at the end of the walks. At the time of my visit there was from six to eight inches of water over the lakes, from which many crystals of pure sulphate of soda were rapidly separating. The pits at the center had many such crystals, often six to ten inches in length, and perfectly transparent. A number of tons of soda were piled on the shore of one of these lakes at the end of a board walk, and had evidently been taken from the pit at the other end. Samples of this soda were taken, but as yet they have not been analyzed. This soda, like that of the Union Pacific Lakes, is the sulphate, and has no admixture of the carbonate.

THE MORGAN LAKE.

The claims embracing this lake, for which an United States patent has been granted, cover an area of 220 acres. It was attempted to take the lake up in one claim of 160 acres, but this could not be done, as it left a large portion of it untaken. Although its exact limits have never been determined, it must contain at least 160 acres. The Morgan Lake lies in Township 28, N. Range 88 W., near the northern boundary and a few miles south of the Sweetwater River.

The pits sunk on the lake, which is dry after August, have never been deeper than twelve feet. In such pits the bottom of the soda has never been struck. Even at a distance of seventy-five feet from the shore the solid and pure soda is over twelve feet deep. The soda when first taken out is clear and transparent, but like all the other sodas quickly effloresces. It consists of a mixture of carbonate and sulphate of soda in varying proportions, and contains little else than these salts. The samples taken from a depth of twelve feet show more sulphate than samples taken near the surface. The soda of this lake is certainly very great in quantity. Taking the area of the deposit at only one hundred acres, and the thickness at but twelve feet, the contents of the deposit would be over 50,000,000 cubic feet, and it probably greatly exceeds that amount.

The sand common to the Sweetwater Valley is abundant at this lake, and it is reported by Pittsburg manufacturers to be good glass sand. Limestone and coal are within less than ten miles, and the Rattlesnake Oil District within less than fifty miles (by the road).

THE DUPONT LAKES.

These lakes, like most of the others, were covered with water at the time I visited them, and the samples I collected were of the crystals which had separated out along the shores of the lake. Much work has been done upon the lakes by the owners, and United States patents have been obtained. The following extract* embraces the information gathered by the United States Geological Survey from various sources:

"The soda deposits of Carbon county are situated in the Sweetwater Valley, near Independence Rock, and nearly fifty miles due north of Rawlins. These deposits contain both carbonate and sulphate of soda and are generally known as the "Dupont Lakes." They are four in number and vary from 6 to 2,000† acres in area and are held by United States patents in the name of L. Dupont. There are five claims known as:

	Acres.
The New York Soda Mine	160.
Philadelphia Soda Mine	80.
Omaha Soda Mine	20.
Wilmington Soda Mine	180.
Wilkes-Barre Soda Mine	20.

The Omaha Soda Mine includes twenty acres, of which, five are covered with carbonate and sulphate of soda mixed with a little chloride of sodium and sand blown in from the surrounding soil. Several bore holes were put down and show an average thickness of about six feet.

Amount of carbonate of soda contained in different samples:

No. 1, 3½ feet from surface, per cent	24.62.
No. 2, surface, per cent	41.55.
No. 3, surface, near shore, per cent	32.42.
No. 4, water, pounds per gallon	1⅛.

A fused sample showed 52.23 per cent of carbonate of soda. A fuller analysis of a sample taken from the surface showed:

Moisture	9.01.
Insoluble matter	2.61.
Sulphate of soda	25.75.
Chloride of sodium	2.13.
Carbonate of soda	30.62.
Bicarbonate of soda	30.09.
Total	100.21.

(*) Mineral Resources of the United States Calendar, year 1885; Washington 1886. David T. Day, Geologist in charge. Chapter on Glass Materials by Jos. D. Weeks.

(†) Probably a typographical error and 200 ocres is meant. The largest lake does not approximate 2,000 acres. As will be seen, this error is not repeated. (R.)

Another sample from near the surface contained 56.3 per cent of water.*

Chloride of sodium	0.65
Sulphate of soda	59.29
Carbonate of soda	27.60
Insoluble matter	1.20

The variations and the proportions of sulphate and carbonate of soda are shown by the following table, the samples having been dried:

Samples.	Chloride of sodium.	Sulphate of sodium.	Carbonate of sodium.
Five feet below the surface	0.970	64.05	15.60
Five feet below the surface	.32	65.08	16.70
Surface	.81	17.02	80.60

The Wilkes-Barre Claim is about one mile west of the Omaha and the soda is in solution. Samples of this solution showed by analysis:

	Carbonate of soda.
No. 1. Grains per gallon	3,728
No. 2. " " "	4,905

The Wilmington claim is located one quarter of a mile west of the Wilkes-Barre and covers 16 acres. The soda is here also in solution; its depth has never been determined. It has been sounded with a 40-foot rope without finding bottom in the center. A sample of the solution contained 2,343 grains per gallon. A sample which had crystallized out by cold, when dried, showed:

Chloride of sodium	1.83
Sulphate of soda	39.04
Carbonate of soda	59.00
Insoluble matter	9.23

The New York and Philadelphia claims are both upon one lake, which is solid and which is four miles west of the Wilmington. Two bore holes have been put down in this lake. One, at a distance of fifty feet from the shore, showed four feet of soda; the other at a distance of 230 feet from the shore showed fourteen feet of solid soda without touching bottom. Three samples taken from this lake showed as as follows:

	No. 1.		No 2.
	per cent.	per cent.	per cent.
Chloride of sodium	1.83	2.04	2.52
Sulphate of soda	71.37	44.74	72.40
Carbonate of soda	3.10	5.00	5.00
Insoluble matter	22.82	47.50	19.03

*It must be remembered that soda dries out rapidly and loses a larger percentage of its moisture when exposed to the air freely. When enclosed in a box or a cloth wrapping it loses water much more slowly. Such exposure probably accounts for the low percentage of water some of these samples show. (R.)

Fifteen miles from these soda deposits in the Seminoe Mountains good limestone occurs, containing 2 per cent. of magnesia. Near the limestone there is a good 8 foot vein of coal."

The Dupont Lakes all lie on the Tertiary rock of the Sweetwater Valley. These rocks, commonly soft whitish chalks or fine grained conglomerates, rest upon an irregular deposit of coarse conglomerate, made up of granite and diorite pebbles, and beneath the latter rock there is granite. In the valley about the lakes there are numerous granite hills rising far above the Tertiary rocks.

From the descriptions given it will be seen that two of the lakes have the soda altogether in solution, and in such a case it would have to be obtained by evaporating the water as common salt is obtained from the water of salt wells. In the New York and Philadelphia Lakes the soda would probably also have to be dissolved in water and treated in the same way.

THE GILL LAKES.

This group of lakes is situated in Section 26, Township 35 N. Range 78 West, and is six miles north of the Platte River at the old Fiddleback Ranch. I have passed by the latter point twice, but did not then know of the existence of the lakes. They are four in number, and are all located in one claim of 160 acres. Of this area between 80 and 90 acres are covered by the lakes. A number of pits have been sunk to a depth of twelve feet on these lakes, and from one of this depth a hole was bored four feet deeper. The soda has never been pierced. A sample of this soda given me shows it to be very clear and pure. When freshly broken it is clear, almost transparent. The outside rapidly loses water when exposed to the air. An analysis of this soda gave the following results:

Sodium sulphate	94.50
Magnesium sulphate	2.52
Sodium chloride	0.54
Water	1.61
Undetermined and loss	.83
	100.00

This sample had necessarily been freely exposed to the air for a long time. The Gill lakes are not only important from the fact that they have very large deposits of sulphate of soda, but also because they are now within seven miles of the railroad grade which passes up the Platte, just across from the Fiddleback Ranch.

I am indebted to Mr. E. S. N. Morgan and Mr. John D. Gill for information furnished regarding these deposits.

THE ROCK CREEK LAKES.

The large deposits of sulphate of magnesium (epsom salt) already mentioned, occur at this locality. The Rock Creek Lakes, which lie in a basin covering an area of twenty-five square miles or more, are situated ten miles from Rock Creek Station on the Union Pacific Railway. In going from the station to the lakes, you pass over the Lower Cretaceous and the Jurassic rocks. The basin area is occupied by the Triassic rocks. The lakes, some twenty-six in number, are scattered over the bottom of the basin and are all contained within a space of not over two square miles. In size they vary from not over a fraction of an acre to nearly or quite 100 acres. Many of the twenty-six lakes are of no importance, either on account of their small size or because they have no deposits in them. Only a few of the more important ones will be described.

According to the map before me, Brooklyn Lake is long and oval. It is about 3,000 feet in length and 1,500 feet wide. It has an area of about 100 acres. On the first visit to this lake it was covered with from six to eight inches of water which was underlaid by a soft crust of sulphate of magnesium. At that time the crust was from four to six inches deep. Beneath the crust of epsom salt there is a soft black mud, similar in appearance to the black mud of the soda deposits. It also has the same odor of sulphuretted hydrogen. On making an emulsion of it and adding hydrochloric acid the black color disappears. A hurried qualitative analysis of it showed it to be made up principally of gypsum and epsom salt. A pit sunk over a hundred feet from the shore showed no other deposit of the pure salt than the top crust but only about six feet of the black mud which gradually changed into the red clay common to the Triassic Formation.

