DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY
GEORGE OTIS SMITH, DIRECTOR

BULLETIN 543

GEOLOGY AND GEOGRAPHY

OF A PORTION OF

LINCOLN COUNTY, WYOMING

BY

ALFRED REGINALD SCHULTZ

WASHINGTON
GOVERNMENT PRINTING OFFICE
1914

CONTENTS.

ILLUSTRATIONS.

GEOLOGY AND GEOGRAPHY OF A PORTION OF LINCOLN COUNTY, WYOMING.

By Alfred Reginald Schultz.

INTRODUCTION.

LOCATION AND AREA.

The area described in this paper lies in the central part of Lincoln County in the extreme western part of Wyoming, east of the Salt River Range and west of Green River, nearly three-fourths of it being in the Teton and Wyoming national forests. (See Pl. I, in pocket.) It comprises Tps. 22 to 39 N., Rs. 113 to 117 W., inclusive, lying between parallels 41° 45′ and 43° 30′ north and meridians 110° 15′ and 111° west, and is about 110 miles long in a north-south direction and 30 miles wide. The total area surveyed and mapped is approximately 2,500 square miles. About two-thirds of the townships have had their exterior or their exterior and subdivision lines run. The remainder have not been subdivided. At the time of examination (1906) all the area here described was a part of Uinta County, but in 1912 Uinta County was reduced so as to include only that part of the former county lying south of an east-west line drawn through Cumberland, Wyo., or all of the area south of T. 19 N. All the remainder of the area, or that part from Cumberland north to the Yellowstone National Park, was designated Lincoln County. The object of the work was to obtain more accurate information regarding the northern continuation of the Kemmerer coal field, which was mapped and examined by A. C. Veatch and the writer in 1905.

FIELD WORK.

Wherever the public domain has been subdivided by the General Land Office into townships and sections these subdivisions become the units of importance; for it is evident that the investor, whether he desires to obtain agricultural, timber, or mineral rights (except those for lode deposits), is primarily interested in the relation of the land to the surveyed lines and must know the relation of the geologic structure and economic deposits to such lines before he can advantageously make an investment.

Nearly two-thirds of the total area investigated has been subdivided by the Land Office. In that part of the region where no legal subdivisions have been made the lines of the survey were projected in east-west and north-south directions from the nearest established land corners and were continued through the unsurveyed territory and tied to the land corners on the other side.

Geologic mapping involved pacing north-south and east-west township and section lines and noting all rock exposures with reference to established corners. Not all the work could be done along section and township lines, and it was often necessary to supplement this method by irregular traverse and meander lines, all of which have been tied to known land corners.

By conducting surveys in this manner it is possible to correct many of the errors shown on the township plats, particularly where the office compilation differs from the field survey or is a generalization from the surveyor's notes. One township line was found to be 1 mile farther east, as located by the Government corners, than is shown on the township plats. In two other townships, shown to be complete by the plats, it was found that the west tier of sections was missing and that each township was only 5 miles wide.

A map thus made lacks the geographic exactness of surveys carefully controlled by triangulation and primary traverse, but its geographic inaccuracies are not serious enough to affect the geologic conclusions, and it will be of more economic value than maps which have been carefully controlled but not tied to land lines. It is remarkable that nearly all the prominent topographic features located during this survey by land corners check very closely with the main topographic features as determined by the primary and secondary triangulations of the Hayden Survey.

In the field only such section and township lines were paced as were necessary to obtain the geologic and topographic detail desired. Most of these lines were 2 to 3 miles apart, but some of them were only a mile or half a mile apart. Most of them were not carried as continuous surveys, but only from corner to corner. Whenever a new corner was found it became a new zero point. The relief was sketched in actual continuous contours directly from the country. The positions of the contours were determined by aneroid barometer readings based on readings at the primary and secondary triangulation stations of the Hayden Survey of 1877 and 1878.

BASE MAP.

Combining a number of separate township plats into a single base map involves many difficulties. Even the best plats show many contradictory details of measurement, and not infrequently more or less fraudulent surveys must be made to fit in with the carefully run lines of earlier or later surveys. The larger the area the greater the difficulty of satisfactory adjustment, and when adjustment to a refined polyconic projection is attempted the difficulty is greatly increased.

In making this base map the expense of a polyconic projection was not warranted, and the map is therefore a square projection made without any assumption of exact geographic accuracy. However, it is accurate in regard to the geologic data shown in each section in the area of economic importance, and the distortions are nowhere sufficient to affect seriously the economic conclusions.

The base map was compiled from the various township plats in the following manner: An arbitrary north-south line was drawn across the sheet, dividing it approximately into two equal parts. This line coincides with the range line along the west boundary of Tps. 29, 30, and 31 N., R. 115 W., as this portion of the range line is near the center of the area mapped. The township plats were then consulted and the total length of each range and township line was computed from the surveyor's measurements as recorded on the plats. From these measurements the intersections of the sixth, seventh, eighth, and ninth standard parallels were located on the north-south line, and arbitrary lines were drawn through these points at right angles to the original line, giving preliminary correction lines. The seventh standard parallel, which was very accurately resurveyed in 1899, was adopted as the east-west control line; it was accurately located according to bearing and distances, and the township corners were established along it on each side of the north-south line according to the recorded measurements.

From these two control lines the remaining township and range lines were drawn as required by the measurements on the respective township plats, and the bearing of the preliminary correction lines, as well as the offsets along them, were changed as the surveyor's measurements required, thereby retaining all the irregularities of the several townships and making each a unit in itself. After the township net was connected, the subdivisions within each township were made according to measurements recorded by the surveyors on the township plats; the irregularities in most townships were thrown into the north and west tiers of sections, but those in a few were thrown into the south and east tiers of sections, as in T. 25 N., Rs. 113 and 114 W., and Tps. 26, 27, and 28 N., R. 119 W.

Resurveys showed that in all these townships either the south or the east boundary line, or both, were defective in measurement and position, thereby making the northwest corner the starting point of the subdivision instead of the customary southeast corner. The west tier of sections in Tps. 23 and 24 N., R. 115 W., is approximately 1¾ miles wide; and the entire western tier of sections in Tps. 23 and 24 N., R. 113 W., is missing, leaving those two townships only 5 miles wide. In T. 28 N., R. 119 W., the eastern tier of sections measures 137.76 chains at the north end and 136.78 chains at the south end; and in T. 27 N., R. 119 W., the eastern tier measures 136.78 chains at the north end and only 86.53 chains at the south end.

While mapping in the field the range line in Tps. 26 and 27 N. between Rs. 115 and 116 W. was found to be 1 mile farther east than is shown on the township plats. This necessitated moving the township line east 1 mile, as shown on the base map (Pl. I, in pocket). Further work proved that Tps. 26 and 27 N., R. 115 W., are full townships 6 miles wide, but that Tps. 26 and 27 N., R. 114 W., are only 5 miles wide and that the entire west tier of sections in these two townships is missing. The west tier of sections in Tps. 26 and 27 N., R. 114 W., coincides with the east tier of sections in Tps. 26 and 27 N., R. 115 W., when Labarge Creek is connected on the two plats according to its bearing. To move the township line, or east boundary line, of Tps. 26 and 27 N., R. 116 W., 1 mile east would give an excess of one tier of sections for Tps. 26 and 27 N., R. 116 W. However, as mapping did not extend to the west boundary of Tps. 26 and 27 N., R. 116 W., and the land plats show the townships to be regular, it did not seem advisable to distribute the extra mile or carry it over into the townships to the west. It was therefore placed in the west tier of sections in Tps. 26 and 27 N., R. 116 W., making these 2 miles wide. The surveys of Tps. 26, 27, and 28 N., R. 119 W., and of what is known east of them indicate that part of this discrepancy may lie in Tps. 26 and 27 N., Rs. 117 and 118 W., as well as in R. 116 W. In fact, Tps. 26 and 27 N., R. 116 W., may be regular and their west boundary may have the same offset as their east boundary. No land lines were run over the range to determine this, however, as this region is outside the area of coal of economic importance.

ACKNOWLEDGMENTS.

In the base map all available data, whether in the form of manuscript, blue prints, copies from the original sheets, or published maps, have been incorporated, although some of them have been slightly modified by field work. The railroad maps and profiles along the line of surveys in the northern part of the area have been regarded as correct; certainly they are the most accurate in the area.

The writer desires to acknowledge his indebtedness to the Chicago, Burlington & Quincy Railroad Co., Lew Henderson, W. H. Newbrough, the Oregon Short Line Railroad Co., and Walter C. Wright for assistance in various ways; to P. J. Quealy, manager of the Kemmerer Coal Co., Frontier, Wyo., for plats of the mines at Frontier, just south of the area surveyed, and for general assistance in carrying on the work; and especially to C. D. Walcott, T. W. Stanton, F. H. Knowlton, and George H. Girty for paleontologic determinations.

The field party of 1906 comprised five men: E. Eggleston Smith was chief assistant, Berthold A. Iverson and Hugo C. Schleuter were aids and helpers, and William H. Longhurst was cook and teamster. Mr. Smith's assistance, both in the field and in the office, has contributed greatly to the value of this report.

GEOGRAPHIC AND GEOLOGIC EXPLORATIONS.

HAYDEN SURVEY (1868-1878).

Members of the Hayden Survey began work in the region south of this area as early as 1868 and continued it in 1870 and 1871, but no work was done in this exact locality until 1872. The Hayden Survey worked in the district in 1872, 1877, and 1878. In 1872 one of Hayden's parties (the Snake River division) under the direction of James J. Stevenson, with Frank H. Bradley as geologist, went from Ogden, Utah, to Fort Hall, Idaho, up the east side of Snake River to the Teton Basin, up Henry Fork, and across the watershed by way of Targee Pass to the Madison Valley, up Madison River to the Firehole Basin, up Madison River, and over the divide into the headwaters of Snake River, down that stream to Jackson Lake, down Snake River across the northwest corner of this area to Fort Hall, where the party disbanded. Thus only a very small portion of the area was examined in 1872. In the same year Cope conducted an expedition from a point on Green River 17 miles above Green River City up Green River to the mouth of Labarge Creek; returning a short distance south, he ascended Fontenelle Creek nearly to its source in the outlying ranges in the mountains; then he descended Hams Fork to the Union Pacific Railroad, and returned to Bridger. Other special expeditions were made to the region around Evanston, Wyo., where fossils were collected in the Wasatch group between Hilliard and Evanston, near the present railroad bridge over Bear River.

In 1873 Capt. W. A. Jones, of the Engineer Corps, United States Army, in command of the expedition that made a reconnaissance survey in northwestern Wyoming, including Yellowstone National Park, passed this area on the east and north. Theodore Comstock was attached as geologist to this expedition, and the map accompanying his report indicates the occurrence and distribution of the geologic formations over the eastern section of the area between Snake and Green rivers.

In 1877 Peale and Gannett, of the Green River division of the Hayden Survey, mapped geologically and topographically, on a scale of 4 miles to an inch, contour interval 200 feet, all the region in the vicinity of Hams Fork, between the northern boundary of the survey of the fortieth parallel (King Survey) and the forty-third parallel, a few miles south of Snake River. In the same year St. John and Bechler, of the Teton division of the Hayden Survey, mapped geologically and topographically, on a scale of 4 miles to an inch, contour interval 200 feet, 6,000 square miles of the 11,000 square miles of territory lying between meridians 109° 30′ and 112° and parallels 43° and 43° 15′.

In 1878 Wilson completed the primary triangulation over the entire area north of the tract surveyed in 1877. St. John and Clark, of the Wind River division of the Hayden Survey, mapped geologically and topographically, on a scale of 4 miles to an inch, contour interval 200 feet, most of the territory not surveyed in 1877 by St. John and Bechler.

PRESENT PERIOD (1881-1906).

Although the United States Geological Survey took up the work of the older organizations, practically no work was done in this area until 1905, when A. C. Veatch[1] examined the coal and oil fields of southwestern Uinta County, Wyo. Work had been done in the region south of this by Ward in 1881, by C. A. White in 1885, by C. A. White and T. W. Stanton in 1891, by T. W. Stanton and F. H. Knowlton in 1896, whose studies had yielded some very important geologic results. The determination by T. W. Stanton of the true stratigraphic position of the Bear River formation at the base of the marine Cretaceous and underlying the Colorado group was not restricted to the stratigraphy of the small locality in southwestern Wyoming, where the work was done, but applied equally to this area. Most of the geologic data concerning this field that have been obtained during the present period are shown by G. E. Bailey, former State geologist of Wyoming, on his economic geologic map of 1885; by W. C. Knight, State geologist of Wyoming, in 1900, in his reconnaissance map of Wyoming; by L. S. Storr on his map of the Rocky Mountain coal field in 1902; and by L. W. Trumbull on his map of the Wyoming coal-bearing area in 1905. Although these reports show many distinct advances in the geology and cartography of this region, they are based primarily on the Hayden maps and show clearly that they are compilations modified to fit the facts suggested by later work in other localities.

During this period (1881 to 1906) coal mines were opened just south of this field at Twin Creek and Adaville, but were abandoned in a few years. The coals at Frontier and in its vicinity were first worked in the early nineties, and owing to the building of the Oregon Short Line Railroad and the high quality of the coal were rapidly developed. There are now important mines at Frontier, Diamondville, Oakley, Glencoe, and Cumberland. The mine at Frontier is about 6 miles south of the south boundary of this area. The Kemmerer Coal Co., soon after opening the mine at Frontier in 1897, spent some time in prospecting coal beds on Willow Creek north of Frontier, in the southern part of this field, in an effort to find coking coal. Thus far no real development work has been done on any of the coal beds in this area.

[1] Veatch, A. C., Geography and geology of a portion of southwestern Wyoming, with special reference to coal and oil: Prof. Paper U. S. Geol. Survey No. 56, 1907.

GEOGRAPHY.

GEOGRAPHIC POSITIONS.

The longitude, latitude, and altitude of several points near and within this area, together with descriptions of the triangulation stations, are given below. The determinations of A. D. Wilson, of the Hayden Survey of 1877 and 1878, are also given for the purpose of comparison, as the triangulation and level control of Wilson's survey were used as control in making the topographic map accompanying this report.

Geographic positions in Lincoln County, Wyo., near or within the area discussed in this report.

	Latitude.			Longitude.			Altitude.
	°	′	″	°	′	″	Feet.
Medicine Butte [a]	41	21	9.9	110	54	26.39	8,742
Medicine Butte [b]	41	21	6.5	110	54	42.5	8,769
Wyoming Peak (two quadrangles south of Grand Teton) [b]	42	36	14.9	110	37	39.7	11,490
Fremont Peak (Fremont Peak quadrangle) [b]	43	07	28.5	109	37	17.3	13,790
Fremont Peak (Fremont Peak quadrangle) [c]	..	..	....	...	..	.....	13,730
Gannett Peak (Fremont Peak quadrangle) [c]	43	11	05.8	109	39	09.3	13,785
Kendall Peak (Fremont Peak quadrangle) [c]	43	11	08.8	109	54	27.3	11,070
Hoback Peak (quadrangle south of Grand Teton) [c]	43	05	06.8	110	34	06.2	10,830
Hoback Peak [b]	43	05	04.2	110	34	27.3	10,990
Mount Baird (south of Grand Teton) [b]	43	21	46.7	111	05	54.8	9,990
Grand Teton (Teton quadrangle) [d]	43	44	30.8	110	40	3.4	13,747
Grand Teton [b]	43	44	29.6	110	48	22.8	13,691

[a] Bull. U. S. Geol. Survey No. 181, 1901, p. 195; Twentieth Ann. Rept. U. S. Geol. Survey, pt. 1, 1899, p. 277.
[b] Determinations of A. D. Wilson, of the Hayden Survey, in the primary triangulation in 1877 and 1878: Eleventh Ann. Rept. U. S. Geol. and Geog. Survey Terr., 1879, p. 661; also Twelfth Ann. Rept. Geol. and Geog. Survey Terr.
[c] U. S. Geol Survey manuscript notes.
[d] Twenty-first Ann Rept. U. S. Geol. Survey, pt. 1, 1900, pp. 298, 300, 302, 304.

Medicine Butte: Station on a butte of the same name (also called Almy Mountain) a few miles east of Almy, about 6 miles north of Evanston. Station mark: Copper bolt cemented in limestone rock on the summit; reference point, a rock monument 3.8 point, the true azimuth of which is 173.

Fremont Peak (not occupied): A well-known peak of Wind River Mountains and the third highest peak in Wyoming. The most prominent and conspicuous peak of the Wind River Mountains, as viewed from the south or west from the Green River Basin. First climbed by Frémont's party in 1842.

Gannett Peak (not occupied): Highest peak in Wyoming. Most prominent peak of Wind River Mountains, as viewed from the north and east; from south and west not conspicuous; view cut off by Fremont Peak.

Kendall Peak, Fremont County: High north end of a rocky ridge at the head of New Fork of Green River; about 6 miles east of Horchin's ranch on Green River. On account of fallen trees and steep rocky slopes the station is difficult to reach. Station mark: Bronze tablet cemented into a large bowlder over which a rock monument was built.

Hoback Peak (not occupied): Prominent peak on the Hoback Range between the headwaters of Little Greys and Fall rivers.

Grand Teton (not occupied): Second highest peak in Wyoming. A well-known peak about 55 miles east of Market Lake, Idaho, from which it is plainly visible. Station mark: Flag erected by Owens's party, which first climbed the peak in 1897. Gannett Peak, in the Wind River Mountains, is 38 feet higher than Grand Teton.

TOPOGRAPHY.

RELIEF.

The entire area except a narrow strip along the eastern part is a succession of rugged mountain peaks and ridges cut by numerous gorges and canyons, whose sides in many places are nearly perpendicular. The altitudes range from 5,700 feet on Snake River to 11,500 feet on the crest of the mountains. In the vicinity of the canyon of Sheep Creek, a tributary to Greys River, where the topography is the most rugged, there is a difference in altitude of 3,000 feet in less than half a mile in horizontal distance.

The area is traversed from west of north to east of south by two somewhat parallel mountain ranges, the Salt River Range and the Wyoming Range.

The Salt River Range, with an escarpment along its east side, forms the main topographic feature on the west. It is rough and rugged and reaches its maximum altitude in Wagners Peak, 10,809 feet above sea level. Throughout most of its extent it forms the divide between the two important southern branches of Snake River, Salt River on the west and Greys River on the east, the latter cutting across the range just before joining the Snake. The range extends to Snake River, north of which it is known as the Snake River Range. To the south it is prolonged in two ranges that form the divide between the tributaries of Bear and Green rivers. The principal passes of the Salt River Range from south to north are (1) Wagner Pass, near the south end a few miles southeast of Mount Wagner, through which the Lander road crosses the range; (2) McDougal Pass, through which the Star Valley trail crosses the range and which, though high, is not difficult for pack animals; (3) Stuart Pass, through which the Stuart trail crosses the range from Greys River valley to Strawberry Valley; (4) a pass through Greys Canyon along Greys River; (5) a pass at the north end of the range, formed by the canyon of the Snake. Several trails that serve more or less as cut-offs to the main trails cross the range at various points and are sometimes used by sheepmen, cattlemen, and hunters.

A short distance south of Mount Wagner the Salt River Range is divided into two distinct ranges, the west ridge lying between Bear River and Hams Fork developing into Tump Range, and the east ridge with the escarpment along the east side (a continuation of the escarpment along the east base of Salt River Range) forming the divide between Fontenelle Creek and Hams Fork, where it is known as Absaroka Ridge. Still farther south Absaroka Ridge loses its topographic importance and is deeply buried by the Tertiary rocks north of Hams Fork. East of the Salt River Range, between Greys River and the tributaries of Little Greys River, a short range, known as Greys Ridge, parallels the Salt River and Wyoming ranges.

The Wyoming Range, lying for the most part 8 to 10 miles east of Salt River Range and parallel to it, forms one of the main topographic features of the district. Along its east side the range presents an abrupt base with basset edges of limestone strata dipping west. The main portion of the range is about 60 miles long and from 6 to 10 miles wide. The topography is rugged and mountainous, with peaks ranging in altitude from 10,000 to 11,490 feet (Wyoming Peak).

The Wyoming Range is crossed by Snake River between the mouth of Bailey Creek and the mouth of Fall River, north of which it either loses its topographic distinctness or becomes part of the Snake River Mountains. At its north end it is a single distinct ridge, but to the south it greatly widens and north of Sheep Creek forms two nearly parallel ridges in many localities connected by spurs. On the east ridge are Mount Lander and Mount Darby; the west ridge forms the divide between Greys River and the tributaries of Green River. Both of these ridges reunite in a common point near the Lander road south of South Piney Creek.

Sheep Creek is the only stream that cuts across both the east and the west ridges, and at the intersection the range loses some of its escarpment characteristics. North of Sheep Creek several of the tributaries of Greys River cut across the range, the most striking example being Little Greys River, whose waters come from the west slope of the Hoback Range. The principal passes are (1) Thompson Pass, at the south end, through which the Lander road crosses the range at the head of the south branch of Piney Creek; (2) McDougal Gap, at the head of North Cottonwood Creek, through which the Star Valley trail, at one time the important trail of the Shoshone and Bannock Indians, crosses the range; (3) Greys Gap, through which the Fall River trail and the Cliff Creek trails, after uniting, cross along the north bank of Little Greys River; (4) Willow Creek Gap, through which the Willow Creek trail crosses the range and unites with the trail passing down Little Greys River; (6) Snake River valley, at the north end of the range. Several minor trails lead across the range at other places, but they are only occasionally used.

South of South Piney Creek the continuation of the Wyoming Range forms a broad table-land, known as the Thompson Plateau, which ranges in altitude from 10,000 to 10,300 feet. This plateau has steep cliffs facing the west and a gentle slope on the east formed by the Tertiary formations lapping over the older rocks. South of Labarge Creek Thompson Plateau passes into Meridian Ridge, which declines in altitude from 10,000 feet at the north end to 8,000 feet at the south end, near which it loses its topographic importance and is deeply covered by Tertiary rocks. Meridian Ridge, although controlling to a large extent the arrangement of the drainage, lies entirely in the Green River drainage basin and is cut nearly at right angles by deep canyons of three of the principal tributaries of that stream—Labarge, Fontenelle, and Slate creeks. West of Meridian Ridge and Thompson Plateau, a series of pronounced hogbacks, the most marked of which is East Oyster Ridge, are produced by the hard beds of rock.

Along the east base of Absaroka Ridge similar hogback ridges, the most pronounced of which is West Oyster Ridge, are partly covered by talus from Absaroka Ridge and are of minor topographic importance. East Oyster Ridge and West Oyster Ridge join between Labarge and Fontenelle creeks. Between the two Oyster ridges a broad valley, known as Mammoth Hollow or Pomeroy Basin, forms the northward continuation of Mammoth Hollow, near Cumberland, Wyo.

The area examined terminates along the south base of the Gros Ventre Mountains, which extend from Jackson Hole southeast to Wind River Range nearly opposite the mouth of Green River canyon. The crest of the range is nearly uniform in height, averaging about 11,000 feet, the highest point being near the east end a few miles northwest of Gros Ventre Peak, where the altitude reaches a maximum of 12,200 feet. This range forms the divide between Fall River and Gros Ventre River, both tributaries of Snake River.

South of the Gros Ventre Mountains for about 30 miles the Hoback Range averages from 4 to 6 miles in width. At its north end it has an altitude of about 10,000 feet, but south of Fall River canyon it gradually rises and finally culminates in Hoback Peak at an altitude of 10,818 feet. South of Hoback Peak the range is less prominent, passes into a low anticlinal ridge whose topographic features are more or less obliterated by the Tertiary covering that in many places conceals the older rocks, and finally terminates abruptly against the north face of Thompson Plateau. A few miles south of Fall River canyon the range has a double crest, the eastern and more prominent ridge forming the divide between Cliff and Willow creeks, and the western ridge forming a huge buttressed spur with outlying eminences but little inferior in height to the main ridge. In many places the east ridge presents an abrupt escarpment about 500 feet high.

East of Cliff Creek is Cliff Creek Ridge, an outlying ridge parallel with and in a way a part of the Hoback Range. This ridge lies about 4 miles east of the Hoback Range and is persistent for 10 or 12 miles south of Fall River, but farther south it is enveloped by Tertiary rocks, which here extend high on the eastern flank of the Hoback Range.

The Hoback Range forms the drainage divide only locally. The rivers, flowing east into Green River between Thompson Plateau and Horse Creek, cut across it nearly at right angles, and nearly all its northern portion lies in the drainage basin of Fall River. Fall River cuts across the range at two places: South of Hoback Peak it occupies a deep canyon nearly at right angles to the range (which presents from either side a very broken appearance with steep and even precipitous walls), and about 20 miles farther north it again crosses in a narrow defile closely hemmed in by mountain slopes with mural escarpments several hundred feet high. Six miles north of Fall River canyon the Hoback Range is crossed by Horse Creek, a small tributary of Snake River, which rises on the southern slope of the Gros Ventre Mountains. The topographic features along this canyon are much the same as those along Fall River.

East of the Hoback, Wyoming, and Meridian ranges is the great plainlike area of the Green River basin, whose mean altitude is about 7,500 feet. The coal field lies along the western margin of the Green River basin, and in places the mantle of Tertiary rocks extends high up on the ranges, indicating that the horizontal Tertiary beds are in many places worn away and the underlying highly inclined beds exposed. The prevailing difference in dip in the Tertiary and the older formations has resulted in two very different types of topography. The horizontal beds produce relatively flat, table-like forms, many of which are bounded by escarpments of considerable length, and the streams show characteristic dendritic forms. On the other hand, the steeply dipping harder layers of the older rocks produce long hogback ridges and corresponding parallel valleys wholly different from the irregularly distributed hills and valleys in the younger rocks. So striking is this difference that an observer can tell at a glance whether the topographic features of any given place are carved from the younger or the older rocks.

A notable example of the topographic expression of the older rocks occurs about 8 miles east of Meridian Ridge and Thompson Plateau, where Labarge Ridge, which rises out of the Tertiary, can be recognized for miles as being carved in beds of older rock. Labarge Ridge is 1 to 2 miles wide, about 18 miles long, and in many places its crest is no higher than the Tertiary beds on either side. Four streams, the largest of which is Labarge Creek, cut across the ridge. (See Pl. I in pocket.)

The relatively horizontal Tertiary formations near the northern end of the area form the divide between Green River and Fall River. The present divide in this locality is located on what was once a deep depression, which has since been filled with Tertiary deposits. The divide between the Green River and Snake River drainage basins cuts across the various mountain ranges in a very irregular manner and separates the field into two approximately equal parts.

DRAINAGE.

The drainage in this region belongs to three great systems—Snake River, whose waters flow to the Pacific; Green River, whose waters flow to the Gulf of California; and Bear River, whose waters enter Great Salt Lake.

The only tributary of Bear River in the area is Smith Fork, which drains a small region southwest of Salt River Range in the southwest corner of the field.

The streams that drain to Green River are Hams Fork, Slate Creek, Fontenelle Creek, Labarge Creek, Dry Piney, South Piney, Middle Piney, South Cottonwood, North Cottonwood, Horse, and Beaver creeks. Most of them, like Smith Fork, are fairly large clear mountain streams with sufficient water to irrigate much of the bottom lands along their courses. The largest of the streams is Hams Fork. Hams Fork and Labarge and Fontenelle creeks have been utilized to float mine timber and logs down from the mountains.

The largest stream is Snake River, which flows across the northwest corner of the field and cuts the Wyoming and Salt River ranges. Its principal tributaries in this region are Salt River, Greys River, and Fall River; the last named cuts the Hoback Range twice in narrow defiles which exhibit essentially the same features as Snake River canyon. Several small streams flow into Snake River, the most important being Bailey and Horse creeks. All the Snake River tributaries are mountain streams, but as most of them are within the national forest and have little bottom land along their courses very little of their water is used for irrigation. Some of the water from these streams has been utilized in mining on Snake River. In places along most of these mountain streams the hills recede short distances and inclose little parks that contain good agricultural land. Terraces occur in places along most of the streams and on some of them as many as six were observed, some of them not more than 5 or 10 feet apart.

ALTITUDES.

On the topographic map the approximate altitudes are indicated by 100-foot contours. Along the line of the railroad survey, shown by the single black lines along Fall and Snake rivers, the contours give the altitudes as determined by these surveys. Broken contours have been taken from the map of the Hayden Survey and modified by more authentic data. The altitudes of the three highest peaks in this general region are Gannett Peak, 13,785 feet; Grand Teton, 13,747 feet; and Fremont Peak, 13,730 feet.

RAILROAD AND STAGE ROUTES.

No railroad line has been built in the area, the nearest being the Oregon Short Line, which passes through Kemmerer, 6 miles south of the southern boundary. The St. Anthony branch of the Oregon Short Line passes about 80 miles west of the northwest corner.

A stage leaves St. Anthony, Idaho, daily except Sunday, and goes via Teton Pass to Jackson, Wyo., a distance of about 80 miles. Two days are required for the trip.

From Kemmerer, Wyo., a stage leaves daily except Sunday for Pinedale, Wyo., requiring two days for the trip. The route followed crosses the southeastern part of the area and skirts the eastern margin along Green River, passing Slate Creek, Palisade, Labarge, Midway, Big Piney, Ball, Daniel, Burns, and Pinedale on the way northeast from Kemmerer. This stage line makes Kemmerer the main supply station for all the upper Green River basin and for the Fall River basin east of the Hoback Range.

There are only three practical railroad routes across this country. The best one passes south of Meridian and Absaroka ridges and was in part surveyed in 1886 by the Wyoming & Eastern Railway Co. It runs down Big Sandy River, thence across Green River near the mouth of Slate Creek, up that creek a short distance, crosses the southeastern corner of the field in T. 22 N., Rs. 113 and 114 W., and connects with the Oregon Short Line in the vicinity of Old Hams Fork, a short distance west of Kemmerer.

A second route, which has never been surveyed, but along which a road might be built at great expense, leaves Green River basin near the mouth of Labarge Creek, follows up Labarge Creek nearly to its headwaters, crosses the divide at the south end of the Salt River Range, and thence goes along Star Valley, or, at a somewhat greater expense, it might follow somewhat closely the Lander road; this, however, would necessitate another tunnel through the divide between South Piney and Labarge creeks. It is not probable that a line will ever be built along either of these routes, for, so far as the mineral deposits in the southern part of the district are concerned, it would be more economical and much more serviceable to build a spur from the Oregon Short Line north from Kemmerer up Mammoth Hollow or Willow Creek along the strike of the coal-bearing beds as far as the headwaters of Fontenelle Creek, or possibly of Labarge Creek. A preliminary survey has already been made along this route as far north as the Willow Creek prospect, in the southern part of the district. The coal east of Meridian Ridge along the east base of the Labarge Range could best be reached by a spur from some point on the Oregon Short Line or from some other line extending up Green River.

The third route crosses the northern part of the area along Snake River. A survey has been made, but whether the line will be built along Fall River across the divide into Green River basin, or pass north of the Gros Ventre Mountains along Gros Ventre River or Buffalo Fork to connect with the Wyoming & Northwestern Railroad, or cross the Continental Divide and continue eastward down Wind River remains to be seen. In 1890 the Nebraska & Wyoming Railroad Co. made a survey along the Fall River route. The survey led up Green River to the mouth of the Middle Beaver, up this stream across the divide into Fall River basin, and thence down Fall and Snake rivers into Idaho. The location of the line of survey in this field is shown on Plate I (in pocket) by the single black line along Fall and Snake rivers. Although a steep grade would be required in crossing the divide between Fall and Green rivers, the route would give a good road, which would be within a short distance of all the important coal beds in the northern part of the field. With a few spurs it could readily reach all the coal beds east of Wyoming Range, including those of Willow Creek, a tributary of Fall River, which rank as high in quality as the Frontier, Willow Creek, and Cumberland coals of Lincoln and Uinta counties. The coal beds along Greys River and its tributaries could probably be reached from this road by way of Greys Canyon or by way of Bailey Creek west of the Wyoming Range. In 1905 the Idaho & Wyoming Railway Co. surveyed a line from Jackson, Wyo., down Flat Creek and Snake river, connecting with the St. Anthony branch of the Oregon Short Line just north of Idaho Falls, Idaho; its location is shown on Plate I by a single line along Snake River. The Wyoming & Northwestern Railroad surveyed a line in 1905 up Wind River and across the Divide into Buffalo Fork, thence down this stream to Snake River, and up Snake River to the vicinity of Yellowstone National Park. The completion of these two projected railroads would entirely alter economic conditions in the northern part of this field, materially increase the population of Jackson Hole, and tend to make that district popular as a summer-resort country as well as a center of mining activities.

GEOGRAPHIC NAMES.

In the development of a country the names applied to mountain ridges, streams, and other geographic features are often changed. To this rule the area here treated is no exception, although the changes are not so numerous as in some other localities. The early fur traders as well as the Indians had names for most of the more important streams, ridges, and passes, but many of these names have been lost and only a few have become permanent. Other names given by later explorers have had no better fate. Lander, in 1857 and 1858, gave names to the most important streams, and many of these names have persisted. The Hayden Survey named most of the important ridges, and most of these names are still in use, although some of them have been modified and restricted. The Hayden Survey changed the name of John Greys River as shown on Wagner's map to John Days River, but this change has never been accepted, and everywhere in Lincoln County this stream is now known as Greys River.

The topographic features for which different names are known to have been recorded in print are listed below. The first column gives the name at present used in this region, and the second column the names used on earlier maps, with reference to the publication in which they were used, thus enabling easy correlation to be made with former maps. For most names only one reference is given, although the same name may occur in several reports or publications. The references are abbreviated in the list, but full titles are given with corresponding numbers in the bibliography that follows the list.

Changes of geographic names in Lincoln County, Wyo.

Present name.	Former name.
Bear Mountains	Prices Range, Salt River Range, Wyoming Range; Warren's map (1).
Cottonwood Creek	Marsh Creek; Hayden's map (2).
Dry Piney Creek	Feather Creek; Hayden's map (2).
Fall River basin	Hoback Basin; Hayden report, vol. 12, pt. 1 (3). Hoback River and Basin were named for one of Hunt's guides, formerly a trapper in Henry's party.
	Jacksons Little Hole; Lander and Wagner's map (4).
Fish Lake	Alice Lake (named after Mr. Gannett's daughter Alice); Hayden's map (2).
Grand Teton	Three Tetons, Trois Tetons; Parker's Rocky Mountain report (5), 1838, p. 82.
	Grand Teton, Pilot Knobs; Irving's report (6), Astoria, vol. 1, p. 280.
Green River	Sisk-aa-dee-wazh-e (=Prairiehen River), the headwaters of the Colorado, generally called Green River; Washington Hood's report (7).
Greys River	Upper Green River (= Spanish River, from information given by the Indians that Spaniards resided upon its lower waters); Irving's report (6), Astoria, vol. 1, p. 280.

Present name.	Former name.
Greys River (continued)	Seeks-ke-de; Captain Bonneville's adventures, by Irving (8), vol. 1, p. 104; also Colorado River, Irving (8), vol. 2, p. 134.
	John Grey's River; 35th Cong., 2d sess., S. Ex. Doc. 36, p. 33, also Lander's map (5).
	John Day's River; Hayden's maps (2) and Land Office maps.
Gros Ventre Mountains	Wyoming Mountains; W. A. Jones's report (9).
Hams Fork Plateau	Hams Fork Mountains, divide between the waters of Green and Bear rivers; Hayden report, vol. 7 (2, 10).
Hoback Anticline	Meridional Fold; Hayden report, vol. 11 (10), Pl, LIII, p. 540.
Hoback Range	Hoback Canyon Ridge, Wyoming Range; Hayden's reports and maps (2, 10).
Landers Peak	Volcanic Cone, Hayden's report (2, 10).
Landers Road	New Emigrant road; Wagner and Lander's map (4).
	Cut-Off; Peale's maps (2) and Hayden reports (10).
	Lander Trail; Land Office plats and township maps.
Lander Syncline	Meridional Valley; Hayden report, vol. 11 (2, 10); Pl. LIII, p. 540.
Meridian Ridge	Green River Mountains west of Green River, including Oyster Ridge and Fontenelle hogbacks; Cross's report, pp. 59, 61.
	Meridian Ridge; Hayden's maps and reports (2, 10).
Middle Piney Creek	Lake Creek; Hayden report, vol. 12 (3).
Montpelier Creek	Davis Creek, Tulick's Fork; Hayden (2) and Wagner and Lander's maps (4).
Muddy Creek	White Clay Creek; Hayden's maps and reports (2, 10).
North Piney Creek	Bitterroot Creek; Wagner's map (4).
Salt River Range	Wyoming Range; Hayden report, vol. 12 (3), pt. 1, p. 178.
	Wasatch Range; Wagner and Lander's map (4).
Sheep Creek	McDouglas Creek; Hayden's map (2).
Snake River	Lewis River; Hood's report (7), p. 29, 35th Cong., 2d sess., S. Ex. Doc. 36, p. 33.
	Lewis Fork; Warren's map (1).
	South Fork of Snake River; Warren's map (1).
	Mad River; Astoria (6), vol. 1, p. 285.
South Piney Creek	Piney Creek; Wagner's map (4).
South Beaver Creek	Lead Creek; Wagner's map (4).
South Cottonwood Creek	Lander Creek; Hayden's map (2).
South Horse Creek	Lynx Creek; Hayden's map (2).
Sniders Basin	Fort Piney. Approximate location of old fort during construction of Landers Road or Cut-Off.
Sublettes Road	Sublette Road; Wagner's map (4).
	Sublette Cut-Off; Land Office plats.
	Overland Road; Hayden's map (2).
Twin Creek	Tolos Fork; Wagner's map (4).
Tosi Creek	Onion Creek (tributary to Green River); Wagner's map (4).
Willow Creek	Crow Creek; Wagner's map (4); Hayden report, vol. 12 (3).
	Lower South Fork; Hayden report, vol. 12 (3), pt. 1, p. 190.