At a second visit in December, 1887, this lake was dry and the crust of magnesium sulphate was then six or seven inches thick. The total amount of the pure sulphate on the surface of the lake would therefore exceed 2,000,000 cubic feet, and with that in the black mud there is certainly much more. The following is an analysis of the water taken from the Brooklyn Lake in the spring. It was made by Ladoux and Ricketts, of New York:

	Grains per gallon.
Magnesium sulphate	17552.55
(Magnesia)	5850.85
Calcium sulphate	4.61

(Lime)	1.96
Alumina and iron sesquioxide	14.92
Potassium and sodium chlorides	1124.65
(Potassa and soda)	596.51
Silica	31.56
Total mineral matter	18728.39

My analysis of the salt deposited in this lake—taken when the lake was nearly dry—shows much less common salt than the above analysis would seem to demand. The soda contents given in this and the following analyses are all obtained by calculation from the otherwise uncombined sulphuric acid, as I had no facilities for making a soda determination. The following is an analysis of the pure salt from the Brooklyn Lake:

Insoluble residue	0.11
Water	49.75
Sulphur trioxide	33.08
Magnesia	16.26
Sodium chloride	0.21
Sodium oxide	0.43
	99.84

The Philadelphia Lake has an area of about 40 acres and is very irregular in outline. Close to the shore the bottom is composed of black mud similar to that in the Brooklyn Lake. Further out there is a thin crust of magnesium sulphate over the mud. But in this lake the mud is found to rest upon a heavy deposit of solid salt. Two pits sunk out in the lake showed in one case four, in another six and one half feet of this salt. A third pit sunk near the shore showed less than one foot. These few pits do not afford sufficient data for an estimation of the size of the deposit, but they do develop the fact that it is a large one. The following analysis will show the composition of this salt. The insoluble residue in this and other analyses means the residue insoluble in hot water:

Insoluble residue	3.38
Water	48.90
Sulphur trioxide	31.33
Magnesia	15.62
Sodium chloride	0.44
Sodium oxide	0.07
	99.74

The Chicago claim contains several lakes, all rather small, the largest of which is the furthest away from the Philadelphia

Lake but not more than half a mile distant. This lake is about ten acres in area and is several times longer than it is broad. Numerous pits sunk in it develop the fact that it contains a deposit of pure salts from four to six feet in thickness. This salt as taken out is clear and on the side of the pits it has a deep blue color. As soon as the deposit is pierced water rapidly rises to the surface. On long exposure to the air, the salt rapidly effloresces and falls away leaving however, some hard crystals which do not lose their moisture so rapidly. The two following analyses from different specimens from the same lake show that the deposit consists of a mixture of the magnesium and sodium sulphates:

	No. 1.	No. 2.
Insoluble residue	0.16	tr.
Water	32.43	33.50
Sulphur trioxide	41.19	40.12
Magnesia	11.06	11.90
Sodium oxide	14.78	12.40
	99.62	97.92

Many other lakes varying in size between twenty and a quarter of an acre occur in this basin, but they either have not been prospected or they show no deposits. One sub-group of three lakes show not even the presence of the black mud, and the water in them is the ordinary alkali water common to all lakes found in enclosed basins.

USES OF SODIUM SALTS.

The deposits of the sulphate and of the mixture of the sulphate and carbonate of sodium in Wyoming, are of great interest and importance on account of the immense amounts in which they occur, their purity, and the fact that there is a large market for such material when facilities for placing it upon the market,—namely, cheap transportation, and the erection of manufactories for using the soda at home, and making products that will permit transportation to a large market—are available. Already there are important beginnings in the latter direction, and there can scarcely be a doubt that there will be henceforward a continuous and constantly growing demand for, and a consequent production of, these salts. All that has to be done to the Wyoming soda is to dig it out and dry it, and it is then the salt cake of commerce.

Salt cake is produced in the Eastern States at a few places where salt is cheap and sulphuric acid can be produced as a by-product. But the larger amount is imported from England where it is manufactured from common salt by treating it with sulphuric acid in a proper furnace and afterwards roasting it in other parts of the same furnace. The common salt used is almost invariably obtained by evaporating brine, and the latter substance should therefore cost as much as the dried soda at the deposit in Wyoming. The average price paid for salt cake in 1885 at the glass works throughout the United States was $16.95 per long ton,* and since it is imported for the most part, the glass works in Illinois and in the West generally, must have paid more than this by several dollars, probably over $20 per ton. When it is remembered that the Rock Springs coal is mined, the freight paid to Omaha, sold and retailed at $6.50 per ton, and that profits are made presumedly upon all these transactions, it certainly seems probable that a profit could be made by the railroads by shipping the salt cake of Laramie City to the Mississippi, a distance not much greater, and allowing it to be sold at prices which would yield a fair profit to the owners and yet compete with the eastern market. Whether the railroad can do this or not, will soon be seen, for Wyoming will have, in the near future, three separate roads well extended within her limits. These roads will pass by other soda deposits besides those of the Laramie Plains, namely the Sweetwater and Gill Lakes, and there will also arise a competition which will cause the roads to take every pound of freight they can haul with a profit.

The other sodium salts of commerce are made from common salt, mostly in England and Europe. In Wyoming an important beginning has been made in deriving these products from the natural sulphate. Until recent years the largest product, the carbonate of soda or soda ash of commerce, was obtained by treating the salt cake, obtained as described, with crushed limestone and coal slack in proper furnaces, and dissolving out the carbonate of soda produced with tepid water. Recently it has been produced by a new process, or rather by a recent adoption of a process nearly a half a century old called the Solvoy or ammonia process. The common salt, as a strong brine, is treated with carbonic acid gas and carbonate of ammonia, by which soda ash and chloride of ammonium is produced. In whatever way made it is chiefly imported into this country. In 1885, 167,000 long tons of soda ash were used in the United States, of which 60,050 long tons were used in glass making alone.† Caustic soda is made from the carbonate by a simple chemical process. In 1885, 35,000 tons of it were imported.

*Mineral resources of the United States, 1885, p. 546.

†Mineral Resources of the United States, 1885.

Altogether the total value of the sodium salts sold in the United States amounts to about $10,000,000 annually. It is extremely important that Wyoming should have a share in supplying this demand for sodium salts. So far, no regular shipments of salt cake have been made, but in two notable instances home manufactories have been started for using the natural sodas and making products that will stand the freight and compete with like products made elsewhere. Both of these enterprises have been started at Laramie City, the only point as yet where a track has actually been laid to the soda deposits. Of these two enterprises the first started was the Laramie Chemical Works. The object of these works is to make the various sodium products from the natural sodas, and already salt cake, soda ash and caustic soda are being made. The works have recently been doubled in capacity and are now working, it is understood, very successfully.

The following extract was written by the superintendent:*

The Laramie Chemical Works, located about 1 mile north of the city of Laramie are the property of the Union Pacific Railway Company, and are leased to Mr. Howard Hinckley.

At these works the crude soda from the extensive deposits west of Laramie is converted into marketable products, caustic soda, salt cake, soda ash, and concentrated lye. The remarkable deposits which are the source of supply of crude material for the works deserve especial mention. They are found about 13 miles from Laramie, with which place they are connected by the Laramie, North Park and Pacific Railway. They occur in a basin comprising some 200 acres in extent, and are known as the Soda Lakes. This sulphate of soda is brought to the works and there, by the Leblanc process, somewhat modified, is converted into the various merchantable products of soda.

In July, 1885, experimental work was begun at the plant, and for two years this has been continued, with considerable outlay of money. Extensive additions and alterations have been made in the works, and now the plant is a very valuable one, comprising many new and valuable features in machinery and furnaces. These are the only works in the country which are developing the natural-soda deposits, and it is hoped that this industry will become a very important feature of Wyoming's resources before many years."

The capacity of these works has been stated as given below

*Report of the Governor of Wyoming to the Secretary of the Interior. Governor Thomas Moonlight, Washington, 1887, p. 29.

and although I have not tried to confirm the figures, I believe them to be correct.

	Pounds.
Concentrated lye	4,800
Caustic soda	8,000
Soda ash	16,000
Salt cake	4,000

The limestone needed in the works is found in abundance near Laramine City. The coal is brought from Carbon and Rock Springs.

The second enterprise is prehaps the more important of the two and is, namely, glass making. Limestone and sand both of excellent quality occur close togther in the Upper Carboniferous strata a few miles east of Laramie City. In consequence of the nearness of all the constituents of ordinary glass a company was organized about one year ago to put up glass works.

The following extract from a letter to Governor Moonlight written by Col. John W. Donellan, the President of the Company, is a very conservative statement.

"The Laramie Glass Company was incorporated under the general incorporation laws of Wyoming Territory on the 6th of April, 1887. The present works are included in a substantial stone building 210 feet long by 70 feet wide, divided by stone fire-proof partitions into three departments, viz: the pot room and mixing department on the south, the furnace room in the center, and the flattening and cutting rooms on the north. The flattening room is one story high, the balance of the building two stories. The capital of the company is $50,000, which will be nearly all used when the works are complete. The works are fitted with water-pipes throughout, connected with the city water system. They are also fully equipped with the Edison incandescent light from the Laramie central station. Every device in the way of modern improvement in window-glass manufacture is provided in these works, and the verdict of travelled experts is that this is the most complete and substantial window-glass factory in the United States. This is not said by way of boasting, but is a simple statement of facts.

"This is the only window-glass factory west of Rock Island, Ill., there being none on the Pacific Coast, so that we have a wide market for our products, with a considerable margin of profit in the matter of freight alone. The pecuniary success of our enterprise is assured. Our skilled workmen are of varied nationalities; about one-quarter of them are Belgians; the rest are Irish, English, French, and Germans, with a few Americans.

"The occasion of the establishment of glass works in Laramie is the occurrence here of all of the necessary ingredients of glass manufacture in boundless quantities and of extraordinary purity.

"Our company has a bed of sand 3½ miles east of the works, which seems to be inexhaustible, perfectly white, without a trace of iron or other impurities. Seen under a magnifying glass, every grain is a perfect quartz crystal, as clear as glass itself. From my limited reading on the subject, I believe it to be one of the most valuable deposits of glass-sand in the world. We calculate the cost of the sand, delivered at the works, at not to exceed 75 cents per ton.

"The limestone used occurs on this same land—the property of the company—where the sand is found. This limestone is a species of marble and is of extraordinary purity, as the analysis hereto attached will show, it being nearly 99 per cent. carbonate of lime.

LIMESTONE SAMPLE.

	Per cent
Carbonate of lime	98.83
Carbonate of magnesia	.45
Carbonate of iron	.12
Bisulphide of iron	.02
Alumina	.10
Silica	.43
Moisture	.05
	100.00

"The limestone is used raw, being simply pulverized, in which state it costs us about $2 per ton.

"Our soda is the natural sulphate, which is also chemically pure. It is used precisely as it is taken from the natural deposit, the only preparation necessary being to calcine it.

SULPHATE OF SODA SAMPLE.

	Per cent.
Sulphate of soda	44.03
Carbonate of soda	.04
Insoluble matter	.10
Water	55.83
	100.00

"We at present purchase our soda from the Laramie Chemical Works, but our company contemplates developing some deposits which it expects to purchase, but which are at present some distance from railroad transportation.

"It will be seen from the above that Laramie has extraordinary advantages for the manufacture of glass, and although our fuel is somewhat dearer than at the eastern factories, yet we think we can take possession of the market west of the Missouri River, and with the co operation of the Railroad Company we can hold it against the eastern manufacturers. We also think that we can take the trade of the Pacific Coast from the importers of foreign glass, who now hold undisputed sway in all the Pacific States and Territories."

The glass works when they first started were successful in making most excellent glass, but the pot furnaces were not satisfactory and soon got out of order. In consequence the works were closed down, and furnaces similar to those generally used in the East were built. These improvements are now completed and the Laramie Glass Works are now turning out window glass second to none in quality.

In comparing the analysis of the limestone used at these works with those found to be superior for the purpose of glass making, the former is shown to be fully as good if not better than the latter. No analyses have been made of the sand. It is exceedingly pure, and the best of all tests, namely glass making, shows it to be of superior quality.

It must be remembered that Laramie, though she promises to become a flourishing city in consequence of these industries, is not the only point in the Territory where there are exceptional facilities for glass making. At the other localities I have mentioned, especially on the Sweetwater, there is an abundance of sand, limestone and coal all within a radius of ten miles and there is a prospective production of oil, perhaps of natural gas within less than fifty miles.

There is no railroad on the Sweetwater at present but the Northwestern System is approaching it and is now graded to a point within less than 60 miles of the Dupont Lakes. Although several preliminary lines of survey have been located, the topography of the adjacent country would lead one to infer that the one passing by the soda deposits will be the one selected. In any event the road will pass near them and bring them within reach of a market.

CHAPTER IV.

THE MINING DISTRICTS.

This chapter will not be found exhaustive because the various mining districts of the Territory could not be thoroughly examined. In fact, only a few of them were visited by the writer. This is due to the fact that in order to examine and report intelligently on the mines of any district, they have not only to be carefully inspected, but many assays should be made, and it was found impossible to do this and at the same time give attention to the other important industries of Wyoming. The Platte Canon, Silver Crown, Douglas Creek, Seminoe and Sweetwater Mining districts only are referred to, and the other districts, including the Cummins City, Owl Creek, Bridger, etc., have been left out because they could not be visited, and no definite information could be gathered concerning them.

The writer is forced to notice and to criticise the prospectors of Wyoming for the fact that all the mines so far discovered are located at points remarkably easy of access, while when he inquires for information concerning the lofty and rugged mountain regions of the Territory he can learn scarcely anything at all. No one knows anything of the rugged peaks of the Big Horn, and especially of the Wind River Mountains, although in such places not only have the forces, the results of whose action seem to be associated with the occurrence of metalliferous deposits, been the most intense but also the older rocks, which usually contain such deposits, are exposed from the granites to the older limestones. It is therefore suggested that some attention should be given by prospectors to these localities. It is true that in such prospecting it is necessary to endure hardship, but one can hardly expect to seek new mines without suffering much inconvenience.

THE PLATTE CANON MINING DISTRICT.

The principal claims of this district are located in Muskrat, Whalon and Eureka Canons though there are other mining claims in various gulches adjoining them or in gulches tributary directly to the Platte River. As will be seen later all the important mining claims with one exception occur in one particular formation. The geology of the country is particularly interesting and well worth describing. I visited the district by going from Bordeaux Station on the Cheyenne & Northern to Fort Laramie and Rawhide Buttes. From the latter point I went to Muskrat Canon and through some of the Buttes and then went through Whalon and Eureka Canons to Fairbank Smelter and on to Cottonwood where I again took the cars.

From Bordeaux to Fort Laramie the country presents few features of general interest. The rock exposed is altogether Tertiary and consists for the most part of soft and fine white or gray marls and sandstones with white chalk bluffs and occasional outcropping strata of harder dark colored grits or fine conglomerates. On approaching the Platte River and beginning the descent into the broad high bottom higher hills are visible with the Rawhide Buttes in the distance. After passing Fort Laramie a number of miles the first of these high hills are reached and prove to be small but rugged, and bare of soil and consist of a coarse grained granite. At first they lie entirely on the west side of the road but finally occur on both sides of it with a broad flat made up of Tertiary rock in between. The highest of all these hills are Rawhide Buttes. These consist of three peaks which rise to perhaps seven or eight hundred feet above the level of Rawhide Creek which flows at their base. They are made up almost altogether of granite, coarse grained, hard and massive and showing no plain indication of a bedded structure. Through this granite there are occasional belts of a black mica schist. I noticed also in several instances veins of quartz which usually run parallel with the schist and have the same as one of the walls while the granite forms the other. The quartz, however, is massive and glassy and beyond an occasional slight greenish and rusty stain it shows no signs of any other minerals occurring with it. The granite, being hard and massive and the joints irregular, weathers to smooth rounded surfaces of large extent and the sides of the Buttes are always steep and often precipitous. There are gently sloping gulches near the top, however, which are fed by springs, and have a deep soil and an abundance of fine timber, much of it fit for lumber. Higher points rise above these timbered flats which are composed of the normal coarse grained granite. The view from the top of the Buttes shows the Tertiary extending from the base, far out towards Nebraska, in rough broken bad lands. The same formation also lies to the west, but on this side it only occupies the valley bottoms. On both sides the Tertiary comes directly against the base of the Buttes and signs of its having existed much higher up on the slopes may be recognized. The Tertiary rocks all lie perfectly flat and no signs of a disturbance from the horizontal position were anywhere observed.

The important mining claims all lie to the west and southwest of Rawhide Buttes, the nearest being in Muskrat Canon, which lies five miles to the west in Section 19, T. 30, R. 64, and Section 24, T. 30, R. 65. As a description of this portion of the Platte Canon Mining District applies to all the other portions, it may be well to give a general description of the structure of the whole district and then to describe the various deposits.

From Fairbank, where the copper smelter is situated, in Section 27, T. 27, R. 66, there is a series of metamorphic rocks

which runs with an average strike of N. 25° E., and, passing through Eureka, Whalon and Muskrat Canons, forms the belt on which the mines are situated. Although the average direction of the strike of these rocks is that stated, it varies somewhat, and while at Fairbank it is N. 45° E., in Muskrat Canon it is nearly due north and south. On the east the metamorphic rocks are seen to lie against granite where there are any hills on that side, or if there are no such hills they disappear under a covering of Tertiary rock. To the west they are covered with nearly level strata of limestone. The latter rocks cover a large portion of the series, and even in the heart of the district they form the hill tops and are called the "cap rock" by the miners. Consequently, on following the metamorphic rocks from Fairbank to Muskrat Canon, it must be remembered that they are partially covered with younger rocks, and are only fully exposed along the sides of the various gulches and on the lower hills. As it is, the belt is easily traced for twenty-five miles from the Platte River, and is last seen some three or four miles north of Muskrat Canon. The longest partial cross section of the series is exposed along the sides of Muskrat Canon, where it is shown to consist of unusually heavy deposits of quartzites, marbles, gneisses and mica-slates. Near the head of the gulch and at the point farthest west at which the series is exposed, the rock is a quartzite, which as a rule is stained a deep brown color with oxide of iron, and is finely bedded, often breaking into plates not over an inch in thickness. Large masses of "float" quartzite were also observed, which were massive and white. The iron stained quartzite came from near the Michigan mine, and this may explain the presence of so much metal. Still further to the west the quartzite passes beneath the limestone cap rock. To the east, however, the quartzite may be traced for several hundred feet, until it ceases and gives place to a heavy deposit of marble, which, maintaing its normal dip of about 60° to the east, may be traced for several thousand feet along the sides of the canon. The western portion of this marble for a distance of several hundred feet is of a light pink or flesh color. Then there is a belt of marble of darker color, usually bluish, although a closer inspection shows that it is not homogeneous in color, but that it has fine streaks of pink, gray and black running through it. A third great band is again pink in color, and the fourth and last is of darker shades. This marble reaches high up on the sides of the canon, but ceases along a nearly level line, and the limestone capping takes its place. To the east of the marble there is a belt of gneiss and mica-slates which have the same dip of about 60° E. The latter belt extends to the mouth of the canon, and only disappears when the Pliocene rocks of the mesa west of Rawhide Buttes cover it up. In Whalon Canon both the gneisses and the marbles are exposed. The former are very heavy. They are finely bedded, and though they generally have much somewhat coarse mica they sometimes show it only in minute specks, and are better called mica-slates. In color they are generally greenish. The occurrence of garnets and staurolite in imperfect crystals is quite common, and along certain lines there is much impure graphite. In the broad gulch bottom there is a covering of Tertiary rocks.