Present name.	Former name.
Wyoming Range...........	John Day's Ridge; Hayden report, vol. 12 (3), pt. 1, p. 179.
	Wasatch Mountains; Lander report, 35th Cong., 2d sess., S. Ex. Doc. 36 (4), pp. 47–73, refers to the Wasatch Mountains, that portion of the Wyoming Range between Piney Creek and Labarge Creek and from Piney Canyon west to Salt River.
	Hoback Canyon Ridge (considered part of Wyoming Range); Hayden report, vol. 12 (3), pt. 1, p. 179.

The titles of the publications cited in the foregoing list are given in fuller form below, to aid in identification. The numbers correspond to the numbers in parentheses used in the list.

1. Warren, G. K., Map of the Territory of the United States from the Mississippi to the Pacific Ocean to accompany the reports of the explorations for railroad route, 1854–1857: S. Ex. Doc. 1861, 36th Cong., 2d sess.
2. Hayden, F. V., Map of western Wyoming, southwestern Idaho, and northeastern Utah: Twelfth Ann. Rept. U. S. Geol. and Geog. Survey Terr., 1883.
3. Hayden, F. V., Report on the geology of the Wind River district by Orestes St. John: Twelfth Ann. Rept. U. S. Geol. and Geog. Survey Terr., pt. 1, 1883, pp. 175–271.
4. Lander, F. W., and Wagner, W. H., Preliminary map of the central division, Fort Kearney, South Pass and Honey Lake wagon road, surveyed and worked under the direction of F. W. Lander: S. Ex. Doc. 36, vol. 10, 1859, 35th Cong., 2d sess.
5. Parker, Samuel, Journal of an exploring tour beyond the Rocky Mountains under the direction of the American Board of Commissioners for Foreign Missions, performed in the years 1835, 1836, and 1837, containing a description of the geography and geology, climate and productions, and the number, manners, and customs of the natives, Ithaca, N. Y., 1838, pp. 82–88.
6. Irving, Washington, Astoria, or Anecdotes of an enterprise beyond the Rocky Mountains, vols. 1 and 2, Philadelphia, 1836.
7. Hood, Washington, Map exhibiting the practical passes of the Rocky Mountains, together with topographical features of the country adjacent to the headwaters of the Missouri, Yellowstone, Salmon, Lewis, and Colorado rivers (unpublished), Office of the Chief of Engineers, War Dept., Washington, D. C.
8. Irving, Washington, The Rocky Mountains, or scenes, incidents, and adventures from the journal of Capt. B. L. E. Bonneville, vols. 1 and 2, Philadelphia, 1837.
9. Jones, W. A., Maps of the military department of the Platte, Wyo. (several sheets), compiled under the direction of Capt. W. A. Jones, Corps of Engineers, Omaha, Nebr., 1874.
10. Peale, A. C., Report on the geology of the Green River district: Eleventh Ann. Rept. U. S. Geol. and Geog. Survey Terr., 1879, pp. 673–710.

CLIMATE.

The location of the area in the central part of the western mountain region at an altitude between 5,700 and 11,500 feet above sea level gives it a semiarid and semiboreal climate, with a wide range in temperature and precipitation, varying somewhat with the altitude in the different parts of the field.

ARABLE LAND.

On account of the small precipitation, the land in this area is of agricultural value only where water for irrigation can be obtained. As only a small amount of water is available and most of this is already appropriated and used on the bottom lands along the various streams, little more land suitable for farming is obtainable. If all the available land along the stream bottoms was irrigated the water would be exhausted on all the streams with the possible exception of Fall, Greys, and Snake rivers. The land which is irrigated at present, as well as that which in the future may be irrigated by the remaining available water and the areas within the forest reserve where water is plentiful and irrigation possible, represents approximately 2 per cent of the whole. This does not include land that might be irrigated by building storage reservoirs near the headwaters of the various streams.

The main sources of the water for irrigation are in side streams that rise in the mountains and flow into Green and Snake rivers. Most of the streams east of the mountains flow on or near the surface of the plains, and their water can be carried laterally far enough to cover the areas along the stream bottoms, most of which are sufficient to absorb all the water available. Of this type are the tributaries of Fall River above the canyon, Hams Fork, South Beaver, Middle Beaver, North Cottonwood, South Cottonwood, North Horse, South Horse, North Piney, Middle Piney, South Piney, Dry Piney, Labarge, Fontenelle, and Slate creeks. On most of these streams the irrigable area is a strip along the stream one-eighth of a mile to 1 mile in width. These areas necessarily include the best pasture tracts, the land back from the bottom lands remaining a sage-brush desert with scattered grasses. The more common crops are grass, alfalfa or lucerne, wheat, oats, barley, flax, potatoes, and garden truck. Sugar beets are raised extensively in Idaho on the Snake River bottoms and probably could be cultivated to advantage on the bottom land in Jackson Hole.

Jackson Hole, the south end of which lies in this field, is an extensive valley of fertile land traversed by Snake River and numerous creeks. Prior to 1871 this great valley was practically unknown to others than the hardy trapper and prospector and it was not suspected that farms would so soon cover its fertile expanse. The soil of Jackson Hole is a rich sandy loam. The principal crops produced are native hay and tame grasses, but vegetables and small fruits are raised in sufficient quantities to supply all local demand. All kinds of cereals will mature, and although the approximate elevation of the valley is 6,200 feet above sea level, the surrounding mountains protect it from the killing winds and insure its becoming one of the agricultural districts of Wyoming.

The stock raised here consists entirely of cattle and horses. Owing to the location and the climatic conditions, the valley is not a good place for sheep, and thus far the sheepmen have kept out. The stock is generally fed and sheltered during the more inclement part of the winter. All the cattlemen have become well to do and have built large irrigation canals, comfortable residences, and large barns.

Star Valley, part of which is shown on Plate I, is traversed by Salt River, Cottonwood Creek, numerous mountain streams, and many large canals and laterals. The population is about 3,000. The people, mostly Mormons, are thrifty and prosperous. They raise timothy, alfalfa, hay, oats, barley, and winter wheat, large crops of potatoes, and garden truck. In agricultural wealth and in ranches for cattle the inhabitants rival the people of Uinta County and the eastern portion of Lincoln County. In this valley several creameries have been established and their products have become famous throughout the West. They not only supply local demand, but ship butter and cheese to Butte, Anaconda, Helena, and cities and towns in Oregon and Washington. Outside of the small irrigated areas along the creeks and bottom lands the greater part of the broad valley has agricultural value only as grazing land.

VEGETATION.

Owing to the climate and the geographic position of this area, the range in vegetation is wide. Its general character is best represented by the views accompanying this report. The timber tracts are very irregular, but nearly all of them lie within national forests. Outside of the forests the vegetation along the streams consists of patches of wild grass which is occasionally cut for hay or is otherwise used for grazing. A sparse growth of bunch grass affords a relatively fair range throughout the hills. Along the streams are willow, quaking aspen, cottonwood, and hawthorn trees. Quaking aspen are irregularly distributed, but generally grow near the head or on the sides of deep valleys. These, together with the rock cedar, which grows sparingly over part of the area, are used to some extent for fences, posts, and firewood. Some of the ridges bear irregular small patches of pine and fir, but most of the area outside of the national forests is barren.

Within the national forests the vegetation is more abundant and more diversified. In many places lodgepole pine, balsam fir, jack pine, red fir, spruce, and Englemann spruce grow luxuriantly.

Practically all the timber in the area grows in the Teton National Forest. The prevailing species are red fir, lodgepole pine, Englemann spruce, balsam fir, and quaking aspen, with scrub alpine fir and limber pine at the extreme upper limits of tree growth, a small amount of cottonwood along the banks of some of the larger streams, and some scattering rock cedar on southern and western exposures below 7,000 feet. (See Pl. II.) The commercial timber is of three main types—lodgepole pine, commonly growing on areas once denuded by fire; red fir, generally growing on western and northern exposures; and mixed red fir, lodgepole pine, spruce, and balsam fir, growing on northern and western exposures and in the bottoms of deep, narrow canyons, where soil and moisture are most favorable.

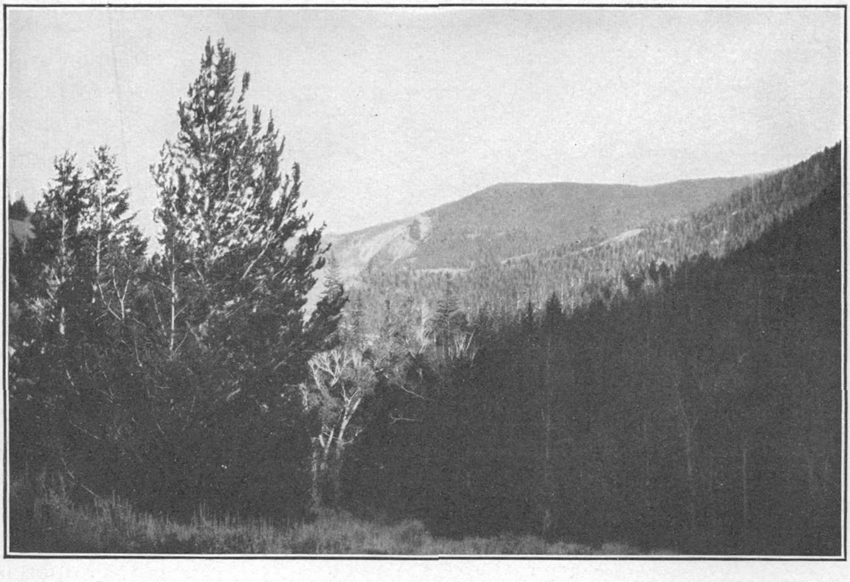
One of the most heavily forested areas in the national forest south of the ninth standard parallel lies on the east slope of the Salt River Range and Absaroka Ridge, extending from the crest of the range to Greys River. This almost unbroken timber belt is approximately 10 miles wide and extends north to and includes a portion of T. 35 N., R. 117 W.

Most of the portion of the Teton National Forest around the headwaters of Labarge Creek and Greys River in Tps. 29, 30, 31, and 32 N., Rs. 115 and 116 W., is well timbered, though large areas have been burned and the country in many places is covered with fallen timber. Sheep have grazed over this area for several seasons. The portion of the national forest east of Greys River along the Wyoming Range in Tps. 33, 34, 35, and 36 N., Rs. 115 and 116 W., is more open. Some excellent timber grows on the east and west slopes of Thompson Plateau, particularly on the north slopes of some of the ridges along the streams flowing into Green River. The north hillsides in the canyons are fairly well timbered. Some of the plateaus bear dense clumps of timber, but most of this section is much more open and is apparently better adapted for grazing than the portion west of Greys River. Around Fish Lake, in T. 28 N., R. 117 W., the forests appear to have been dense at one time, but fires have destroyed almost everything and the ground is covered with fallen timber. The southern portion of the national forest, Tps. 25, 26, 27, and 28 N., Rs. 115, 116, and 117 W., is a rough, rocky, mountainous country not well timbered and not nearly so well suited for grazing as the country farther north. In this region the heaviest timber is within a few miles of the west boundary of the forest, in Tps. 26 and 27 N., R. 117 W., where fire has done little damage. Near the eastern boundary of the southern portion of the forest the country is open and there are many large tracts in which not much timber is found except on the north slopes of the large hillsides. Lodgepole pine is gradually restocking the burned areas.

No very definite knowledge concerning the total area or total stand of commercial timber on the reserve is at hand. Areas of commercial timber range from a few acres up to several thousand acres. The yield per acre varies from less than 1,000 feet, on areas of the pure lodgepole type where the trees are small and of the red-fir type where

A. THICK GROWTH OF PINE, FIR, AND BALSAM IN T. 28 N., R. 116 W.

Sheep grazing among timber and in open parks.



B. NORTH AND WEST SLOPES OF HILLS ON FALL RIVER, T. 38 N., R. 115 W.

Showing heavy growth of timber extending to very crest of hills.

the stand is especially open and scattered, up to 20,000 feet on the best portions of the mixed type. It is in the mixed-type areas that all the species attain their best development, with an average height of 80 feet for all matured trees and a maximum diameter, breast high, of 20 to 24 inches for the lodgepole pine and of 30 to 36 inches for the red fir and spruce. In a few places, as on Thompson Plateau and in the Wyoming and Salt River ranges, some of the trees are 4 to 4½ feet in diameter.

Previous to the extension of the national forest to Tps. 26 and 27 N., R. 117 W., a large amount of red fir and lodgepole pine was cut in those townships for railroad ties and floated down Hams Fork. At present logs and poles are floated down to the mining towns of Frontier, Diamondville, and Oakley for use in the mines. With this exception, the consumption of national-forest timber has been confined to the small amount necessary to supply near-by settlers.

GEOLOGY.

STRATIGRAPHY.

SEQUENCE OF THE ROCKS.

The field work for this report was done in 1906, and was a reconnaissance in which especial attention was given to the coal-bearing formations and no detailed work was done on the pre-Cretaceous rocks. The classification and nomenclature adopted were those which had been used by Veatch in the area adjoining on the south. Subsequent detailed work by Richards and others in connection with the mapping of the phosphate field in southeastern Idaho has resulted in several changes in the classification of the Carboniferous and Triassic rocks. This modified classification is probably applicable to at least a part of the area here described, but as the mapping was done on another basis and the report prepared upon the completion of the field work, it is not considered expedient to use the new nomenclature in this report, though the probable equivalents of the formations in the Idaho sections will be pointed out.

Much of the bedrock exposed in the area is of Carboniferous or later age, but in the eastern part of the district, at Labarge Ridge and vicinity, Cambrian and later pre-Carboniferous rocks rise out of the Tertiary beds like monadnocks.

The stratigraphic relation of these rocks to the Carboniferous rocks of Thompson Plateau was not determined, as the formations in the intervening area are concealed by overlying Tertiary rocks. The evidence indicates that the eastern part of Labarge Ridge presents a conformable sequence of strata including, it is believed, representatives of the Cambrian, Ordovician, Silurian, and Devonian systems. There were no pre-Carboniferous mountain-building movements in this immediate region, but there were possibly several intervals in early Paleozoic time when deposition was interrupted. From Carboniferous until late Cretaceous time there was no profound disturbance. So far as can be seen the strata are conformable and the succession complete, but the absence of formations that are present in other parts of the Rocky Mountains suggests that during this interval land areas produced by broad epeirogenic movements may have extended to this region. There is no paleontologic evidence of the presence of Lower Jurassic and little indication of the Middle Jurassic in all the Rocky Mountain region, and it is more than probable that the Triassic as well as the Lower Cretaceous is not completely represented. There have probably been, therefore, at least two or three intervals in the lower Mesozoic era when deposition was interrupted, but the break in sedimentation was not accompanied by mountain-making movements. Movements of this kind probably occurred in the interval between the deposition of the Jurassic strata and that of the Bear River formation (Upper Cretaceous), giving rise to the unconformity that occurs between these beds but in many parts of the field causing no discordance in dip between them.

During late Cretaceous time the Paleozoic and Mesozoic formations were profoundly disturbed, folded, faulted, and eroded, as shown by the unconformity between the Adaville and Evanston formations. The period following this profound disturbance was one of shallow fresh-water deposition during which a series of coal-bearing strata, succeeded by conglomeratic beds, were deposited upon the upturned eroded edges of the older rocks. This epoch was closed by further orographic movements in which the recently deposited Evanston and Almy formations were slightly folded and eroded. For the most part the movements occurred along lines of disturbance initiated at the close of the Adaville epoch. Orographic movements at the close of the Almy epoch were by no means so extensive as those at the close of the Adaville epoch. Subsequent to the post-Almy movement, Tertiary strata containing fresh-water and land forms, Knight and Green River formations, accumulated to a great thickness in lake basins extending over much if not all of the Green River basin.

The deposition of these beds was followed by a long epoch of erosion, during which wind, water, and ice developed the present topographic features. In places the younger Tertiary beds have been removed, enabling geologists to study and examine the older underlying rocks and determine their stratigraphic relation and succession. A summary of the occurrence, thickness, economic importance, and stratigraphic position of the various formations is given in the following table:

Succession, age, and thickness of beds in central Lincoln County, Wyo.

For graphic representation of thickness of formation and lithologic character, see Plate III, in pocket.

Geologic age.		Formation.	Thickness.	Character of strata.	Economic value.
			Feet.		
Quaternary.	Recent.		0-250	Hillwash, talus, and landslide material.	Clay derived largely from the weathering of underlying shales in Mammoth Valley have been used for making brick near Glencoe, Wyo., but not developed north of Glencoe. Important agricultural land.
Quaternary.	Recent.		0-250	Valley fill, terraces, flood-plain deposits, and small-stream bottom lands.	
Quaternary.	Recent.		0-150	River terraces.	Gold placers worked along Snake River. Similar deposits of auriferous gravel occur both up and down Snake River beyond this area and on some of its tributaries.
Quaternary.	Pleistocene.		1-150	Bowlders, gravel, and morainal material associated with hill wash.	
		Unconformity.			
Tertiary (Eocene).	Wasatch group.	Green River formation.	2,000 [a]	Thin-bedded shales, sandstones, and limestones, for the most part light colored.	Important for its fossil remains.
Tertiary (Eocene).	Wasatch group.	Knight formation.	500 [b]	Red and yellow sandy clays and shales interlaminated with white, gray, yellow, or reddish sandstones. Local areas of concretionary limestone.	East of Labarge Ridge yields oil which has probably risen from underlying Cretaceous formations.
		Unconformity.			
Tertiary (Eocene).	Wasatch group.	Almy formation.	2,500 + [c]	Red and yellowish-white conglomerates, sandstones, and sandy clays. Typically exposed north of Fall River and east of Snake River.	Of probable importance as a water-bearing formation.
Cretaceous or Tertiary.		Evanston formation.[d]	9,500 + [e]	Gray, yellow, and black carbonaceous shales and clays interbedded with sandstones and containing several small coal beds, none of which are developed. The coal beds are of the same age as the Evanston coals near Evanston, Wyo., sometimes called "Upper Laramie." These beds rest on Jurassic and Carboniferous beds.	Coal bearing. Several coal beds of workable thickness have been observed in Fall River basin. None have been prospected or developed.
		Unconformity.			
Cretaceous (Upper Cretaceous).	Montana.	Adaville formation.	2,800	White, gray, yellow, and brown carbonaceous clays and shales with irregularly bedded brown and white sandstones and numerous beds of coal. The lower part of this formation contains fossil plants and invertebrates that are referred to the uppermost Montana; the upper beds contain Laramie leaves.	Prolifically coal bearing throughout. A few prospect pits only are opened in this area. At Sayle's mine a 180-foot drift has been opened in a 6-foot bed and considerable coal mined for local use. Several other mines supply coal for ranch use. Along the east side of Labarge Ridge the formation contains many beds of coal.

[a] Estimate of Clarence King of maximum thickness in Green River basin southeast of this region; only a portion of the Green River formation is exposed in this area.
[b] Only a portion of Wasatch group is exposed in this area.
[c] Total thickness of formation probably not exposed.
[d] Near Evanston, Wyo., these beds have been called Wasatch by White and Laramie by Hayden and King.
[e] Upper limit not seen.

Succession, age, and thickness of beds in central Lincoln County, Wyo.—Continued.

Geologic age.		Formation.	Thickness.	Character of strata.	Economic value.
Cretaceous (Upper Cretaceous).	Colorado.	Hilliard formation.	*Feet.* 3,000	Gray and black sandy shales, with some clay and shaly sandstone. Weathers readily and affords few exposures. Usually a region of low relief.	
		Frontier formation.	2,400 to 3,800	Alternating beds of gray and yellow clays, shales, and sandstones containing numerous beds of coal. Forms prominent ridges or hogbacks in southern part of area east of Absaroka Ridge. Near top of formation a pronounced bed of coarse sandstone, in places conglomeratic; contains numerous large oysters. This is the Oyster Ridge sandstone member. To the north, east of Salt River and Wyoming ranges, this formation loses its characteristic hogback topography. Of Benton age.	Generally coal bearing throughout the area. Far south the Kemmerer, Willow Creek, Carter, and Spring Valley coals, belonging in the same formation, have been developed. The Kemmerer coal beds are extensively mined at Frontier, Diamondville, Oakley, Glencoe, and Cumberland. In this field only Wright's mine and a few prospect pits have been opened. Contains good building stone.
		Aspen formation.	1,200 to 1,800	Gray and black shales, shaly sandstones, and beds of compact gray sandstone, containing fish scales; commonly weathering silver-gray and showing little white specks in some of the sandstones. Of Benton age.	Oil bearing in southern Uinta County.
		Bear River formation.	800 to 1,500	Black shale, shaly sandstone, and shaly limestone with abundant invertebrate fossils. Several thin beds of coal and bituminous shale.	Coal bearing. Coal beds so far as noted are too thin and impure to be of value. Oil bearing in Uinta County.
		Unconformity.			
Jurassic.		Beckwith formation.	900 to 2,400	White, gray, yellow, brown, and reddish-yellow shales and sandstones, with some dark-gray and black shales and limestones containing considerable calcite and some quartz, and a few beds of red or gray conglomerates and quartzite sandstone containing Jurassic fossils. Jurassic fossils found at top of formation in this area.	Gold and silver has been reported from recent prospects on Horse Creek in T. 34 N., Rs. 114 and 115 W.
		Twin Creek limestone.	1,600 to 2,400	Chiefly black, gray, and bluish gray shaly limestones with interbedded shales and yellow, white, and gray sandstones, the whole containing numerous Jurassic fossils.	
Jurassic or Triassic.		Nugget sandstone.	500-800	Yellow, thin-bedded sandstones, red quartzitic sandstones, bluish and purplish limestones and sandstones.	Of importance for building stone and ballast.
Triassic (Lower Triassic).		Ankareh shale.	500	Reddish brown shale and shaly sandstone.	Has been prospected for copper throughout this region.

Succession, age, and thickness of beds in central Lincoln County, Wyo.—Continued.

Geologic age.		Formation.	Thickness.	Character of strata.	Economic value.
			Feet.		
Triassic (Lower Triassic).		Thaynes limestone.	1,000-2,000	Yellow, gray, and blue cherty limestones, with some yellow sandstones.	Bluish-gray limestones, very fossiliferous.
Triassic (Lower Triassic).		Woodside formation.	400	Red and brown shaly sandstone and shales.	
Carboniferous.	Permian (?). / Pennsylvanian.	Park City formation.	1,400	Chert and cherty limestone at top; succeeded below by brownish black sandstones that weather coal black; brown and red shales; brown, yellow, gray, and bluish-white limestones.	Prospected a little for coal, copper, gold, and graphite without results. Contains some carbonaceous material that was taken for coal and graphite. Middle portion contains the phosphate deposits of the Bear River valley throughout this region and in the Wasatch and Wind River mountains as well.
Carboniferous.	Pennsylvanian.	Weber quartzite.	1,000	Gray and white quartzitic sandstone, in places calcareous and slightly brecciated.	Prospected for copper. Showing of carbonates has been found on Rock Creek, southwest of area.
Carboniferous.	Pennsylvanian. / Mississippian.	Undifferentiated Pennsylvanian and Mississippian.	8,000-9,000	The upper portion (about 4,000 feet) consists of limestones in many places red, yellow, gray, brown, and light gray, associated with calcareous shales and quartzites. These beds contain Pennsylvanian fossils. The lower 5,000 feet consists of hard blue-gray cherty limestones containing Mississippian fossils.	Prospected in places for gold without results. Contains traces of copper. Contains iron deposits on Sheep Creek.
Devonian, Silurian (?), Ordovician.				Sequence broken on account of Tertiary covering, except on Labarge Ridge, where the Carboniferous rocks conformably overlie the Devonian, and where the Silurian (?) and the Ordovician are represented.	
Cambrian.			(?)	Gray cherty limestone, bluish-gray limestone and sandstones, reddish conglomerate. Beds much folded and fractured. Somewhat brecciated.	Prospected for gold and copper without success.

PRE-CARBONIFEROUS ROCKS.

The oldest rocks in the region belong to the Cambrian system. They are brought to the surface by an overthrust fault in Labarge Ridge, and perhaps in some small outliers east of the ridge, which may be remnants of the Cambrian that formerly capped the Cretaceous rocks, but that has been mostly removed by erosion. The beds are exposed from 2 to 6 miles east of the Carboniferous rocks composing Thompson Plateau, but the stratigraphic relation between the rocks of Thompson Plateau and those of Labarge Ridge is not positively known, for Tertiary deposits cover the intervening area and conceal the older rocks. The trend of Labarge Ridge, which is approximately parallel to Meridian Ridge, and other stratigraphic evidence indicate that the Carboniferous rocks overlie conformably the Devonian-Cambrian sequence, which in turn is thrust up over beds of Cretaceous (Montana) age. The general outline of the rocks composing Labarge Ridge is shown in figure 1. Devonian strata have been positively identified by Kindle, and Ulrich has identified Richmond fossils (Ordovician) from underlying limestones which the author believes include also a representative of the Silurian system. Along the east face of Labarge Ridge the Adaville formation (Upper Cretaceous) is in contact with the Cambrian and the entire ridge is surrounded by Tertiary rocks. The three sections across Labarge Ridge shown in figure 2 give the structure of the range so far as known.

The lowest, or Cambrian, rocks are composed for the most part of grayish-white limestone and blue cherty limestone that may weather yellow or red. The lower part of the limestone is grayish brown and is very siliceous. With the limestone are associated some green and drab shales, a bed of reddish conglomerate about 20 feet thick, and some whitish sandstone, which in places resembles quartzite. The entire mass is very cherty, breaks with a conchoidal fracture, and on weathering produces an irregular surface. The rocks are considerably folded.

The fossils collected along the line *X–X′* (fig. 2) were studied by Charles D. Walcott, who reports as follows:

500 feet west and 750 feet north of the east center corner of sec. 6, T. 26 N., R. 113 W. Ptychoparia (?) sp.

Along the line *Y–Y′* (fig. 2) no fossils were collected, but along the line *Z–Z′* an excellent collection was obtained in the limestone just below the 20-foot conglomerate bed. Concerning this collection Dr. Walcott says:

The brachiopod species are specifically identified, but the trilobite species, as identified, are only tentative.

1,700 feet east and 600 feet north of the southwest corner of sec. 18, T. 27 N., R. 113 W.: *Obolus matinalis.*

500 feet north of the southwest corner of sec. 18, T. 28 N., R. 113 W.: *Obolus sinol.*

1,750 feet east and 500 feet north of the southwest corner of sec. 18, T. 28 N., R. 113 W.:

Orthis (Plectorthis) iddingsi.
Solenopleura sp.
Anomocare (?) sp.
Ptychaspis sp.
Ptychoparia (?) sp.
Crinoidal fragments.

The fossils from the last locality are of Upper Cambrian age; the fossils of the other three localities are not distinctive, but lithologically the rock in which they occur appears to be the same as that in the locality last given above, and it is believed that all four localities represent Upper Cambrian deposits.

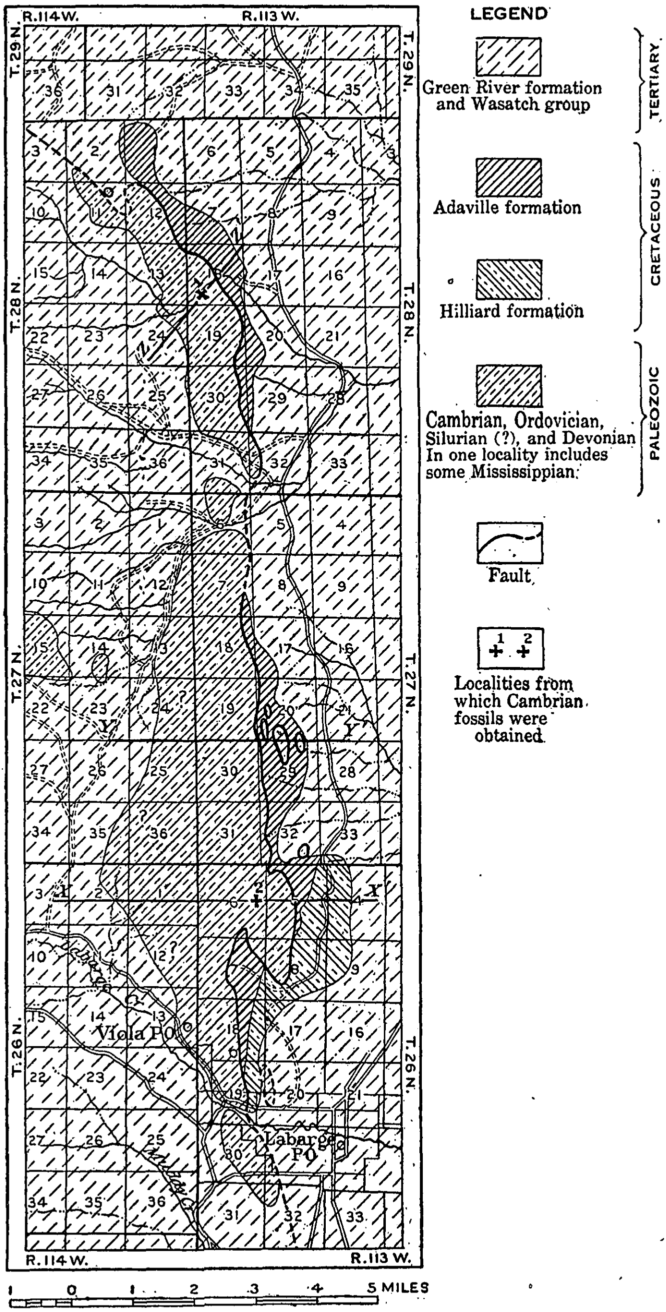


FIGURE 1.—Sketch map showing the occurrence of pre-Carboniferous rocks in their relation to the surrounding beds in the vicinity of Labarge Mountain. *X-X'*, *Y-Y'*, *Z-Z'*, location of sections in figure 2.

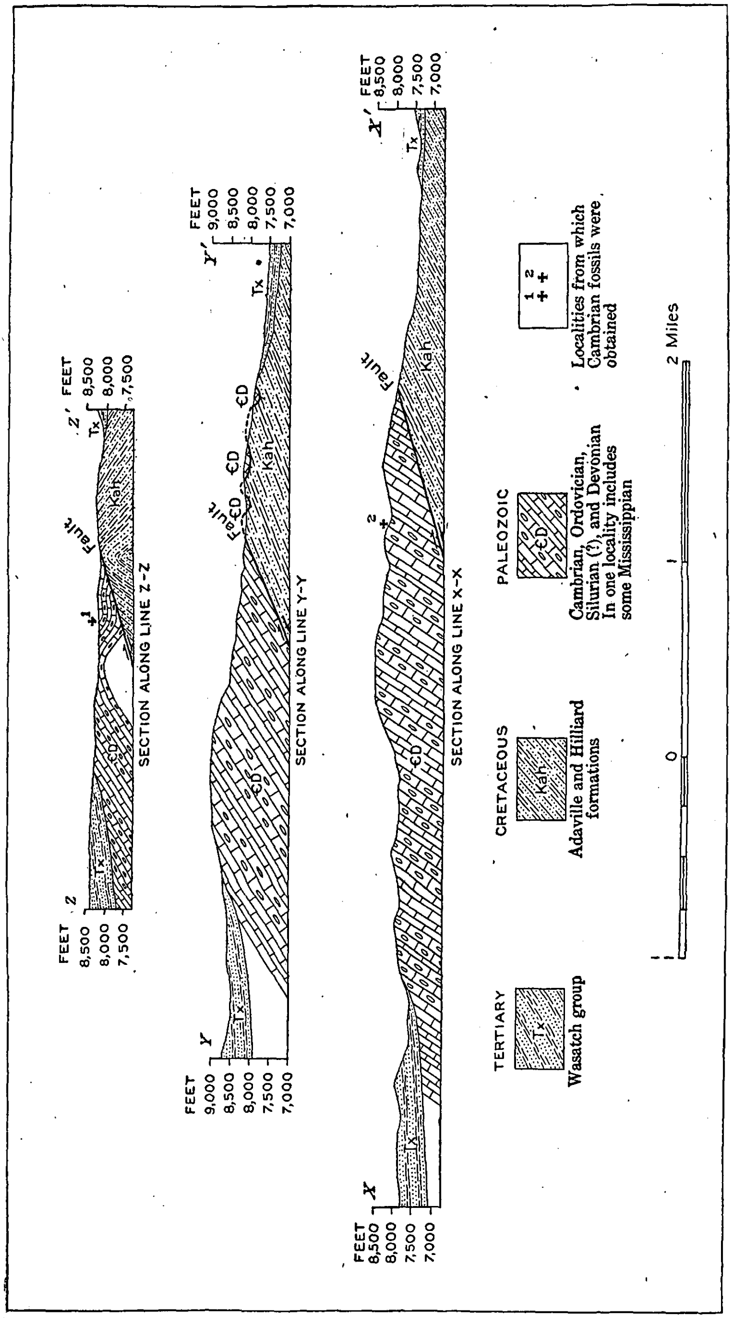


FIGURE 2.—Sections across Labarge Ridge along lines X-X', Y-Y', and Z-Z' of figure 1.

During a visit to Labarge Ridge in the fall of 1907 T. W. Stanton and the writer collected a few fossils at several places along the ridge. These collections, as well as those made by E. M. Kindle, were studied by E. O. Ulrich, who reports as follows:

No. 1275a (V 201). Outlier of Paleozoic on east side of Labarge Ridge near southern end and just north of Labarge Creek. From limestone breccia. Collectors: T. W. Stanton and A. R. Schultz, 1907. A mottled dark and light gray dolomite containing very imperfect fossils, suggesting *Strophomena fluctuosa, Dinorthis subquadrata, Streptelasma rusticum.* These and the type of rock containing them indicate a horizon corresponding to the upper part (Richmond age) of the Bighorn limestone.

No. 1275b (V 201). Same locality as 1275a but from loose fragment of thin-bedded limestone. Two pieces of semioolitic and conglomeratic limestone containing imperfect trilobite remains and grains of glauconite (or chlorite). The trilobite is of a type known to me only from the widespread conglomeratic and glauconitic horizon marking the base of the "Ozarkian" or, when both are present, the top of the Acadian. In Missouri it is at the base of the Elvins formation and the top of the Bonneterre limestone, in Oklahoma at the top of the Reagan sandstone and the base of the Arbuckle limestone. In the Bighorn Mountains it is in the upper part of the Cambrian that locally underlies the Bighorn limestone.

No. 1278 (V 204). North side of North Fork of Dry Piney Creek near east end of its canyon through Labarge Ridge uplift. Second limestone from east end of canyon, Uinta [Lincoln] County, Wyo. Collectors: T. W. Stanton and A. R. Schultz, September 29, 1907. A conglomeratic, partly crystalline grayish or pinkish limestone, with fragments of trilobites but no grains of glauconite. The horizon is regarded as nearly the same as No. 1275b.

No. 1279 (V 205). 200 yards east of No. 1278, from easternmost exposure of limestone in canyon of North Fork of Dry Piney Creek, Uinta County, Wyo. A grayish speckled subcrystalline limestone filled with *Billingsella coloradoensis,* a common species in the upper half of the Acadian.

For convenience the beds of Labarge Ridge have been mapped as a unit, although, as already stated, Cambrian, Ordovician, and Devonian strata have been identified, and the author believes the Silurian also is represented. Most of the fossils collected came from beds near the east base of the ridge. Other than the conglomerate bed shown in the section along line C–C (Pl. III, in pocket) no distinct lithologic break was noted in the beds of Labarge Ridge.

It is not improbable that the beds east of Labarge Ridge shown in section B–B (Pl. III) may prove to be Middle or Lower Cambrian. In the short time devoted to the study of these rocks no fossils were collected. Concerning these beds, as well as those along the west flank and crest of Labarge Ridge, Peale [1] says:

Nine or ten miles below the mouth of Piney [Dry Piney] a small, dry creek bed is crossed. Followed up, this creek is seen to spread out feather-like on the slopes reaching eastward from Thompson Plateau. * * * It has two main stems, between which is a V-shaped mesa of Green River beds. West of this mesa is a hill of Carboniferous rocks surrounded by Wasatch beds. This Carboniferous island was not visited but is doubtless similar to the one just south of it known as Labarge Mountain. On the latter two stations were made, namely, Nos. 19 and 20. These stations are located

[1] Peale, A. C., Eleventh Ann. Rept. U. S. Geol. and Geog. Survey Terr., 1879, p. 530.

on a long hill or mountain that forms a rather prominent landmark as we came down the valley of the Green. It is about 5 miles long and is composed of Carboniferous limestone dipping about 25° N. 73° W. The trend of the mountain is about 17° W. Station 19 was located at the north end and station 20 at the south end. The outcrop of limestone to the east of station 19 is about 400 or 450 feet in thickness. The valley between the station and the mesa is about 1,200 feet to 1,400 feet below the stations and 600 to 800 feet below the mesa top. The mesa just referred to is a mesa extending along the south side of Feather Creek toward Green River. This mesa is capped with the lower part (?) of the Green River group and slopes at an angle of from 5° to 10° from Labarge Mountain toward Green River. The gap between the mountain and the mesa was not visited from want of time but should be examined before the region can be fully described. It is probably filled with Wasatch beds, judging from what could be seen from the summit of the mountain. If the latter is a remnant (western side) of an anticlinal, evidences of the eastern side might possibly be found appearing in places above the Wasatch beds. As it shows now, it is a monoclinal ridge facing the east. A few indistinct crinoidal markings were observed on station 19, and on station 20 some indistinct corals, Productus, and a poor Strophomena.

The Adaville and Hilliard formations (Upper Cretaceous) outcrop in places along the east side of Labarge Ridge in the gap referred to by Peale. These beds and the Paleozoic rocks forming the ridge, as well as the isolated outliers of Paleozoic rock within the gap, are overlain unconformably by late Cretaceous or early Tertiary rocks, which form the crest of a low anticline along the east side of the ridge.