On the west side of Whalon Canon there is no capping of limestone on the hill tops but large masses of float indicate the former existence of such a cap. The granite on the east side of the gneiss belt forms the hills at the lower and eastern side of Whalon Canon but keeping its northeasterly course for some distance further the granite passes back beneath the Tertiary to the east.

Eureka Canon differs in no way from those already described except that the gulch is narrower, and has not cut so deep into the metamorphic rocks and as a consequence the limestone cap rock covers a large area. The gneisses and marbles are both visible at many points and resemble the same rocks as shown at other places. Finally at Fairbank on the Platte River, the marble is again exposed with the ever present cap rock above it.

We have now traced the belt of metamorphic rocks as far as it shows croppings, namely from the Platte River to a point beyond Muskrat Canon, a distance of over 25 miles. It now remains to speak briefly of the cap rock and then a description of the mineral deposits of the district will be in order.

Where the contact of the metamorphic rocks with the limestones is exposed that line is approximately level, and in some cases the limestone rests directly upon the older series. At other points there appears to be a thin stratum of coarse hard sandstone, highly metamorphosed but showing traces of coarse pebbles. This stratum is not at most more than six feet in thickness. The limestone lying above is of a dirty white color. Its thickness was not accurately determined but is probably about 75 feet. Above the limestone there is a stratum of sandstone, very dense and hard and almost a quartzite, which is sometimes deep red in color, sometimes red and white. Above the latter stratum there is another deposit of limestone whose thickness is not apparent because it is always more or less eroded. Specimens

of fossils characteristic of the Carboniferous Age were found in both strata of limestone and hence the entire series appears to be of this age.* The Silurian rocks appear to be entirely absent as if this area were a land surface during that period.

The Platte Canon mining district is of interest to the mineralogist, from the fact that it contains a large variety of minerals. Among the minerals noticed in a hasty examination were the following: Hematite, cuprite, copper glance, galena, garnet, staurolite, muscovite, biotite, tourmaline, beryl, pyromorphite and malachite. But the district is also of interest to the miner, because iron ore, copper ore, isinglass and marble occur in quantities that render them of commercial importance. These four classes of deposits deserve further mention.

THE COPPER DEPOSITS.

In Muskrat Canon there are a number of copper deposits in several places, but the more important claims are all located on the same ledge with the Michigan mine. The Michigan has but little work done on it but, notwithstanding, it is the best developed claim in the canon. The ore deposit occurs in finely bedded quartzites or "slates" on the western side of the metamorphic rocks as shown in Muskrat Canon, and near where it passes beneath the limestone cap. In fact, in many places, the vein is entirely covered with the latter rock, and this is one of the reasons why the vein in adjoining claims has not been more thoroughly prospected.

The largest development of ore on any of these claims is shown in the principal shaft of the Michigan. The shaft is some thirty feet in depth, in a direction diagonal to the dip of the vein, yet it has developed neither the hanging nor the foot wall. The ore is evidently a low grade copper ore, carrying much iron in the shape of hematite. The copper is in the shape of the oxide, carbonate and sulphide. Some large lumps of ore high in copper and smaller streaks of like quality often occur, but the general grade of ore taken out is low in copper; but there is a very large body of ore. The ore from this shaft, roughly sorted, without much breaking, would probably yield fifteen per cent. copper. The gangue has large amounts of iron in it, and the ore would need no roasting, and is evidently very nearly self-fluxing. If anything other than limestone would have to be added it would be quartz. A high gold or silver value is not claimed, and the ore would be classed as a copper ore alone.

At two other points besides the one above mentioned, the

*Spirifer Camaratus (Morton) according to Mr. F. W. Stanton, of Denver.

Michigan shows a similar character of ore, but the ore body does not seem to be so large.

At one point on the mine as well as on the Mary Jane, the contact between the cap rock and the vein is shown. The copper runs into the cap rock in neither instance. The Mary Jane mine is opened up to a slight extent by a tunnel which shows much the same character of ore as the Michigan. The tunnel, however, seems to have left at one side a richer streak of ore, which it at first followed.

Whalen Canon also affords many indications of copper, and many copper lode claims have been located. The development work on the lodes proper has been heretofore very small, and most of the work in the canon on copper claims has been off the lodes altogether. No large body of ore has yet been developed in any claims which I was able to examine.

The copper claims which have been extensively developed in the Platte Canon mining district lie in Eureka Gulch. The chief mine in this gulch is the Sunrise, and much work has been done upon it.

I have already described the appearance of Eureka gulch and mentioned that it is narrow, 200 feet or more in width at the bottom at the Sunrise mine, and that the upper half of the hills forming it are of the nearly level lying limestones, while the metamorphic rocks underlie these and only outcrop along the bottom and half way up the sides of the gulch. The Sunrise mine and all of its chief workings lie on the northwest side of the gulch. The workings consist of large open cuts and surface workings, and a double compartment shaft 100 feet or more in depth, with levels and stopes from it. The underground workings could not be examined because they were filled with water to within less than fifty feet of the surface. The most striking feature about the mine is the great quantities of fine looking hematite exposed in the surface workings. The copper ore is everywhere surrounded by it, and on this account I was unable to discover the position of the deposit in the metamorphic rocks.

The copper occurs as the oxide and carbonate and some sulphide mixed with large amounts of hematite. It lies in large lenticular bodies and in gashes through bodies of pure looking iron ore. The stopes show a number of spaces from ten to fifteen feet in height by five to eight feet in width, for forty to fifty feet in length, from which the ore has been taken. These bodies often contract and are narrow for a few feet and then expand again. Again the ore occurs in great pear shaped bodies,

one of which is exposed as a stope thirty feet or more in height by twenty feet in diameter. This lens seemed to thin out toward the bottom of the stope but as other workings were under it, it must have widened again. A stringer of ore was followed further up the hill and led up vertically through the hematite to the over-lying limestone cap, where the hematite ceased. The copper, however, could be followed up as a stringer along jointing planes of the limestone and led to several small bodies of ore spread out parallel to bedding planes. A very interesting specimen from this horizon was a piece of copper ore with numerous pieces of carboniferous fossils impressed on one side of it.

The ore taken from the Sunrise was hauled about three and one half miles to a smelter built by the company who own the mine and there smelted. The smelter is on the Platte River above Fort Laramie and is about 100 miles from Cheyenne. The coke used for smelting together with all other supplies were hauled from Cheyenne and the bullion produced was hauled back and shipped.

A little over 4,000 tons of ore were smelted producing 475 tons of copper bullion, 97½ per cent fine. The matte and shot copper shipped made the output a round 500 tons of copper. The loss in smelting was from two to two and one-half per cent. which makes the average of the ore smelted 15 per cent copper.

The fluxes used in smelting were about 10 per cent. quartz and 3 per cent. limestone. At times the ore was smelted without fluxes of any kind but the results were not as good as with the addition of the fluxes. Besides the Sunrise ore about 100 tons of Green Mountain Boy ore, running about 40 per cent. in copper were used. The silver of the Sunrise ore did not exceed two to three ounces to the ton and was not regarded in selling the bullion. For these facts regarding the treatment of the ore I am indebted to Mr. I. S. Bartlett who was superintendent of the work at the time the ore was smelted. I am also informed by the same gentleman that large bodies of ore are still showing in the mine and that the smelter closed because the cost of the fuel and the transportation of the bullion was too great. Now that the Cheyenne & Northern is within ten miles of the mine and copper has risen to such value it is to be hoped that work will soon be resumed. The Green Mountain Boy is the only mine which has produced rich copper ore at the same time containing a large amount of silver. The mine, which I was unable to visit, is in the hills facing the Platte River, between Fairbank and Whalon Canon. It lies, I understand, in the Carboniferous limestone and has produced some large bodies of ore.

The ore is chiefly copper glance with narrow streaks of the carbonate passing through it.

HEMATITE ORES.

The hematite surrounding the copper ores at the Sunrise mine has been already mentioned. This hematite evidently exists in an enormous body as it may be seen everywhere. Certain claims lying near the Sunrise, including the Village Belle, Fidelity and New York, also show hematite in great quantity. It has every appearance of being a very pure ore and many analyses taken show it to be remarkably fine in every particular. The analyses of the samples collected could not be made in time for this report. Besides the locality in Eureka Gulch there are hematite deposits indicated in other localities by the color of the soil, and by pits sunk on the mineral and showing it though not developing the size of the body.

MARBLE.

A very few remarks will suffice concerning the marble of the metamorphic series, as its mode of occurrence has already been described. As already mentioned, it outcrops in many places and presents streaks and layers of siliceous matter which render it of uneven hardness. This siliceous character and uneven hardness does not preponderate, however, and in some places the marble is altogether free from it. In Muskrat Canon, where it is best exposed, two colors predomiate—the pink marble, which is of perfectly uniform color; and mottled marble, which is generally of a dark blue color, with narrow veinlets of white, pink and red running through it.

The metamorphism has been so great that the bedding planes of the marble are irregular, but jointing planes and bedding planes do exist. Although scarcely any work has been done and no rock has been taken out from beyond the mere surface this marble, which takes a fine polish, is very fine and solid and only seems to show a few scarcely visible cracks, which are evidently due to frost. The pink marble as well as the mottled takes a fine polish and would make an excellent marble for ornamental work. The rock could be quarried, with the proper precautions and methods of marble quarrying, in large blocks.

THE MICA VEINS.