During the summer of 1907 E. M. Kindle visited Labarge Ridge and made a study of the rocks in the vicinity of Saley's mine northeast of Viola. Mr. Kindle measured a section across Labarge Ridge due west from Saley's mine, beginning at the fault contact on the east edge of the Paleozoic rocks, approximately 500 feet west of the mouth of the mine, as follows:

Section across Labarge Ridge northeast of Viola, Wyo., T. 26 N., Rs. 113–114 W.

	Feet.
Carboniferous:	
J. Limestone, light to dark gray, oolitic in lower 20 feet (Madison limestone)	500
Devonian:	
I. Shale, drab, and limestone, thin bedded, shaly, magnesian and siliceous	80
H. Limestone, buff to gray, with much black magnesian limestone in the upper part, saccharoidal in texture, and weathering with roughly pitted surface; covered in part (Jefferson limestone)	1,000
(?):	
G. Limestone, gray, partly covered	700
Cambrian:	
F. Limestone, gray, with abundant Cambrian trilobites	40
E. Shale, green and covered	300
D. Shale, drab and covered	30
C. Limestone, thin bedded, gray, with abundant Cambrian trilobites	10

	Feet.
Cambrian—Continued.	
B. Shale, drab, mostly covered	100
A. Limestone, lead-gray, checked by innumerable small joints which are generally filled with calcite	120
Cretaceous (Montana):	
Sandstones, yellow and gray; shale and clay with thin beds of coal	250
Shale, sandy, containing fossils (see p. 66)	2
Coal bed; opened at Saley mine	6
Sandstone, shale, and clay, containing some beds of coal, extending several hundred feet below coal bed at Saley's mine.	

Regarding this section Mr. Kindle makes the following statement:

In this section the gray and black limestone is preceded by beds holding a Cambrian fauna and followed by a limestone holding the usual Madison limestone fauna. The shale formation (I) at the top of the magnesian limestone appears to occupy the position of the Threeforks shale, but it is barren of fossils. Composition, texture, manner of weathering, and relationship to the other parts of the section all indicate the magnesian limestone to be the same as the Jefferson limestone of the Montana sections.

The Jefferson limestone of Labarge Ridge is nearly barren of fossils, the only ones obtained being Zaphrentis and fragments of an undetermined coral. The gray limestone (C and F of the section) contains a fauna which E. O. Ulrich reports to be of late Middle or basal Upper Cambrian age.[1]

Positive information is lacking regarding the age of the 700 feet of gray limestones below the saccharoidal limestones of the Jefferson. These beds (G of the section) may in part be the same as the 40 feet of limestone at their base, the age of which is known by its fossils to be Cambrian. It seems probable, however, that Silurian and Ordovician formations are included in this mass. Ordovician rocks are present in the Bighorn Mountains to the north, and both Silurian and Ordovician are present in northeastern Utah. The fossil evidence given by Peale and Kindle places the rocks along the entire west flank of the southern slope of the ridge in the Carboniferous.

CARBONIFEROUS SYSTEM.

UNDIFFERENTIATED MISSISSIPPIAN AND PENNSYLVANIAN LIMESTONES.

Along the Salt River, Wyoming, and Hoback ranges well-exposed Carboniferous rocks are shown by meager collections of fossils to represent nearly if not quite all the Carboniferous formations in the Utah (Wasatch Mountains) section,[2] including beds from the bases of the Madison limestone to the top of the Weber quartzite. The actual contacts were not traced in the field, but enough lines were surveyed across the formations to give their general distribution.

[1] Letter to the writer, Feb. 11, 1908.

[2] King, Clarence, Rept. U. S. Geol. Expl. 40th Par., vol. 1, 1878, p. 155.

The lithologic characteristics of the beds are persistent and the main subdivisions may be recognized in the field. The lower limestones are generally massive and form precipitous cliffs; they are generally coarse grained and siliceous and contain cherty layers and masses which weather to a rough surface. These lower beds contain a typical Mississippian fauna.

An outlier at Lander Peak, in sec. 35, T. 33 N., R. 115 W., may be Carboniferous or older. It appears from the relations about the peak to be a remnant of beds that were thrust over the underlying rocks by faulting and that once covered a larger area than they do at present. Lithologically, they resemble the Carboniferous rocks exposed a little farther west in the cliffs of Lander Mountain, but so far they have yielded no fossils. The peak itself is surrounded by coal-bearing beds, suggesting that its rocks form an outlier of the older beds brought to place by thrust faulting. (See Pl. VII, *B*, p. 84.)

The oldest Carboniferous beds exposed in the area lie along the east face of the Wyoming Range near Lander and McDougal mountains (Pl. VII, *A*), along the Hoback Range, and along the east front of the Salt River Range. These beds consist chiefly of limestones that vary in color and composition, but that are characterized by Carboniferous faunas. These beds consist of 8,000 to 9,000 feet of limestone and are readily divisible into two parts. The lower, about 5,000 feet thick, consists of dark-blue, dark-gray, and drab limestones, which in places are massive, cherty, and coarsely crystalline. Some of them are crystalline and contain small veins of calcite, but normally they are dense and compact, carry fossils, and weather to blue, yellow, brown, and white surfaces. The fossils collected from these beds are of Mississippian age. The limestones of the upper part are less massive and dense, are in places red, yellow, gray-brown, and light gray in color, and have a slightly sandy texture. Associated with the limestones are calcareous shale and quartzite and reddish sandstones and shales which stand out in marked contrast to the dark blue of the lower formation. The fossils collected near the top of these upper beds may be of Pennsylvanian age.

The above-described limestone series is resistant to erosion and constitutes the nucleus of the three mountain ranges in the district. No fossils were obtained from the beds at the bottom of the lower part of the limestone series, and it is not known whether these beds are Carboniferous or whether they should be referred to the Devonian or the Silurian, but as no lithologic break suggests a change of beds they have been mapped as Carboniferous.

The fossils collected by the Hayden Survey from Carboniferous strata in this area are listed below:

Hill south of South Fontenelle Creek (station 25 of the Hayden Survey): Fragments of Zaphrentis.

Labarge Ridge (stations 19 and 20, Hayden Survey): Zaphrentis sp.?, Productus sp.?, Hemipronites sp.?

Thompson Plateau, south of Piney Creek (station 47, Hayden survey): Zaphrentis sp.,

Mount Piney between the heads of Piney Creek (station 48, Hayden survey): Archimedes sp.?, crinoidal stems, corals indistinct.

In 1878, in the heavy grayish-drab, more or less cherty limestone south of Fall River canyon, St. John[1] found Zaphrentis?, crinoidal remains, polyzoans, Hemipronites, Spirifer, etc. The beds compose the walls of the lower part of Fall River canyon and are unquestionably Carboniferous.

In the cherty dark-drab and gray limestone along the Wyoming Range west of the headwaters of Willow Creek St. John[2] found Zaphrentis, crinoidal remains, Orthoceras, and Syringopora, the upper layers being charged with Zaphrentis and Syringopora.

In 1872 Bradley[3] examined the rocks in the grand canyon of Snake River and found in the débris a few species of Spirifer, Macrocheilus, and Zaphrentis.

In 1877 Mushbach[4] collected fossils at Virginia Peak, among which C. A. White identified the following:

Zaphrentis sp.?
Syringopora sp.?
Crinoid columns.
Fenestella sp.?
Glauconome sp.?
Rhombopora sp.?
Chonetes platynota?
Spirifer striatus.
Spirifer sp.?
Spirifer (Martinia) planoconvexus.

Concerning this list G. H. Girty makes the following statement:

The name "Wasatch" has been discontinued for rocks of Carboniferous age, but as used by the geologists of the Fortieth Parallel Survey the Wasatch comprised a great series of strata, consisting chiefly of limestones and belonging largely if not wholly in the Mississippian. The lower part of the Wasatch contains a fauna of lower Mississippian age, which was rightly compared to that of the Waverly group of Ohio. The same fauna also occurs in the Madison limestone, which name would best be applied to this part of the section. The upper part of the Wasatch contains faunas of upper Mississippian age. The identifications in the foregoing list do not absolutely fix the position of the fauna, but they indicate that it is from one of the upper Mississippian horizons.

At Stewart Peak, 8 miles north of Glacier Creek (station 57 of the Hayden Survey), the sections given by Peale,[5] beginning at the west end and going down, are as follows:

Section at Stewart Peak.

1. Limestone, massive blue, with fragments of corals, and an indistinct Spirifer.
2. Limestone, blue, weathering light yellow, with light bands.

[1] St. John, Orestes, Twelfth Ann. Rept. U. S. Geol. and Geog. Survey Terr., 1883, p. 184.
[2] Idem, p. 189.
[3] Bradley, F. H., Sixth Ann. Rept. U. S. Geol. and Geog. Survey Terr., 1873, p. 268.
[4] Mushbach, J. E., Eleventh Ann. Rept. U. S. Geol. and Geog. Survey Terr., 1879, p. 546.
[5] Peale, A. C., Eleventh Ann. Rept. U. S. Geol. and Geog. Survey Terr., 1879, p. 548.

3. Limestone, blue and yellowish, in rather thin bands that are highly fossiliferous.
4. Limestone, dark blue.
5. Limestone, yellowish, with perhaps bands of quartzite.

These beds were seen only from a distance. No. 4 or No. 5 may possibly be equivalent to the fossiliferous beds of Virginia Peak. No. 3 represents the limestone outcropping on the station, about 150 feet in all, and containing fossils at five horizons, as follows:

1. At the top: Zaphrentis, Platycrinus, *Hemipronites crenistria*, Euomphalus.
2. 50 feet lower down: Synocladia, *Hemipronites crenistria*, Productus, Spirifer, Murchisonia, Euomphalus.
3. 40 feet below No. 2 and 90 feet below the summit of the station: Murchisonia, Euomphalus.
4. A few feet lower: Streptorhynchus, Spirifer, Proetus.
5. 60 feet below No. 3 and 150 feet below the station: Ptilodictya, Streptorhynchus, Productus.

Peale further states:

These prove the Carboniferous age of these limestones, and it is probable that they represent the coal measures. They are higher than the beds of Virginia Peak and below the beds in which fossils were found on the ridge north of station 56. So much has the range been folded and eroded that the more definite place of the beds can not be determined with the limited data at our command.

The fossils collected by members of the present party have been studied by George H. Girty, who has furnished the following list of species from the lower part of the limestone:

Ridge east of Bailey Creek Lake, 2,500 feet west and 625 feet north of the southeast corner of sec. 2, T. 37 N., R. 116 W.: Menophyllum? sp.

Head of Greys River, 4,500 feet north of the northwest corner of sec. 6, T. 29 N., R. 116 W.: *Syringopora surcularia*, Menophyllum sp., Zaphrentis sp., Amplexus sp., *Spirifer centronatus*?, Spirifer? sp.

Mount McDougal, 1,000 feet north of the southwest corner of sec. 20, T. 34 N., R. 115 W.: Zaphrentis sp., crinoidal stems.

Fall River Canyon, 3,750 feet up Hoback Canyon from Sulphur Springs: *Eumetria marcyi*.

Ridge east of Willow Creek between Willow and Cliff creeks, 500 feet north, 2,500 feet east of the southwest corner of sec. 23, T. 37 N., R. 115 W.: *Spirifer centronatus*?

Hoback Range east of Willow Creek, 1,800 feet west of the southeast corner of sec. 35, T. 38 N., R. 115 W.: Menophyllum sp.

Ridge west of Greys River, center of sec. 24, T. 30 N., R. 117 W.: Menophyllum sp.

Ridge west of Greys River, near source, 1,000 feet west and 1,250 feet south of west of the center of sec. 9, T. 30 N., R. 116 W., in bowlder lying on Bear River formation, but not in place, probably coming from ridge west of Greys River: *Chonetes illinoisensis*, *Spirifer mysticensis*.

Mount Lander, 1,250 feet west of the southeast corner of sec. 33, T. 33 N., R. 115 W.: *Spirifer* aff. *keokuk*.

The Carboniferous limestone which comprises the two divisions of the undifferentiated Pennsylvanian and Mississippian beds given in the section on page 31 contains a fauna representative of the Madison limestone of Montana and Wyoming. Fossils collected by Kindle from the lower 100 feet of bed J, Labarge Ridge, northeast of Viola, have been determined by Girty as follows:

Menophyllum excavatum.
Schuchertella inflata.
Rhipidomella pulchella.
Camarotœchia metallica.
Camarotœchia aff. C. sappho.
Spirifer centronatus.
Spiriferina solidirostris.
Martinia rostrata.
Composita humilis.
Composita immatura.
Cleiothyridina aff. C. hirsuta.
Eumetria verneuiliana.

Girty states that all these lots probably belong to the "Lower Wasatch fauna" of the Utah section, a zone which can be correlated with the Madison limestone of Yellowstone National Park. The collection from Labarge is the only one of sufficient extent to be definitely recognizable. A collection containing only Loxonema aff. *L. difficilis* may be Devonian, though this is not likely. On the other hand, one containing Spirifer aff. *S. keokuk* possibly represents a horizon in the upper Mississippian.

The following three lots probably belong in the Pennsylvanian. They seem to be higher than those of the preceding list but lower than the faunas yet to be mentioned. They may be upper Mississippian but nothing very definite can be said of them.

Thompson Plateau north of Thompson Pass, 1,500 feet east and 1,000 feet north of the southwest corner of sec. 13, T. 29 N., R. 116 W.: Zaphrentis sp., Syringopora aff. *S. surcularia.*

Fish Creek, 250 feet west of east center of sec. 30, T. 30 N., R. 115 W.: *Spirifer rockymontanus, Composita subtilita.*

Hoback Range east of Willow Creek, 800 feet west of the southeast corner sec. 34, T. 38 N., R. 115 W.: Zaphrentis sp.

Peale [1] gives the following section of the beds at Mount Darby:

Section at Mount Darby.

		Feet.
1.	Quartzites on station 48.	
2.	Limestones, blue and yellow	1,400
3.	Quartzites.	
4.	Limestones, blue, with crinoidal stems; indistinct corals and fragments of Archimedes?	800
5.	Limestone, red.	
6.	Limestones, massive blue, reaching from the base of the cliffs to a point about 1,600 feet above; thickness about	2,700

He adds:

The lower layers have a very old look, and are in all probability sub-Carboniferous although they may be Devonian or upper Silurian.

No. 6 of the section is probably lower Mississippian, equivalent to the Madison limestone of the Yellowstone Park section; Nos. 2 to 5 are upper Mississippian, and No. 1 Weber quartzite or Pennsylvanian.

---

[1] Peale, A. C., op. cit., p. 541.

WEBER QUARTZITE (PENNSYLVANIAN).

Rocks identified as the Weber quartzite consist of white and gray fine-grained sandstone, well cemented and compact. In some places this sandstone is yellowish white, in others bluish, and in a few pinkish. In part of the field, as along Absaroka Ridge and Thompson Plateau, this formation consists in part of rather massive limestone, from which were obtained several lots of fossils that place its age as Pennsylvanian. To this age also belong the beds immediately overlying.

The quartzite, which is for the most part compact and fine-grained, weathers in places into massive blocks, but more commonly it breaks into small angular fragments that form the débris slopes along the mountain ridges. With the quartzite in places are associated sandy limestone and conglomeratic beds. Good exposures of this quartzite occur along Absaroka Ridge on Fontenelle and Labarge creeks and at several places along the Wyoming Range.

The quartzite apparently has the stratigraphic position of the Weber quartzite and was recognized as such in the adjacent section at Cokeville by F. B. Weeks during the summer of 1906. Weeks's identification carries great weight because of his intimate knowledge of the Paleozoic section of the Rocky Mountain region. The correlation of the quartzite of the area with the quartzite at Cokeville was made by way of Rock Creek, halfway between Absaroka Ridge and Cokeville, where the same beds outcrop and were studied by the writer in 1905. The Rock Creek area has been described by A. C. Veatch.[1] The Weber quartzite as here defined has more recently (1912) been included in the Wells formation, as a result of the detailed work of Richards [2] in eastern Idaho. It constitutes a part of the upper portion of the Wells formation, which also contains the lower member of the Park City formation and probably the upper or Pennsylvanian part of the beds here described as undifferentiated Mississippian and Pennsylvanian limestones (pp. 37–41).

The following small lots of fossils were collected from the formation by the present party and were studied by Mr. Girty, who reports as follows:

A rather well characterized fauna is represented by the four lots following, which represent the Weber quartzite in the Utah (Wasatch Mountain) section:

West crest of Thompson Plateau, sec. 5, T. 27 N., R. 114 W.: Deltopecten aff. *D. texanus*, *Plagioglypta canna*, Schizodus sp., *Euphemus inspeciosus*.

Thompson Plateau, sec. 8, T. 27 N., R. 114 W.: Leda? sp.

---

[1] Veatch, A. C., Geography and geology of a portion of southwestern Wyoming, with special reference to coal and oil: Prof. Paper U. S. Geol. Survey No. 56, 1907, p. 54.

[2] Richards, R. W., and Mansfield, G. R., The Bannock overthrust; a major fault in southeastern Idaho and northeastern Utah: Jour. Geology, vol. 20, 1912, pp. 681–709.

Thompson Plateau, 2,000 feet north and 500 feet west of the southwest corner of sec. 5, T. 27 N., R. 114 W.: Deltopecten? sp., *Plagioglypta canna*, *Euphemus inspeciosus*.

Ridge southeast of Thompson Pass, 250 feet north of the southeast corner of sec. 29, T. 29 N., R. 115 W.: Fistulipora ? sp., Spiriferina ? sp., Bellerophon sp.

As little work was done west of the east crest of the Salt River Range the map of this portion of the area has not been colored, but in order that the structure of the range may be better understood sections across the range are given on page 88.

PARK CITY FORMATION (PENNSYLVANIAN AND PERMIAN?).

Conformably overlying the Weber quartzite is a great series of strata, consisting of alternating sandstone, shaly sandstone, and laminated limestone. These beds weather red or brown. Although three separate and distinct formations are present, the series of beds was mapped in the field as a unit, as the formations lie for the most part outside of the area examined for coal, and it was not considered advisable to take time to map the contacts. However, sections at several places in the field prove conclusively that the series consists of three distinct formations. The lowest, 1,400 feet of strata, represents the Park City formation of the Park City section. The 400 feet next overlying is identified as the equivalent of the Woodside shale of the Park City section, and the remaining 2,000 feet as the equivalent of the Thaynes limestone of the Park City section, including the "Meekoceras beds" of the Hayden Survey. As a result of the detailed work of Richards and Mansfield [1] in eastern Idaho the Park City formation has recently (1912) been divided. The upper two members of the Park City formation as here used are equivalent to the Phosphoria formation, and the lower member has been included in the Wells formation, which also includes beds equivalent in age to those mapped in this report as Weber quartzite and probably also the upper or Pennsylvanian part of the beds here described as undifferentiated Mississippian and Pennsylvanian limestones (pp. 37–41).

About 27 miles north of the south boundary of this area, where Fontenelle Creek cuts across Absaroka Ridge, the following section was measured, beginning at the east base of Absaroka Ridge and going west along the north bank of Fontenelle Creek to the overlying beds on the west side of the stream:

Section of beds along north bank of Fontenelle Creek from east base of Absaroka Ridge across the first ridge (T. 27 N., R. 117 W.).

	Feet.
Top not seen.	
Thaynes limestone:	
Limestone, fossiliferous, blue, containing "Permo-Carboniferous" fossils	400
Woodside formation:	
Sandstone, red, and sandy shale	380

[1] Op. cit.

	Feet.
Park City formation:	
Limestone, brown, sandy; weathers brown	430
Sandstone, calcareous, cherty shale, and gray limestone, containing phosphate	260
Shale, cherty, containing considerable supposed bituminous matter; prospected for coal west of Walter Wright's place and on Absaroka Ridge, T. 23 N., R. 116 W. Important phosphate horizon	50
Limestone, bluish white	300
Weber quartzite:	
Sandstone, fine grained, compact, white; breaks in small angular pieces and forms part of talus slope	640

Beds similar to those in the section above occur along the Meridian, Wyoming, and Hoback ranges. Only small collections of fossils were made from these beds along Absaroka Ridge, and in many other parts of the field no collections were made. This lack of fossils and also the fact that the soft, easily weathered Woodside formation is in many places concealed by weathered material are additional reasons why it did not seem advisable to attempt, in the time available, to separate the Park City from the overlying Woodside and Thaynes formations. The lithologic resemblance of these three formations is very marked throughout the major portion of the field. For a more complete discussion of these formations the reader is referred to the preliminary report on the phosphate deposits in southeastern Idaho and adjacent parts of Wyoming and Utah by Hoyt S. Gale and R. W. Richards and to the report of Eliot Blackwelder on the phosphate deposits east of Ogden, Utah.[1]

The Park City formation as identified in this area consists of bluish-white limestone, black siliceous and cherty shale containing bituminous matter, brown sandy limestone that weathers brown, and more or less limestone, sandstone, and reddish shale. It is divisible into an upper cherty limestone; a series of phosphatic shales, phosphate rock, and limestone bands; and an underlying massive limestone commonly containing much chert. The Park City formation was first named by J. M. Boutwell, from Park City, Utah, where it is extensively exposed and where it has been exhaustively studied by him in connection with his investigation of the Park City mining district. The name was first applied to the formation in Wyoming by A. C. Veatch.[2]

The fossils collected from the Park City formation in this area were studied by Mr. Girty, who makes the following report:

> The three small lots noted below contain three species, only partly identifiable. Fortunately one of them is *Spiriferina pulchra*, a form peculiarly diagnostic of the limestone members of the Park City formation, in which it is in many places abundant, and never yet found in any other formation. Its presence satisfactorily denotes the correlation of the beds in which it occurs.

[1] Bull. U. S. Geol. Survey No. 430, 1910, pp. 457-551.
[2] Prof. Paper U. S. Geol. Survey No. 56, 1907, p. 54.

Absaroka Ridge, on second ridge northwest of Wright's ranch, sec. 15, T. 24 N., R. 116 W., 250 feet east of southwest corner: *Spiriferina pulchra.*

Absaroka Ridge, northwest of Wright's ranch, sec. 15, T. 24 N., R. 116 W., 615 feet west of south center: Spirifer or Spiriferina.

Crest of Absaroka Ridge, west of Holden's ranch, 1,250 feet west of south center, sec. 35, T. 27 N., R. 116 W.: Bellerophon? sp.

At the head of Bear Creek (Sickle Creek, according to Hayden), Peale[1] found specimens of *Productus multistriatus* in blue cherty limestone just above a layer of quartzite. Peale further states that opposite McDougals Pass the crest of the range is the edge of a monoclinal fold, or what appears to be monoclinal, for at this point there may be an obscure anticline, of which the upper members of the eastern half are removed. The western members form a bluff face about 500 feet high, in which the following general section was observed:

Section at head of Bear Creek, No. 13 of Hayden Survey.

1. Limestone, interlaminated like those of No. 3, but probably more arenaceous.
2. Limestone, reddish, and shale.
3. Limestone, interlaminated, and shale; some of the latter is probably arenaceous.
4. Limestone, massive.
5. Shale, black.

At the base of layer No. 2 occurs *Productus multistriatus*, a species which Girty regards as a characteristic Park City form. Farther east and stratigraphically lower appears a quartzite, which is probably identical with the Weber quartzite, and below this quartzite occur fossils similar to those that are found at Virginia Peak, in the Mississippian. In beds 3 to 5 of the section occur *Aviculipecten pealei* and Gervillia sp. ?

TRIASSIC SYSTEM (LOWER TRIASSIC SERIES).

CORRELATION.

The Lower Triassic rocks of the Park City district have been divided by Boutwell into three formations called in ascending order the Woodside shale, Thaynes limestone, and Ankareh shale. It is not easy to correlate these formations with those recognized by the earlier surveys, but apparently the Thaynes limestone corresponds in a general way to the "Permo-Carboniferous" of the geologists of the Fortieth Parallel Survey. The Ankareh was combined by them with the Nugget sandstone under the term Triassic, and the Woodside (and probably the lower part of the Thaynes) appears to have been included with the Park City formation as the "Upper Coal Measures limestone."

[1] Peale, A. C., Eleventh Ann. Rept. U. S. Geol. and Geog. Survey Terr., 1879, p. 546.

The Woodside, Thaynes, and Ankareh have been correlated on stratigraphic and paleontologic evidence with strata in Idaho which contain, at the horizon of the Thaynes, the ammonitic Meekoceras zone. This is the typical Lower Triassic of Idaho, and it becomes necessary to abandon the age determination suggested by the name "Permo-Carboniferous."

Fossils are in many places abundant in this series of beds, but they are often poorly preserved. In the Wasatch Mountains the Woodside is almost unfossiliferous, though extensive faunas have been obtained from the Thaynes. Until rather recently, however, ammonites of Triassic aspect were not known from the Thaynes in this area, so that the correlation with the Lower Triassic of Idaho was less obvious. In Idaho, on the other hand, the Woodside and Thaynes are not always well marked lithologically, and the base of the Thaynes has conventionally been taken at the first ammonite zone. In Idaho also, the Woodside is in many places rather abundantly fossiliferous, and the faunas of the Woodside, Thaynes, and Ankareh appear to be closely related. For this reason, and because the faunas have not yet been carefully investigated, it is seldom possible to say definitely on paleontologic evidence to which formation a given collection should be referred.

The faunas consist mainly of pelecypods, among which small pectinoid shells play a prominent part, and since such forms are rare in the Carboniferous below, the Lower Triassic fauna can usually be recognized even when the individual species can not be named nor the three subdivisions distinguished.

WOODSIDE FORMATION.[1]

The Woodside formation as here developed is made up of red sandstone and sandy shale. It is limited below by the sandy limestone of the Park City formation and above by the fossiliferous blue and brownish-gray limestones of the Thaynes limestone. The formation is characteristically exposed on Fontenelle Creek, and its stratigraphic position is shown in the section on pages 43 and 44. The shale and sandstone are soft and weather readily and in many places are concealed. The beds are exposed at various places in the field but have been included in the geologic mapping with the Park City and Thaynes formations for the reasons explained on page 43. (See Pl. I in pocket.) No collections of fossils definitely known to have come from the Woodside formation have been obtained in this region.

THAYNES LIMESTONE.[1]

The Thaynes is composed of fossiliferous blue and gray limestone, brownish-gray sandy limestone, and thin-bedded yellow sandstone.

[1] See Park City formation, p. 43.

Its stratigraphic position with reference to underlying formations is shown in the section on pages 43 and 44. The Thaynes is very fossiliferous and furnished most, if not all, of the following collections:

Absaroka Ridge, 625 feet west of the southeast corner of sec. 3, T. 26 N., R. 116 W.: Edmondia? sp. 1, Edmondia? sp. 2.

Thompson Plateau, 1,600 feet west and 800 feet north of the southeast corner of sec. 20, T. 27 N., R. 114 W.: Indeterminable pelecypods.

Thompson Plateau, 1,800 feet west and 800 feet north of the southeast corner of sec. 20, T. 27 N., R. 114 W.: Aviculipecten sp.

Labarge Creek, 750 feet east of south center of sec. 21, T. 27 N., R. 116 W.: Aviculipecten sp.

Fontenelle Creek, at fork in the NW. ¼ sec. 9, T. 27 N., R. 116 W.: Aviculipecten sp., *Aviculipecten weberensis*?

Fontenelle Creek, 1,000 feet west of the southeast corner of sec. 27, T. 27 N., R. 116 W. (same horizon as next above): Indeterminable pelecypods.

Wagner Pass, 1,250 feet south and 600 feet west of the south-central corner of sec. 1, T. 29 N., R. 117 W., west of Labarge Creek where Lander Road crosses the first ridge: *Myalina permiana*, *Aviculipecten weberensis*?, Aviculipecten sp., *Aviculipecten parvulus*?

Salt River Range, 250 feet west of the southeast corner of sec. 23, T. 30 N., R. 117 W.: *Aviculipecten parvulus*?, Aviculipecten sp., *Myacites inconspicuus*.

Wyoming Range, hill east of Greys River, about 2 miles north of south township line, in bluish-gray limestone, NE. ¼ sec. 27, T. 30 N., R. 116 W.: Indeterminable pelecypods.

Wyoming Range, hill east of Greys River, about 2 miles north of south township line in light-gray limestone, NE. ¼ sec. 27, T. 30 N., R. 116 W.: Indeterminable pelecypods.

Salt River Range, 1,500 feet west of south center of sec. 23, T. 30 N., R. 117 W.: Aviculipecten sp. 1, Aviculipecten sp. 2, *Aviculipecten parvulus*, *Aviculipecten curticardinalis*?

Wyoming Range, 500 feet south and 280 feet west of the southwest corner of sec. 31, T. 33 N., R. 115 W., in limestone just below red beds of the Ankareh shale: The single specimen shows part of an arm of an ophiurian.

Sheep Creek, east of Greys River, sec. 10, T. 33 N., R. 116 W.: Aviculipecten sp., Edmondia? sp., Nucula? sp., Monopteria? sp., indeterminable pelecypods.

West portion of Hoback Range, on top of hill under red beds, northwest corner of SE. ¼ NW. ¼ sec. 32, T. 39 N., R. 115 W.: Aviculipecten sp., Lingula sp., Edmondia? sp., indeterminable pelecypods.

Some fossils from the Thaynes limestone collected during the summer of 1905 by members of A. C. Veatch's[1] party near the south end of Absaroka Ridge were identified by Mr. Girty as follows:

East crest of Absaroka Ridge, SW. ¼ NW. ¼ sec. 16, T. 23 N., R. 116 W.: Lingula sp., *Aviculipecten weberensis*, *Aviculipecten curticardinalis*, *Aviculipecten occidaneus*, *Schizodus ovatus*, and Goniatites? sp.

These fossils formed the basis for identifying the Thaynes limestone in this general region with the Thaynes limestone of the Park City section and correlating it with the "Permo-Carboniferous" beds of the Wasatch Mountain section of the Fortieth Parallel Survey. In 1877 Peale collected *Aviculipecten pealei* and Gervillia sp. from beds

[1] Veatch, A. C., Geography and geology of a portion of southwestern Wyoming: Prof. Paper U. S. Geol. Survey No. 56, 1907, p. 51.

1 and 3 of the section at the head of Bear (Sickle) Creek (p. 45). These fossils are identical with species obtained near station 66 (section 19) of the Hayden Survey, just south of John Grays Lake, Idaho, in strata Nos. 1 and 2 of the following section.[1] Correlations are by the author, who, however, did not visit the place.

Section made by A. C. Peale in 1877, just south of John Grays Lake, Idaho-Wyoming.

[Thickness of beds estimated.]

	Feet.
1. Limestone and shale alternating, outcropping in ridge running south from station 66.	1,000+
2. Limestone outcropping on station 66 (Thaynes limestone)	
3. Sandstones, greenish and reddish, limestone and shale	850
4. Limestone, bluish-gray	700
5. Sandstones, reddish and greenish, laminated (Woodside formation)	400
6. Limestone, dark blue (Park City formation)	800
7. Quartzite, white (Weber quartzite)	
8. Limestone, massive, outcropping on station 65 (upper part of Madison limestone)	400+
	4,150+

The combined thickness of beds 1 to 4 (approximating 2,500 feet) agrees well with the thickness of 2,600 feet attained by the Thaynes limestone along Rock Creek in Uinta County. The following fossils were collected by Peale from the beds in the section:

Stratum No. 1:
- Terebratula semisimplex White.
- Terebratula augusta Hall.
- Aviculipecten idahoensis Meek.
- Gervillia and undetermined conchifers.

Stratum No. 2:
- Eumicrotis curta Hall.
- Aviculipecten idahoensis Meek.

Stratum No. 3:
- Three or four undetermined conchifers and a new species of Aviculipecten.

Stratum No. 4:
- Meekoceras gracilitatis White.
- Meekoceras mushbachanus White.
- Arcestes? cirratus White.
- Arcestes, two species.
- Eumicrotis curta Hall.

Similar beds were observed by Peale[2] in the vicinity of Deadmans Creek, a tributary to Greys River, but no fossils were collected at this place. Peale states that the "Meekoceras beds" are probably shown near the west base of the Wyoming Range. Stratigraphically these "Meekoceras beds" are a part of the Thaynes limestone. The above-listed fossils from strata Nos. 2 and 4 were identified by C. A. White, who referred them to the "Juratrias." They are now generally considered characteristic of the Lower Triassic, except the Jurassic species *Eumicrotis curta*, which is probably not correctly identified.

[1] Peale, A. C., Eleventh Ann. Rept. U. S. Geol. and Geog. Survey Terr., 1879, p. 560.
[2] Idem, pp. 545, 622–624, section No. 12.

Peale also collected fossils in 1877 from the "Permo-Carboniferous" on the hill immediately west of Sheep Canyon on a tributary of Rock Creek, a few miles west of the southern part of the field. The material was examined by C. A. White,[1] who reported the following forms, supposed to be Jurassic: *Eumicrotis curta* ?, *Myalina whitei* ?, *Aviculipecten idahoensis* ?, Myacites ?, and Modiola (Volsella ?). All the identifications are doubtful, and both Stanton and Girty are of the opinion that the original specimens were probably Triassic forms.

ANKAREH SHALE.

The Thaynes limestone is overlain by 500 feet of reddish-brown shale and shaly sandstone, which correspond to the Ankareh shale of the Park City, Utah, section. In Veatch's report on southwestern Wyoming[2] this shale was included with the overlying sandstones and mapped with it as the Nugget formation. Throughout much of the area discussed in the present report this shale is more or less concealed by weathered material, and although it is here recognized as a distinct formation, it is for convenience mapped with the overlying Nugget sandstone. No fossils were found in the Ankareh shale in this area, but from fossils collected from it in northeastern Utah and southeastern Idaho the formation has been definitely assigned by other writers to the Triassic.

JURASSIC OR TRIASSIC SYSTEM.

NUGGET SANDSTONE.

The Nugget sandstone, which overlies the Ankareh shale, consists of about 800 feet of thin-bedded and massive sandstone or quartzite, generally pink, brown, or light yellow on fresh exposures, but commonly weathering dark brown or pink. These quartzite beds form rugged topography whose slopes are covered with heavy talus blocks. No fossils were found in the formation in this area, and those obtained from it in other areas are so few and so poorly preserved as to leave its age in doubt. It is regarded, however, as of either Triassic or Jurassic age.

JURASSIC SYSTEM.

TWIN CREEK LIMESTONE.

The Twin Creek consists for the most part of dark and blue-gray thin-bedded limestone, calcareous shale, and some beds of massive blue limestone. In many places beds of light-colored sandstone are interbedded with the light-gray shaly limestone, and in some localities the sandstone beds are persistent. The limestone is very fossil-

[1] White, C. A., Eleventh Ann. Rept. U. S. Geol. and Geog. Survey Terr., 1879, pp. 575, 626.
[2] Prof. Paper U. S. Geol. Survey No. 56, 1907, p. 56.

iferous and for this reason serves as one of the best horizon markers in the field. The Jurassic fossils are in part identical with those found in the Ellis formation of the Yellowstone National Park. Typical Twin Creek rocks were observed in the southeast corner of the area and were traced northward across the field in several belts. (See Pl. I.) The thickness of the formation as measured along several sections varies from 1,600 to 2,400 feet.

In 1877 Peale[1] collected fossils from the Twin Creek limestone south of Fontenelle Creek and measured the following section:

Section south of Fontenelle Creek.

	Feet.
Quartzite, reddish, thin, and without fossils. It forms the summit in some places and is eroded away in others	100
Limestone, bluish, containing *Pentacrinus asteriscus, Ostrea strigilecula, Camptonectes bellistriatus*, Mytilus sp.?, Myalina sp.?, Modiola sp.?, Trigonia sp.?, Ostrea sp.?, Volsella sp.?	
Sandstone, reddish	
Limestone, bluish, laminated, and blue argillaceous shale	150
Limestones, bluish and gray	
Quartzite, reddish, appears to reach the valley of the creek west of ridge. It is much broken and appears to have been abruptly folded. The distance to the creek level is about	600
	850

The lowest stratum is probably the Nugget sandstone and the rest of the section is the Twin Creek.

Peale adds:

In the canyon limestone probably outcrops, and if the quartzite (base of the section) is Triassic, as I believe, the limestone would be of Carboniferous rocks.[2] In one of the Carboniferous strata, he (Cope) says, "I found a well-marked horizon of carbonaceous shales extending as far as I explored them." The erosion that has excavated the valley at the west side of the ridge has therefore cut into a portion at least of the Carboniferous. The ridge is therefore an anticline with the sharpest portion of the fold on the western side. This is the portion eroded. Erosion has considerably obscured the beds, and at one time I thought it probable a fault extended along the ridge.

The carbonaceous shales referred to are in the Ankareh shale and are similar to the shale observed on South Piney Creek.

In the same year Peale[3] collected *Pentacrinus asteriscus* and Neritina sp. (?) from beds in the Lander syncline on the north side of Middle Piney Creek.

Farther north on Sheep Creek (McDougal Creek according to Hayden's map), on the north side at an angle 1½ miles above mouth, Peale gives the following section, whose total thickness is 1,500 feet:

---

[1] Peale, A. C., Eleventh Ann. Rept. Geol. and Geog. Survey Terr., 1879, pp. 536–537.
[2] Seventh Ann. Rept. U. S. Geol. and Geog. Survey Terr., 1874, p. 440.
[3] Eleventh Ann. Rept. U. S. Geol. and Geog. Survey Terr., 1879, p. 539.

Section on Sheep Creek 1½ miles above mouth.

Quartzite.
Shale, reddish, arenaceous.
Sandstone, green, laminated.
Limestone, greenish gray, with very irregular structure; some of the layers appear to be arenaceous. The following fossils were obtained: *Belemnites densus*, *Aviculipecten idahoensis*, Gryphæa (?), and other undetermined bivalves.
Shale and sandstone, reddish and gray.
Limestone, gray, and shale, near the top of which are *Pentacrinus asteriscus*, etc.
Limestone, blue, laminated, with *Pentacrinus asteriscus*, *Camptonectes bellistriatus*, Trigonia sp.?, and Myacites sp.