Some mica of very excellent quality and color has been mined and sold from the Platte Canon district, and good prices obtained for it. The mica occurs in dykes of granite which lie in the mica slates and gneisses on the east side of Whalon Canon. These dykes universally conform with the metamorphic rocks both in dip and strike. In width they vary from eight to twenty-five feet or more. Very little work has been done upon them. The rock exposed is very coarse crystalline. It consists of much quartz and feldspar with a great deal of very coarse and unevenly laminated mica. The mica of good quality occurs in books which are sometimes sixteen inches long, ten or twelve inches wide, and from five to eight inches thick. Tourmaline is quite prominent as an accessory mineral and in one dike large, but inferior crystals of beryl are frequently found.

The work performed upon the isinglass claims has not been sufficient to establish their value. From the appearance of some of the cuts, however, it is judged that a few of the claims are well worth further development.

THE SILVER CROWN DISTRICT.

The mines of the Silver Crown all lie in the coarse hornblendic granite of the Laramie Mountains. The veins usually lie in the granite—sometimes between the granite, and heavy streaks of mica schist.

The work in the district has not been especially active during the past season, but much work has been done on some of the claims. Among these the development on the Louisa has been the greatest. The Louisa shaft was sunk to a depth of 120 feet and levels run for short distances from the shaft both to the north and south. The ore extracted, which is chiefly iron and copper pyrites with a quartz gangue varied in thickness from a few inches to six feet. About 250 tons of first-class ore and about twice as much second-class were obtained. A part of this ore together with a few wagon loads from the King David mine were treated in the roaster and stack furnace erected this spring on the banks of Middle Crow Creek about three miles from the mine. The smelter was closed down in consequence of a business failure of some of the parties interested in it and has not been again blown in. Two car loads of copper matte were produced and shipped to St. Louis. The returns from this shipment have not been made public. The King David, Eureka, Colorado and a number of other claims have also had some work done upon them but they are idle for the present. The only active work being carried on at present is upon the Stanton Copper King, and upon several recently discovered veins which are being worked by Major Glafcke, who with the others interested are well satisfied with the prospects.

THE DOUGLAS MINING DISTRICT.

The only work performed in this locality during the past season was upon the Keystone. This mine and another claim upon the same vein are the property of the Hon. Stephen W.

Downey, of Laramie City. The Keystone was worked several years ago, and over 3,000 tons of ore were milled which returned over 1,700 ounces of pure gold from the plates. The ore contains rich sulphides, and a saving of scarcely 50 per cent. of the assay value of the ore was made.

The mine was not worked for several seasons, but it was again started up early last summer. At the time of my visit in July last the sinking of the shaft was just begun, and all the ground developed above the first level was stoped out along the line of the ore chute. The Blue Jay mining claim adjoining shows, I understand, good ore, and the levels from the Keystone shaft should be run into it.

The vein is well defined and is a true fissure. The gangue is quartz carrying free gold, and the richest ore has sulphide and carbonate of copper through it.

The Florence Mine is another claim on which work was done in early days. The vein showed, besides free milling quartz, some iron pyrites which was exceedingly rich in gold. Almost any of the dump at this mine will pan colors, and I took a piece of quartz with much iron pyrites in it from the dump, which assayed $64 in gold.

All the veins of this district lie in fine grained gneiss. Mica schists also occur through it, but I did not see it in direct contact with any of the veins.

THE SEMINOE MINING DISTRICT.

I am indebted to Charles E. Blydenburgh, M. E., for most of the information concerning this district. The most work performed during the past season was upon the mines of the Penn Mining Company and upon the Hidden Treasure, Hidden Treasure No. 2, the King, the Hope and the Star claims.

The Penn Mining Company have been working all summer upon their claims—the Deserted Treasure and the Emeletta. These, which are the only claims in the district upon which United States patents have been issued, are worked through a cross-cut tunnel 200 feet in length. From the point where the tunnel strikes the vein, drifts have been run on the vein nearly 200 feet southeast and about 900 feet northwest. An up-raise has been made to the surface, and an incline on the vein has been sunk to a depth of 69 feet. I have been unable to ascertain the results obtained on the ores taken out. They were milled in a good 10-stamp mill belonging to the company.

The Hidden Treasure and the Hidden Treasure No. 2 are located upon the same vein, and take up 3,000 feet in length upon it. The vein lies across the gulch from the last described properties, and a cross-cut tunnel, already run some 270 feet, starts in nearly opposite and lower than the tunnel of the Penn Mining Company. This tunnel, which was not run during the past season, is estimated to be within thirty feet of the vein, and the point where it starts is 142 feet below the surface at the shaft. The assessment work for the year has been done at the shaft mentioned. The vein here shows twenty inches of free milling gold ore, on which assays have averaged 2 ozs. in gold per ton.

The Hope and the Star claims are likewise located on one vein and take up 3,000 feet in length upon it. The developments consist, among other pieces of work, in a shaft 200 feet deep. At this point and at six others where openings have been made the vein shows ore. The nine samples taken by Mr. Blydenburgh a number of years ago assayed from $20 to $208 per ton. Most of the samples he tells me, were carefully selected averages; the highest assay was of picked ore.

The King claim has had a great deal of development work made upon it. A cross-cut tunnel is run at one point about 100 feet below the surface and an up-raise follows the vein to the surface. Another cross-cut started lower down, also strikes the vein. This cross-cut was run last season. It is about 270 feet long. From the point where the vein is pierced an up-raise is made to the surface. The mine is reported to show excellently. The workings expose from eighteen inches to over four feet of ore which will mill $18 per ton in gold. The King No. 2, located on the same vein with the former is being worked by a vertical shaft. At a depth of eighty-one feet a cross-cut was run which struck the hanging wall of the vein at about thirty feet, and showed thirty inches of ore similar to that of the King claim. The shaft was then sunk deeper and is sinking now. Delay was caused by water encountered, but now that a pump has been put in it causes less trouble. The shaft when last heard from was 117 feet deep and has not yet struck the vein. The dip of this vein at the surface is only 44° from the horizontal. At the 81-foot level it was 55°. This increase of dip was the cause of the vein not being struck at a depth of about 100 feet.

The ore of the Seminoe district is all a free milling quartz, loose and honeycombed, and deeply stained in the surface workings. Some of the veins show also some iron and copper pyrites and other common minerals resulting from their decomposition. It is probable that the ore will change at a depth of several hundred feet into quartz, with iron and copper pyrites, and with very little of the oxides.

SWEETWATER MINING DISTRICT.

A heavy fall of snow and continued stormy weather late in October last prevented the writer from visiting this district, and it cannot be described fully. The following extract from a letter from Mr. Emile Granier will throw much light upon the very important enterprise in which he is now engaged:

* * "In 1884 I bought from the original locators some placer claims on Willow Creek, Rock Creek, Strawberry Creek and Sweetwater River, and the next year I commenced digging ditches for the purpose of washing those creeks. The ditch on Rock Creek is 10.5 miles long, 3 feet wide at the bottom, 6.75 feet wide at water line, 2.5 feet deep with 10 feet grade to the mile, and can carry about 40 feet of water per second. I expected that the ditch would be filled up with the water of Rock Creek alone long enough to wash during the whole summer, but Rock Creek was not sufficient, and I had to finish the big ditch that will carry the water of Christina Lake to the head of Rock Creek. The last mentioned ditch is 6 miles long, 5 feet wide at bottom, 11 feet at water line, and 3 feet deep and 16 feet grade to the mile, and can carry 144 feet of water per second. It was cut through solid granite rock for more than half of the way. It has a flume, on trestles 70 feet high and 500 feet long, 6 feet wide and 4 feet high.

"Christina Lake is about one mile and a half long and one mile wide, and it is situated at the foot of Atlantic Peak at 10,000 feet above the level of the sea.

"I intended to wash the Rock Creek bottom with one of Joshua Hendy's Hydraulic Elevators because the grade of the bed of the creek is so small that it is impossible to wash off the tailings. It is not yet quite certain that this machine will work well."

This extract will give a very complete idea of the work which has been undertaken and carried out by Mr. Granier. It has necessitated a very large outlay of capital and certainly deserves a very rich reward. All reports concur in saying that the ground to be worked is very rich. As much as the placer gravel in the vicinity has paid for hauling to water it is probable that this ground will prove very profitable now that an abundance of water has been brought upon it. It is to be hoped that the enterprise will have the success it promises, for such a success would not only reward the enterprise of Mr. Granier, but it would call attention of capital to the Territory and cause other deserving properties to be worked.

CHAPTER V.

DESCRIPTIVE GEOLOGY.

The sedimentary rocks of Wyoming are not, as a rule, remarkably thick. The older stratified rocks are in fact, very thin and poorly represented in most localities, and it is only when the Triassic rocks are reached that the formations begin to have any considerable thickness. The rocks of the Cretaceous Age are well developed and will average between 5,000 and 6,000 feet in thickness while in most cases all of the rocks of greater age will not aggregate more than 2,500 to 3,000 feet. The total thickness of the stratified rocks from the oldest to the top of the Cretaceous is, therefore, under 10,000 feet. These rocks, as will be seen later, have, practically speaking, covered the whole of the Territory and have at one time laid flat and one over another in the order of their age. The Tertiary rocks occupy a large portion of the present surface of Wyoming. In thickness they vary greatly and are, in some places, many thousand feet thick, in others but a few hundred.

Although in most cases the total thickness of the sedimentary rocks is not very great, all of the various geological formations from the oldest to the most recent are represented without a member being missing and in this way we have within our boundaries a complete geological history from the begining to the present time.

The oldest sedimentary rocks of the Wasatch Mountains bear a like relation to the same rocks in Wyoming that the older strata of the Appalachian system bear to those of the eastern Mississippi Valley. In either case the rocks along the former are far thicker than over the latter. But here the similarity ceases, for while over the eastern Mississippi valley there is no rock younger than the Upper Carboniferous, Wyoming has all the rocks up to the most recent exposed at many places.

It is proposed to give in this chapter a brief description of the various strata. An attempt will also be made to introduce with this description a brief sketch of their origin and manner of deposition. This is done for the benefit of those citizens of Wyoming who are interested in the development of her mineral resources, and who desire to obtain some insight into the theory and rudiments of geology. In order to do this some introductory remarks on the nature of sedimentary rocks will first be necessary.

A number of very simple but, notwithstanding, very important observations, may be made on a visit to a shore line of a continent. First the great accumulations of gravel, sand and mud which evidently come from the land surface by the wearing power of wind, rain and frost, and the transporting power of water; the latter carrying the various materials to and past the shore, sorting and depositing them separately according to the velocity of the water current. Again, the animal life of the sea may be observed, and it will be seen that the various forms of marine life flourish. That such life is born, thrives and ceases; that where the water is clear and conditions are favorable, the calcareous refuse of such life collects by itself in beds; that where the waters are less clear impurities in the way of clay and sand are deposited with it, and that in all cases the remains of some marine life are buried in the various sediments collecting. Together with such marine life, it will be observed that land life in the shape of leaves and wood—even the carcasses of land animals—are carried out to sea and likewise covered up by the collecting sediments. If, instead of going to an ocean, we go to some great fresh water lake, the same phenomena will be observed, except the water life will always be characteristic of fresh water and different from the salt water fauna.

In places, land surfaces may be found which consist of deposits of gravel, sand, mud and calcareous matter, more or less pure, still loose and soft and containing the remains of land and and water life as they did before they were raised above the level of the waters that once covered them. Again, we may find sedimentary rocks, soft, it is true, but still with their particles more or less cemented together with lime or iron, or some other material, and in no other way showing a difference from the dried or submerged detritus of the beach itself. They are just the same, and show the effect of the sorting power of water in their stratification; the same remains of life; the same marks of the action of water; and the same products of water in every way. Another stage, and the rocks are firmer and more solid. They afford, perhaps, building stone, and may no longer lie flat as they were originally deposited, but the strata "dip" in some particular direction and at some considerable angle from a level. But the same gravels, sands, muds or calcareous detritus now forming solid strata of conglomerates, sandstones, shales and limestones are easily recognized, and show as fossils the skeletons of former living things, whether animal or vegetable. Finally, we find the sedimentary rocks changed by what are known as metamorphic agencies. They are no longer merely sediments which have been subjected to pressure alone, and in which the various fragments forming them, however firmly cemented together, are separate fragments still. These fragments are now more or less blended one into another, and cannot be distinguished even with a lens. These rocks then become quartzites, marbles and various kinds of crystalline or semi-crystalline rocks like slates, schists, gneisses, etc. As the sedimentary rock is thus changed the fossil life is destroyed or loses its individuality. But in such changes the composition of the rocks remains the same, and the lines of stratification are not completely destroyed, and the sedimentary origin of the resulting rocks cannot be questioned. By thus tracing rocks which show signs of stratification back through a gradual series, we universally arrive at the bottom of some great primeval ocean, sea or lake, with its accumulations of sediments from a land surface, and with the remains of the life that lived in and about it buried in them.

Besides this class of rocks there is another which never shows signs of an origin from sediments, namely the eruptive and igneous rocks which have resulted from the cooling and solidifying of great masses of molten rock. It is sometimes hard to distinguish the latter from the metamorphic rocks which have been subjected to very long and intense metamorphic action.

Geological History takes us back to the time when the earliest sedimentary rocks, that may be plainly recognized as such and which still contain well preserved specimens of life then existing, were deposited. From that time to the present we may study the various strata, and the fossils therein contained and thereby gain a complete and continuous history of the formation of and life upon the earth's crust. Before that time the rocks are altogether igneous or as is more commonly the case sediments so metamorphosed from original condition as to destroy all individuality of the life which was once preserved in them.

ARCHÆAN TIME.

Archæan Time includes all time from the beginning to the time when the sedimentary rocks, now existing as such were just beginning to be deposited. The rocks belonging to this period consist then of granites, gneisses, schists, marbles and other crystalline and semi-crystalline rocks. The only appearance of the existence of animal life during this time is in the graphite and marble. The Archæan period has been divided into two great ages, the Laurentian and Huronian. The latter is the younger and is recognized by the fact that it lies unconformably upon the former wherever it is found. It shows more distinctly than the former, a sedimentary origin and its rocks are more commonly semi-crystalline rocks or crystalline rocks which show bedding planes distinctly. Both the Laurentian and the Huronian rocks are found in Wyoming. The granite tops of the Laramie Mountains for instance are probably of the former period while the series of metamorphic rocks extending through the heart of the Platte Canon Mining District is probably of Huronian age.

PALAEOZOIC TIME.

At the close of the Archæan the area now occupied by the North American continent was almost altogether covered by an ocean and only the skeleton of the continent, so to speak, existed as a land surface. The largest of these land surfaces was shaped somewhat like the letter V and was situated in what is now British America, the point towards the present seat of the Great Lakes and the arms passing on either side of Hudson Bay. Another land surface followed the general course of what is now the Appalachian System, while in the west the land formed a chain of granite islands following the general course of the present Rocky Mountains. Still further west other land masses existed but their limits are at present little known. The detrital matter torn from these land masses was deposited in the seas around them and certain animal life in these seas formed limestone and all of these sediments were deposited in level layers over the sea oottoms.

The Silurian Age. The first series of rocks deposited during this time is known as the Silurian rocks. In Utah and southwestern Wyoming they are very thick, but over the major portion of Wyoming they are abnormally thin. Usually not over 200 feet in thickness—sometimes even less. At one locality at least, namely in the area north of Fort Laramie, there seems to be no Silurian rocks at all, indicating that this area was a land surface at that time. On the northern side of the Rattlesnake Mountains the Silurian rocks are altogether sandstones and fine conglomerates and are not more than 200 feet in thickness. At Shirley Mountain, north of Carbon, it presents a similar appearance but it is not over 100 feet thick. According to King* the Silurian rocks near Granite Canon, on the east side of the Laramie Mountains, are not over 150 feet in thickness.

In many cases the Silurian sandstones are partially changed to quartzites as along the northern slopes of the Rattlesnake Mountains. They are almost always sandstones or quartzites wherever found and as far as observed have no well defined strata of limestone or dolomite, as they have in many places in Colorado. As a consequence of the small thickness of the Silurian rocks

*This and all following references to King are obtained from The United States Geological Explorations of the Fortieth Parallel, Vol. I, Descriptive Geology, by Clarence King.

over the most of the Territory, no attempt has been made to subdivide them into groups as has been done with the enormously thick deposits of the Appalachian System. At most only two groups, the Cambrian and the Upper Silurian, can be distinguished.

The Devonian Age—Rocks of this age cannot be definitely observed throughout Wyoming. King believes they exist in exceedingly thin strata between the Silurian and Carboniferous rocks, but as a rule they have not been definitely determined. In other words, the fossil life found below the Carboniferous (with the exception of certain localities in the Black Hills) has all been of Silurian types, but no fossils have been found for a short distance below the Carboniferous, and this has been referred to the Devonian.

The Carboniferous Age—As far as observed the lowermost rock of the Carboniferous is limestone. Usually it is dull white in color and sometimes, as in the Silver Crown mining district, it is of a reddish, or pink color on the jointing planes. Frequently it is very pure and free from both magnesia and silica; usually it is homogeneous in texture and composition. This bottom stratum of limestone varies greatly in thickness. Near Granite Canon it is not over fifty feet thick (King). On Shirley Mountain it attains a thickness of over 300 feet, and is massive and apparently pure. The cave on Shirley Mountain is in this limestone. On the north side of the Rattlesnake Range this stratum is about 200 feet thick, and in appearance resembles the limestone of Shirley Mountain. North of Fort Laramie, about the Platte Canon mining district, the Lower Carboniferous limestone lies directly upon the Archaean. In all these localities specimens of fossil life, chiefly of *spirifer camaratus*, are abundant.

The rock overlying the limestone is usually a sandstone. It is, as rule, dull gray or perfectly white in color. In many places it is strangely unaltered, and the grains of sand are but loosely cemented together. In thickness it varies greatly. Usually it exceeds 200 feet. In places where the Middle Carboniferous has not been carefully examined by the writer, namely, along the outcrops bordering the Laramie Plains, Clarence King describes it as consisting chiefly of limestone more or less arenaceous. But west of Laramie City there are numerous strata of Carboniferous sandstone from which the sand for making glass is obtained, and it appears probable that these sandstones, but poorly represented toward Sherman, become more abundant and partially replace the limestones toward the south. In the Rattlesnake Mountains the Carboniferous sandstone is about 200 feet thick, dull gray in color, and is sometimes partially changed to quartzite. In the Wind River Mountains the thickness as exposed in the Canon of the Little Popoagie is much greater, but could not be accurately determined. It is here soft and easily eroded, but stands well, so that the sides of the canon are precipitous. Along the western flanks of the Big Horn Mountains this sandstone also shows a thickness greater than the average. It is here, as a rule, very white and pure, and is worn into bold bluffs and escarpments, and forms the walls of many precipitous canons. In some of the localities mentioned the sandstone extends to the top of the Carboniferous. But in the majority of cases there is a thin stratum of limestone of the same age overlying it. Thus, in the Rattlesnake Mountains there is such a stratum not exceeding 35 to 40 feet in thickness. This stratum is directly overlaid by the Triassic rocks. It is dull white in color and usually lies in layers of from one to two feet in thickness. Flint concretions are abundant throughout, and fossils in it are rare. The Little Popoagie Canon exposes the same stratum here between 50 and 60 feet thick. Below it becomes impure and merges into a calcareous shale, then into a sandstone. It seems to be not improbable that this stratum is the one that carries the oil obtained at the Shoshone Wells. On the west side of the Big Horn Mountains this stratum of Upper Carboniferous limestone does not exist.