Peale[1] gives the following section still farther north of Greys River, along Deadman Creek, which affords a key to the stratigraphic position of the Sheep Creek section given above:

Section along Deadman Creek, a north tributary to Greys River.

	Feet.
Cretaceous:	
Shales, variegated reddish and grayish	3,300
Shale, yellow, sandy	
Sandstone and shale, gray and greenish	
Jurassic:	
Limestones, bluish and gray, with shale and sandstone near the top. [Fossiliferous beds of section at Sheep Creek (Hayden's McDougal Creek) occur here]	
Limestones, gray and blue	
Triassic:	
Sandstone, red	3,600
Sandstone and quartzite, reddish, light colored near the base	
Limestone, blue, somewhat laminated near the top	2,100
Carboniferous: Limestone, yellow, and quartzite	
	9,000

St. John[2] observed fossils in the Twin Creek limestone on Fall River just below the mouth of Granite Creek. He says:

Two or three miles lower down the stream (below the mouth of Cliff Creek) the west slope is flagged with drab spar-seamed limestone, containing a small Ostrea and Pentacrinites. These beds dip about west-northwest at angles of 35° to 65° and are overlain by limestone and indurated calcareous shale, containing an abundance of *Gryphæa calceola*, which are, however, soon concealed beneath the débris lower in the slope

Gryphæa calceola was also found by St. John[3] near the confluence of Bailey Creek with Snake River.

Still farther south, on a tributary of Little Greys River, a cherty limestone contains obscure fragments of fossils, a small gastropod referred provisionally to *Lioplacodes veternus* M. and H. being most numerous and best preserved.

---

[1] Op. cit., p. 545.
[2] St. John, Orestes, Eleventh Ann. Rept. U. S. Geol. and Geog. Survey Terr., pt. 2, 1878, pp. 180, 184.
[3] St. John, Orestes, Twelfth Ann. U. S. Geol. and Geog. Survey Terr., pt. 1, 1883, pp. 192-193.

During the summer of 1906 fossils were collected at various places throughout the field and were studied by T. W. Stanton, who identified the following species:

Fossils collected from Twin Creek limestone in 1906.

Lot No.	Locality.				Species.
	Creek or range.	Section.	T. N.	R. W.	
3819	Slate Creek, on bend in Sublett road east of Slate Creek.	200 feet north of northwest corner sec. 9.	23	115	Pentacrinus, Camptonectes.
3821	Slate Creek, half through canyon.	NW. ¼ NE. ¼ sec. 28	23	115	*Pentacrinus asteriscus* M. and H., *Ostrea strigilecula* White, *Camptonectes pertenuistriatus* H. and W., *Trigonia americana* Meek.
3800	Meridian Ridge, east of Fontenelle Creek.	750 feet east and 500 feet north of northwest corner sec. 13.	25	115	Coral, Serpula, Lima, Trigonia.
3822	South bank of Fontenelle Creek.	SW. ¼ SE. ¼ sec. 3	26	115	*Pentacrinus asteriscus* M. and H., *Ostrea strigilecula* White, *Camptonectes pertenuistriatus* H. and W., *Trigonia elegantissima* Meek, *Astarte meeki* Stanton, *Thracia weedi* Stanton, Pholadomya, Pleuromya, etc.
3815	Meridian Ridge, south of Labarge Creek.	500 feet east of northwest corner sec. 4.	26	115	*Pentacrinus asteriscus* M. and H., Astarte, Pleuromya, Anatina.
3844	North of Labarge Creek	3,800 feet west and 800 feet north of southeast corner sec. 20.	27	114	*Pentacrinus asteriscus* M. and H., Pinna sp.
3816	.....do	NW. ¼ SE. ¼ sec. 23	29	116	*Pentacrinus asteriscus* M. and H., *Camptonectes pertenuistriatus* H. and W.
3817	Hill south of South Piney Creek, east of Labarge Creek.	150 feet west of northeast corner sec. 24.	29	115	*Pentacrinus asteriscus* M. and H., Camptonectes.
3860	North of North Piney Creek.	SW. ¼ NW. ¼ sec. 29	31	114	*Pentacrinus asteriscus* M. and H., Camptonectes sp., *Trigonia quadrangularis* H. and W.
3842	North Piney Creek	1,000 feet east of northeast corner sec. 30.	31	114	Ostrea, Trigonia, Camptonectes, etc.
3854	South of North Piney Creek.	375 feet north of northeast corner sec. 36.	30	115	Pentacrinus, Ostrea, Lima.
3859	North of South Cottonwood Creek.	Sec. 12	32	114	*Camptonectes pertenuistriatus* H. and W.
3814	Hoback Range, north of Horse Creek.	250 feet north of southwest corner sec. 6.	34	114	Pentacrinus, Camptonectes, Trigonia.
3839	Hoback Range	1,000 feet south of northeast corner sec. 19.	34	114	*Gryphæa calceola* var. *nebrascensis* M. and H., *Pentacrinus asteriscus* M. and H.
3808	.....do	1,000 feet east of northwest corner sec. 31.	37	114	*Gryphæa calceola* var. *nebrascensis* M. and H.
3848	Hoback Range, west of Cliff Creek.	500 feet north of southwest corner sec. 22.	38	114	*Camptonectes pertenuistriatus* H. and W.
3830	Hoback Range, east side of Willow Creek.	2,125 feet north and 1,750 feet west of east center sec. 33.	38	115	*Gryphæa calceola* var. *nebrascensis* M. and H., *Trigonia americana* Meek.
3834	East side of Willow Creek.	3,750 feet north of southeast corner sec. 33.	38	115	*Gryphæa calceola* var. *nebrascensis* M. and H.
3832	.....do	2,250 feet north and 2,000 feet west of east center sec. 33.	38	115	*Pentacrinus asteriscus* M. and H., Lima sp.
3831	Hoback Range, north of Fall River.	300 feet north of southeast corner sec. 13.	39	115	*Gryphæa calceola* var. *nebrascensis* M. and H.

BECKWITH FORMATION.

At the type locality east of Beckwith station the Beckwith formation is a characteristic and conspicuous heavy red conglomerate; but through most of the area described in this report this phase is not well developed, the rocks resembling more closely the upper member of the formation at the type locality and being a direct northward extension of the Beckwith formation of the eastern belt of Uinta County, where the conglomerate phase merges with the upper sandstone and shale. The Beckwith is lithologically distinct from the underlying Twin Creek limestone and is not nearly so fossiliferous. The beds are composed of light-colored shale, sandstone, and clay. The sandstone is usually light yellow, pink, or white, and the clay varies from yellow or light pinkish red to dark purple. With the sandstone, shale, and clay are associated beds of white to light-yellow and red conglomerate and black limestone. In places, as on Greys River, Fall River, and South Cottonwood Creek, conglomerate beds constitute an important part of the formation.

Stanton found marine Jurassic fossils at two localities south of this area in beds which are regarded by Veatch as representing the lower part of the Beckwith. Near old Bear River City, in Uinta County, just west of the Absaroka fault and east of the main conglomerate bed, Stanton[1] found *Belemnites densus* M. and H., *Trigonia quadrangularis* H. and W., and *Myacites* (*Pleuromya*) *weberensis* Meek.[1]

South of Rockport, on Weber River, he found a specimen of *Trigonia quadrangularis* H. and W.? about 2,000 feet above the characteristic fossiliferous, blue, thin-bedded limestone and shale of the Twin Creek limestone, and 3,500 feet or more below the lowest observed black shale with fish scales representing the Aspen formation, which here, in the absence of the Bear River, forms the base of the known Cretaceous.[2]

The Beckwith formation throughout this area does not seem to be very fossiliferous and at only four localities were fossils collected. These were studied by Stanton, who referred three of the collections to the Jurassic, and stated that the fourth was not sufficient for age determination though it suggested the Jurassic.

Fossils from the Beckwith formation.

Lot No.	Locality.				Species.
	Range or creek.	Section.	T. N.	R. W.	
3799	Hoback Range	595 feet east of northwest corner sec. 13.	25	115	*Eumicrotis curta* (Hall).
3806	Meridian Ridge, east of Fontenelle Creek.	720 feet east of northwest corner sec. 21.	26	115	Camptonectes, *Eumicrotis curta* (Hall).
3801	West of Greys River, northeast of Poison Meadows.	NE. ¼ SW. ¼ sec. 20	30	116	*Camptonectes pertenuistriatus* H. and W., *Eumicrotis curta* (Hall).
3818	Ledge on east side of Willow Creek above Fall River.	6	38	115	Trigonia fragment, cardium?

[1] Am. Jour. Sci., 3d ser., vol. 43, 1892, p. 103.
[2] Bull. U. S. Geol. Survey No. 106, 1893, p. 44.

Lots 3801 and 3818 come from the top of the Beckwith formation and indicate that it is Upper Jurassic. The Lower Cretaceous is absent, for the Upper Cretaceous (Bear River formation) here appears to lie conformably upon the Beckwith.

Although the relation of the Bear River formation and the Beckwith formation in this region is one of apparent conformity, it is known by the fossils collected from the Bear River at Sage and from beds at the base of the Bear River formation immediately above and in contact with the Beckwith formation 4 miles southeast of Cumberland, Wyo., on Little Muddy Creek, that there is an unrepresented interval between the Beckwith and the Bear River formations and that the Lower Cretaceous is absent.

CRETACEOUS SYSTEM (UPPER CRETACEOUS SERIES).

BEAR RIVER FORMATION.

The Bear River formation unconformably overlies the Beckwith formation, from which it is lithologically distinct and may for the most part be readily separated, though in some places the lower sandstone and calcitic limestone near its base resemble the Beckwith and make it difficult to draw the contact line. The light-colored nonfossiliferous conglomerate, sandstone, shale, and clay of the Beckwith formation are succeeded by limestone, sandstone, and dark-colored shale. The limestone is in places more or less massive and is filled with secondary calcite that gives it a distinctive appearance and permits it to be readily identified. The whole formation, particularly the shale and limestone, is very fossiliferous.

The name was probably derived from Bear River City, an early construction camp on the Union Pacific Railroad, repeatedly mentioned by Hayden in the paragraph in which he proposed this name,[1] but he may have been influenced somewhat by the nearness of the type exposures to Bear River.

White in 1877 collected Bear River fossils 7 miles north of Evanston, and Peale in the same year collected Bear River fossils near Waterfall and at Sage and found extensive outcrops of the formation in this area. Outside of the small area extending from Bear River City northward through the Wyoming and Salt River ranges to Idaho no Bear River strata have been recognized anywhere on this continent.

The studies of Stanton[2] in 1901 at old Bear River City, 7 miles north of Evanston, near Waterfall, at Sage, and on Smiths Fork determine the true stratigraphic position of this formation. The work of A. C. Veatch's party in 1905, of which the writer was a

[1] Hayden, F. V., Third Ann. Rept. U. S. Geol. Survey Terr., 1873, pp. 91–92.
[2] Stanton, T. W., Am. Jour. Sci., 3d ser., vol. 43, 1892, pp. 98–115.

member, added many details of the areal distribution of these beds and by finding many complete exposures with simple structural relations confirmed Stanton's conclusions that the Bear River formation is near the base of the Upper Cretaceous and that it rests upon marine Jurassic.

In 1877 Peale[1] collected fossils from the west side of Meridian Ridge in the Lander syncline on a small branch of Middle Piney Creek. A small lot consisting of Corbula sp.? and undetermined forms was identified by C. A. White as equivalent to that of the Bear River "estuary beds." This lot came from the Bear River formation on Middle Piney Creek, north of Snider Basin, and on the strength of it all the beds east of the Wyoming Range were classed as probably Laramie, for at that time the Bear River was considered a part of the so-called Laramie group.

In 1878 St. John[2] examined the rock forming the high outlying ridge between Willow and Hunter creeks about 12 miles south of the mouth of Willow Creek and found *Goniobasis macilenta* (White), *Corbula pyriformis* (Meek?), *Pyrgulifera humerosa* (Meek), *Unio vetustus* (Meek), and obscure vertebrate remains, all Bear River forms, in beds of fresh gray and buff sandstone, dark-blue, drab, chocolate-colored, and red shale, containing more or less indurated layers, and some beds of dark siliceous limestone.

The following section across Willow Creek basin, given by St. John,[3] shows the relation of the Carboniferous rocks along the west crest of the Hoback Range and along the Wyoming Range with the intervening beds and fossil horizons. The section extends eastward down the slope of the Wyoming Range, ending just east of the mouth of Hunter Creek. The formation names have been added to St. John's section for the purpose of correlation.

Section across Willow Creek valley.

Overthrust fault, Madison limestone:

1. Light and dark drab and gray limestone, cherty and spar-seamed, containing Zaphrentis, crinoidal remains, Orthoceras; upper layers charged with Zaphrentis, Syringopora, and other Carboniferous fossils. Dip 10° to 40° WSW., a vertical thickness of about 800 feet exposed in east face and crest of Greys Ridge, 5 miles north of station 8.

Bear River, Aspen, and Frontier formations:

2. Heavy series of gray, buff, and bluish, rusty and reddish-weathered sandstone, in places with ripple markings, outcropping in ledges separated by intervening softer deposits, and exposed over an extent above a mile across. Dip 30° to 45° WSW.

Beckwith formation:

3. Dark shale, passing above into drab shales with indurated bands, 300 to 500 feet.

---

[1] Peale, A. C., Eleventh Ann. Rept. U. S. Geol. and Geog. Survey Terr., 1879, p. 539.
[2] St. John, Orestes, Twelfth Ann. Rept. U. S. Geol. and Geog. Survey Terr., pt. 1, 1883, p. 188.
[3] Idem, p. 189.

Beckwith formation—Continued.

4. Reddish shales, including a bed of light-drab limestone and rusty indurated clay, overlain by reddish and light-gray sandstones, 300 to 500 feet.
5. Greenish sandstone and chocolate-red streaked shales, capped by gray, rusty-weathered sandstone, 100 to 150 feet.

Twin Creek limestone:

6. Blue limestone and drab indurated calcareous shales, with Camptonectes, Gryphæa, etc., 300 feet or more.
7. Red, partially indurated shales.
8. Blue fragmentary even-bedded limestone, with shaly partings, Jurassic fossils. Dip 32° WSW.
9. Drab indurated and nodular calcareous shales, with Pentacrinus, Gryphæa, etc.
10. Rather hard fragmentary drab limestone, with Jurassic fossils. A heavy bed.
11. Soft buff brecciated vesicular limestone, with calcite, forming a heavy ledge. Dip 25° WSW.

Woodside and Thaynes (?) formations:

12. Triassic red sandstones, in which the valley of the creek is here excavated. This series is here made up of red sandstones and grayish-red arenaceous shales, capped by a heavy bed of buff sandstone, dipping 35° WSW. 1,500 to 2,500 feet.
13. Reddish and buff siliceous Carboniferous deposits, plating the west slope of station 5, Hoback Canyon ridge.

There appears to be no break in the conformity of the earlier and later deposits of this series of strata, and this fact, notwithstanding the modern appearance of the upper sandstones, suggests their identity with the Laramie formation.

Farther north, on the low ridge east of Willow Creek and about 2 miles south of the mouth of Willow Creek, in obscure ledges of grayish-buff and reddish laminated sandstone interbedded with bluish shale and indurated clay, St. John found Bear River fossils, among which White recognized *Limnæa vetusta* Meek, *Campeloma macrospira* Meek?, *Corbicula (Veloritina) durkeei* Meek?, and a fragment of a reptilian bone. The following list gives the localities in this area from which Bear River fossils were obtained and a list of the species as determined by Stanton. In this list are also included the fossils which were collected in 1905, in southwestern Uinta County, but which were stored with the camp outfit and sent in with the first lot collected in 1906.

Bear River fossils.[a]

Lot No.	Locality.				Species.
	Creek, range, or station.	Section.	T. N.	R. W.	
3862	Bear River, south of Fossil cut.	SE. ¼ SW. ¼ sec. 31	14	119	*Unio belliplicatus* Meek, *U. vetustus* Meek, *Corbicula durkeei* Meek, *Corbula pyriformis* Meek, *Pyrgulifera humerosa* Meek.

[a] The fossils in the Bear River formation have been described and figured in detail by C. A. White (The Bear River formation and its characteristic fossils: Bull. U. S. Geol. Survey No. 128, 1895.)

Bear River fossils—Continued.

Lot No.	Locality.				Species.
	Creek, range, or station.	Section.	T. N.	R. W.	
3869	Leroy station	300 yards north of center sec. 6.	15	117	*Corbula pyriformis* Meek, *Campeloma macrospira* Meek, *Pyrgulifera humerosa* Meek, *Pachymelania cleburni* White, *P. chrysalis* (Meek), *Rhytophorus priscus* Meek.
3863	Spring Valley	SW. ¼ SW. ¼ sec. 24	15	118	*Unio vetustus* Meek, *Corbula pyriformis* Meek, *Pachymelania cleburni* White.
3865	.....do	On railroad track, 1 mile northeast of Spring Valley.	15	118	*Unio belliplicatus* Meek, *Corbula pyriformis* Meek.
3868	West of Bridger station	SE. ¼ sec. 8	16	117	*Corbula pyriformis* Meek.
3861	Anticline on Little Muddy Creek.	On line between secs. 3 and 4, 4 miles southeast of Cumberland.	18	116	*Unio belliplicatus* Meek, *Corbicula durkeei* Meek, *C. pyriformis* Meek. Typical Bear River fauna from base of Bear River formation. *Campeloma macrospira* Meek?, *Pyrgulifera humerosa* Meek.
	.....do	.....do	18	116	Cardium sp., Mactra sp., Corbula sp. (related to *C. pyriformis*, Liopistha (Psilomya)? sp., Lunatia sp.
3804	Meridian Ridge	1,250 feet east of northwest corner sec. 14.	25	115	*Corbicula durkeei* Meek, *Corbula pyriformis* Meek.
3835	Labarge Creek	20	27	115	*Corbula pyriformis* Meek, *Campeloma macrospira* Meek, *Pyrgulifera humerosa* Meek.
3796	North of Labarge Creek	750 feet north and 750 feet west of south center sec. 15.	29	116	*Corbula pyriformis* Meek?, *Campeloma macrospira* Meek.
3805	Labarge Creek, east side	1,000 feet northwest of north center sec. 22.	29	116	*Corbula perundata* M. & H.?
3793	.....do	250 feet east and 1,750 feet south of north center sec. 22.	29	116	*Corbula subtrigonalis* M. & H.?, Modiola sp.
3843	Middle Piney Creek	1,000 feet south and 1,000 feet east of northwest corner sec. 12.	30	115	*Corbula pyriformis* Meek.
3858	Fish Creek	1,100 feet west and 1,000 feet north of southeast corner sec. 25.	30	115	*Corbicula durkeei* Meek?
3811	Greys River	2,250 feet west of center sec. 29.	30	116	*Corbicula durkeei* Meek, *Corbula pyriformis* Meek.
3812	.....do	500 feet north and 750 feet west of center sec. 29.	30	116	Corbula sp., Goniobasis? sp.
3795	West of Greys River	500 feet north and 125 feet west of east center sec. 1.	31	117	*Corbula pyriformis* Meek, *Campeloma macrospira* Meek, *Pyrgulifera humerosa* Meek.
3846	South Cottonwood Creek	1,000 feet north and 300 feet west of southeast corner sec. 14.	32	115	*Corbula pyriformis* Meek.
3826	Greys River	1,375 feet north of southwest corner sec. 26.	35	117	*Corbula pyriformis* Meek, *Pyrgulifera humerosa* Meek.
3828	Greys Ridge	875 feet north and 250 feet east of southwest corner sec. 22.	36	117	Unio n. sp.?, Viviparus, Pyrgulifera?
3827	Wyoming Range	2,500 feet west and 1,000 feet north of southeast corner sec. 1.	37	116	Unio sp., *Corbula pyriformis* Meek?, *Pyrgulifera humerosa* Meek.
3813	Willow Creek and Fall River.	6	38	115	*Pyrgulifera humerosa* Meek, *Campeloma macrospira* Meek.

Lots 4045 and 4046 (not listed in the foregoing table), containing a limited gastropod fauna, were collected north of South Cottonwood Creek. Stanton makes the following statement about them:

The fossils in the larger lot are partly silicified, and since Girty has separated them from the matrix by acid a considerable number of different forms are recognizable and it is evident that they belong to the Bear River fauna. One undescribed species which I am now doubtfully referring to Pyrgulifera is the form which especially misled both Girty and myself because of its superficial resemblance to certain Paleozoic forms. I now think it is a fresh-water shell, as most of its associates certainly are. This same species is the only one that was located at your locality in sec. 31, T. 33 N., R. 114 W. (lot 4046).

On the lot collected at Sage Stanton reports:[1]

In a thin bed of sandstone, 15 or 20 feet below the coal, *Modiola multilingera*,[2] *Barbatia coalvillensis*, and a few other species of the Colorado Cretaceous were found.

About 500 feet east of (below) this locality are exposures of sandstone and calcareous shale containing Bear River fossils interstratified with thin beds of coal, in some of which excavations have been made. A few miles north of Sage and east of Beckwith station the writer found in 1905, above a coal bed which is either the extension of the Sage coal or a higher bed, a number of characteristic Bear River forms.[3]

The relations of the Bear River to the underlying Beckwith formation (Jurassic) lend interest to marine species found in beds exposed along the anticline on Little Muddy Creek, 4 miles east of Cumberland, on the line between secs. 3 and 4, T. 18 N., R. 116 W. Veatch[3] says:

These fossils occur only a few feet above typical Beckwith beds, at the very base of the Bear River formation, and conclusively prove that the Bear River is Upper Cretaceous. Stanton lists the following species: Cardium sp., Mactra sp., Corbula sp. (related to *C. pyriformis* Meek), Liopistha (Psilomya)? sp., and Lunatia sp. The whole assemblage of forms is unfamiliar, but the horizon is clearly Upper Cretaceous.

In the summer of 1906 fossils were collected from the same locality and formation, although not from the same place or bed, along the east crest of the anticline south of Little Muddy Creek. Stanton lists (lot 2861) *Unio belliplicatus* Meek, *Corbicula durkeei* Meek, *Corbula pyriformis* Meek, *Campeloma macrospira* Meek, and *Pyrgulifera humerosa*. This is a typical Bear River fauna.

In connection with the marine species found on Little Muddy Creek should be mentioned lot 3812, collected near the head of Greys River on the east bank, 500 feet north and 750 feet west of center of sec. 29, T. 30 N., R. 116 W., where Corbula sp. and Goniobasis? sp.

[1] Stanton, T. W., Am. Jour. Sci., 3d ser., vol. 43, 1892, p. 108.

[2] In 1893 Stanton stated that this or a similar form occurred here in the Bear River formation: Bull. U. S. Geol. Survey No. 106, 1893, p. 88. See in this connection Bull. U. S. Geol. Survey No. 128, 1895, p. 33.

[3] Veatch, A. C., Prof. Paper U. S. Geol. Survey No. 56, 1907, p. 63.

were obtained. Stanton states that these do not look like typical Bear River fossils. This collection, like the one from Little Muddy, comes from the base of the Bear River formation near the contact of the Beckwith formation; 1,500 feet west (stratigraphically higher) typical Bear River fossils were obtained.

These relations prove beyond question that the Bear River formation belongs to the Upper Cretaceous and, in connection with the Jurassic fossils listed above, that the Lower Cretaceous is absent in this area and that the Dakota of the Upper Cretaceous is absent unless it be represented by a part or the whole of the Bear River formation.

ASPEN FORMATION.[1]

The name "Aspen" for a formation unit was first used by A. C. Veatch for beds exposed near old Aspen station, and as these have been traced northward into this area the same name is used here.

The Aspen formation consists of black shale, dark-drab arenaceous shale, and gray sandstone from 1,200 to 1,800 feet thick (average, 1,600 feet). In places the sandy shale weathers into small splinty fragments and produces long, rounded hills of a peculiar silver-gray color.

The formation outcrops occur along both the east and the west sides of the Wyoming Range. A carefully measured section across the north end of T. 27 N., R. 115 W., shows the following beds:

Section across Aspen formation near south end of Labarge Creek.

	Feet.
Sandstone, fine grained, siliceous	75
Shale, light colored (fish scales)	145
Sandstone, medium, fine grained	250
Sandstone, fine grained, grayish	350
Shale, gray to black (thin bedded)	130
Shale, black (contains fossils, Lingula, and fish scales)	600
	1,550

The Aspen formation contains the oil yielded by the wells near Spring Valley, in Uinta County, and it and the Bear River formation are the two formations in which oil should be looked for in this area.

The Aspen formation, although containing abundant fish scales, furnished few good collections of fossils. The localities in this area from which fossils were obtained are given in the following table:

[1] Veatch, A. C., op. cit., p. 64.

Fossils from the Aspen formation.

Lot No.	Ridge, creek, etc.	Locality.			Species.
		Section.	T. N.	R. W.	
3870	Spring Valley	Sec. 24, SW. ¼ SW. ¼	15	118	Fish scales and other fragmentary fish remains.
3792	East of Oyster Ridge	Sec. 19, 500 feet west of northeast corner.	24	115	Lingula sp.
3810	East of Pomeroy Basin	250 feet east of southeast corner sec. 31.	27	115	Do.
3845	South Cottonwood Creek	Sec. 11, NW. ¼, in black shale south of end of hill on north side of creek.	32	115	Fish scales.
3837	do	Sec. 31, 4,000 feet west of southeast corner.	33	114	Fish scales and bones.

Fish scales and bones were observed in the Aspen formation at many other localities in the area, but no collections were made.

FRONTIER FORMATION.

The Frontier formation was named and defined by Knight, in a paper read before the Geological Society of America in December, 1901,[1] as a coal-bearing formation containing a marked sandstone layer and characterized by the presence of *Ostrea soleniscus*, a very long and slender oyster. The name was taken from the coal town of Frontier, near which the formation is well developed.

The formation consists of a series of sandstone layers, which form pronounced hogback ridges, alternating with beds of gray and yellow clays. The uppermost of the conglomeratic sandstones forms a prominent ridge, which was named Oyster Ridge by Hayden[2] in 1872, and which has been followed by the writer for more than 100 miles north from Hilliard and found to retain its characteristics throughout. The sandstone forming the ridge was named Oyster Ridge sandstone member by Veatch in his report on southwestern Wyoming.[3] Oyster Ridge does not extend north of Labarge Creek and Thompson Plateau and the characteristic hogback ridges of the Frontier formation are also lacking. Although *Ostrea soleniscus* is common throughout the Frontier formation, it is not characteristic, as Knight asserted, for it occurs abundantly in the Hilliard formation at several horizons 3,000 to 4,000 feet above the Oyster Ridge sandstone, which is itself about 400 feet below the top of the Frontier formation. Indeed, the similarity between the Frontier formation and the overlying Hilliard formation is so great that in the northern part of the field, where the characteristic hogback ridges made by bands of sandstone in the

[1] Knight, W. C., Eng. and Min. Jour., vol. 73, 1902, p. 721; Bull. Geol. Soc. America, vol. 13, 1903, pp. 542–544.

[2] Hayden, F. V., Fifth Ann. Rept. U. S. Geol. and Geog. Survey Terr., 1872, p. 149.

[3] Prof. Paper U. S. Geol. Survey No. 56, 1907, p. 65.

Frontier formation are absent, it is almost impossible to separate the two.

The Frontier formation ranges from 2,400 to 3,800 feet in thickness. It is exposed along both sides of Mammoth Hollow, east of Absaroka Ridge and the Salt River Range, and east of the Wyoming Range. It undoubtedly occurs on the east flank of the Hoback fold, but it was seen there in only one locality (T. 31 N., R. 115 W.), for in this part of the area it is deeply buried beneath the Tertiary cover.

Cretaceous fossils were obtained in this area by the Hayden Survey only from the Fontenelle hogbacks of the Frontier formation. Peale [1] states that these hogbacks extend from Hams Hill southeast of Kemmerer northward into the valley of Labarge Creek and include Oyster Ridge. He gives the following generalized section across the valley or depression in which the hogbacks occur:

Section across hills east of Mammoth Hollow.

	Feet.
1. Base shales and limestones, with bands of sandstone. The lower beds dip 5° and the upper beds 8° or 9°. The thickness as estimated is about	500
2. Above the layer No. 1 follow sandstones, with pink and gray shales, above which are yellow sandstones. The dip in these beds is 10° W	900
3. Yellow siliceous sandstones, forming well-marked hogbacks; dip 10°	500
4. Space probably filled with sandstones and limestones dipping 5° to 18° W. In these is a bed full of *Ostrea soleniscus.* Thickness	1,000–1,500

Peale further states that Cope informed him that he obtained Cretaceous fossils from shale somewhere in this neighborhood.

At the head of Willow Creek (Crow Creek) just east of Oyster Ridge, where the old Sublette road meets the stream, Peale [2] found *Ostrea soleniscus,* Ostrea sp.?, Trapezium sp.?, and Inoceramus sp.? in a bed of soft sandstone.

The fossils collected during the summer of 1906 from the Frontier formation have been identified by T. W. Stanton. The list of species is given below. The localities from which the fossils were obtained are arranged by townships and ranges, beginning at the south end of the area.

[1] Peale, A. C., Eleventh Ann. Rept. U. S. Geol. and Geog. Survey Terr., 1879, p. 537.
[2] Idem, p. 538.

Fossils collected from the Frontier formation in 1906.

Lot No.	Locality.				Species.
	Ridge, creek, etc.	Section.	T. N.	R. W.	
3864	Oyster Ridge, near Willow Creek mine.	NW. ¼ sec. 19	22	115	Ostrea sp., *Inoceramus labiatus* Schloth., Cardium sp., Mactra sp.
3389[a]	Do	Contact of Hilliard and Frontier formations, sec. 13.	22	116	*Ostrea sannionis* White, Lima sp., Cardium sp., Mactra sp. c, *M. formosa* M. and H.
3835A	West Oyster Ridge	Second outcrop west of prospect, 950 feet north and 140 feet east of south center sec. 10.	23	116	Single rock fragment full of small imperfect fresh-water shells.
3791	Oyster Ridge	NW. ¼ sec. 13	23	116	*Ostrea soleniscus* Meek, *Inoceramus erectus* Meek, *Cardium curtum* M. and H.
3370	Do	NW. ¼ sec. 28, and 1,000 feet north of southeast corner sec. 16.	23	116	*Corbula nematophora* Meek, *Glauconia coalvillensis* (Meek), *Admetopsis subfusiformis* Meek.[b]
3835	Do	6,000 feet west, 1,000 feet north of southeast corner sec. 18.	24	115	Ostrea sp., Corbula sp.
3838	Do	On line between secs. 18 and 19, 750 feet from west township line.	24	115	Ostrea (Alectryonia) sp.
3807	West Oyster Ridge	500 feet west of northwest corner sec. 31.	25	115	Ostrea glabra M. and H.
3824	Fontenelle Creek	250 feet west of line, 1,575 feet north of southeast corner sec. 24.	26	116	Ostrea, Inoceramus, Barbatia.
3803	Do	4,200 feet west of northeast corner sec. 36.	26	116	Ostrea, Inoceramus, Avicula, *Cardium curtum* M. and H.
3798	Do	do	26	116	Mactra sp., Pholadomya sp.
3857	South of Snyder Basin	2,000 feet east and 500 feet south of northwest corner sec. 35.	29	115	Ostrea sp., *Cardium subcurtum* Meek?, Turritella sp.
3853	Do	1,000 feet east and 375 feet south of northwest corner sec. 35.	29	115	Ostrea, *Cardium pauperculum* Meek?, Mactra, Gyrodes, Turritella, *Fusus utahensis* Meek?
3797	Labarge Creek	900 feet north of southwest corner sec. 16.	29	116	Ostrea sp., Corbula sp.
3790	Do	1,750 feet west and 1,500 feet south of northeast corner sec. 26.	29	116	*Inoceramus labiatus* Schloth.?
3847	Northeast of Mount Darby.	1,000 feet east and 500 feet north of southwest corner sec. 11.	30	115	Cardium, Mactra, imperfect casts.
3866	North Piney Creek	1,375 feet west and 750 feet north of east center sec. 16.	31	115	Concretionary sandstone; no fossils.
3850	East of Mount Schidler	1,000 feet north of east center sec. 15.	31	115	Fragments of Ostrea and Inoceramus.
3789	Head of Willow Creek, east of Wyoming Range.	SE. ¼ NE. ¼ sec. 2	36	116	Ostrea sp., *Inoceramus labiatus* Schloth.?, Inoceramus sp.
3836	Little Greys River	2 miles west of southwest corner sec. 31 (unsurveyed.)	37	115	Ostrea sp.
3809	Wyoming Range	Ridge between Snake River and Willow Creek, about 1 mile west of northwest corner sec. 31.	38	116	Ostrea, Anomia, Cardium Inoceramus, Goniobasis?.

[a] From the horizon of the Third Ridge of the section at Coalville, Utah, which is believed to be in the lower part of the Montana group.
[b] Indicate a low horizon in the Colorado group.

The only collection of plants made during the summer of 1906 from the Frontier formation came from the west bank of a small ravine that drains into one of the main south tributaries of Horse

Creek, 1,000 feet east of the southwest corner of sec. 11, T. 34 N., R. 115 W. The plants were obtained from a soft bluish-drab shale dipping 65° and striking N. 10° E., and overlying a compact gray sandstone. Half a mile to the east near the crest of the westward-sloping hill excellent exposures of the Aspen formation were seen.

F. H. Knowlton, to whom the material was referred, reports as follows:

This material contains three species, a fern, a conifer, and a dicotyledon, the last the most abundant. The fern, a minute fragment, I do not know. The conifer appears to be *Taxodium distichum miocenum* Heer, and the dicotyledon *Populus zaddachi* Heer. Both these species range from the Fort Union to the Miocene, being, however, most abundant in the upper beds. I am a little uncertain just where to place them, but should incline to regard them as Green River or Bridger. More material will be needed to fix their place positively. Neither could possibly belong to the Cretaceous.

In connection with the plants collected at this locality may be noted the extremely interesting material collected by the writer in 1905 in sec. 8, T. 18 N., R. 117 W., 2 miles southwest of Cumberland reservoir, from the beds thought in the field to be Frontier formation, at or near the horizon of the "Fremont leaf bed." [1] Concerning this material Knowlton reported as follows:

One leaf, much broken, seems to be *Quercus platania;* others are fragments. This is decidedly younger than the beds from the old Fremont locality and should be approximately Laramie, but of this I am uncertain.

This lot of fossils was unquestionably collected from a bed in the Frontier formation, but may have come from a horizon slightly higher than the "Fremont leaf bed"; the lot from Horse Creek may be still higher, but the field relations indicate that it came from the lower half of the Frontier formation. The plants collected at both localities and studied by Knowlton place the beds much higher than the stratigraphic relations seem to warrant.

HILLIARD FORMATION.[2]

The name Hilliard was proposed for the dark-colored shaly and sandy strata overlying the coal-bearing Frontier formation and underlying the coal-bearing Adaville formation, by Knight in a

[1] Veatch, A. C., Geography and geology of southwestern Wyoming: Prof. Paper U. S. Geol. Survey No. 56, 1907, p. 68.

[2] Synonymy and usage of Hilliard formation:

Equal in a general way to the Sulphur Creek formation of Powell at the type locality, Geology of the eastern portion of the Uinta Mountains, U. S. Geol. and Geog. Survey Terr., 2d division, 1876, p. 50.

Greater than the Sulphur Creek formation of Powell at other points, op. cit., pp. 50, 154, 157, atlas.

Exact equivalent of the Hilliard formation of Knight, W. C., Eng. and Min. Jour., vol. 73, 1902, p. 721; Bull. Geol. Soc. America, vol. 13, 1903, p. 543.

paper read before the Geological Society of America, in which he says: [1]

I propose the name Hilliard for this horizon, the name being derived from the town of Hilliard, which is located on these beds of shale, and cite the shale beds west of Kemmerer and extending as far west as the east portal of the Oregon Short Line tunnel as a typical section.

The formation, which consists of dark-colored sandy shale, clay, and shaly sandstone, is soft and weathers readily. In it a great depression known as Mammoth Hollow has been worn.

West of Frontier and near the south end of this area the Hilliard formation contains a series of pronounced white sandstone lentils, each having a thickness of 50 to 100 feet. These lentils, which are best exposed just north and south of Hams Fork, where the stream cuts across the formation, have a longitudinal outcrop of only about 5 miles. Farther north they grade into a sandy clay that forms low ridges covered with large *Ostrea soleniscus* and that do not in any way suggest the sandstone lentils.

No coal beds were seen in the Hilliard formation in the area examined, although it lies between two main coal-bearing formations and resembles in many respects the shale of the Frontier formation. Its total thickness is about 5,000 feet, as compared with about 6,500 feet in Uinta County. Its surface exposures are few and are chiefly in the southern part of the district, in Mammoth Hollow south of Fontenelle Creek, where Peale [2] found beds of sandstone containing *Ostrea soleniscus*, and undoubtedly belonging to this formation.

Outside of Mammoth Hollow the Hilliard formation was observed in only two localities: (1) East of Labarge Ridge northeast of Saleys mine (T. 27 N., R. 113 W.), where a small area is exposed in the depression between the pre-Carboniferous rocks and the Tertiary beds surrounding Labarge Ridge, and (2) in Snyder Basin north of Thompson Plateau, SE. ¼ NW. ¼ sec. 20, T. 29 N., R. 115 W., where fragments of *Inoceramus exogyroides* and fragments similar to those in lots 3383, 3388, obtained in the shale of the Hilliard formation at upper Hams Fork Bridge (sec. 27, T. 22 N., R. 116 W.), were collected.