GENERAL REMARKS UPON PALAEOZOIC TIME.

It will be seen that the Silurian rocks are but poorly developed over the major portion of Wyoming, that the Devonian are scarcely ever recognizable and that the Carboniferous, though better developed, are, as a rule, less than 1,000 feet in thickness. King places the total thickness of the Palæozoic where erosion has not attacked them, at about 800 feet near Granite Canon and at from 1,000 to 1,200 feet at various points along the Laramie Plains. Along the Wind River and the Big Horn Mountains no measurement was taken by the writer, but the thickness must be considerably greater. Along the Rattlesnake Mts. the Palæozoic is not more than 700 feet thick. It will be remembered that the siliceous rocks are all coarse grained and it is important to observe that they show abundant signs of wave action like ripple marks and a plunge and flow structure. Everything indicates that during the whole of the Palaeozoic, Wyoming was covered with a shallow ocean, and that the subsidence of this ocean bottom over the eastern portion was scarcely perceptable. The period was a very long one, and if there had been a deep ocean for any length of time, or if there had been a subsidence amounting to many hundreds of feet, the thickness of the strata which would have filled up the sea would have been far greater than we actually find. Along the region now occupied by the Uinta Mountains there was evidently a gradual subsidence of the sea bottom throughout the whole period and the sediments collecting as fast as the subsidence took place, there resulted the enormously heavy deposits of Palaeozoic rock found in this portion of Wyoming. (King.) Although such differences in the amount of subsidence are observed it must be remembered that the maxima and minima were in widely separated localities and as a consequence no lack of parallelism of the various strata can be observed.

At the end of the Palæozoic Time Wyoming was still covered with a shallow ocean, with the exception of the few island land surfaces already mentioned, and the strata deposited all lay level over the bottom of it. In this position the strata formed during the next period were deposited over them.

MINERAL PRODUCTS OF THE PALAEOZOIC ROCKS.

The Coal Measures of the East, with one exception, all lie in the Palæozoic rocks i. e. in the Middle Carboniferous. In the West, however, these rocks do not carry coal in quantity sufficient to mine. In Colorado narrow seams of anthracite coal of impure quality and strata of highly bitumenous shale have been found in the Carboniferous and doubtless like materials occur in places in Wyoming, but the Carboniferous rocks of the West have been known to contain no nearer approach to coal seams. Iron ores are common to the Palæozoic rocks and are not confined to any one horizon. The Rawlins hematite which is celebrated for its purity occurs in the Carboniferous. In the Rattlesnake Mountains the Carboniferous limestone also carries hematite. For gold, silver and lead no accurate horizon can of course be given, but all three of these metals and especially silver and lead occur very abundantly in the Palæozoic. Fully four-fifths of the silver of Colorado comes from the Carboniferous limestones. It is worthy of notice that where large deposits of silver and lead are found in these rocks they are almost universally associated with large outbreaks of some eruptive rocks as at Leadville and Aspen.

The Palæozoic rocks of Wyoming show copper in many places and in certain localities they promise to become of economic importance.

The petroleum of the East is all derived from this series chiefly from the Devonian rocks which are so poorly represented in Wyoming and the natural gas is chiefly derived from a still lower horizon. In the west it is exceedingly improbable that either natural gas or petroleum will be found at any horizon lower than the Upper Carboniferous.

MESOZOIC TIME.

During Mesozoic time all the rocks from the top of the Palaeozoic to and including the coal bearing rocks of the west were deposited. Like the Palaeozoic it is subdivided into three ages, the Triassic, Jurassic and Cretaceous.

Triassic and Jurassic Rocks. All who have been through the country north of Rawlins, over the Laramie Plains, about Lander, on the Nowood River or in the Rattlesnake or Sweetwater Mountains will have noticed great outcrops of brilliant red sandstones which show a tendency to weather into a series of great red blufs which offten extend for many miles, singly or in tiers, in the direction of the strike. These rocks so plainly marked and easily recognized are the Triassic strata. Above them the strata, which have some red layers but in which white sandstones and gray dolomites usually preponderate, form the Jurassic rocks. The latter in the aggregate are seldom more than one third as thick as the Triassic. These two series of rocks merge from one into the other very gradually and as a rule it is difficult or impossible to tell just where one ends and the other begins. Morever they are, as far as their economic features go, practically one and as one they are grouped together in this brief description.

Throughout Wyoming the Jura-Trias rest conformably upon the Palaeozoic rocks. That is to say their strata are parallel. The sea in which they were deposited was shallow throughout and as a consequence they contain few shales, the sandstones are more or less coarse and show abundant signs of wave action and the limestones are impure. Throughout the period was one of gradual subsidence of the sea bottom, and this subsidence allowed room for an accumulation of a considerable thickness of rock. As already mentioned the Triassic rocks are of a deep red color, especially towards the base. Usually they are sandstones of moderately coarse grain. The red color is due to oxide of iron which probably forms the cement which holds the particles of the rock together. Strata of impure magnesian limestone occur in the Triassic. They are seldom more than thirty feet in thickness. Gypsum also occurs in very heavy deposits, often fifty, sometimes nearly one hundred feet in thickness. Both the limestone and gypsum strata, but especially the latter, appear to occur with little or no regularity and to be more in the nature of local deposits than of strata which extend over a great area. The Jurassic rocks are for the most part sandstones, usually white or cream colored; red sandstone and magnesian limestone strata are also found in it. Gypsum also occurs in the Jurassic in large quantities.

The thickness of the Jura-Trias shows great variations over the whole Territory. According to King they are not over 300 feet thick at one point on the eastern slope of the Laramie Mountains. Along the edge of the Laramie Plains the same authority places the thickness between a 700 feet minimum and a 1,200 feet maximum while along the eastern terminus of the Uinta Mountains he places the thickness at 2,500 feet. The Jura-Trias on the north side of the Rattlesnake Mountains are about 1,500 feet thick, while along the Wind River Mountains and on the Nowood River it is at least 2,000 feet.

The Cretaceous Rocks. The Cretaceous are, from the products which they yield, by far the most important rocks in Wyoming. Almost all of the oil of Wyoming seems to come from them and also all the coal.

At the beginning of the Cretaceous and throughout the age the same great ocean, now contracted by the building up of other portions of the continent into a great mediterranean sea which extended from the gulf northward and westward to the Wahsatch Mountains, existed and in it the various Cretaceous strata were deposited in level layers upon the still level strata that had been before deposited. The Cretaceous rocks thus formed greatly exceed in thickness and variety the rocks of the ages which preceeded and a number of groups of rock, usually easily distinguished by their physical appearance as well as by the fossils they carry, have been recognized. Beginning at the bottom these groups are known as the Dakota, Colorado, Fox Hill and Laramie.

The Dakota Group. The Dakota, being the lowermost member of the Cretaceous, lies directly upon the top of the Jurassic and as a rule may be easily distinguished from the latter both by its color and texture. The base of the group usually consists of conglomerates of varying thickness and coarseness. Clarence King gives the thickness of the Dakota along the line of the Survey of the Fortieth Parallel, i. e. along the northern part of Colorado and the southern part of Wyoming at between 200 and 300 feet. Over the whole of Wyoming the thickness varies greatly and rarely it is not over 50 feet, again rarely as much as 500 or 600 feet thick.

The conglomerate, which is usually at the base, and also wherever it occurs throughout the group, is composed of pebbles varying in size and cemented together by a very firm and tenacious cement which withstands the action of the atmosphere so well that the conglomerate weathers into great blocks and boulders formed by the rock splitting up along the joints and stratification planes instead of crumbling into a gravel. The pebbles are peculiar in the fact that they consist altogether of a sort of chert or flint varying in color from white to gray, blue and blue-back. Usually they are somewhat translucent on thin edges. The presence of pebbles of material that may be absolutely referred to any of the Archaean rocks is very rare. Sometimes the conglomerate is coarse and contains pebbles over an inch in diameter, but usually it is finer, and the largest pebbles then do not exceed half an inch in diameter. Again, the conglomerate is so fine that none of the pebbles are larger than grains of coffee, as at the exposure at the oil well on Powder River. Very rarely there is no conglomerate whatever. The Dakota then consists entirely of sandstone, as at points where it is exposed on the Nowood and on the Little Popoagie Rivers.

Along the base of the Rattlesnake Range the Dakota is remarkably thick. The dividing line between it and the Jurassic rocks is very distinct, with the white sandstone of the latter and the coarse conglomerate of the former in contact. Almost all of the first 150 feet of the Dakota is here made up of the conglomerate, and whatever sandstone is interstratified with it lies in thin and very irregular layers which cannot be traced for any great distance. Above this are strata of conglomerate and coarse sandstone, the former the more abundant. Usually the top of the group terminates in a sandstone. In one instance, also, a stratum of shale was observed in the Dakota. The latter stratum was not over 10 feet thick, and lay about 50 feet from the top of the group. The total thickness of the Dakota in this locality is probably not far from 500 feet except at the north end of Rattlesnake Mountain, where it does not appear to exceed 300 feet. The exposure of the Dakota on the Little Popoagie shows it to be altogether a coarse sandstone not over 75 feet in thickness, and near the Nowood at the mouth of Paint Rock Creek the thickness and character is about the same.