North of Snyder Basin along the Lander syncline, as well as north of Labarge Creek in the Greys River syncline, no Hilliard strata were seen. The formation possibly occurs farther north, near the fault contact, but if so it is concealed by the heavy talus along the east slope of the ridges. In most localities, however, the rocks along the fault have been thrust over so far as to cut out the beds above the

[1] Knight, W. C., Bull. Geol. Soc. America, vol. 13, 1903, p. 543. In Eng. and Min. Jour., vol. 73, 1902, p. 721, he says: "For this shale formation I propose the name Hilliard, on account of the great development near that place."

[2] Peale, A. C., Eleventh Ann. Rept. U. S. Geol. and Geog. Survey Terr., 1879, p. 536.

Frontier formation and to cause the coal-bearing beds of the Frontier to extend up to the Carboniferous contact.

Fossils collected from the Hilliard formation were identified by Stanton as follows:

Fossils from Hilliard formation.

Lot No.	Creek, ridge, etc.	Locality.			Species.
		Section.	T. N.	R. W.	
3368	Mammoth Hollow	Northeast corner sec. 3	22	116	*Ostrea soleniscus* Meek.
3390	Upper Hams Fork Bridge.	½ mile northwest of source of lot 3383, sec. 22.	22	118	Cardium sp., Mactra sp., *Corbula subtrigonalis* M. and H. Probably from the Montana group.
3383	.....do	27	22	116	*Inoceramus exogyroides* M. and H.
3388	.....do	27	22	116	Ostrea sp., Inoceramus sp. (fragments of thick-shelled forms, probably *I. exogyroides*), Tellina? sp., Mactra sp. cf. *M. formosa* M. and H. The Mactra indicates that this lot came from the Montana group, though its horizon may be as low as the top of the Colorado.
3825	Mammoth Hollow	1,250 feet west of northeast corner sec. 23.	23	116	*Ostrea soleniscus* Meek.
3367	.....do	Southwest corner sec. 33	23	116	Do.
3833	.....do	3,350 feet west and 375 feet south of northeast corner sec. 24.	24	116	*Inoceramus* cf. *erectus* Meek. Fragments of a large specimen. Known elsewhere only from the Niobrara, and may be said to be characteristic of the base of the Niobrara or the top of the Benton.
3829	Fontenelle Creek	250 feet east and 500 feet south of northwest corner sec. 8.	25	115	Pinna fragment.
.....	East of Labarge Ridge	SW. ¼ SW. ¼ sec. 4	26	113	Inoceramus sp., related to *I. erectus* Meek. Cardium sp., either *C. pauperculum* Meek or *C. speciosum* M. and H. The specific characters are not preserved. Baculites? sp. Small obscure casts, probably belonging to Baculites.
.....	Near north end of Labarge Mountain.	SE. ¼ SE. ¼ sec. 12.	28	114	Lingula, *Corbula subtrigonalis* M. and H. Marine Cretaceous forms, probably from pretty well down in the Hilliard.

ADAVILLE FORMATION.

The Adaville formation was first defined by A. C. Veatch[1] as follows:

> The group of strata immediately overlying the Hilliard shale has from the earliest settlement of this region been noted for the great number and thickness of the coal beds it contains. At the Adaville mine, 2 miles south of the Hodges Pass tunnel, on the Oregon Short Line, a bed of coal 84 feet thick has been cut, and as the whole formation shows a like phenomenal amount of coal and is, moreover, well exposed at this point, it has been named the Adaville formation.

[1] Veatch, A. C., op. cit., p. 72.

As these beds occur in two localities in Mammoth Hollow near the south end of the area here treated the name has been extended to this region.

The Adaville formation consists of gray, yellow, and black carbonaceous clays and irregularly bedded brown, yellow, and white sandstones. The sandstone beds do not weather so readily as the interbedded or underlying shales, and the Adaville strata rise distinctly above the area underlain by the Hilliard formation.

Mammoth Hollow lies in a synclinal valley, bounded on the east by the hogbacks of the Frontier formation, of which Oyster Ridge is the most prominent, and on the west in part by the hogbacks of the Frontier formation, of which West Oyster Ridge is the most important, and partly by the sandstones of the Adaville formation. These sandstones, however, do not form the pronounced hogback ridges observed farther south.

The Adaville formation outcrops in two localities in Mammoth Hollow near the south end of the area along the synclinal axis of the Lazeart syncline, where the maximum thickness approximates 4,500 feet. Exposures of the Adaville formation also occur along the east side of Labarge Ridge north of Labarge Creek.

A meager collection of fossils obtained from the Adaville was studied by Stanton, who reports as follows:

Species from the Adaville formation.

Lot No.	Ridge, hollow, etc.	Locality.			Species.
		Section.	T. N.	R. W.	
3823	Mammoth Hollow........	SW. ¼ sec. 29..............	25	115	Inoceramus fragment, Tellina.
3851	Labarge Ridge, Saley mine.	2,250 feet south and 2,625 feet west of northeast corner sec. 29.	26	113	Modiola sp., *Corbula subtrigonalis* M. and H., *C. perundata* M. and H., *C. undifera* Meek.
3856	North of Labarge Ridge....	830 feet south of southeast corner sec. 31.	29	113	*Corbula subtrigonalis* M. and H., *C. perundata* M. and H.

Three of the species above mentioned are the same as those collected south of the old Adaville mine.

Fossils obtained by earlier investigators just south of the old Adaville mine are of the utmost importance from the evidence they give as to the age of the Adaville formation and of the beds east of Labarge Ridge. Concerning this material Veatch[1] says:

One-half mile south of the Adaville mine and 2½ miles from Hodges Pass tunnel, at a point where the Adaville coal has burned out and baked the adjoining beds, numerous well-preserved shell and leaf impressions were found in masses of baked clay. The exact stratigraphic relation between the coal and the baked clay is not known,

[1] Veatch, A. C., op. cit., p. 74.

but it is inferred that the clay formerly overlaid the coal. This horizon is stratigraphically 200 or 300 feet above the base of the Lazeart sandstone, which was traced from this point to the eastern end of Hodges Pass tunnel. Dr. T. W. Stanton makes the following report on the invertebrates:

Secs. 29 and 30, T. 21 N., R. 116 W., Adaville mine.

Anomia sp. cf. A. micronema Meek.
Modiola sp. cf. M. laticostata White.
Nemodon sp.
Sphærium? sp.
Corbula subtrigonalis M. and H.
Corbula perundata M. and H.
Corbula sp.
Melania sp. cf. M. insculpta Meek.
Admetopsis? sp.

"With the exception of the Nemodon, which is a marine genus and the Sphærium?, which is fresh water, all the species in lot 3384 are brackish-water forms and belong to types that have a great vertical range in the Upper Cretaceous. Several of them have near relatives in lot 3385, which is probably from a much lower horizon. I judge the horizon of this lot to be somewhat lower than the Laramie and in the upper part of the Montana group, though nearly all the species are represented in the Laramie by identical or closely similar forms."

Dr. Knowlton reports regarding the leaves:

"*NW. ¼ sec. 29, T. 21 N., R. 116 W.*—Beyond question this is the most puzzling lot in the collection. It consists of a large number of specimens in a red hard-baked shale. The following genera are represented: Populus, Quercus (two or three forms), Diospyros, Cinnamomum, etc.

"By all tokens it would seem that this flora should be the same as that at Hodges Pass, namely, Laramie, but it certainly is not. Not a single form from this locality appears to be common to the beds at Hodges Pass, nor are they familiar to me in the Laramie at other places. I am undecided as to the age of these beds. At first I was inclined to call them Dakota, but they may be as late as the Montana. I do not think they can be later."

* * * * * * *

The apparent conflict between the evidence furnished by the Ward collection from Hodges Pass and the collection from a point 2½ miles from the tunnel at a horizon known to pass through the tunnel, naturally demands an explanation. The original field labels on a number of Ward's specimens were examined and showed that they came from the west end of the tunnel.[1] A section of this tunnel, furnished by the railroad company, shows a thick bed of sandstone at the east end of the tunnel, which is believed to be the Lazeart sandstone. Over this is a thin bed of coal and 65 feet higher is a coal bed more than 30 feet thick. This is about 300 feet from the base of the formation and is the extension of the thick bed encountered in the Adaville mine. This fixes the horizon of the fossils listed above with reference to the tunnel. The beds exposed at the west end of the tunnel are stratigraphically 338 feet above this coal bed, and there is thus no distinct stratigraphic conflict between the two collections. They merely suggest that the line between the Laramie and the Montana lies somewhere between the two points, and that Ward's collection is to be regarded as from the very base of the Laramie.

Plants were also collected from the Adaville formation west of Hodges Pass tunnel, or about 2,600 feet stratigraphically higher than the beds that yielded the Ward collection from Hodges Pass tunnel.

[1] All the original field labels were not examined and the conclusion that all the material collected by Ward came from the west end of the tunnel can not be held to be proved.

Lester F. Ward[1] described and figured **Dryophyllum bruneri* Ward (=*D. subfalcatum* Lx.),[2] **Dryophyllum falcatum* Ward, **Alnus grewiopsis* Ward, **Nyssa buddiana* Ward, *Cinnamomum lanceolatum* (Ung.) Heer.[3]

Ward says:[4]

> There are good reasons for believing that these beds belong to the uppermost series of Laramie strata, and until more is known of them they may be regarded as forming a northern member of the Evanston coal field. The plants, however, differ widely from any found elsewhere.

In order to ascertain whether Evanston fossils occurred near the old Twin Creek mines in the NW. ¼ SE. ¼ sec. 7, T. 21 N., R. 116 W., above the horizon from which Ward obtained his plants, a few hours were spent in collecting fossils at this locality. Concerning this material Knowlton reports: "1,250 feet west of old Twin Creek mine opening north of valley: *Cinnamomum affine?* Lesq., *Dombeyopsis obtusa?* Lesq., fragments of dicotyledons. The age of this is probably lower or true Laramie."

CRETACEOUS OR TERTIARY SYSTEM.

EVANSTON FORMATION.

Overlying the Adaville formation, but chronologically separated from it by a long period of folding, faulting, and erosion, is a series of gray and yellow shales, clays, sandstones, and some small coal beds, which in southern Wyoming is known as the Evanston formation.

The Evanston formation was first defined by A. C. Veatch[5] in 1906 while studying the coal-bearing beds that outcrop in the bluffs on the east side of Bear River just north of Evanston, Wyo. The rocks had previously been called "Evanston beds,"[6] "Evanston coal series,"[7] "Evanston coal-bearing strata,"[8] and "Evanston group"[9] by the geologists who studied the region.

As defined by Veatch the formation consists of the same beds to which White and Lesquereux applied the geographic term Evanston. Rocks in this area to which the name Evanston formation is applied resemble in their lithologic aspects the coal-bearing Adaville formation. They consist of yellow, gray, and black carbonaceous shales,

[1] Veatch, A. C., op. cit., p. 73.
[2] Knowlton, F. H., Bull. U. S. Geol. Survey No. 152, 1898, p. 91.
[3] These species were figured in Sixth Ann. Rept. U. S. Geol. Survey, 1885, and figured and described in Bull. U. S. Geol. Survey No. 37, 1887. Species first described from this locality are marked *.
[4] Sixth Ann. Rept. U. S. Geol. Survey, 1885, p. 541.
[5] Veatch, A. C., Bull. U. S. Geol. Survey No. 285, 1906, p. 332; Prof. Paper U. S. Geol. Survey No. 56, 1907, p. 76.
[6] Emmons, S. F., U. S. Geol. Expl. 40th Par., vol. 2, 1877, p. 337.
[7] White, C. A., Bull. U. S. Geol. and Geog. Survey Terr., vol. 4, No. 4, 1878; Eleventh Ann. Rept. U. S. Geol. and Geog. Survey Terr., 1879, p. 240.
[8] Bannister, H. M., Am. Jour. Sci., 3d ser., vol. 17, 1879, p. 244.
[9] Lesquereux, Leo, Bull. U. S. Geol. and Geog. Survey Terr., vol. 1, No. 5, 2d ser., 1875, p. 244.

brown, yellow, and white sandstones, dark-colored clay and sandy conglomeratic material, with numerous coal beds. The thickness of the formation in the Fall River basin is at least 9,500 feet; how much more is not known, for the top of the beds was not seen.

The Evanston formation is also exposed in the northeastern portion of the field east of Hoback Range.

On the east bank of Snake River near the north end of the area mapped coal-bearing beds were observed, apparently conformable below the Almy formation, but whether these belong to the Evanston formation was not determined. These beds were examined by St. John,[1] who makes the following statement:

The conglomerate deposits may be traced in beautifully weathered exposures in the outlying slopes along the west foot of the Hoback Canyon ridge (Hoback Range) to the north and south of the little stream (Horse Creek), where they were also examined by Mr. Perry. To the west they are underlain by a gray ledge, consisting of waterworn pebbles of gray limestone, various kinds of sandstone, quartzite, and chert, the light-gray calcareous matrix, or cementing paste, often replacing the coarser material and forming a coarse light-gray limestone quite free from pebbles. This bed, of which a thickness of above 50 feet is exposed, also dips northeastward at an angle of 20°, appearing in the hills just north of the Hoback [Fall River] a couple of miles above its mouth, and outcropping in the edge of the high terrace on the east side of Snake River, several miles to the north. At the former locality on the Hoback [Fall River] the exposures reach an elevation of 1,500 or 1,600 feet above the Snake, and a few hundred yards to the west a heavy underlying series of grayish sandstone outcrops, showing about the same direction and rate of inclination. The latter deposits afford obscure vegetable remains, which, together with their lithology, warrant their identification with the Laramie. If there be unconformity between these beds and the gray calcareous conglomerate, it is not apparent at this locality.

It is the lower beds here described that should probably be referred to the Evanston. They may, however, be Frontier or Bear River.

The Evanston formation in the Fall River basin reaches a maximum thickness of about 9,500 feet. The beds generally dip 15°–45° E., but farther west, toward the older beds, they dip more steeply. The Evanston in this basin lies unconformably upon Weber quartzite and later Carboniferous, Triassic, and Jurassic beds, involving an unconformity of more than 20,000 feet. The rocks consist chiefly of clay, carbonaceous shale, shaly sandstone, and brown, gray, yellow, and white sandstone. Associated with these rocks are some coal beds, but owing to the extensive talus cover, to their ready weathering, and to the lack of prospecting it is not possible to state how thick or numerous they are. Probably they contain nearly as much coal as the Adaville formation east of Labarge Ridge.

The fossils collected in these beds by members of this party were studied by T. W. Stanton, who makes the following report:

---

[1] St. John, Orestes, Twelfth Ann. Rept. U. S. Geol. and Geog. Survey Terr., pt. 1, 1883, p. 191.

Fossils in the Evanston formation in Fall River basin.[a]

Lot No.	Ridge.	Locality.			Species.
		Section.	T. N.	R. W.	
3840	Travis	1,250 feet south of northwest corner sec. 18.	37	113	Sphærium, Bulinus, Planorbis, Columna ?
3841	....do	1,500 feet west and 500 feet south of east center sec. 31.	38	113	Sphærium, Bulinus, Planorbis, *Limnæa tenuicostata* M. and H.?, Campeloma?, Hydrobia, Chara.
3849	....do	750 feet south and 250 feet east of north center sec. 31.	38	113	Unio, Sphærium, Viviparus, Planorbis, Goniobasis? *Thaumastus limnæiformis* M. and H.?
3852	....do	1,625 feet north of west center sec. 31.	38	113	Bulinus, Planorbis, Columna?, Chara (nutlets), etc.

[a] These purely fresh-water fossils suggest the Evanston formation or so-called Upper Laramie.

The Evanston formation is overlain by a series of conglomeratic sandstones and interbedded clays which are correlated with the Almy formation of Uinta County. These two formations are separated from the overlying Knight formation by an unconformity which represents a period of minor folding and faulting and erosion amounting to several thousand feet. Thus a series of beds over 12,000 feet thick, apparently conformable and certainly nowhere so greatly disturbed as those that preceded or succeeded them, is separated from the rest of the section by unconformities due to pronounced orographic movements and erosion. The great break occurs between the Evanston formation and the known Cretaceous.

Some paleontologists have regarded the Evanston formation as Laramie and have referred it to the Cretaceous, whereas others have called it Wasatch and have referred it to the Eocene. The relation between the conglomerates of the Almy and the Evanston formation as observed in the Lincoln County field is apparently the same as between the Denver and Arapahoe formations of the Denver region.[1] The classification of the Evanston formation, therefore, involves the determination of the dividing line between the Eocene and the Cretaceous in the Rocky Mountain region.

The early geologists who studied the Evanston formation were inclined to consider it part of the Laramie. White, while studying in detail the invertebrate fauna and comparing it with the material found at Wales, Utah, concluded that the Evanston was undoubtedly Wasatch. Ward [2] and Knowlton [3] have considered it equivalent to the upper coal-bearing series at Carbon, Carbon County; Knowlton further reported that the leaves collected in 1905 from the Evanston formation are of "Upper Laramie" age.

[1] Cross, Whitman, Mon. U. S. Geol. Survey, vol. 27, 1896, pp. 212–213.
[2] Ward, L. F., Sixth Ann. Rept. U. S. Geol. Survey, 1885, p. 443.
[3] Knowlton, F. H., Bull. U. S. Geol. Survey No. 105, 1893, pp. 58–60.

In the summer of 1906 Veatch showed that the upper coal-bearing series about Carbon, Wyo., belongs to the "Upper Laramie," thus confirming Knowlton's correlation of the Evanston. Veatch further proved that in Carbon County the "Upper Laramie" beds (Evanston) are conformably overlain by the Fort Union. It is not at all improbable that the upper beds in the Evanston formation in the Fall River basin may belong to the Fort Union, but as no fossils were obtained from them this point remains doubtful. The stratigraphic evidence, however, strongly suggests that the division line between the Eocene and the Cretaceous should be drawn at the base of the Evanston.

TERTIARY SYSTEM (EOCENE SERIES).

WASATCH GROUP.

ALMY FORMATION.

The Almy formation was first defined by Veatch [1] and named from the town of Almy, Uinta County, Wyo. It forms the lowest formation of the Wasatch group as defined by Hayden [2] at the type locality between Carter, Wyo., and a point 7 miles below Echo City, Utah, on Weber River.

The Almy formation in this area consists for the most part of pronounced conglomerate beds. Some of the pebbles are angular and irregular; others are well-rounded and uniform. In some localities, as east of Thompson Plateau and on South Piney Creek, they are deep red and are associated with irregularly bedded sandstone and reddish clays, whereas at other localities, as on Snake River and east of Lookout Peak, they are light colored and are associated with light-colored sandstone. The color seems to be very irregular and often the reddish conglomerate is found within a few miles of the light-colored beds. The thickness, as well as the relation to the overlying and underlying formations, is difficult to determine. The thickness approximates 2,500 feet and the strata appear to be conformable on the Evanston formation, the same as in southern Uinta County, although the overlying Knight formation in many places rests unconformably on the Evanston formation and conceals the true relations. (See Pls. IV, *A*, p. 72, and V, p. 73.)

The conglomerate of the Almy formation occurs along the east sides of Thompson Plateau and of the Wyoming and Hoback ranges. In many localities outliers of the conglomerate extend high up on Hoback Range, capping unconformably the Cretaceous, Jurassic, and older rocks. At the north end of the field this conglomerate lies along the south flank of Gros Ventre Mountain, extends west over Hoback

[1] Veatch, A. C., Prof. Paper U. S. Geol. Survey No. 56, 1907, p. 89.

[2] Hayden, F. V., [Third Ann.] Rept., U. S. Geol. and Geog. Survey Terr., 1873, p. 90.

Range, and occurs in the Snake River bottoms. Conglomerate beds were also observed near the southwest corner of the area. The contact between the conglomerate and the overlying nearly horizontal Knight formation is not very distinct, but the conglomerate has been mapped wherever it was observed. Its general appearance is shown in Plate V, *A* and *B*.

Peale in his description of the Meridional Valley [1] (McDougal syncline) makes the following statement concerning the conglomerates and their relation to the Hoback anticline:

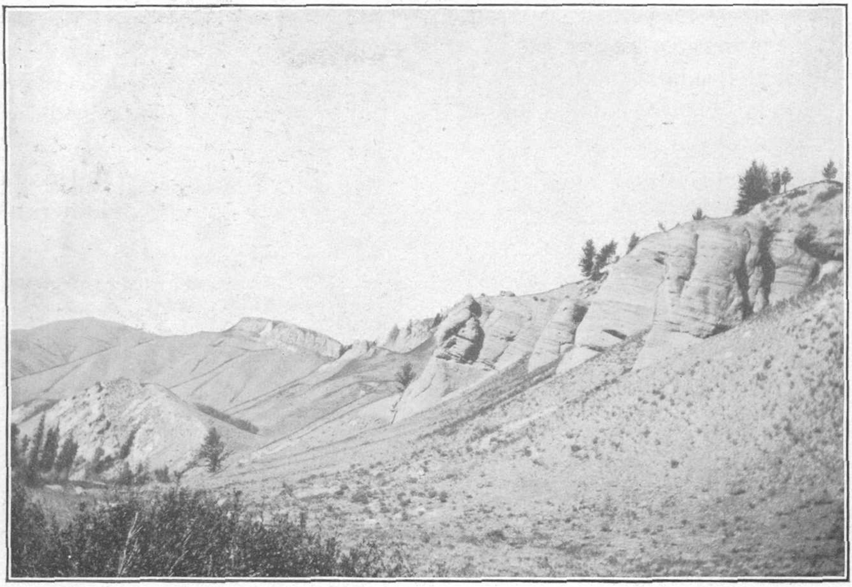
> On the east the variegated Wasatch beds rise on the ridge so as to cover the greater part of the eastern side of the anticline. They dip 6° to the eastward.
>
> * * * * * * *
>
> The section on the south side of Bitterroot Creek [North Piney] shows the fold to be still more gentle, the western members showing dips of 20°. The eastern side is still the more abrupt, and the Wasatch beds still conceal the greater portion of it. North of the Bitterroot the Wasatch beds cover the axes of the fold entirely, and present a bluff face to the westward. On top the beds are covered with the débris of the range to the westward, composed of limestone and quartzite pebbles. Underneath are the following beds:
>
> Yellow sands and conglomerates.
> Red marls and sands.
> Purple sands and conglomerates.
>
> These beds are 500 to 600 feet thick, and dip slightly to the eastward. The conglomerates are composed of quartzite and limestone pebbles and bowlders, evidently derived from the range that lies to the westward. Some of the limestone pebbles contain indistinct fragments of Carboniferous fossils. On the top of the plateau which these beds form I found corals and a Spirifer in some of the pebbles. I think these pebbles were derived from the weathering of some of the upper conglomerates. The bluff of bright-colored conglomerates extends from the Bitterroot [North Piney] to Lander Creek [South Cottonwood]. Between Lander Creek and the main branch of Marsh Creek the anticlinal again shows. On the ridge here station 51 was located, on a hard limestone containing remains of a small gastropod that is probably of Jurassic age. As seen from this point, the beds north of Marsh Creek are more folded than was noticed at any point south. The strike is about N. 13° W. There are three anticlinals, all rather gentle; west of the most western the dip of the sandstones was 30°, and next to the Carboniferous Range an angle of 20° was noticed. Between these two points, however, the beds are nearly horizontal, as shown in the section. The Wasatch beds rise on the hills on the east side, and remnants are seen resting on the upturned edges of the sandstones on the west side.

KNIGHT FORMATION.

The Knight formation, named by A. C. Veatch [2] from Knight station on the Union Pacific Railroad, near which Cope [3] obtained vertebrate remains in 1872 forms the upper formation of the Wasatch group as defined by Hayden. It consists of yellow and reddish clays, yellow and reddish sandstones, and some thin layers of fresh-water

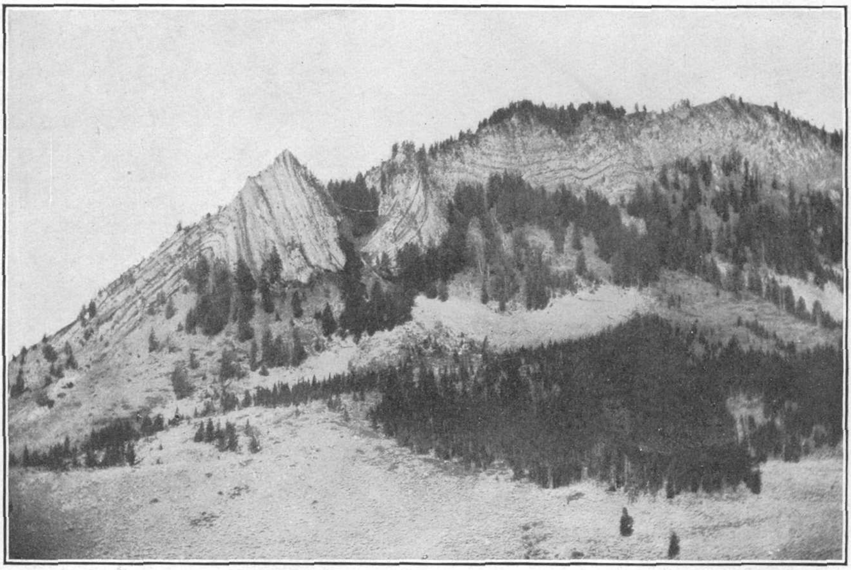
---

[1] Peale, A. C., Eleventh Ann. Rept. U. S. Geol. and Geog. Survey Terr., 1879, pp. 539–540.
[2] Veatch, A. C., op. cit., p. 92.
[3] Cope, E. D., Sixth Ann. Rept. U. S. Geol. Survey Terr., 1873, p. 545.



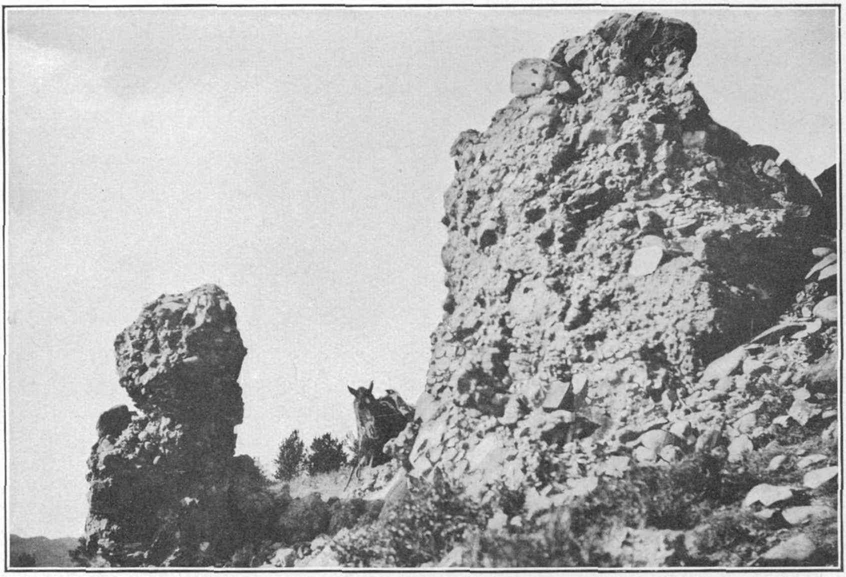
A. LIGHT-COLORED CONGLOMERATE OF THE ALMY FORMATION IN JACKSON HOLE NORTH OF FALL RIVER AND EAST OF SNAKE RIVER.

Beds dip 15°-25° NE. and form ridge several miles long.



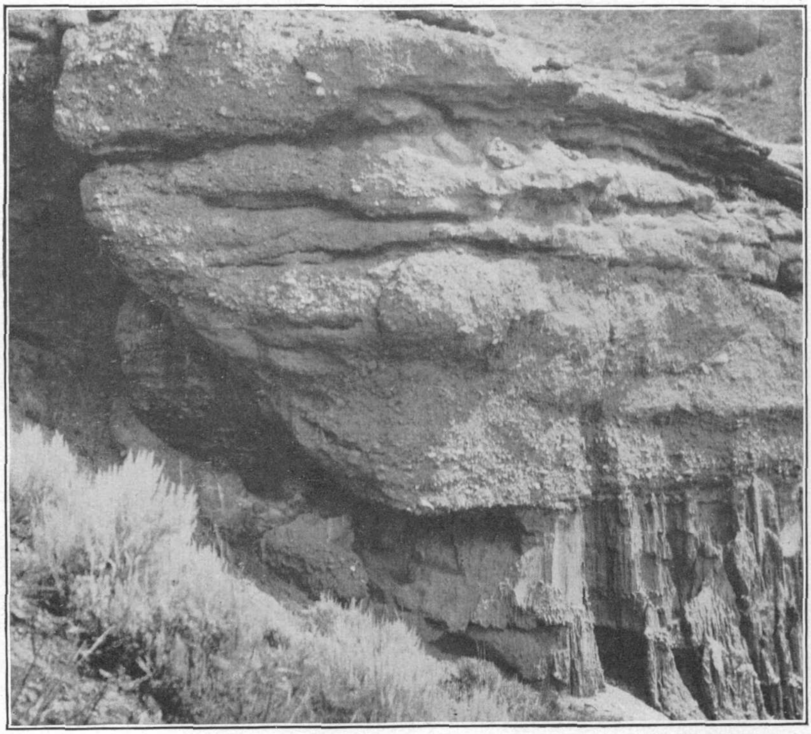
B. SHARP FOLD IN JURASSIC ROCKS ON FALL RIVER NEAR HEAD OF CANYON, T. 38 N., R. 114 W.

Showing proximity of anticlinal and synclinal axes.



A. CONGLOMERATE RESTING ON JURASSIC ROCKS WEST OF LOOKOUT PEAK, T. 35 N., R. 115 W.

Showing size of bowlders and pebbles. Many of the pebbles are very angular; others are well rounded.



B. RED CONGLOMERATE BEDS BETWEEN LABARGE RIDGE AND MERIDIAN RIDGE, T. 27 N., R. 114 W.

Showing peculiar weathering.

limestone. For the most part it dips toward the east at an angle in few places exceeding 5°. The formation rests unconformably upon the Evanston formation and apparently unconformably upon the Almy formation, although in places the dips are so nearly alike that the beds appear to grade into one another.

The Knight formation occurs along the eastern part of the field, east of Meridian Ridge and of the Wyoming and Hoback ranges. It apparently grades up, without erosional unconformity, into the Green River formation, the overlap that seems to exist in certain parts of the field probably being being due to conditions of sedimentation and to the accompanying minor earth movements. In parts of the field the Knight formation was not separated from the overlying Green River formation, and the two have been mapped together as undifferentiated Eocene. About the only differentiating lithologic characteristic between them is that the Knight formation generally consists of reddish sandy clay and shaly sandstone, whereas the Green River formation is light colored and more calcareous.

At one place in T. 26 N., R. 114 W., fossils were found near the base of this formation, a short distance above the underlying conglomerate of the Almy formation. The fossils must originally have been derived from the older rock to the west, reworked by the water, and deposited with the sediments in the Wasatch sea. The collection of lot No. 3820 was obtained 1,000 feet west of the southeast corner of sec. 16, T. 26 N., R. 114 W., and consists of Ostrea and Trigonia. Stanton, who examined these fossils, states that they are probably Jurassic.

The Knight is the formation in which characteristic mammals were first found in the vicinity of Evanston, Wyo., where E. D. Cope obtained the first vertebrate remains found in the Wasatch strata and in 1872 collected numerous vertebrate specimens in the vicinity of the "Bathmodon bone bed" locality, from which the first specimen of Coryphodon was obtained in 1872.

Concerning the Wasatch group, Peale [1] makes the following statement:

The largest areas of the Wasatch are in the northern portion of the Green River basin, where a large part of the surface is covered by its deposits. The overlying Green River group in this region is mostly absent, having been eroded away. Isolated buttes, however, still remain, proving its former existence and extension over the whole region. Along the southwestern slopes of the Wind River Mountains the Wasatch beds rest on the granitic rocks, and were evidently derived from the disintegration of the granitic rocks that farther to the eastward make up the main range. They consist of yellow, gray, and pink sands and marls, which dip from 5° to 10° from the mountains. West of Green River the character of the beds is similar to those on the east. They are generally brick red in color and weather into picturesque badland forms. Along the edge of the basin they are found to be composed mainly of conglomerates,

[1] Peale, A. C., op. cit., pp. 635–636.

which contain pebbles of limestone, and which were evidently derived from the adjacent mountains. When these beds were deposited it is evident that a large part of the land had been eroded, for the Mesozoic beds must have been largely removed from the mountains.[1] The red character of the sediments, however, is due to the wearing down of the red Mesozoic rocks, as the conglomerates of the Wasatch are cemented by siliceous material, the predominating color of which is red. The red color, however, is more marked farther from the mountains, where the sediments are finer.

* * * * * * *

North of Thompson Plateau the group rests on Jurassic, Cretaceous, and Laramie ["Upper Laramie"] beds, and isolated patches rest on the latter, close to the mountains. Nowhere along the western edge do we get the entire thickness of the group. The thickness exposed is only about 500 to 800 feet. This is due to the fact that the region of the eastern outlying fold was above the level of the lake, through the earlier portion of its existence, and a portion of its sediments were derived from the erosion of the ridge formed by this fold.

An arm of the lake in the later stage of its existence reached northward, around the southern end of Absaroka Ridge in Hams Fork basin. A second arm extended northward in the region of Bear Lake and the Bear Lake Plateau. This arm was separated from the first by a long, narrow peninsula, which now forms the range between Bear River valley and Hams Fork basin. During the early stages of the lake this was probably a Mesozoic range, but the rocks of that age were largely removed by the time the subsidence had carried it down almost to the level of the lake. In the Green River epoch it was probably under water. The Wasatch group, resting on its eastern flanks, is on the Carboniferous, and is not very thick. On the Bear Lake Plateau the thickness is greater, especially toward the west, and on the eastern flanks of the Bear River Range it is still greater. It increases also to the southward until it is several thousand feet in thickness. In the Bear River Plateau it rests on Paleozoic and Mesozoic rocks, which are folded and eroded, and along the Bear River Range the underlying rocks are Silurian quartzites.

GREEN RIVER FORMATION.

The Green River formation was originally named and defined by Hayden in 1869 from exposures along Green River near the town of Green River for the beds between the Wasatch and Bridger formations. King, in the Fortieth Parallel Survey, likewise placed the Green River formation above the Wasatch and below the greenish beds of the Bridger formation. Later, however, Cope included in the Green River formation both the Wasatch and the Green River of Hayden, and Lesquereux used the term in a still broader sense, including the Wasatch, Green River, Bridger, Uinta, and White River in the Green River formation.

As the mapping was not carried far beyond the contacts of the coal-bearing formation and the overlying nearly horizontal Tertiary beds, there was very little opportunity for the writer to study the Green River formation in this area. It consists of light-colored shale, a few sandstones, light-colored calcareous limestone, and some bands of red or purple calcareous shale. Near the south end of the field the Green River formation can readily be differentiated from the

[1] I have already alluded to the probability of a portion of this erosion having taken place during the latter part of the Laramie.

underlying Knight formation, for here light-colored sandstones of the Green River overlain by calcareous layers and fissile shale rest conformably on the soft variegated beds of the Knight formation. Peale[1] says:

On the west side of Green River above Labarge Creek the group is present only in isolated mesas. South of that stream, however, it is the surface formation, rising from Green River to the westward and breaking off in bluffs that face Meridian Ridge. Whenever seen, the group rests conformably on the Wasatch. It is seen dipping with the latter where it rises on Meridian Ridge and in the Hams Fork Plateau, but when upturned it appears to have been very easily eroded, so that it generally ends in a bluff face just east of the steeper inclination. This often makes it resemble an unconformity, but it is only apparent, for the Wasatch beds are always seen in position beneath the Green River group, dipping in the same direction and at the same angle. As we recede from the line of greatest elevation the angle decreases, and that portion of the Green River group which was most inclined has been removed.

Farther north, however, some difficulty was experienced in locating the contact. The white calcareous limestone of the Green River, which is so characteristic near the southern part of the field and which yields the well-preserved fish and plant remains obtained in the cliffs around Fossil, on the Oregon Short Line Railroad, loses its identity toward the north and more and more of white limestone appears in the Knight formation. For this reason, as well as because no detailed examination was made of the areas where the beds are best developed, the Green River and the Knight formations of this part of the area are represented on the map as undifferentiated Eocene.

No attempt was made to collect fossils from the Green River formation. A few picked up by one of the men at one locality were sent in with the other lots and were examined by W. H. Dall, who makes the following statement:

The material consists of defective casts of Anodonta or Unio, and what is probably Vivipara—nothing characteristic whatever—and all that can be said is that the formation is fresh water and probably Tertiary.

The shales of the Green River formation are highly fossiliferous and have yielded fossils at several localities. Cope,[2] in speaking of numerous remains of fishes found by him in 1873, on Fontenelle Creek, says:

In the lower strata in this locality as well as on the east side of Green River above the mouth of Labarge Creek are numerous remains of fishes similar to those of Green River City, with insects and their larvæ, shells like Pupa and Cyrena, and millions of Cypris. The larvæ are dipterous, some nearly an inch long and others minute, and in prodigious numbers. With them are found stems of plants but no leaves.

In beds of limestone that probably belong to the upper part of the Green River, A. C. Peale discovered at the mouth of Horse Creek an interesting collection of petrified cases of caddis-flies, all belonging to

[1] Peale, A. C., op. cit., p. 637.

[2] Cope, E. D., Seventh Ann. Rept. U. S. Geol. and Geog. Survey Terr., 1874, pp. 439, 440.

a single species to which the name *Indusia calculosa* was applied. For further information regarding this discovery the reader is referred to Hayden's Eleventh Annual Report.

QUATERNARY SYSTEM.

The Gros Ventre Mountains and probably the Wyoming and Salt River ranges were covered with glaciers during a part of the Quaternary period. Deposits of doubtful glacier age were seen along the east side of the Salt River Range, the northern part of Absaroka Ridge, and the Wyoming and Hoback ranges, and elsewhere. However, over much of the area the glacial material has been partly eroded and modified by land slips, river terraces, and valley fill, so that it is very difficult to determine how much of the material is due to glaciation. Along the south flank of the Gros Ventre Mountains in the vicinity of Granite Creek were observed the thickest glacial deposits. The morainal material covers many of the hills, slopes, and valleys, clings to the steep slopes, and overrides some of the higher hills. Farther down the mountain slopes the moraines diminish in thickness and spread out laterally over the more gentle declivities. A few miles from the mouth of Granite Creek a moraine which forms a low embankment clear across the valley has been cut by the stream in a narrow channel 25 to 30 feet in depth. Whether this marks the lower terminus of the ice advance was not determined. The terraces, river bottoms, and valley fill are well defined along these streams and are partly if not entirely fashioned out of the Quaternary deposits.

The numerous terraces along the more important streams and the peculiar hummocky ridges and knolls, many of whose hollows contain wet meadows, suggest glacial activity, but how much of this topography is due to glaciation and how much to landslips, snowslides, and water work required more time to determine than could be devoted to it in the present investigation.

Travertine deposits were seen at several places. Small sulphur deposits were seen about several springs in the northern part of the field, where the water is highly charged with sulphureted hydrogen and in places reached a maximum temperature of 125°. The largest of these deposits was observed on the south bank of Snake River in the vicinity of Count's ranch, where several warm springs are located along the fault line west of the anticlinal axis, here composed of quartzite. The water from several of these springs escapes through the gravel near the edge of the river on the south bank and emits an abundance of sulphureted hydrogen. The temperature of the water, which is slightly mixed with river water, was 118° F. Several similar springs are scattered over the valley bottom and farther up the creek. Over one of these springs a bathhouse has been built and the water is utilized for bathing and medicinal purposes. A few rods downstream a group of calcareous springs has built up a dam so as to flood several acres about the vents, which are now inaccessible. The temperature of the water in the pool was 95° on October 8, 1906.

STRUCTURE.

PRINCIPAL FEATURES.

The main disturbance giving rise to the structural features in this region occurred near the close of the Cretaceous period, before the deposition of the Evanston, Almy, and Knight formations. In the beds of the Almy and Knight were found fossils of the older beds that had been reworked by the waters and redeposited in the Eocene sea. An earlier disturbance probably occurred between the deposition of the Jurassic and that of the Bear River formations, as the evidence indicates that the Lower Cretaceous series and the Dakota of the Upper Cretaceous series (unless the Bear River is the equivalent of the Dakota) are wanting in this area. There was, however, at this time no great folding and faulting, for throughout the area the Bear River strata are apparently conformable upon the known Jurassic beds. A minor movement also occurred after the deposition of the Evanston and Almy formations. Movement during this disturbance was for the most part along the old lines of weakness, the younger beds being faulted, folded, and tilted in places to dips of 25° to 50° in opposite directions to those of the older underlying beds. Most of the beds, however, were very little disturbed and the two disturbances mentioned had very little effect on the structural features or units of the region. The greatest modification of the topography is due no doubt to the blanket of Tertiary beds, which in many localities has protected the older rocks from erosion.

The principal structural features of this region give rise to the main topographic units and are closely associated with the mountain ranges—the Gros Ventre Mountains, Hoback Range, Wyoming Range, and Meridian Ridge on the one hand and the Salt River Range and Absaroka Ridge on the other. These lines of weakness are parallel to one another and have a north-south trend with a slight westward deflection which increases toward the north. They are the direct northward continuation of the faults and folds observed in the northern portion of the area in Uinta County mapped during the summer of 1905. Owing to the heavy covering of Tertiary deposits some of the structural features are visible at only one or two localities.

The main structural units extend north and south throughout the area. Their structural continuity, however, is more or less broken north of Thompson Plateau and south of the Wyoming Range by a fault that cuts them at right angles and considerably displaces the anticlinal and synclinal axes. North of this cross fault the structure is somewhat more complicated and the topography more rugged. The broader structural features on both sides of the fault, however, may be correlated and treated genetically as a unit.

The principal features, enumerated from east to west, are the following (Pl. I):

1. Gros Ventre anticlinorium.
2. A rather complex anticline—the Labarge anticline.
3. A rather regular syncline—the Cliff Creek syncline.
4. A rather complex anticlinorium, part of folds overturned—the Hoback anticline.
5. An irregular syncline, in part a monocline, developing one or two folds near the northern end—the McDougal syncline.
6. A large and persistent thrust fault, presenting a very irregular scarp front—the Darby fault.
7. An east-west fault cutting across the Wyoming and Hoback anticlines and the Lander syncline at nearly right angles—the Thompson fault.
8. A rather irregular complex anticline—the Wyoming anticline.
9. A very irregular and in places overturned syncline—the Lazeart-Greys River syncline.
10. A very large and persistent thrust fault with a somewhat irregular eastward-facing scarp—the Absaroka fault.
11. A complex anticline—the Salt River anticline.
12. A broad syncline west of this area—the Fossil syncline.

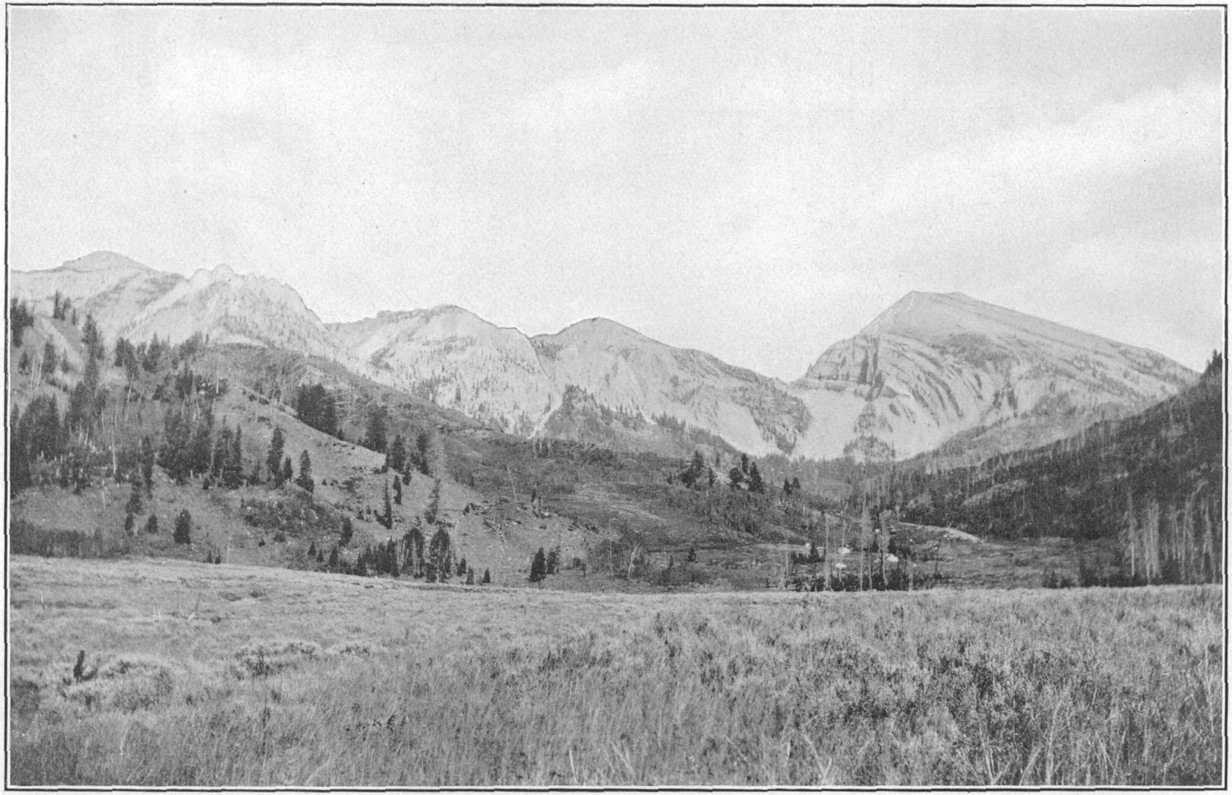
GROS VENTRE ANTICLINORIUM.

The Gros Ventre Mountains lie at the northeast corner of the area and constitute one of the important structural units of the region. As the mapping of the present party extended only to the base of the mountains, the following extracts from Hayden[1] are given to show the relation of the folds southwest of the mountains to the main Gros Ventre uplift. (See Pl. VI.)

Although the trend of the range, topographically, is as above stated, east-southeast and west-northwest, the axis of elevation lies more nearly in a southeast and northwest direction. The upheaval, which was evidently an event closely following the close of the Mesozoic age and probably extending into Cenozoic time, was accompanied by at least two principal mountain corrugations parallel with one another, and perhaps not more than 5 miles apart. Besides the principal folds there were other minor undulations, whose extent and relations can only be worked out by a careful detail survey. The respective extent of the longer axis of the principal folds can not at this time be determined, but the amount of vertical displacement in the southern fold was at least a few hundred feet in excess of that in the northern one. In the eastern half of the range, however, the southern fold has been entirely removed by erosion, so that the south flank of the mountain in the latter quarter is formed by the abrupt slope of the northern fold. South of Gros Ventre Peak the site of the greater fold is concealed by Tertiary deposits, which reach high up on the mountain flank at this point and thence incline off gently into the Hoback-Green River basin.

---

[1] Twelfth Ann. Rept. U. S. Geol. and Geog. Survey Terr., pt. 1, 1883, p. 208.



SOUTH SLOPE OF GROS VENTRE MOUNTAINS. TERRACE BANK OF GRANITE CREEK IN FOREGROUND.

Showing south limb of anticline and steeply southward-dipping beds.

An interesting and important coincidence is the existence of strongly marked broad, deep gaps at both ends of the range. On the east, in the vicinity of the Wind River Mountains, it appears from the low fold of Carboniferous rocks exposed along Green River, 6 miles south of the big bend, where the upper course of Green River leaves its mountain gorge and flows southward, that the uplift was much less emphasized than on the west, in the vicinity of the Teton uplift, where the metamorphic nucleus has a much more abrupt termination on the borders of Jacksons Basin fronting the Teton Range.

On the whole the Gros Ventre Range has a more intimate relation with the Teton and Wyoming ranges than with the Wind River Range, although they are all tied together by the transverse uplift of the Gros Ventre Mountains. Hayden[1] says:

> It is apparent that the present condition of the range does not preserve its original proportions; that in pre-Cenozoic times it was subjected to erosive agents, whose action has degraded and removed an enormous quantity of rock materials over its whole extent, but especially active were these degrading influences in the western portion of the uplift where half its original bulk has been swept away and the comminuted materials intermingled with the thousands of feet thickness of Tertiary sediments filling the neighboring basin areas. Although the vertical displacement varied considerably, being greatest in the western half, erosion has reduced the crest of the range to a nearly uniform average height of 11,000 feet. The highest point, 12,200 feet, lies about 12 miles to the northwestward of Gros Ventre Peak; at Station XII in the western part of the range the altitude is 11,196 feet above the sea.

LABARGE ANTICLINE.

The crest of the Labarge anticline is exposed along the east side of Labarge Ridge in only two localities, at both of which numerous minor folds are visible. Throughout the remainder of the region the anticline is covered by Tertiary deposits, which commonly dip regularly eastward across it and give no hint of its position. Just north of the pre-Carboniferous outcrops at the north end of Labarge Ridge a minor anticline in the Evanston formation may indicate the crest of the main fold and give the location of the anticlinal axis. North and south of Labarge Ridge no trace or clue of the anticline was observed, and the older rocks of the mountain are completely surrounded by Tertiary formations, which here rest unconformably on the upturned edges of the older rocks.

At the north end of the field, on Little Granite Creek along the southwest base of the Gros Ventre Mountains, an anticlinal axis west of the creek may represent the northward extension of the Labarge anticline. The anticline on Little Granite Creek is crested by Carboniferous rocks and is slightly overturned in one locality. Between the Labarge Ridge and Little Granite Creek the anticline, if continuous, is concealed beneath the Tertiary beds.

---

[1] Loc. cit.

CLIFF CREEK SYNCLINE.

The Cliff Creek syncline lies along the east flank of the Hoback Range and is genetically a part of the Hoback anticlinorium. The axis of the syncline lies for the most part west of Cliff Creek and its trough is occupied by Jurassic rock. (See Pl. IV, *B*, p. 72.) North of Fall River older rocks occupy the trough, which forks near the north end of the area, forming two synclines, leaving between them a minor anticline, along whose crest Carboniferous rocks are exposed. The syncline shows many minor folds and disturbances, including several small closely folded anticlines along the east limb. The low ridge to the east of the syncline is made up almost exclusively of Mesozoic strata and structurally seems to have been determined by a sharp and in places slightly overturned fold in the older beds, which locally exhibit a regular anticline. Upon the upturned edges of these beds rest unconformable Tertiary formations, dipping eastward. This relation is attributable to denudation along the old Tertiary shore line, and the tilting of the Tertiary rocks indicates conclusively a late uplift within the area occupied by the Hoback Range, for the present Tertiary beds slope into the basin eastward or away from the older beds at an angle of decreasing steepness.

Within the Fall River basin Tertiary rocks in places completely envelop the low ridge and extend high up on the eastern limb of the syncline, but south of the basin all traces of the Cliff Creek syncline are lost and Tertiary formations conceal the underlying structure.

HOBACK ANTICLINE.[1]

The crest of the Hoback anticline is exposed throughout most of the area north of the Thompson Plateau. However, at four localities Tertiary beds conceal the anticlinal crest and at many others Tertiary conglomerates extend high on the east flank of the anticline and occur as remnants or outliers along its west flank. From the Thompson Plateau north to Horse Creek the anticline is slightly overturned and is accompanied by minor folds. North of Horse Creek it exhibits two distinct anticlinal crests, separated by a synclinal trough, all three of which are overturned in places. The southern portion of the crest of the eastern anticline is composed almost wholly of Jurassic beds, and the northern third is composed of older rocks. On South Piney Creek the Nugget sandstone is exposed along the crest of the anticline but does not reappear between this place and a point north of Horse Creek. To the north the crest of the western anticline is composed for the most part of Carboniferous rocks, but to the south the fold is capped by the Nugget, Twin

[1] The south end of this anticline Peale named Meridional fold and the north end St. John called Hoback Canyon Ridge (Eleventh Ann. Rept. U. S. Geol. and Geog. Survey Terr., 1879, Pl. LIII, p. 540; Twelfth Ann. Rept., pt. 1, 1883, p. 179).

Creek, and Beckwith formations, and it finally dies out in the Cretaceous beds south of Horse Creek. The northern part of the anticlinal fold becomes flatter and finally disappears beneath Tertiary conglomerates north of Fall River and east of Snake River. This western fold south of Fall River divides into two anticlinal crests, inclosing between them a small syncline, which, like the eastern fold, is buried beneath Tertiary beds. The low western fold crosses Fall River and Snake River just above the mouth of the former and is not concealed by the later beds.

Concerning the structure of this range St. John[1] makes the following statement:

For a few miles south of the Hoback Canyon the main mountain ridge presents a sort of double crest. * * * Its structure throughout is that of two parallel folds, separated by a shallow synclinal trough. The eastern, or Station II, ridge presents an abrupt and often escarped wall 500 to 800 feet high, facing the Hoback Basin. * * * From the foot of the escarpment on the east a rugged wooded belt steeply descends into the parallel valley, in which the strata, though much disturbed and complicated, apparently form the eastern flank of an anticlinal fold. * * * Lower in the slope there are indications of a second lower fold, also arched by the Trias, whose east flank declines into the synclinal trough occupied by the parallel valley, and which is partially filled with Jurassic deposits. The eastern flank of this synclinal is the same as the outer barrier ridge [Cliff Creek syncline] already described. While the above-mentioned structural features may be regarded as normal in this part of the east slope of the Hoback Canyon Ridge [Hoback Range], it was undoubtedly subject to greater or less local variation, recording the variable action of the dynamical forces, which uplifted and folded the strata into a broad north-south mountain zone. * * *

The western ridge rises abruptly from the valley of the lower fork of the Hoback [Fall River], its crest nearly corresponding to the axis of a sharp anticlinal fold in the Carboniferous limestones, which is preserved as far north as the lower entrance to the Hoback Canyon [Fall River Canyon]. The upper portion of the western slope is faced by the westward-dipping Carboniferous limestones, succeeded by the buff and flesh-colored hard sandstones lower in the slope, which is covered with angular siliceous débris. The latter horizon holds the brecciated layers, composed of angular fragments of the quartzitic sandstone and drab limestone. * * * From the crest of the ridge the inner synclinal is overlooked, occupying a belt about 1½ miles across, extending over to Station II [east] ridge, and which is eroded into irregular sharp ridges more or less parallel to the border mountain ridges. This synclinal trough is filled with the Triassic "Red Beds," overlain by a few hundred feet thickness of the drab-colored Jurassic limestones and shales, the latter being mainly confined to the eastern portion of the depression, rising into the crest of the east ridge. The latter mountain, however, is principally composed of the inferior "Red-Bed" series, which also reaches well up on the eastern flank of the west ridge, upon which it is steeply inclined.

The continuity of the western ridge is interrupted by deep gorges cut by tributaries flowing west into the lower south fork of the Hoback [Fall River]. * * * These canyons afford natural sections, in which the structure of the ridge is fully revealed, besides affording excellent facilities for detail stratigraphical examinations.

[1] St. John, Orestes, Twelfth Ann. Rept. U. S. Geol. and Geog. Survey Terr., pt. 1, 1883, pp. 182-184.

One of the must interesting sections across this mountain belt is that presented in the sides of Hoback Canyon [Fall River canyon]. This gorge traverses the ridge in a direction a little north of west, and that portion here alluded to is about 5 miles in length. The Hoback [Fall River] flows in narrow defiles at intervals, several miles above this point. Throughout this distance the south side of the canyon is closely hemmed in by steep mountain slopes, which are frequently broken by mural escarpments several hundred feet high, in which the strata are well exposed.

St. John studied this section in 1878 and his description so well covers the essential features that it is here given with few slight changes:

At the upper entrance to this stretch of canyon stands the before-mentioned eastern border ridge, in which the Triassic red sandstones are steeply tilted, dipping westward into a synclinal depression, whose axis apparently is but a few hundred yards distant. The west flank of this synclinal rises with a more gradual ascent, bearing a heavy series of Jurassic deposits, which consist of a rather heavy deposit of rusty buff limestone, resting upon hard reddish sandstone, probably belonging to the upper portion of the Trias. Then succeed heavy ledges of drab limestone, associated with drab nodular and indurated calcareous shales, charged with quantities of *Gryphæa calceola*, the whole dipping a little north of east at angles of 30° to 35°. The latter deposits are overlain by a series of chocolate-red and gray, more or less arenaceous shales. In the latter series, at a point on the north side of the stream a short distance above the upper entrance to the canyon, a thick bed of brownish-drab limestone forms a rather prominent outcrop in the slope, rising to the westward at an angle of 45°, finally curving over past verticality in the crest of the low ridge. The same flexure is also noticeable in inferior ledges lower down the canyon, though less marked than in the above instance. Although no fossils are detected in these higher strata, they are presumed to belong to the Jura, with the lower fossiliferous beds of which they are conformable. On the east flank of the synclinal the latter beds reappear, affording abundance of their characteristic fossils.

Just east of the debouchure of a gulch heading in the north end of Station II ridge [east ridge], the Triassic red sandstones rise up and curve over in a fold with sharp, in places almost vertical, inclination on the west side, the same deposits in the east slope of the fold dipping at an angle of 25° north of east. Higher up the gulch the steeply tilted ledges have been weathered into narrow walls, presenting interesting examples of atmospheric erosion. The outer parting of this west-side slope consists of gray ledges, probably of the age of the Jura. On the north side of the canyon these horizons are not as well exposed, the slopes being strewn with red sandstone débris. In the opposite side of the gulch [west], a few hundred yards below, a heavy series of buff or pale flesh-colored and gray, very hard sandstone, including layers of siliceous limestone, occurs, which rises up into a fold with rather steep inclination in the east flank. The strata descend much more gently on the west flank of the fold, the ledges as seen in the exposures along the south side of the canyon gently undulating, until reaching a point half to three-fourths of a mile below the above-mentioned gulch, where they again more steeply rise to the westward, as shown in the mural exposures, which rise 500 to 800 feet above the stream on either side. The upper siliceous deposits here occupy the crests of the ridges and are underlain by a heavy series of grayish-drab, more or less cherty limestone, containing Zaphrentis, crinoidal remains, polyzoans, Hemipronites, Spirifer, etc. The latter beds rise descending the canyon, presenting marked inequalities or undulations, and finally make up the bulk of the canyon walls, and showing a thickness of a thousand feet, perhaps more. Approaching the debouchure of the canyon, where these strata exhibit their greatest vertical exposure, the limestones are crumpled into two low anticlinals, the axis of the lower fold, or that forming the west flank of the Hoback Mountain belt, exposing a nucleus of brownish-gray magnesian limestone, which lithologically resembles the so-called Niagara horizon. A short distance within the mouth of the canyon a small cave has been fashioned out of this bed in the wall rising over the north side of the stream, and just below this issues the sulphur spring previously mentioned. The west flank of the canyon ridge is here much eroded, the ledges in the steep slope farther south showing their basset edges, dipping westward. Higher up the canyon the limestone beds exhibit interesting examples of irregular deposition, in places a heavy bed wedging out, so that subjacent and overlying beds elsewhere separated by many feet thickness of intervening layers are brought into immediate contact.

South of the Thompson fault the Hoback anticline can not be traced, but it may be continued in an anticlinal fold of Triassic beds observed on Labarge Creek and southeast of the Thompson Plateau.

McDOUGAL SYNCLINE.[1]

The McDougal syncline lies west of the Hoback anticline and has a similar trend. It was called Meridional Valley by Peale,[2] who called the fold just east Meridional fold. Peale also, erroneously, connected the syncline east of Absaroka Ridge and made the Hoback anticline the northward extension of the Thompson Plateau, thus making the Wyoming Range the northward continuation of Absaroka Ridge and the Darby fault the northern extension of the Absaroka fault, neither of which is correct.

Owing to a fault contact the south end of the McDougal syncline terminates abruptly against the north end of the Thompson Plateau. The strike of the syncline follows approximately the bends and irregularities of the Hoback anticline, and its west boundary terminates against the Darby fault. Throughout most of its extent the McDougal syncline is a simple monocline, with beds dipping 15° N. 70° W. In places, however, it shows minor folds, as on Horse Creek, where the beds dip 65° E. At the head of Little Greys River a minor anticline and syncline were observed; west of Willow Creek and near the crest of the Wyoming Range the syncline is slightly overturned and the beds of the west limb dip 55° W.; and at the north end of the field, where the syncline crosses Snake River just below the mouth of Fall River, a small syncline and anticline were observed. Whether these minor folds are connected throughout the northern part of the area was not determined.

South of the Thompson fault the McDougal syncline was not traced, but it may be represented by a low syncline observed near the lower end of Labarge Canyon, just west of the anticlinal crest that crosses Labarge Creek east of Labarge Canyon, or this anticline may represent the southward extension of the Hoback anticline.

---

[1] In the preliminary report on this region (Coal fields in a portion of central Uinta County, Wyo.: Bull. U. S. Geol. Survey No. 316, 1906, pp. 212–241) this structural feature was called the Lander syncline; but this name has been abandoned on account of the confusion likely to arise by its application at so great a distance from the well-known town of Lander, in Fremont County.

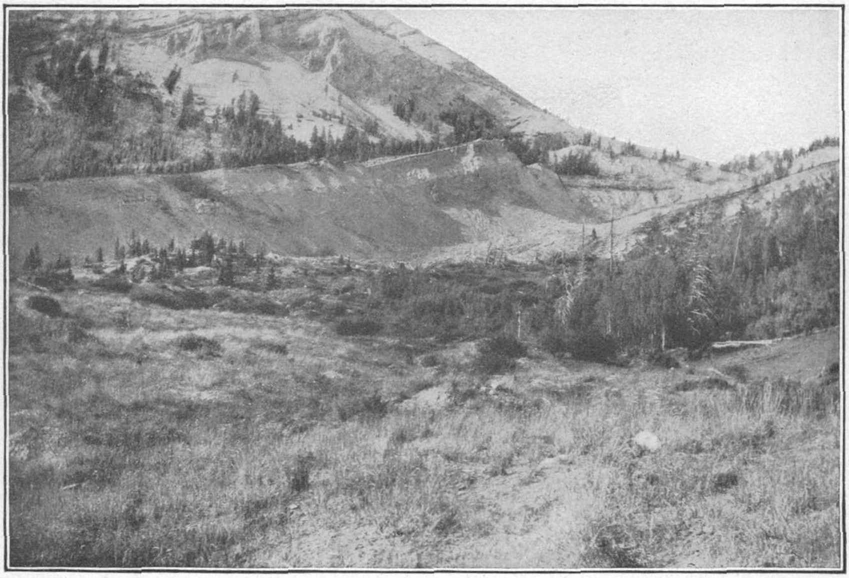
[2] Peale, A. C., Eleventh Ann. Rept. U. S. Geol. and Geog. Survey Terr., 1879, Pl. LIII, p. 540.

DARBY FAULT.

A large fault on the east side of the Wyoming Range has been named Darby fault from Mount Darby, the highest point along its east scarp. This fault was observed by Peale[1] in 1877 and was indicated in his section as the northward extension of the Absaroka fault. It is an enormous thrust fault in which the thrust has come from the west. Its south end terminates east and south of the Labarge Ridge. North of Thompson Plateau the Thompson fault cuts the beds between the Darby and the Absaroka faults at nearly right angles to the strike of the beds and in a way connects these two overthrust faults. The north end of the Darby fault was not seen, as it extends northward across Snake River beyond the limits of this area. At several places along the fault line Mississippian rocks are brought into contact with the Frontier formation, indicating a throw of over 20,000 feet. The fault line is represented by a very irregular eastward-facing scarp, and in several localities in the larger valleys the underlying Cretaceous beds extend far up the valleys, suggesting a considerable horizontal thrust. In the vicinity of South Cottonwood Creek there is a small outlier or remnant of Carboniferous rocks which supports the evidence of horizontal thrust and gives rise to the topographic feature called Lander Peak. Near the north end of the Wyoming Range a secondary fault or an overturned anticline has exposed the Bear River formation in contact with the Carboniferous rocks on the west and with the Frontier formation on the east. The relations just east of the Wyoming Range along part of the Darby fault suggest an overthrust syncline, and toward the north, in the vicinity of Snake River, there is an overturned anticline just east of the fault. The Bear River exposure above mentioned may represent the Bear River rocks underlying the Carboniferous beds and exposed in their present position through weathering. The irregular fault line is no doubt due in part to weathering agents. The three localities where the fault contacts may best be studied are on South Cottonwood Creek, where the eastern remnant may be seen in Lander Peak; at the head of Sheep Creek; and at the head of Little Greys River, where the stream has cut through the Carboniferous beds and by rapid cutting in the softer Cretaceous rocks has exposed to view the relations along the fault contact. From the evidence thus far gathered it seems evident that the horizontal thrust is at least 2 miles and may be considerably more. Plate VII shows the relations of the formations in the vicinity of the fault contact.

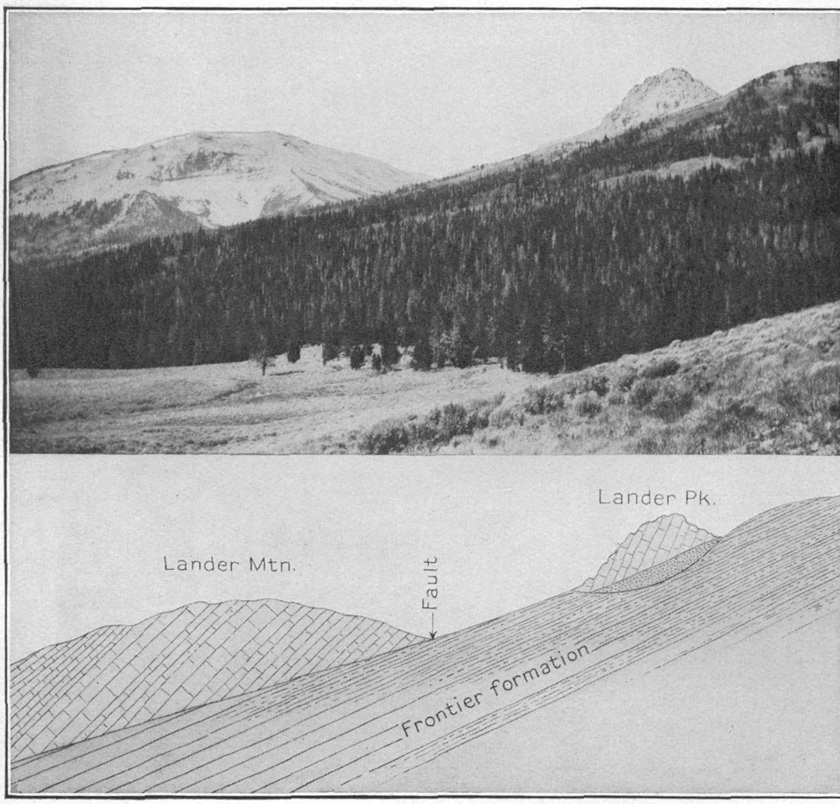
Near the north end of Labarge Ridge, toward the east, the southward continuation of the Darby fault swings abruptly toward the south and lies along the east front of Labarge Ridge, producing

[1] Op. cit., Pls. XLV, LIII, and LIV.



A. FAULT CONTACT NEAR SOUTH END OF MOUNT McDOUGAL, HEADWATERS OF SHEEP CREEK.

Carboniferous rocks on left. Heavy ledge of white sandstone on right. Overthrust nature of fault has been exposed by stream erosion.



B. FAULT CONTACT EAST OF LANDER MOUNTAIN.

an irregular scarp rising out of the surrounding Tertiary beds, and bringing the Cambrian rocks into contact with the Adaville and Hilliard formations. Several small areas of Cambrian rocks occurring east of the main scarp suggest a considerable horizontal thrust similar to that of the Darby fault, north of Thompson Plateau. For lack of time the exact relation of these small areas to the main mass composing Labarge Ridge was not fully determined. It is believed, however, that they are remnants of an extensive overthrust.

Concerning the Darby fault Peale[1] makes the following statement:

> The line of the fault along the eastern side of the Wyoming Range is not a straight line; but the Laramie sandstones fill bay-like recesses in the Carboniferous limestones of the range. This is especially the case in the northern portions and led me at first to think that the range had formed a portion of the shore of the Laramie Sea; but afterwards the contact of the sandstones with the limestones was well seen, and the former were seen to have a dip to the westward against the limestones, which also dip to the westward. It was clearly seen to be a fault. The latter seems to have taken place a little after the sandstones were folded, or perhaps they were crowded against the mass of Carboniferous limestones at the time the fault occurred.

The Laramie, as here used by Peale, is equivalent to the Frontier formation and in a few localities, as in Snider Basin, may include part of the Hilliard formation. It includes all the formations in the McDougal syncline from the base of the Bear River formation to the fault contact.

THOMPSON FAULT.

In the vicinity of Thompson Pass, along the north side of the plateau, is developed a fault to which the name Thompson fault has been given. This fault connects the Absaroka and Darby faults, and cuts across the main trend of the Wyoming and Hoback anticlines nearly at right angles. The extension of the fault for a short distance east of Thompson Plateau could not be traced, as it is completely covered by talus and Tertiary beds, but it is very probable that the Thompson fault connects with the overthrust fault along the east side of the Labarge Ridge, which represents the southward continuation of the Darby fault. The displacement of the beds in the Lazeart-Greys River syncline along the Thompson fault is about 5,000 feet, with the downthrow on the south. North of Thompson Plateau the fault contact is concealed, and the exact relation of the Carboniferous rocks of the plateau to the rocks in the McDougal syncline and the Hoback anticline was not determined.

WYOMING ANTICLINE.

The Wyoming anticline is somewhat irregular and complex. It gives rise to the Wyoming Range and is nearly parallel to the Darby fault. North of the Thompson fault the anticlinal axis strikes

[1] Op. cit., p. 630.

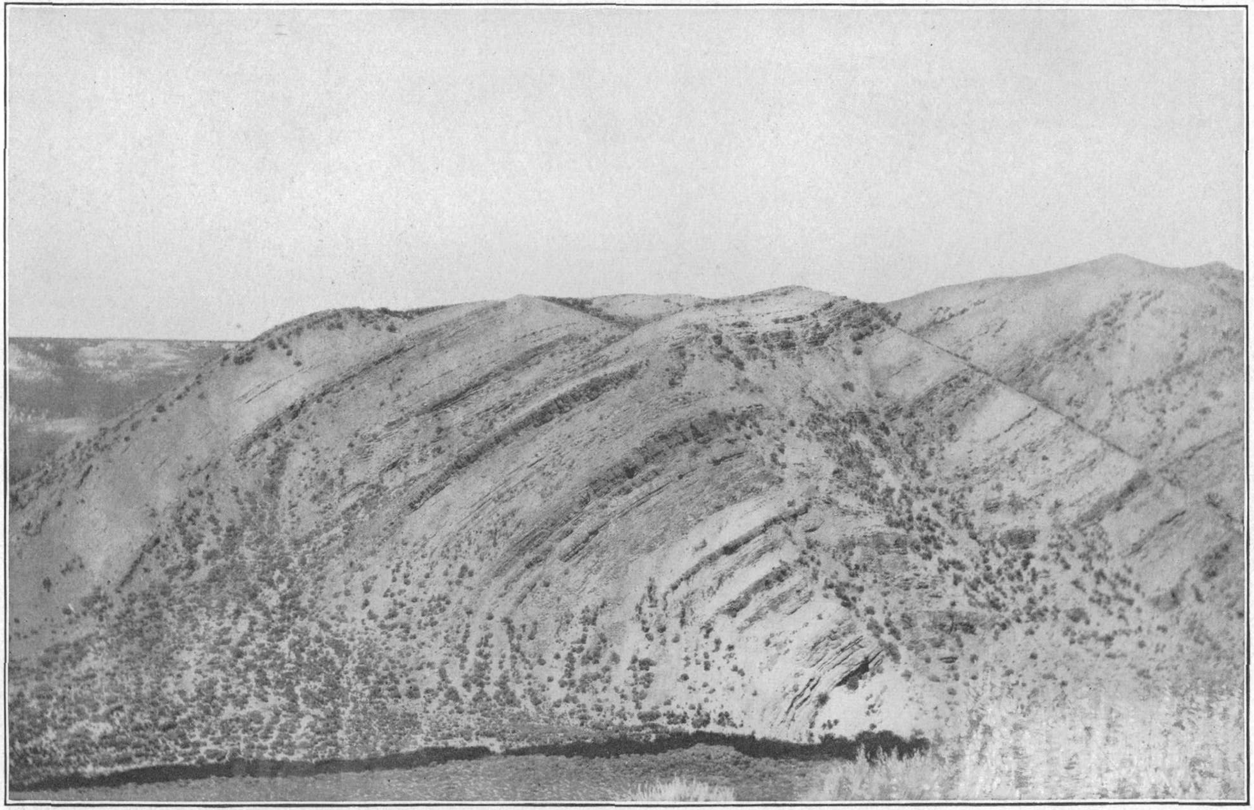
nearly east and west, but within a short distance it turns and strikes a little west of north to the northern part of the field. From Thompson Pass north to Deadman Creek the range consists of two ridges separated by a synclinal valley. The west ridge consists of a western anticline, whose crest is composed of Triassic rocks. The syncline is composed in part of Jurassic, Triassic, and Carboniferous formations at different places (p. 45), and the canyon of Sheep Creek shows Carboniferous rocks on both the synclinal and the anticlinal axes. The east edge is composed of Carboniferous rocks that dip toward the west. These beds form the rugged escarpment along the east face of the Wyoming Range and mark the location of the Darby fault.

North of Deadmans Creek only the west limb of the anticline remains, and from Deadmans Creek to Snake River the Wyoming Range consists of a monocline of Carboniferous rocks dipping toward the west. South of Thompson Pass the extension of the Wyoming Range is represented by Meridian Ridge, of which Thompson Plateau forms the north end.

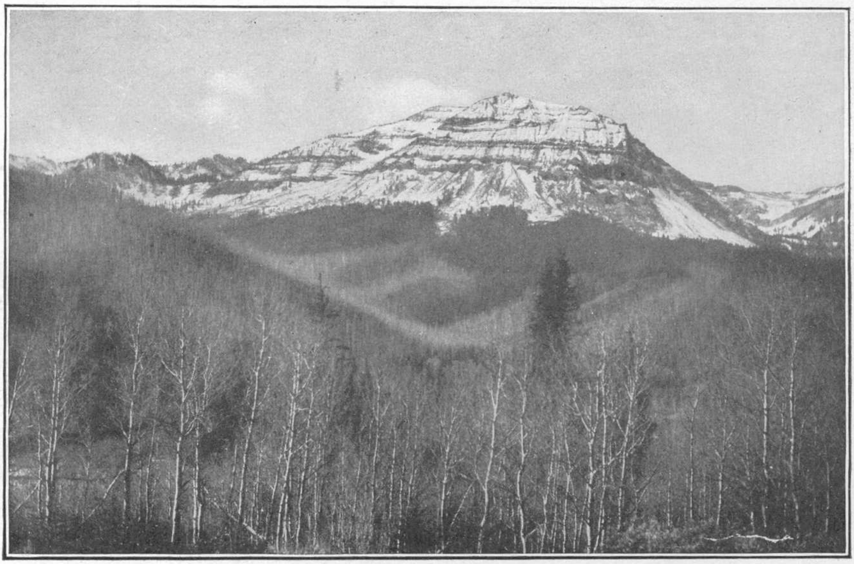
The Hoback and Wyoming anticlines and all the structural features between them terminate against the north end of Thompson Plateau or are concealed by the overthrust fault, and it is rather difficult to decide which of the anticlines south of Thompson Plateau represent the continuations of those north of it.