The Colorado Group. These rocks lie next to the Dakota and are deposited conformably upon it. They include three sub-groups, which are sometimes distinguished by the character of the rocks which form them; more often by the character of their fossils alone. It is not proposed to enter into a description of the sub-groups and only a brief description of the group as a whole

will be given. The Colorado Group is chiefly characterized by the presence of argillaceous and calcareous shales, the former predominating. Most prominent of all are the dark blue argillaceous shales (the Fort Benton sub-group) which lie at the base of the Colorado. This shale is quite soft and very finely bedded. It weathers first into thin chiplike pieces, frequently with conchoidal fracture, then into a fine soil or clay. Thin strata of sandstone, generally only a few feet in thickness, occur through this shale. Everywhere the shale shows the presence of large amounts of organic matter and almost every piece will show the impression, however imperfect, of some form of animal or plant life—fossil shells, seaweeds and fishscales are abundant.

Farther from the base of the group the shale becomes lighter in color and more calcareous, and sometimes strata of argillaceous limestone occur near the top. The top of the group often consists of very light-colored shale and strata of sandstone, which are sometimes 50 feet or more in thickness.

The Fox Hill Sandstones is the name of the third group of the Cretaceous. These rocks are deposited conformably upon the Colorado group and the line of demarcation is usually distinct. The group consists chiefly of sandstones, as the name indicates, but, especially where it attains a greater than the average, thickness there is often also much sandy shale interstratified with the sandstones. The sandstones are usually gray or yellowish in color and soft and pliable. Although the Fox Hill is considered a separate group of the Cretaceous, where it ceases and the Laramie begins can seldom be determined, and, in fact, the only difference it may be said to have from the Laramie is that the Fox Hill seems to have a salt water fauna while the Laramie fauna is more characteristic of fresh and brackish water life.

The Laramie Group—This, the great Coal Measure series of the west, forms the highest member of the Cretaceous. The rocks of this group are as a rule predominantly shallow water rocks. The great mediterranean sea of the preceding periods of the Cretaceous evidently became very shallow, and the fresh water draining down from the mountains to the west rendered the waters brackish, or even fresh. Although there was, upon the whole, a gradual subsidence throughout the period, the collecting sediments kept steady pace with it and formed great areas but thinly covered with water, upon which a luxuriant vegetation grew. Grasses and trees closely resembling species existing to-day grew and flourished, and dying, accumulated as huge peat bogs. Finally, such a peat bog would subside and the water cover it to a greater depth, and sediments would be deposited over it. Then a coal seam in its first stage of existence was formed. When the conditions were again favorable another growth would spring up above the old one, and this process repeated again and again gave rise to many coal seams, many perhaps too thin to work, but usually with some that were sufficiently thick. Such was the character of the Laramie Sea. The rocks that were deposited in it are chiefly sandstones, sometimes pure and white, and coarse grained and massive; more often soft and easily eroded, uneven in grain and containing much fine material. Conglomerates are rare and usually fine, although in one instance a stratum of very coarse conglomerate was noticed and referred to the Laramie. Shale is common as the black carbonaceous shale overlying coal, as a light blue shale occurring independently of the coal, it is more rare. Irregular strata of impure carbonate of iron, often weathered into limonite are of common occurrence. They are very irregular and seldom exceed a foot in thickness.

The thickness of the Laramie rocks is exceedingly variable. King places the thickness between a maximum of 5,000 and a minimum of 1,500 feet. In northern and central Wyoming they are very thick especially in the latter locality.

Such is a brief description of the Cretaceous strata. That it is a formation abounding in mineral wealth is very evident. Almost all the oil springs of Wyoming come from it, chiefly from the Dakota but also from each of the other groups. All of the coal comes from the Laramie group and it is probable that the Cretaceous will also afford both building stone and iron.

DISTURBANCES AT THE CLOSE OF THE CRETACEOUS.

It will be remembered that from the beginning of the deposition of the Palaeozoic rocks to the close of the Cretaceous there has been an ocean or sea over the entire surface of Wyoming, excepting the various granite islands already described as existing at the beginning of the former and lasting throughout, that this ocean has been a shallow one most of the time and that throughout the ocean bottom has on the whole subsided and made room for the accumulating sediments. Also that the various strata accumulating were deposited one upon another, like so many blankets laid out upon a floor, one upon the next. Finally it will be remembered that towards the close of the Cretaceous what remained of this ocean became filled up with the Laramie sediments and scarcely a trace of its former vastness was left. At the close of the Cretaceous the remains of this ocean was finally destroyed during a great period of dynamical disturbance. The mountain ranges of Wyoming were then

formed, the strata bent, folded and broken, and the sea bottom practically became a land surface—practically a land surface because there still remained a system of fresh water lakes in which the Tertiary rocks were deposited. It must not be supposed that this great disturbance took place with a crash, as if it were the result of a convulsion resembling a gigantic earthquake, but it must be supposed to be the result of a gradual rising of the sea bottom, which took many thousand years for its completion, if indeed it is actually completed yet, for perhaps some such changes are now progressing without their being manifest to us. When it is remembered that through careful measurements along certain portions of the Atlantic coast lines it is found that the land is slowly rising in some places, apparently stationary in others and again slowly sinking with no demonstration of such changes to any but the careful observer, the plausibility of such an idea, aside from any definite proofs (which do exist), becomes apparent

After the Cretaceous period then Wyoming was a land surface, chiefly, with its strata of sedimentary rock more or less tilted and bent and not necessarily level but turned at an angle with the horizontal. The mountains followed, as a rule, the old lines of the granite islands and the strata, tilted up along the mountains, extended far up along their sides where the old islands existed or all the way over them in the shape of a wave, as a rule, where the now mountain top was once under the level of the sea. In the great plains or basins between such ranges the rocks were lifted up bodily and much as one mass and consequently, although there was sometimes local faulting and folding, they lie quite flat, as a rule, and do not have the steep dips of the strata on the mountain sides. Some of these basins became land surfaces, but most of them in Wyoming became the seats of great fresh water lakes.

As the old land surfaces in the ancient seas were eroded and gave the sediments which made the strata hitherto described, so now the rain and wind and frost and running water cut and scored the newly made Wyoming hills and the sediments were carried down into the great fresh water lakes and formed the Tertiary strata. By such destructive agencies the land was chiseled and sculptured towards its present shape and after the Tertiary period when its great lakes were destroyed this erosion was continued until Wyoming has assumed its present topography. Naturally this erosion has been greater when the surface has been steep and the waters have attacked it with greater force. In such places the younger rocks have been entirely or largely worn away and the older exposed often even to the primeval granites. Where the erosive action has not been so great younger rocks are found. Finally some places are found where erosion has not removed even the youngest rocks. At such places a complete natural section may often be obtained by going towards the nearest mountains and thus passing over each successive stratum till the granite core of the range is reached. It is by seeking such natural sections and studying such exposures that a description of the geology of a country is rendered possible.

THE TERTIARY ROCKS.

As these rocks are not of any great importance economically speaking it is not proposed to give any detailed description of them here or anything further than a very general description of the areas which they occupy. For the areas in southern Wyoming I follow King. Hayden defines certain other areas and I have also seen areas in the north which, as far as I know, have not been noticed.

In southern Wyoming one of the largest Tertiary areas begins at a point on the Union Pacific Railway about fifty miles west of Rawlins and with but two important breaks it extends on westward into Utah. It occupies, practically, all of the area between these east and west lines south to the Colorado and Utah lines, extending as it does far south of these lines. On the north it extends far up the valley of the Green River and its tributaries. The two important breaks referred to are those at which the Laramie Coal Measures outcrop at Rock Springs and at Almy and on Sulphur Creek. At these places the Eocene rocks have been thinner than elsewhere and have been scored away.

The next great area of Tertiary rock to be mentioned is the Pliocene beds on which Cheyenne is situated. The limits of this rock towards the east are far beyond Wyoming. On the west they border the Laramie Mountains towards the south and, diverging from them, strike the Platte River between Douglas and the mouth of Cottonwood Creek. Northward the Pliocene extends east of the Black Hills in Dakota and, according to King, far to the north.

A third area of Tertiary rock (Pliocene) extends from North Park into Wyoming nearly to the Union Pacific Railway, its present northern terminus being near the western end of Elk Mountain (King). The water in which this rock was deposited extended, perhaps as a chain of lakes, northward along the present course of the North Platte River for I have noticed areas of Tertiary rock, scored down to the underlying rocks in many

places, north of Shirley Basin at the head of Bates Hole and on the heads of Dry and Little Canon Creeks. The Tertiary rocks in these places rest for the most part upon granite. The great Tertiary deposits, of which the Sweetwater Valley form a part, are directly connected with those on Little Canon Creek. From the lowest point on the Sweetwater at which I have been, namely from a point about twelve miles below Independence Rock westward beyond Signor's on the Rawlins and Lander Stage Road, the entire valley bottom, except where the granite outcrops, is Tertiary rock. From Devil's Gate northeast the same rock extends across the Rattlesnake Divide past Poison Spider Creek and connects with the Tertiary of the Powder and Wind River Basin. Again I have observed the same rock north of the Owl Creek Range on the headwaters of the Nowood. It occurs here well up upon the side of the range and rests upon the basset edges of the Triassic. Although only seen at one exposure it is believed that it covers a large area.

Since the Tertiary were deposited after the great upheaval which formed the Rocky Mountains, consequently they are not disturbed like the older strata and generally they lie nearly level, but cases are by no means wanting in which they assume a dip of from 5° to 15° and I have observed cases where the dip is 35°. Other indications of considerable dynamical disturbance since the close of the Tertiary are exhibited by an abnormal elevation of these rocks above the probable level of the old lakes, but I have not yet studied these phenomena sufficiently to speak further concerning them.

FINIS.