The western anticline that crosses Labarge Creek near the center of Labarge Canyon probably represents the southward extension of the Wyoming anticline and is so named. This anticline, which is marked by the main crest of Meridian Ridge for a short distance, turns abruptly eastward north of Fontenelle Creek and disappears beneath the Tertiary formations south of Fontenelle Creek. The only evidence of this anticline south of Fontenelle is in the vicinity of Deer Creek, near the south end of the field, where the Twin Creek limestone is exposed dipping toward the west.

In the southern part of the field the Meridian anticline forms the main crest of Meridian Ridge. This anticline lies from 2 to 4 miles west of the Wyoming anticline and is separated from it by a small syncline. The Meridian anticline extends for only a few miles north of Fontenelle Creek, but continues for many miles southward into Uinta County, crossing Hams Fork east of Waterfall and farther south disappearing beneath Tertiary formations. Between Fontenelle and Slate creeks there is a second anticline, which parallels the Meridian anticline about 2 miles to the west. The sharpest portion of this fold is on the west side and all the beds are considerably obscured by erosional débris. With these two anticlines are associated minor folds and synclines. (See Pl. VIII.)

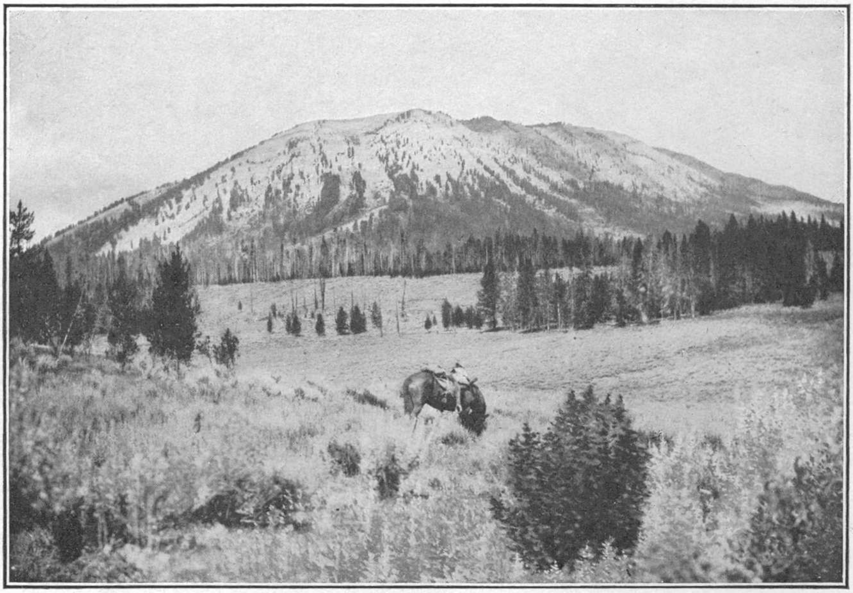


DOUBLE ANTICLINAL FOLD IN SHALES OF TWIN CREEK LIMESTONE, T. 24 N., R. 114 W.



A. VIRGINIA PEAK, ON GREYS RIVER.

Showing heavy growth of timber in valleys and on slopes in Cretaceous rocks and lack of it on peaks and slopes in Carboniferous rocks.



B. MOUNT DARBY.

Mountain is composed of Carboniferous rocks and level stretch of Cretaceous rocks. Linders Basin, on South Pine Creek, in foreground.

LAZEART–GREYS RIVER SYNCLINE.

The Lazeart-Greys River syncline, although very irregular, faulted, and broken, can be traced from one end of the field to the other. In places it is double. In the southern part of the field both the east and the west limbs are present locally, but north of Fontenelle Creek only the east limb is present. North of Deadmans Creek two distinct anticlines and synclines extend northward across Snake River.

At the south end of the area the west limb of the Lazeart-Greys River syncline is much steeper than the east limb and is in places overturned. Toward the south the syncline plunges rapidly and passes under the Tertiary beds just south of Hams Fork a few miles south of the area. Through much of the area this syncline is not susceptible to direct study, being concealed beneath a heavy talus covering along the east faces of Absaroka Ridge and the Salt River Range.

ABSAROKA FAULT.

The Absaroka fault, the northward continuation of the "big thrust" mapped by A. C. Veatch[1] in Uinta County, extends northward along the east side of Absaroka Ridge more or less parallel to the trend of the Lazeart-Greys River syncline. In many respects it resembles the Darby fault and north of Thompson Pass is approximately parallel to that fault, instead of joining it, as shown by Peale.[2] As a whole it does not exhibit as irregular a scarp as the Darby fault, but in the vicinity of Virginia and Stewart peaks it shows considerable irregularity. Like the Darby it is an enormous thrust fault in which the thrust has come from the west. Near the south end of the field the beds on the west side of the Lazeart syncline are not greatly disturbed and the Frontier formation rests directly against the Weber quartzite, indicating a throw of over 15,000 feet. To the north the throw increases and in the vicinity of Virginia Peak it exceeds 20,000 feet.

The relation of these abrupt Carboniferous scarps to the softer Cretaceous beds is shown in Plate IX.

SALT RIVER ANTICLINE.

West of the Absaroka fault and parallel to it lies the Salt River anticline, which forms the Salt River Range. The geologic mapping of the present party terminated along the east crest of the range and consequently no sections were made across it, but the structure is undoubtedly very similar to that of the Wyoming and Hoback ranges.

---

[1] Prof. Paper U. S. Geol. Survey No. 56, 1907, p. 109.

[2] Peale, A. C., Eleventh Ann. Rept., U. S. Geol. and Geog. Survey Terr., 1879, Pls. XLIX, LIII, LIV.

Peale[1] states that this range is the most complicated in the region, particularly where it merges into Absaroka Ridge and the ridge that forms the divide between Hams Fork and Smiths Fork and connects with Tump Ridge east of Rock Creek. In order to facilitate the

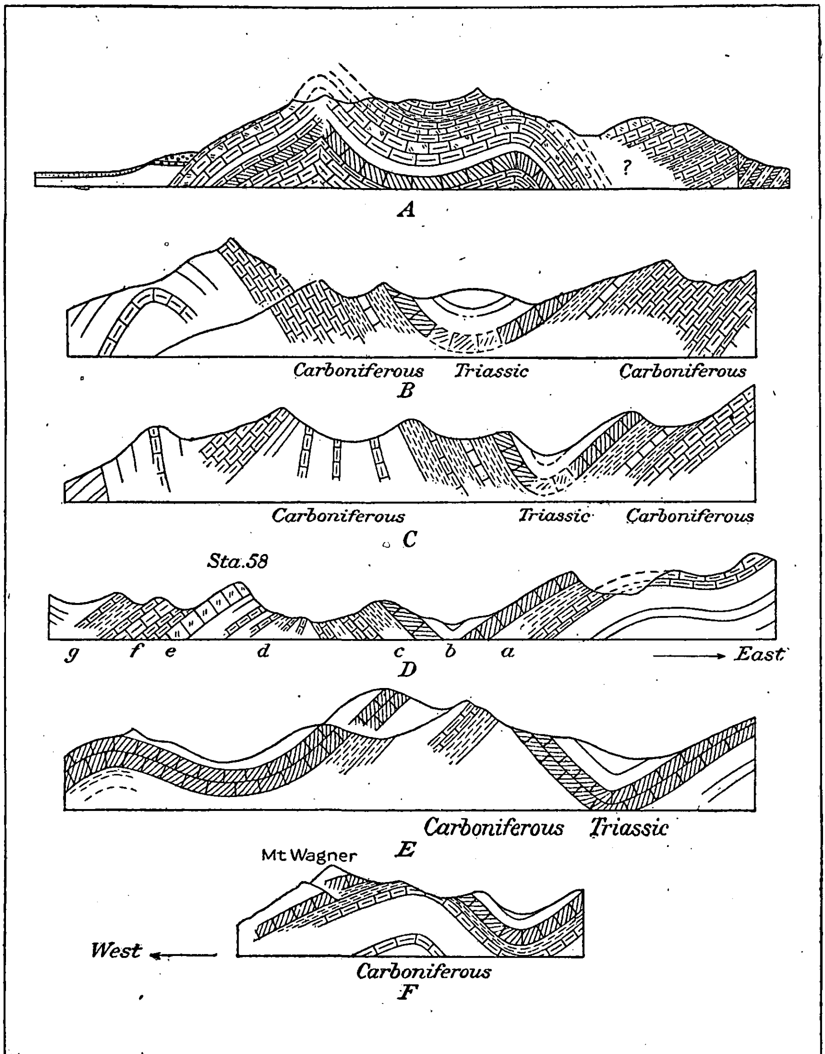


FIGURE 3.—Sections between Strawberry Valley and Mount Wagner, showing structure of Salt River Range. After Hayden, Eleventh Ann. Rept. U. S. Geol. and Geog. Survey Terr., 1879, Pls. LVII, LVIII, LVIX. A, On Strawberry Creek; B, south of Strawberry Creek; C, south of Sherman Peak; D, east of Afton and south of Swift Creek; E, north of Mount Wagner; F, at Mount Wagner.

interpretation of the structure west of the Absaroka fault six sections across the Salt River Range between Strawberry Valley and Mount Wagner are shown in figure 3.

[1] Op. cit., p. 545.

The beds in section D (fig. 3) are described by Peale[1] as follows:

Section in the Salt River Range (fig. 3, D).

1.	Massive limestone	a
2.	Gray shaly sandstones and limestones	a
3.	Red sandstones and shales, probably Triassic	b
4.	Same as No. 3, only reversed in dip	b
5.	Same as No. 2, reversed in dip	c
6.	Massive limestones, the portion nearest No. 5 being the same as those of layer No. 1. They stand almost on end in the center, but dip westward as they are followed toward the station, showing an overturn	d
7.	Quartzites	e
8.	Massive blue limestones	f
9.	Yellow and gray shales and limestones	g

FOSSIL SYNCLINE.

Near the south end of Absaroka Ridge the Carboniferous, Triassic, and Jurassic beds dip regularly westward and the overlying beds form a gentle syncline whose axis is in the neighborhood of Fossil.

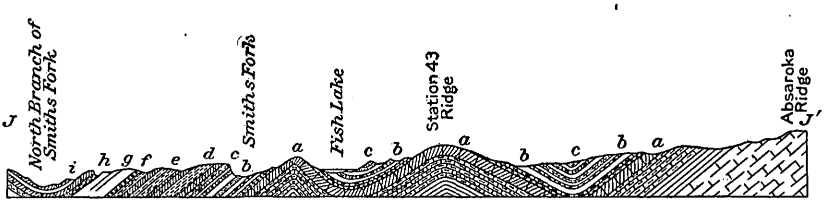


FIGURE 4.—Section along Smiths Fork west of Absaroka Ridge, showing structure west of Absaroka Ridge. After Peale, Eleventh Ann. Rept. U. S. Geol. and Geog. Survey Terr., 1879, Pl. LXVIII, p. 578.

Veatch[2] says that the syncline appears to be very nearly coincident with the syncline in the underlying strata, and that it has therefore been named the Fossil syncline.

The Fossil syncline extends northward up Hams Fork valley and may continue northward into the Salt River Range. Throughout the southern area it is deeply buried by Tertiary deposits, but its position may be roughly inferred from the adjoining structural features. Farther north, near the headwaters of Hams Fork, it lies in the older beds and is not concealed by Tertiary deposits, thus permitting the structure of the older beds to be readily observed. This syncline just south of Fish Lake and the structure west of Absaroka Ridge to Smiths Fork are shown in figure 4, in which the eastern syncline near the western base of Absaroka Ridge is represented as the northward continuation of the Fossil syncline.

The western half of the generalized section of the beds shown in figure 4 is given by Peale,[3] and the eastern half is compiled from the

[1] Op. cit., p. 550.
[2] Veatch, A. C., Prof. Paper U. S. Geol. Survey No. 56, 1907, p. 110.
[3] Op. cit., p. 579.

data of the United States Geological Survey. The letters correspond to those in the section below.

Section along Smiths Fork west of Absaroka Ridge (Hayden's section 25, west from station 43).

		Feet.
a.	Greenish-gray sandstones.	
b.	Black shales	1,300
c.	Sandstone, shales, and sandstones.	
d.	Conglomerate	4,000
e.	Space covered with débris of sandstones and shales	4,000
f.	Reddish shales and sandstones	1,800
g.	Calcareous shales.	
h.	Blue limestones containing Jurassic fossils (*Ostrea strigilecula*, *Pentacrinus asteriscus*, Tancredia sp.?, undetermined conchifers, undetermined gastropods)	800
i.	Red sandstones outcropping on station 43.	
	Base.	
		11,900

In this section *i* is probably Nugget sandstone; part of *h*, all of *g* and *f*, and part of *e* are Twin Creek limestone; the remainder of *e*, all of *d*, and part of *c* are Beckwith formation; and the remainder of *c* and all of *b* and *a* are Bear River formation.

Peale[1] adds that station 43 (Hayden Survey)—

is on the axis of a fold which is well shown in a high hill a couple of miles farther north. The axis of the fold appears to have a direction somewhat west of north. Toward the south, however, it appears to curve so as to be north and south, and the topography indicates that it is the same fold shown in the Carboniferous limestones east of Rock Creek (Tump Ridge). Here, however, red sandstones (probably Trias) form the surface of the fold.

ECONOMIC GEOLOGY.

COAL.

GENERAL CONDITIONS.

As indicated in the geologic table (pp. 29–31) coal occurs in four formations, the Bear River, Frontier, Adaville, and Evanston. The first three are of known Cretaceous age, and the last is Cretaceous or Tertiary. In all but two of the Cretaceous formations, the Aspen and Hilliard, in the area coal was found; and it may yet be found in the Hilliard, which in some respects resembles the Frontier formation. Both the Aspen and the Hilliard formations yield coal in adjoining parts of the Rocky Mountains. Carbonaceous shale has been observed in the Carboniferous rocks overlying the Weber quartzite. Practically no prospecting has been done in these beds, but the exposures and the known character of the older rocks render it highly improbable that coal in commercial quantities occurs in formations lower than the Bear River.

[1] Loc. cit.

CARBONIFEROUS BEDS.

In the Park City formation overlying the Weber quartzite occurs some bituminous shale (see p. 44) that has been prospected for coal at several localities.

The beds have not been prospected on Fontenelle Creek, but farther south on a little creek northwest from Walter Wright's ranch near the east base of Absaroka Ridge, in sec. 27, T. 24 N., R. 116 W., shallow openings or surface diggings show considerable carbonaceous material, though no good coal has been found. Still farther south on Absaroka Ridge, in the SE. ¼ sec. 9, T. 23 N., R. 116 W., prospects by sheep herders have been made, but so far as observed without success.

Southeast of Thompson Plateau, in the SE. ¼ sec. 22, T. 27 N., R. 114 W., where some prospecting for graphite has been carried on, a drift 87 feet long has been driven into the beds and 10 feet of carbonaceous phosphate shale exposed. Examination proved that no graphite was present in this rock, although the locality is known locally as the "graphite pits." The dark-colored band is not a coal, but it lies at the horizon of the phosphate bed and furnishes good samples of phosphate. (See p. 134.)

BEAR RIVER FORMATION.

The dark-colored shale of the Bear River formation contains considerable carbonaceous material. In many localities it has been mistaken for coal and not infrequently has been reported as a bed of coal from 20 to 40 feet thick. However, at Cokeville, near the south end of the area, a few miles west of the west boundary, coal occurs in the Bear River formation. Persistent attempts have been made to develop it since its discovery in 1866,[1] but so far no commercial shipments of importance have been made. The coal is reported as high-grade bituminous, with good coking properties, but the beds thus far discovered are thin and not of a character to justify extensive development. Prospects have also been opened in the Bear River formation east of Beckwith and north of Sage, as well as at several other places in Uinta County.[2] Coal declaratory statements have been filed covering certain 40-acre tracts both east and west of Smiths Fork in Tps. 26 and 27 N., R. 118 W., which probably means that statements are recorded of coal discoveries in Bear River strata along the Smiths Fork syncline. (See fig. 4, p. 89.) In 1899, when Mr. Jones, deputy surveyor, surveyed the fourteenth auxiliary guide meridian, coal was reported near the northeast corner of sec. 25, T. 32 N., R. 117 W., in the outcrop area of the Bear River formation. At several places, including the outcrops of the Bear River on Fall River, Snake River, Greys River,

[1] Map of the United States and Territories showing the extent of public surveys and other details, constructed from the plats and official sources of the General Land Office, by Theodore Franks, 1866.

[2] Veatch, A. C., Prof. Paper U. S. Geol. Survey No. 56, 1907, pp. 113–114.

and Labarge Creek, bands of carbonaceous shale containing thin streaks of coal were observed; also bone having no commercial value.

At no place in the field was coal of workable thickness seen in the Bear River formation. However, the general shallow-water character of the Bear River strata and the persistent occurrence of streaks of bone and coal in the carbonaceous shale make it probable that local deposits of coal of commercial value will be found when the beds are fully prospected.

FRONTIER FORMATION.

OCCURRENCE OF THE COAL.

The Frontier formation is of Upper Cretaceous (Benton) age. It consists of coals, clays, shales, and light-colored sandstones, limited above and below, respectively, by the dark-colored shales of the Hilliard and Aspen formations, which are not known to be coal bearing in this area. Coal beds occur in various parts of the Frontier formation, but they vary considerably from place to place, and their exact equivalence in different parts of the field was not determined In general there is a group of coal beds near the base of the formation that may be correlated with the Spring Valley coal group of Uinta County. Above this coal group and below the Oyster Ridge sandstone member there are several coal beds, of which the Willow Creek bed is the most important. Above the Oyster Ridge sandstone occur the upper coals of the Kemmerer coal group, which comprises at least four distinct beds, including those mined at Frontier, Diamondville, Oakley, Glenco, and Cumberland.

It was not until 1894 and 1897, when the Diamondville and Frontier mines were opened, that coal prospecting was carried on extensively south of this area, and for some time after that prospecting in the area itself was limited to a small district about the mining camps to the south, none of the early surveys mentioning coal in the area.

The present survey has brought out many interesting facts concerning the distribution of the coal beds. The approximate outcrop and distribution of the Frontier formation containing the Kemmerer, Willow Creek, and other coal beds, is shown on Plate I (in pocket). These beds outcrop between Meridian Ridge, the Wyoming Range, and the Absaroka Ridge-Salt River Range in the Lazeart-Greys River syncline and also east of the Wyoming Range between the Hoback and Wyoming ranges north of the Thompson Plateau in the McDougal syncline. In both localities the westward extension of the formation terminates against a fault that extends along the east base of the Salt River Range, Absaroka Ridge, and the Wyoming Range. It is not known whether all the coal beds extend throughout the field or not, but they are present in the southern part, and they or their equivalents may be found throughout the field as further development work progresses. During the present survey most of the coal data could be obtained only from surface exposures or from shallow pits. The location of these pits and prospects are shown on the map. (See Pl. III.) They are numbered consecutively from 1 to 88, beginning at the southeast corner of the field.

LAZEART-GREYS RIVER SYNCLINE.

The coal-bearing beds of the Lazeart-Greys River syncline fall into two natural divisions, a northern field and a southern field. The northern field comprises that portion of the syncline lying between the Wyoming and Salt River ranges and occupied for the most part by the valley of Greys River. The coal outcrops in this field, as well as the exposures of the coal-bearing rocks, are meager and in only a few localities was coal observed, owing to the heavy talus covering along the east slope of the Salt River Range. Coal was observed west of Greys River at several places, and on the west bank of the river, a few miles south of the mouth of Little Greys River, a 3-foot bed of coal was opened (prospect No. 72; analysis No. 4323, p. 108). For this northern field, comprising the coal-bearing beds of the syncline north of Labarge Creek, the name Greys River coal field is proposed. For the southern field, comprising the coal-bearing beds of the Lazeart-Greys River syncline south of Greys River, in which most of the prospecting has been done, the name Kemmerer coal field is proposed.

The first important mine developed in the Frontier formation was that opened in 1894 by the Diamond Coal & Coke Co. at Diamondville, about 7½ miles south of the south boundary of this area. Subsequently mines were opened by the same company at Glencoe and Oakley. In 1897 the Frontier mines were opened by the Kemmerer Coal Co. at Frontier (Pl. X, p. 114), and in 1900 the Cumberland mines were opened by the Union Pacific Coal Co. A full description of these mines and the occurrence of coal in Uinta County is given in the reports of Veatch.[1]

All the Frontier, Diamondville, and Cumberland mines developed the main Kemmerer bed, which lies above the Oyster Ridge sandstone and which varies in thickness in the mine workings from 5 to 20 feet. (See Pl. X.) At the Frontier mine two other coal beds, A and B, have been opened, though only the upper one (A) is worked. This upper bed, which lies 35 feet stratigraphically below the main Kemmerer coal, is 6 feet thick and has a thin parting about 1 foot from the top. The quality of its coal is about the same as that of the main bed. (See analysis No. 2286, p. 109.) The lower coal (B) lies about 10 feet stratigraphically below the A bed and is 6½ feet thick, with a thin parting 17 inches below the top. The material between the A and B beds is shale too soft to allow bed B to be worked.

[1] Veatch, A. C., Coal and oil in Uinta County, Wyo.: Bull. U. S. Geol. Survey No. 285, 1906, pp. 331-353; Geography and geology of a portion of southwestern Wyoming, with special reference to coal and oil: Prof. Paper U. S. Geol. Survey No. 56, 1907.

Shortly after opening the mines at Frontier the Kemmerer Coal Co. spent several years in prospecting the coal beds north of Frontier on Willow Creek in an effort to find coking coal. Besides prospecting the beds of the main Kemmerer coal group the company did some work on coal beds below the Oyster Ridge sandstone. Since 1904 no development work has been done.

The Willow Creek coal is about 550 feet below the main Kemmerer coal and 200 feet below the Oyster Ridge sandstone. In the SW. ¼ NW. ¼ sec. 19, T. 22 N., R. 115 W., where considerable coal was taken out, the bed is 3 feet thick; farther north, in the SW. ¼ SW. ¼ sec. 6, T. 22 N., R. 115 W., it reaches a thickness of 5 feet 8 inches. At both of these prospects small engines were installed and slopes were opened. In 1904 the two mines together produced 3,000 tons of coal and shipped about 750 tons of coke. Since 1904 no development work has been done on the Willow Creek coals. In 1907 a spur line was built northward from Frontier along Willow Creek for 12 miles and several mines were opened on the Kemmerer and Willow Creek beds. Tests show that the Willow Creek coal yields a coke of fair quality.

Two other prospects have been opened in the Willow Creek bed, one in the NE. ¼ NW. ¼ sec. 2, T. 23 N., R. 116 W., by W. C. Wright; the other in the NE. ¼ SE. ¼ sec. 16, T. 25 N., R. 115 W., by H. M. Holden. At both places coal has been taken out for local ranch use. Outcrops were observed at several places as far north as Snake River, but the country is well covered with timber and exposures are rare. Several prospect pits have been opened along the outcrop of the beds below the Willow Creek coal in T. 22 N., R. 115 W.

The Spring Valley coal bed, which is near the base of the Frontier formation, is approximately 1,500 feet stratigraphically below the main Kemmerer coal bed, and the Carter coal bed is approximately 200 feet higher than the Spring Valley bed. These beds have not been prospected in this area, and as they are everywhere covered by weathered surface material the coal is not readily seen. As a rule, the digging of pits or the sinking of diamond-drill holes is necessary in order to locate it. Even when a pit has been opened and a section of the coal exposed the next year may find all traces obliterated and the pit deeply buried by a landslide.

McDOUGAL SYNCLINE.

For the field containing the coal-bearing beds in the McDougal syncline, between Thompson Plateau and Snake River, the name McDougal coal field is here proposed. Owing to the scarcity of prospects and the heavy covering that conceals the coal outcrops the extent and thickness of the coal in this field are only partly known.

The coal beds in the McDougal syncline can not be directly correlated with any particular beds in the Lazeart-Greys River syncline, although they are probably of the same age as the Frontier coals. The prominent sandstone that forms Oyster Ridge (the Oyster Ridge sandstone member of the Frontier formation) and serves as a hori-

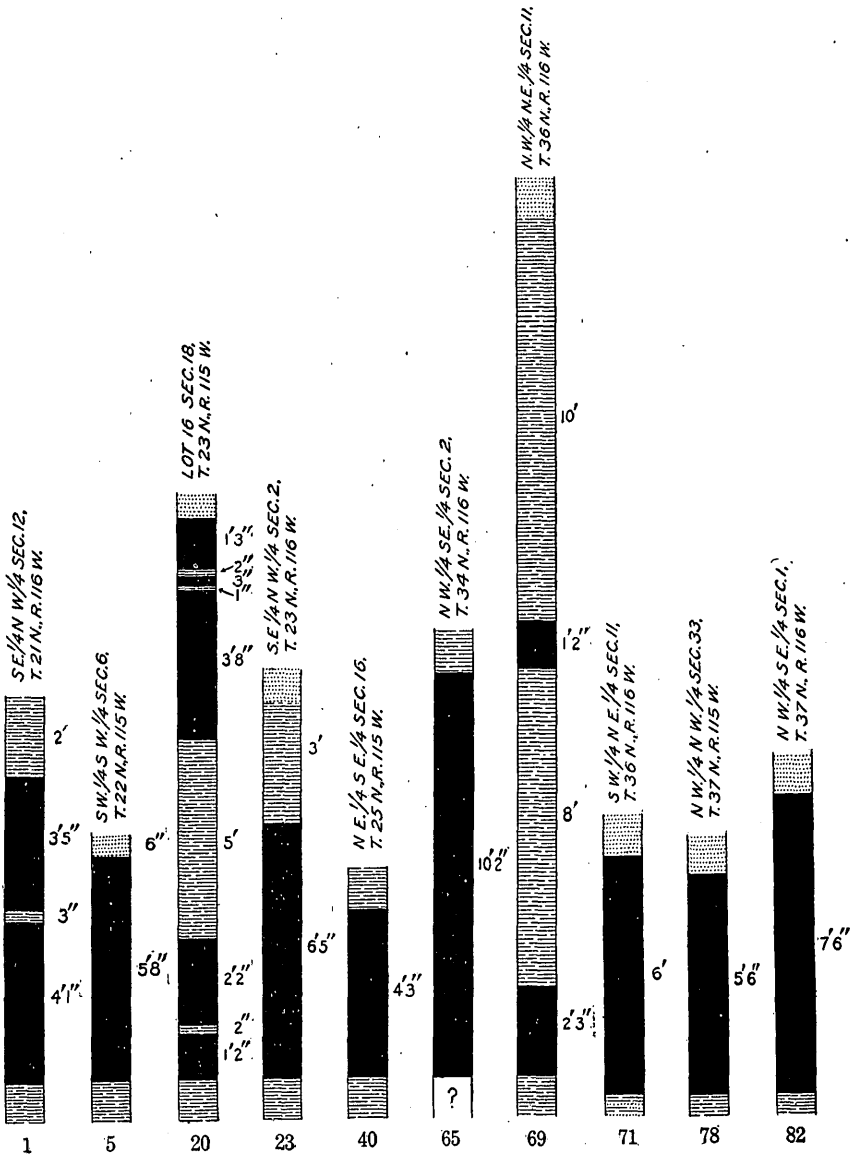


FIGURE 5.—Sections of coal beds in the Frontier and McDougal coal fields.

zon marker is not present in this part of the field or, if present, has lost its important ridge-making characteristic. The coal-bearing rocks, as far as known, belong to the Frontier formation, and the coals, as far as studied, resemble very closely the Kemmerer and Willow Creek coals of that formation. (See fig. 5.)

A mine was opened by Sam Smith in 1906, east of McDougal Mountain, in unsurveyed territory, the location of which, if subdivided, would be in the SW. ¼ SW. ¼ sec. 33, T. 34 N., R. 115 W. A drift was run along the strike for a distance of 20 feet and several loads of coal were hauled away. A road was built to the mine, and it is the intention of Mr. Smith to supply coal to the ranchers in Green River basin. The coal is of high grade and 6 feet 2 inches thick.

South of the Smith mine, in T. 31 N., R. 115 W., east of Bear Mountain, near the forks of the main branch of the north tributary of North Piney Creek, Link Shideler prospected a 10-foot bed of coal for a distance of 500 feet along the surface. This prospect has recently been covered by a landslide and no samples could be obtained for analysis. Mr. Shideler reports that the coal is bright and lustrous and dips about 35° W.

Farther north, east of the Wyoming Range and near the headwaters of Willow Creek, a tributary of Fall River, some prospecting has been done, but most of the pits have been buried beneath landslides, so that the coal can not be examined without reopening the pits.

In the SW. ¼ NE. ¼ sec. 11, T. 36 N., R. 116 W., where the greatest amount of development work has been done, a drift was run 100 feet and a 6-foot coal bed with three partings opened. The analysis shows this to be the best coal in Lincoln County thus far analyzed.

The coal-bearing rocks extend to the northwest for a considerable distance, crossing the Wyoming-Idaho State line south of Teton Pass. In the vicinity of Victor, Oasis, and Hayden, on the east side of the Big Hole Mountains in Idaho, coal-bearing rocks that dip 40°–50° SW. are known to contain seven beds of coal whose thicknesses range from 2 to 20 feet. They may be a continuation of the coal-bearing formations south and east of Snake River. The coal is of unusually high quality and is very desirable for steam and domestic purposes.[1] Some very fine samples of coke have been obtained from it by laboratory tests.

HOBACK ANTICLINE.

Coal and coal-bearing beds similar to those in the McDougal syncline undoubtedly occur on the east flank of the Hoback fold, but they were seen only in T. 31 N., R. 115 W., for throughout most of the area east of the Hoback Range and anticline the Cretaceous beds are deeply buried beneath the Tertiary and Quaternary covering.

ADAVILLE FORMATION.

KEMMERER COAL FIELD.

The coals in the Adaville formation in this area occur only in the southern part of the Lazeart syncline and east of Labarge Ridge. Since the discovery of these coals in 1876 by Smith & Bell Bros.,[2]

[1] Bell, R. N., Rept. State Inspector of Mines, 1905, pp. 63-64.

[2] Peale, A. C., Eleventh Ann. Rept. U. S. Geol. and Geog. Survey Terr., 1879, p. 535.

who opened in the region of Hodges Pass, on the divide between Twin Creek and Hams Fork, 29 beds of coal ranging in thickness from 1½ to 48 feet and aggregating 315 feet, this coal-bearing group has been noted for the great number and thickness of its beds, one of which, at the Adaville mine,[1] in the NE. ¼ SW. ¼ sec. 20, T. 21 N., R. 116 W., reaches a maximum thickness of 84 feet with a single parting of clay 2 inches thick.

On account of the rising and pitching of the Lazeart syncline these coals occupy three basins in southern Lincoln County and Uinta County, the northern part of the northernmost basin being within the area shown on Plate I. Farther north the pitching of the syncline again brings in these beds in a fourth basin on South Fontenelle Creek. Very little prospecting has been done north of Hams Fork and thus far only one pit in the SW. ¼ SW. ¼ sec. 32, T. 25 N., R. 115 W., has been opened in the north basin, where 3 feet of coal whose base was not seen occurs under a bed of shale. This group of coal beds contains a large amount of fuel of fair quality and will undoubtedly be developed in the near future. The coal is clean and compact, having a bright luster and breaking with a conchoidal fracture, but it crumbles badly on exposure to the air. For a fuller description of the coals in Uinta County the reader is referred to the reports of A. C. Veatch, already cited. As far as observed, all the coal beds of the Adaville formation in Mammoth Hollow lie in the Kemmerer coal field.

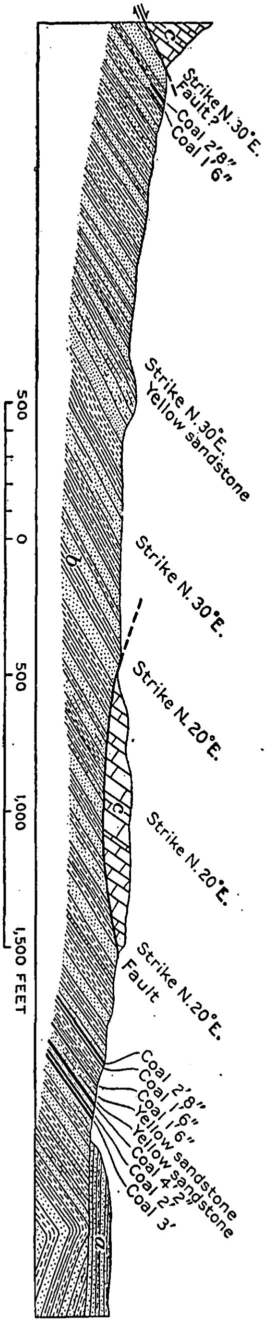


FIGURE 6.—Sketch showing coal beds in Adaville formation in sec. 32, T. 27 N., R. 113 W. Looking eastward from Labarge Ridge (pre-Carboniferous) across Adaville (Cretaceous) and Knight (Tertiary) formations. *a*, Tertiary (Wasatch group); *b*, Cretaceous (Adaville formation); *c*, Cambrian rocks.

LABARGE RIDGE COAL FIELD.

The Adaville formation is also coal bearing along the east side of Labarge Ridge, where several prospect pits have been opened, and in two localities coal has been mined for local ranch use. (See fig. 6.)

[1] Veatch, A. C., Coal and oil in Uinta County, Wyo.: Bull. U. S. Geol. Survey No. 285, 1906, p. 337.

At the Saley mine, in the SW. ¼ NW. ¼ sec. 7, T. 26 N., R. 113 W., an entry 180 feet long has been driven on the strike of the coal bed, which is here from 5½ to 6 feet thick. Most of the coal is not good for forge use, but certain carefully selected parts of the bed will answer for this purpose. The coal comes from the mine in fair-sized blocks, but slacks readily on exposure to air, breaking with a conchoidal fracture. It is used by the neighboring ranchers for fuel, but because it slacks so quickly only small quantities are bought at a time.

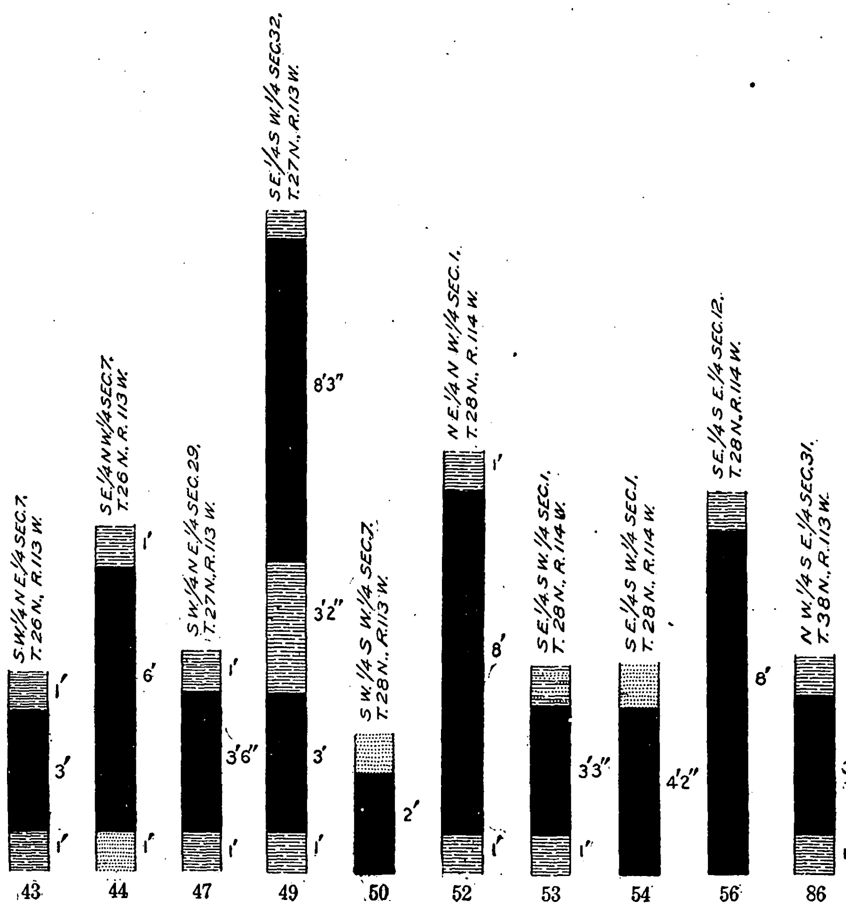


FIGURE 7.—Sections of coal beds in the Labarge Ridge (Adaville formation) and Fall River (Evanston formation) coal fields.

On the east side of Labarge Ridge, near the north end, Mr. Griggs has opened a mine in the SE. ¼ SE. ¼ sec. 12, T. 28 N., R. 114 W., where 8 feet of coal is exposed without reaching the base of the bed. The coal at this mine is of the same quality as that at the Saley mine. Coal is taken from the mine only as it is needed by the near-by ranchers.

Note.-The last paragraph on page 99 should be corrected to read as follows:

Many of the test pits are in the coal beds of the Frontier formation, a less number in the Adaville formation, and still fewer in the Evanston formation. Nos. 25 and 39 in the following table are on Carboniferous beds; No. 60 on beds of the Bear River formation; those designated I and Nos. 38, 41, 43, 44, 47 to 56, inclusive, on beds of the Adaville formation; Nos. 85, 86, and 88 on beds of the Evanston formation; and all the remainder on beds of the Frontier formation.

The corresponding corrections have been made on the map, Plate I, and in the table on pages 100 to 105.

Some prospect pits have been opened between the Saley and Griggs mines, as well as north of the Griggs mine. At several places 7 to 10 beds of coal, ranging in thickness from 1 to 5 feet, have been examined, and the entire formation shows numerous coal beds. The location of prospect pits and mines is shown on figure 7, and sections of the coal beds are given in the table on pages 100–105.

EVANSTON FORMATION.

The coal beds in the Fall River basin occur in the Evanston formation, and the coal resembles the Evanston and Almy coals of western Uinta County. Practically no prospect pits have been dug in this field, and the knowledge of the coal beds is restricted entirely to surface exposures and bank diggings, which are few because of the heavy covering of talus. Besides the prospects or surface diggings shown in figure 7, coal prospects have been opened and reported on Cliff, Granite, and Shoal creeks by ranchers and prospectors, but these pits were opened some time ago and have since been deeply buried by landslides, and the coal was not seen.

SECTIONS OF THE COAL.

The location of the prospect pits examined or dug by the present survey and the sections of the coal beds exposed in them are given in the following table. The mines, prospect pits, and surface diggings are arranged by section, township, and range, beginning at the southeast corner of the field, and numbered consecutively from 1 to 88. The numbers correspond to those on the map (Pl. I, in pocket). The prospect pits in T. 22 N., Rs. 115 and 116 W., south of the area have been added, as some of these have not previously been published. They are given letters in the table instead of numbers so as not to interfere with the numbering.

Many of the test pits are in the coal beds of the Frontier formation, a less number in the Evanston formation, and still fewer in the Adaville formation. Nos. 25 and 39 in the following table are on Carboniferous beds; No. 60 on beds of the Bear River formation; Nos. 1, 38, and 41 on beds of the Adaville formation; Nos. 43, 47 to 56, inclusive, 85, 86, and 88 on beds of the Evanston formation, and all the remainder on beds of the Frontier formation.

Location of mines and prospect pits, and age, thickness, and sections of the coal beds.[a]

No. on Pl. I.	Location. T. N.	Location. R. W.	Location. Section.	Formation.	Section.	Ft.	in.	Analysis No.	Remarks.
1	22	115	6, NW. ¼ NW. ¼	Frontier	Shale Coal Shale Coal Shale.	 3 4	2 5 3 1	......	Willow Creek coal group; prospect pit.
2	22	115	6, NW. ¼ NW. ¼	do	Coal Shale Coal Shale.	2 2	4 8 6	......	Do.
3	22	115	6, NW. ¼ NW. ¼	do	Shale Sandstone Coal (clay parting). Shale Coal Shale Coal Shale.	2 2 2 1 2	 2 6 2 8 2 7	......	Do.
4	22	115	6, SW. ¼ NW. ¼	do	Coal Shale.	5	8	......	Do.
5	22	115	6, SW. ¼ SW. ¼	do	Sandstone Coal Shale.	 5	6 8	......	Willow Creek bed; proposed site of Willow Creek mine; coal and coke shipped from this place in 1904.
6	22	115	7, SE. ¼ NW. ¼	do	Coal Shale.	4	5	......	Willow Creek bed; prospect pit.
7	22	115	7, SE. ¼ SE. ¼	do	Shale. Coal	 3		......	Below Willow Creek bed; prospect pit.
8	22	115	7, NE. ¼ SW. ¼	do	Coal Shale.	4	4	......	Willow Creek bed.
9	22	115	18, NE. ¼ NW. ¼	do	Coal	3	8	......	Do.
10	22	115	18, NE. ¼ NW. ¼	do	do	4		......	Do.
A	22	115	18, SW. ¼ SE. ¼	do	do	2	6	......	Below Willow Creek bed; surface prospect.
B	22	115	19, NW. ¼ NE. ¼	do	do	2	6	......	Do.
C	22	115	19, NW. ¼ NW. ¼	do	do	3	2	......	Willow Creek bed.
D	22	115	19, SW. ¼ NW. ¼	do	do	3		2285	Willow Creek bed; small mine; some coal and coke shipped from this place in 1904.
E	22	115	19, NW. ¼ SW. ¼	do	do	3	2	......	Willow Creek bed.
F	22	115	30, NW. ¼ NW. ¼	do	Sandstone Coal Fine clay Sandstone.	 4	8 5 8	......	Willow Creek bed; prospect pit.
G	22	115	30, SE. ¼ SW. ¼	do	Clay Coal Shale.	1 4	 10	......	Do.
11	22	116	1, NW. ¼ SW. ¼	do	Coal	6		......	Kemmerer coal group.
12	22	116	1, NE. ¼ SW. ¼	do	do	4		......	Do.
13	22	116	1, SE. ¼ SW. ¼	do	do	8		......	Do.
14	22	116	12, NE. ¼ NW. ¼	Frontier	Coal	4		......	Kemmerer coal group; three prospects along strike of bed.
15	22	116	13, NW. ¼ NE. ¼	do	do	8		......	Kemmerer coal group.

[a] Letters designate prospect pits and mines south of the area.

Location of mines and prospect pits, and age, thickness, and sections of coal beds—Contd.

No. on Pl. I.	Location.			Formation.	Section.			Analysis No.	Remarks.
	T.N.	R.W.	Section.			*Ft.*	*in.*		
16	22	116	13, SW. ¼ NE. ¼	Frontier	Coal	8		......	Kemmerer coal group.
H	22	116	13, SW. ¼ SE. ¼	...do	...do	3		......	Do.
I	22	116	21, NE. ¼ NW. ¼	Adaville	...do	18		......	
J	22	116	24, NW. ¼ NE. ¼, north end.	Frontier	...do	4		......	Kemmerer coal group.
K	22	116	24, NW. ¼ NE. ¼, southwest corner.	...do	...do	4		......	Do.
L	22	116	24, SW. ¼ NE. ¼	...do	...do	4	6	......	Three beds of Kemmerer coal group opened.
M	22	116	24, SE. ¼ NW. ¼	...do	...do	3		......	Kemmerer coal group; two prospects opened.
N	22	116	24, SW. ¼ SE. ¼	...do	...do	4	6	......	Kemmerer coal group.
O	22	116	25, NW. ¼ NE. ¼	...do	...do			......	Do.
P	22	116	25, NE. ¼ SW. ¼	...do	...do			......	Do.
Q	22	116	25, SE. ¼ SW. ¼	...do	...do			......	Do.
R	22	116	36, SE. ¼ NW. ¼	...do	...do			......	Do.
S	22	116	36, NE. ¼ SW. ¼	...do				......	Do.
T	22	116	36, SE. ¼ SW. ¼, near center.	...do				......	Do.
U	22	116	36, SE. ¼ SW. ¼, near southeast corner.	...do				......	Do.
V	22	116	36, SW. ¼ SE. ¼, near southwest corner.	...do				......	Do.
17	23	115	6, lot 4	...do	Coal Shale. Coal	2 2	 4	......	Willow Creek coal group; two prospect pits.
18	23	115	7, near northeast corner of lot 6.	...do	Coal Shale Coal Shale Coal Shale Coal Shale Coal Shale.	1 3 5 2 1 	6 2 3 1 3 1 2 2 	......	Willow Creek coal group; prospect pit.
19	23	115	7, near south center of lot 6.	...do	Coal Shale Coal Shale Coal Shale Coal Shale Coal Shale.	1 3 5 2 1 	6 2 3 1 3 1 2 2 	......	Do.
20	23	115	18, near south center of lot 16.	...do	Coal Shale Coal Shale Coal Shale Coal Shale Coal Shale.	1 3 5 2 1 	3 2 3 1 8 2 2 2 	......	Do.

Location of mines and prospect pits, and age, thickness, and sections of coal beds—Contd.

No. on Pl. I.	Location. T. N.	Location. R. W.	Location. Section.	Formation.	Section.	Ft.	in.	Analysis No.	Remarks.
21	23	115	19, near south center of lot 16.	Frontier	Coal Clay Coal Shale Coal Shale Coal Shale Coal Clay Coal Shale.	2 2 1 3 1 3 	2 6 4 2 3 1 5 4 2 2 10 	......	Willow Creek coal group; prospect pit.
22	23	115	31, west part of lot 16.	...do	Coal Clay Coal Sandstone Coal Shale.	1 3 2 1 	10 8 9 8 8 	......	Willow Creek coal group; prospect pit.
23	23	116	2, SE. ¼ NW. ¼	...do	White sandstone. Shale Coal Shale.	 3 6 	 5 	3572	Willow Creek coal group; Walter C. Wright's mine.
24	23	116	2, SW. ¼ SW. ¼, northwest corner.	...do	Coal			......	Willow Creek coal group.
25	23	116	9, SE. ¼ SE. ¼	Park City.	Shale, bituminous.			......	Not fully prospected; pits opened by sheep herders.
26	23	116	10, NW. ¼ SE. ¼	Frontier	Coal			......	Willow Creek coal group; three beds opened.
27	23	116	10, SW. ¼ SE. ¼	...do	Coal			......	Willow Creek coal group.
28	23	116	12, SW. ¼ SE. ¼	...do	Coal	4		......	Kemmerer coal group.
29	23	116	15, SW. ¼ NE. ¼	...do	Coal	4	3	......	Do.
30	23	116	15, NE. ¼ NW. ¼	...do	Shale. Coal Shale.	 3 	 2 	......	Willow Creek coal group.
31	23	116	15, SW. ¼ NW. ¼	...do	Coal	3	8	......	Willow Creek coal group; two prospects opened.
32	23	116	16, SE. ¼ SE. ¼	...do	Coal	4	2	......	Willow Creek coal group; surface prospect.
33	23	116	21, NE. ¼ NE. ¼	...do	Coal	3	6	......	Willow Creek coal group.
34	23	116	22, NW. ¼ NW. ¼	...do	Shale. Coal Shale.	 4 	 3 	......	Kemmerer coal group; surface prospect.
35	23	116	36, SW. ¼ SW. ¼, southeast corner.	...do	Coal	8		......	Kemmerer coal group; prospect.
36	24	115	19, lot 5	...do	Coal	3		......	Kemmerer coal group.
37	24	115	31, southeast corner of lot 18.	Frontier	Coal Clay, fine Coal Bone Coal Bone Coal Sandstone Coal Shale Coal Sandstone.	1 3 3 8 1 1 1 	8 7 9½ 2 3 1 2 10 12 2 	......	Willow Creek coal group.
38	24	116	24, NE. ¼ SW. ¼	Adaville	Coal	3		......	Surface prospect.

Location of mines and prospect pits, and age, thickness, and sections of coal beds—Contd.

No. on Pl. I.	Location. T.N.	R.W.	Section.	Formation.	Section.	Ft.	in.	Analysis No.	Remarks.
39	24	116	27, SW. ¼ NE. ¼....	Park City.	Shale, bituminous.			......	Not fully prospected.
40	25	115	16, NE. ¼ SE. ¼....	Frontier...	Shale. Coal...... Shale.	 4	 3	3570	Willow Creek bed; Holden's prospect pit.
41	25	115	17, SW. ¼ SW. ¼...	Adaville..	Shale. Coal......	 3		3696	Surface prospect.
42	25	115	28, SE. ¼ SW. ¼...	Frontier...	Coal......	3	2	......	Kemmerer coal group; prospect pit.
43	26	113	7, SW. ¼ NE. ¼....	Adaville..	Shale. Coal...... Shale.	 3		......	Labarge Ridge coal beds; seven beds of coal noted; thickness from 1 to 3 feet.
44	26	113	7, SE. ¼ NW. ¼....	...do.......	Shale. Coal...... Sandstone.	 6		3698	Labarge Ridge coal beds. Saley's mine, 180 feet deep. Several prospects near.
45	26	116	1, SW. ¼ SE. ¼....	Frontier...	Shale. Coal...... Shale.	 3	 2	......	Kemmerer coal group; surface prospect.
46	26	116	1, SW. ¼ SW. ¼....	...do.......	Coal......	3		......	Kemmerer coal group; exposure in west bank of Fontenelle Creek.
47	27	113	29, SW. ¼ NE. ¼...	Adaville..	Shale. Coal...... Shale.	 3	 6	3697	Labarge Ridge coal beds; prospect pit.
	27	113	32, SE. ¼ SE. ¼....	...do......	Coal.......	4	2	......	Labarge Ridge coal beds; three prospect pits; six coal beds ranging in thickness from 1 foot 6 inches to 4 feet 2 inches. (See fig. 6, p. 97.)
49	27	113	32, SE. ¼ SW. ¼...	...do......	Shale. Coal....... Shale..... Coal....... Shale.	 8 3 3	 3[a] 2	3693	Labarge Ridge coal beds; prospect pit. (See No. 47 and fig. 7, p. 98.)
50	28	113	7, SW. ¼ SW. ¼....	...do......	Coal.......	2		......	Labarge Ridge coal beds; prospect pit.
51	28	114	1, NE. ¼ NW. ¼...	...do......	Shale. Coal....... Shale.	 2	 4	3695	Labarge Ridge coal beds; prospect pit, 250 feet east of No. 52.
52	28	114	1, NE. ¼ NW. ¼...	...do......	Shale. Coal....... Shale.	 8		......	Labarge Ridge coal beds; prospect pit, 350 feet west of No. 51.
53	28	114	1, SW. ¼ NW. ¼...	...do......	Sandstone and shale Coal....... Shale.	 3	 3	3700	Labarge Ridge coal beds; drift, 210 feet long.
54	28	114	1, SE. ¼ SW. ¼....	...do......	Sandstone. Coal.......	 4	 2	......	Labarge Ridge coal beds; coal outcrop near crest of hill.
55	28	114	12, SE. ¼ SE. ¼, northwest corner.	...do......	Coal.......	4	2	3694	Labarge Ridge coal beds.

a Sampled.

Location of mines and prospect pits, and age, thickness, and sections of coal beds—Contd.

No. on Pl. I.	Location.			Formation.	Section.			Analysis No.	Remarks.
	T. N.	R. W.	Section.			*Ft.*	*in.*		
56	28	114	12, SE. ¼ SE. ¼....	Adaville..	Shale. Coal.......	 8		 3699	Labarge Ridge coal beds; mine opening 125 feet long; coal mined for ranch use.
57	31	115	24, SE. ¼ NE. ¼....	Frontier..	Coal.......	4		......	Reported by Mr. Springman, postmaster at Stanley, Wyo.
58	31	117	12, SW. ¼ SW. ¼...	...do......	Shale. Coal.......	 3		......	Surface prospect.
59	32	115	10, lot 1...........	...do......	Coal....... Sandstone. Coal.......	2 10 3	8	......	Do.
60	32	117	28, NE. ¼ SE. ¼....	Bear River	Coal.			......	Coal reported by old land survey.
61	33	115	34, NE. ¼ SE. ¼....	Frontier..	Coal.......	1	2	......	Surface prospect.
62	33	115	34, SE. ¼ SE. ¼....	...do......	Sandstone. Coal....... Shale.	 2		 3778	Do.
63	34	115	16, NW. ¼ SE. ¼...	...do......	Coal.......	3		......	Do.
64	34	115	33, NW. ¼ SE. ¼...	...do......	Shale. Coal....... Shale.	 6	 2	 3891	Smith mine; coal mined for ranch use in Green River basin; drift opened 20 feet.
65	34	116	2, NW. ¼ SE. ¼....	...do......	Shale. Coal....... ?	 10	 2	 3890	Surface prospect.
66	34	116	11, NW. ¼ NE. ¼..	...do......	Shale. Coal....... ?	 4	 6	......	Do.
67	35	116	35, NE. ¼ NW. ¼..	...do......	Sandstone, white. Coal....... ?	 6		 4000	Surface prospect; unsurveyed territory.
68	35	116	35, NE. ¼ NW. ¼..	...do......	Sandstone. Coal....... ?	 4		 4004	Do.
69	36	116	11, NW. ¼ NE. ¼..	...do......	Sandstone, white. Shale..... Coal....... Shale..... Coal....... Shale.	 10 1 8 2	 2 3[a]	 4005	Frontier coal; surface prospect; unsurveyed territory. This coal bed lies 85 feet stratigraphically below No. 70.
70	36	116	11, NW. ¼ NE. ¼..	...do......	Sandstone. Coal....... Shale..... Coal....... Shale.	 2 1	 (a) 5 4[a]	 4001 4001	Surface prospect; unsurveyed territory. This coal bed lies 85 feet stratigraphically above No. 69.
71	36	116	11, SW. ¼ NE. ¼...	Frontier..	Coal.......	6		4299	Unsurveyed territory; 100-foot drift opened; 6-foot coal bed has three partings the total thickness of which is 18 inches.[b]
72	36	118	Greys River.......	...do......	Coal.......	3		4323	
73	37	115	32, NE. ¼ NE. ¼...	...do......	Coal.......	5	6	4300	Upper 2 feet[b] pure, clean coal; lower 3½ feet coal and shale. From coal beds just above No. 78.

[a] Sampled. [b] Partings excluded in sampling.

Location of mines and prospect pits, and age, thickness, and sections of coal beds—Contd.

No. on Pl. I.	Location.			Formation.	Section.			Analysis No.	Remarks.
	T. N.	R. W.	Section.			*Ft.*	*in.*		
74	37	115	32, SE. ¼ SW. ¼	Frontier	Coal		6		Surface prospect.
75	37	115	32, SE. ¼ SW. ¼	do	Sandstone, white. Coal	 2	 6	4006	Do.
76	37	115	32, SW. ¼ SW. ¼	do	Coal	3			Do.
77	37	115	32, SW. ¼ SW. ¼	do	Coal	7	6		Do.
78	37	115	33, NW. ¼ NW. ¼	do	Coal	5	6	4303	Counts prospect, lower 2 feet 8 inches fine, clean coal.[b] Coal bed lies just below No. 73.
79	37	116	1, SW. ¼ SE. ¼	do	Coal	3	6	4302	Surface prospect; lower 15 inches dirty; upper 2 feet clean.[b] Bed lies about 40 feet lower than No. 80.
80	37	116	1, SW. ¼ SE. ¼	do	Coal	3	9	4301	Bed has a 7-inch parting[a] and lies about 40 feet above No. 79.
81	37	116	1, NW. ¼ SE. ¼	do	Coal	4	6		Surface prospect.
82	37	116	1, NW. ¼ SE. ¼	do	Coal	7	6		Two prospects opened by G. B. Budd.
83	37	116	1, W. ½ SE. ¼	do	Coal	20			Surface prospect.
84	37	116	1, SW. ¼ SE. ¼	do	Coal and bone Clay, white Coal Clay Coal.	1 1 3 	 6 (b) 1 	4003	Do.
85	38	113	31, NW. ¼ NE. ¼	Evanston	Shale. Coal Shale.	 1 		3892	Fall River coal beds; surface prospect.
86	38	113	31, NW. ¼ SE. ¼	do	Shale. Coal Shale.	 3 		3893	Do.
87	38	116	11, NW. ¼ SW. ¼	Frontier	Coal	2	3		Surface prospect.
88	40	116	34, SW. ¼ NE. ¼	(?)	Shale. Coal Clay.	 1 	 5 	4002	Probably same as Fall River coal beds surface prospect along bank of Snake River.

[a] Excluded in sampling. [b] Sample.

QUALITY AND CLASSIFICATION OF THE COALS.

The coals of the area belong to two distinct classes. The first and best class includes all the coals of the Frontier formation and is of Benton (Upper Cretaceous) age; the second and inferior class includes all the coal beds of the Adaville formation, of uppermost Montana and later Cretaceous ages, and of the Evanston formation ("Upper Laramie"), of latest Cretaceous or early Tertiary age.

The coals of the first class rank as high-grade bituminous coals, have much the same physical characteristics throughout the field, and are remarkably uniform in their properties. The coal is black, moderately hard, and usually compact, and for the most part has a bright luster. It usually contains small partings of clay and shale and some irregular nodules of pyrite ("sulphur balls"). The coal as a rule is not so clean as the Adaville coal but contains much less moisture. Generally it does not slack to any appreciable extent on exposure to the weather. In two localities the coking properties have been tested and yield fairly good results.

The coals of the second class rank as high-grade subbituminous.[1] They are black, are fairly hard, have a bright luster, and break with a conchoidal fracture. When scratched the streak is a dark brown. The coal comes from the mines in fair-sized blocks but slacks readily on exposure to the air, breaking into small pieces. A block exposed to the air for a few hours becomes filled with small cracks owing to the large percentage of moisture given off. Samples for analysis were taken from a clean surface of the whole bed by cutting a channel 3 or 4 inches in width and of even depth, so that an equal amount of coal was obtained from each unit of section. The coal so removed was placed on a clean surface and broken into lumps half an inch or less in diameter and thoroughly mixed. The sample was then quartered and opposite quarters taken and remixed. This process of quartering, selecting, and mixing was continued until the sample was reduced to about 1 quart, which was then sealed in a galvanized-iron can (to prevent the escape of the moisture), marked with a description of the coal and the location of the mine, and shipped to the United States Geological Survey fuel-testing laboratory at St. Louis, Mo., for analysis. In order to determine the "loss of moisture on air-drying," or air-drying loss, the sample was dried in a specially designed oven—

> in a gentle current of air raised from 10 to 20° above the temperature of the laboratory. In this way the coal is air-dried in an atmosphere with a very low dew point and not subject to large percentage variations * * * Another advantage of this method is that it greatly shortens the time of air-drying.[2]

In order that the analyses of the Lincoln County coals may be compared with those of other coals from the Rocky Mountain region, the table that follows has been prepared. It should be borne in mind that most of the coal samples were collected from surface outcrops or shallow pits and that the coal was weathered badly and more or less altered, having a high percentage of moisture, as it was not possible to open the bed and get an unaltered sample. Two samples taken from some of the beds and identical except that one was partly altered and the other was not, differed in calorific power by 2,000 to 3,000

[1] The term subbituminous has been adopted by the United States Geological Survey for that class of coal usually designated "black lignite."

[2] Bull. U. S. Geol. Survey No. 290, 1905, pp. 29-30.

British thermal units. Only 11 samples (laboratory Nos. 3570, 3572, 3693, 3698, 3699, 3891, 4299, 4300, 4301, 4302, and 4303) fairly represent the real values of the coals in their unaltered condition; all others were collected in the zone of alteration and give more or less incorrect results. No doubt the high percentages of moisture and oxygen in these samples are due in part to the altered condition. The air-drying loss may likewise be due in part to the physical conditions and the changes undergone during weathering. In the following table the coal analyses have been arranged by quarter sections, sections, townships, and ranges, beginning at the southeast corner of the field. The numbers in the first column of the table correspond with the numbers of the prospect pits given on Plate I. The laboratory numbers are those of the United States Geological Survey fuel-testing laboratory. The analyses have been calculated on the basis of natural coal (A), air-dried coal (B), dry coal (C), and moisture and ash free coal (D) and have been arranged according to their calorific values as expressed in British thermal units. The ash and sulphur, although accidental impurities varying greatly from place to place in the same bed, are of considerable commercial importance and are therefore retained. In the table are included also, for purposes of comparison, ultimate analyses of 10 coal samples collected by A. C. Veatch and his party during the summer of 1905.[1]

[1] Veatch, A. C., Coal and oil in Uinta County, Wyo.; Bull. U. S. Geol. Survey No. 285, 1906, p. 337.

Analyses of samples of coal from the Lincoln County coal field, Wyoming.

[United States Geological Survey fuel-testing laboratory, F. M. Stanton, chemist in charge.]

Frontier coals.

No. on Pl. I.	Description.	Location.				Laboratory No.	Air-drying loss.	Form of analysis.[a]	Chemical analyses.									Heat value.	
									Proximate.				Ultimate.						
		Quarter.	Sec.	T. N.	R. W.				Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Hydrogen.	Carbon.	Nitrogen.	Oxygen.	Calories.	B. t. u.
78	Prospect on Willow Creek.	NW.	33	37	115	4303	3.5	A.	5.5	35.9	55.5	3.12	0.91	5.26	74.15	1.26	15.30	7,540	13,570
								B.	2.1	37.2	57.5	3.23	.94	5.04	76.84	1.31	12.64	7,810	14,060
								C.	....	38.0	58.7	3.30	.96	4.92	78.46	1.33	11.03	7,975	14,360
								D.	....	39.3	60.7	....	.99	5.09	81.14	1.38	11.40	8,250	14,850
71	Mine on Willow Creek, cut 100 feet from drift mouth.	NE.	11	36	116	4299	1.3	A.	3.7	36.3	56.6	3.44	.70	5.66	77.17	.84	12.19	7,615	13,700
								B.	2.4	36.8	57.3	3.48	.71	5.59	78.19	.85	11.18	7,715	13,880
								C.	....	37.7	58.7	3.57	.73	5.45	80.11	.87	9.27	7,905	14,220
								D.	....	39.1	60.9	....	.75	5.65	83.08	.90	9.62	8,195	14,751
(b)	Mine on Willow Creek. Sample cut 150 feet from drift mouth.	NW.	19	22	115	2285	1.4	A.	4.0	36.1	55.1	4.77	.77	5.17	76.03	1.31	11.95	7,500	13,500
								B.	2.6	36.7	55.9	4.84	.78	5.08	77.11	1.33	10.86	7,610	13,690
								C.	....	37.6	57.4	4.97	.80	4.93	79.16	1.36	8.78	7,810	14,060
								D.	....	39.6	60.4	....	.84	5.18	83.29	1.44	9.25	8,220	14,790
72	Surface prospect on Greys River. Sample weathered.	....	....	....	....	4323	3.6	A.	7.8	36.3	54.3	1.62	.27	5.35	70.34	1.43	20.99	7,095	12,770
								B.	4.4	37.6	56.3	1.68	.28	5.14	72.97	1.48	18.45	7,360	13,240
								C.	....	39.3	58.9	1.76	.29	4.86	76.29	1.55	15.25	7,695	13,850
								D.	....	40.0	60.0	....	.30	4.95	77.66	1.58	15.51	7,830	14,100
40	Prospect of Howard M. Holden, Oyster Ridge.	SE.	16	25	115	3570	3.9	A.	7.7	34.7	53.3	4.30	.46	5.33	71.51	1.13	17.27	7,050	12,690
								B.	4.0	36.0	55.5	4.47	.48	5.10	74.41	1.18	14.36	7,335	13,210
								C.	....	37.5	57.8	4.66	.50	4.85	77.51	1.22	11.26	7,645	13,760
								D.	....	39.4	60.6	....	.52	5.08	81.30	1.28	11.82	8,015	14,430
(b)	Mine No. 1 of Diamondville Coal & Coke Co. at Diamondville. Main Kemmerer bed.	NW.	25	21	116	2284	1.3	A.	5.1	40.5	49.8	4.61	.49	5.63	72.95	1.18	15.14	7,200	12,960
								B.	3.9	41.0	50.4	4.67	.50	5.56	73.91	1.20	14.16	7,295	13,140
								C.	....	42.7	52.4	4.86	.52	5.33	76.89	1.24	11.16	7,590	13,660
								D.	....	44.9	55.1	....	.54	5.61	80.82	1.31	11.72	7,980	14,360
73	Hawkins & Counts prospect on Willow Creek.	NE.	32	37	115	4300	1.6	A.	3.5	35.9	50.6	10.02	.92	5.09	69.67	1.01	13.29	7,150	12,870
								B.	1.9	36.5	51.4	10.18	.93	4.99	70.81	1.03	12.06	7,265	13,080
								C.	....	37.2	52.4	10.38	.95	4.87	72.19	1.05	10.56	7,410	13,340
								D.	....	41.5	58.5	....	1.06	5.43	80.55	1.17	11.79	8,265	14,880

(b)	Mine No. 1 of Kemmerer Coal Co. at Frontier. Bed A.	NW.	12	21	116	2286	2.0	A.	5.8	39.5	51.0	3.65	1.07	5.57	72.96	1.08	15.67	7,100	12,785
								B.	3.9	40.3	52.1	3.72	1.09	5.46	74.45	1.10	14.18	7,245	13,050
								C.	....	41.9	54.2	3.88	1.14	5.23	77.50	1.15	11.10	7,545	13,580
								D.	....	43.6	56.4	....	1.18	5.44	80.63	1.19	11.56	7,850	14,130
23	Mine of W. C. Wright in Mammoth Hollow.	SW.	2	23	116	3572	2.5	A.	6.9	38.0	51.5	3.55	1.76	5.28	70.62	.99	17.80	7,050	12,690
								B.	4.5	39.0	52.9	3.64	1.81	5.13	72.43	1.01	15.98	7,230	13,020
								C.	....	40.9	55.3	3.81	1.89	4.85	75.84	1.06	12.55	7,570	13,630
								D.	....	42.5	57.5	....	1.96	5.05	78.84	1.11	13.04	7,870	14,170
(b)	Mine No. 1 of Kemmerer Coal Co. Main Kemmerer coal bed.	NW.	12	21	116	2287	2.4	A.	5.9	37.6	49.0	7.51	1.39	5.28	68.48	1.07	16.27	6,870	12,370
								B.	3.6	38.5	50.2	7.70	1.42	5.13	70.16	1.10	14.49	7,040	12,670
								C.	....	39.9	52.1	7.98	1.48	4.92	72.77	1.14	11.71	7,300	13,140
								D.	....	43.4	56.6	....	1.61	5.35	79.07	1.24	12.75	7,935	14,280
(b)	Cumberland Mine No. 1 of Union Pacific Coal Co. Main Kemmerer coal bed.	SW.	31	19	116	2245	2.6	A.	6.8	39.8	47.4	6.00	.43	5.56	69.01	1.12	17.88	6,815	12,270
								B.	4.3	40.8	48.7	6.16	.44	5.41	70.85	1.15	15.99	6,995	12,590
								C.	....	42.7	50.9	6.44	.46	5.16	74.03	1.20	12.71	7,310	13,160
								D.	....	45.6	54.4	....	.49	5.51	79.12	1.28	13.60	7,815	14,060
79	Hawkins & Counts prospect on Willow Creek.	SE.	1	37	116	4302	2.3	A.	6.8	33.4	53.6	6.18	.62	4.81	69.45	1.52	17.42	6,750	12,160
								B.	4.6	34.2	54.9	6.33	.64	4.65	71.09	1.55	15.74	6,910	12,440
								C.	....	35.9	57.5	6.63	.67	4.35	74.52	1.63	12.20	7,245	13,040
								D.	....	38.4	61.6	....	.71	4.65	79.82	1.75	13.07	7,760	13,970
64	Sam Smith mine in McDougal Mountain. Sampled 20 feet from drift mouth.	SE.	33	34	115	3891	3.1	A.	9.6	38.7	46.9	4.77	.32	5.49	66.93	1.34	21.15	6,665	12,000
								B.	6.7	40.0	48.4	4.92	.33	5.31	69.07	1.38	18.99	6,880	12,380
								C.	....	42.8	51.9	5.28	.35	4.89	74.04	1.48	13.96	7,375	13,270
								D.	....	45.2	54.8	....	.37	5.16	78.16	1.56	14.75	7,785	14,010
84	Surface prospect on Willow Creek. Coal weathered.	SE.	1	37	116	4003	4.6	A.	10.1	32.9	53.3	3.70	.38	5.27	66.94	1.29	22.42	6,465	11,640
								B.	5.7	34.5	55.9	3.88	.40	4.98	70.17	1.35	19.22	6,775	12,200
								C.	....	36.6	59.3	4.11	.42	4.61	74.43	1.43	15.00	7,185	12,940
								D.	....	38.2	61.8	....	.44	4.81	77.62	1.50	15.63	7,495	13,490
80	Surface prospect on Willow Creek.	SE.	1	37	116	4301	6.0	A.	10.7	30.7	54.3	4.28	.78	5.34	66.18	1.45	21.97	6,355	11,440
								B.	5.0	32.6	57.8	4.55	.82	4.98	70.41	1.54	17.70	6,765	12,170
								C.	....	34.3	60.9	4.79	.87	4.65	74.11	1.62	13.96	7,120	12,810
								D.	....	36.1	63.9	....	.92	4.88	77.84	1.71	14.65	7,475	13,460
70	Surface prospect on Willow Creek. Coal weathered.	NE.	11	36	116	4001	3.0	A.	6.9	31.9	51.9	9.32	1.54	5.01	65.52	1.01	17.60	6,375	11,470
								B.	4.0	32.9	53.5	9.61	1.58	4.83	67.54	1.04	15.40	6,570	11,830
								C.	....	34.3	55.7	10.01	1.65	4.55	70.39	1.08	12.32	6,845	12,320
								D.	....	38.1	61.9	....	1.83	5.06	78.22	1.20	13.69	7,605	13,690
(b)	Richardson mine of Standard Reserve Oil Co.	NW.	12	15	118	2212	2.6	A.	6.8	35.6	43.9	13.67	.94	4.99	63.71	1.12	15.57	6,305	11,350
								B.	4.4	36.6	45.0	14.04	.97	4.82	65.41	1.15	13.61	6,475	11,650
								C.	....	38.2	47.1	14.68	1.01	4.54	68.40	1.20	10.17	6,770	12,180
								D.	....	44.8	55.2	....	1.18	5.32	80.16	1.41	11.93	7,935	14,280

a These letters indicate forms of analysis. A is analysis of sample as it comes from the mine; B, of air-dried sample; C, of dry coal; and D, of coal in moisture and ash free condition.

b Samples collected by A. C. Veatch in 1905 in the southern part of Uinta County.

Analyses of samples of coal from the Lincoln County coal field, Wyoming—Continued.

Frontier coals—Continued.

No. on Pl. I.	Description.	Location.				Laboratory No.	Air-drying loss.	Form of analysis.	Chemical analyses.									Heat value.	
									Proximate.				Ultimate.						
		Quarter.	Sec.	T. N.	R. W.				Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Hydrogen.	Carbon.	Nitrogen.	Oxygen.	Calories.	B. t. u.
62	Surface prospect in Lander Peak. Coal weathered.	SE.	34	33	115	3778	5.5	A.	14.0	34.0	49.1	2.92	0.60	5.36	61.25	1.51	28.36	6,010	10,820
								B.	9.0	36.0	51.9	3.09	.63	5.02	64.83	1.60	24.83	6,360	11,450
								C.	....	39.5	57.1	3.40	.70	4.42	71.24	1.76	18.48	6,990	12,580
								D.	....	40.9	59.1	....	.72	4.57	73.74	1.82	19.15	7,235	13,030
75	Surface prospect of Hawkins & Counts on Willow Creek. Coal weathered.	SW.	32	37	115	4006	5.7	A.	14.4	32.5	48.7	4.43	3.56	5.33	60.67	1.30	24.71	5,725	10,300
								B.	9.2	34.4	51.7	4.70	3.78	4.98	64.34	1.37	20.83	6,070	10,930
								C.	....	37.9	56.9	5.18	4.16	4.36	70.84	1.52	13.94	6,685	12,030
								D.	....	40.0	60.0	....	4.38	4.61	74.71	1.60	14.70	7,050	12,690
65	Surface prospect in Wyoming Range. Coal weathered.	SE.	2	34	116	3890	12.8	A.	21.3	34.8	39.3	4.61	.24	5.69	53.73	1.16	34.57	5,035	9,060
								B.	9.7	40.0	45.0	5.29	.28	4.89	61.62	1.33	26.59	5,775	10,390
								C.	....	44.2	49.9	5.86	.30	4.23	68.25	1.47	19.89	6,395	11,510
								D.	....	47.0	53.0	....	.32	4.49	72.51	1.57	21.11	6,795	12,230
68	Surface prospect in Wyoming Range. Coal badly weathered.	NW.	35	35	116	4000	17.2	A.	27.2	30.3	34.5	7.97	.94	5.89	44.67	1.08	39.45	4,175	7,520
								B.	12.1	36.6	41.7	9.63	1.13	4.81	53.95	1.30	29.18	5,045	9,080
								C.	....	41.6	47.4	10.95	1.29	3.94	61.35	1.48	20.99	5,735	10,320
								D.	....	46.7	53.3	....	1.45	4.43	68.89	1.67	23.56	6,440	11,590
69	Surface prospect on Willow Creek. Coal weathered.	NE.	11	36	116	4005	10.7	A.	21.6	29.2	42.3	6.90	.99	5.49	53.04	1.07	32.51	4,960	8,930
								B.	12.2	32.7	47.4	7.73	1.10	4.83	59.39	1.20	25.75	5,555	10,000
								C.	....	37.2	54.0	8.80	1.26	3.94	67.65	1.36	16.99	6,330	11,390
								D.	....	40.8	59.2	....	1.38	4.32	74.18	1.50	18.62	6,940	12,490
67	Surface prospect in Wyoming Range. Coal weathered.	NW.	35	35	116	4004	10.4	A.	20.4	30.7	42.4	6.49	.42	5.79	53.23	1.30	32.77	5,050	9,090
								B.	11.2	34.2	47.4	7.24	.47	5.18	59.41	1.45	26.25	5,635	10,140
								C.	....	38.5	53.3	8.16	.53	4.42	66.90	1.63	18.36	6,345	11,420
								D.	....	41.9	58.1	....	.57	4.82	72.84	1.78	19.99	6,910	12,430

Adaville coals.

(a)	Adaville mine in Mammoth Hollow. 84-foot bed.	SW.	20	21	116	2283	14.8	A.	22.4	34.5	40.2	2.92	0.50	6.10	56.02	0.88	33.58	5,440	9,790
								B.	8.9	40.5	47.2	3.43	.59	5.23	65.75	1.03	23.97	6,385	11,490
								C.	....	44.4	51.8	3.76	.64	4.65	72.16	1.13	17.66	7,005	12,610
								D.	....	46.2	53.8	....	.67	4.83	74.98	1.18	18.34	7,280	13,110
44	Mine of J. Saley in Labarge Ridge.	NW.	7	26	113	3698	12.7	A.	22.9	34.5	40.1	2.48	.73	6.37	55.71	.94	33.77	5,465	9,830
								B.	11.7	39.5	46.0	2.84	.83	5.68	63.82	1.08	25.75	6,260	11,260
								C.	....	44.7	52.1	3.22	.95	4.96	72.27	1.22	17.38	7,085	12,760
								D.	....	46.2	53.8	....	.98	5.12	74.68	1.26	17.96	7,325	13,180
49	Surface prospect in Labarge Ridge.	SW.	32	27	113	3693	11.6	A.	22.4	35.8	38.8	3.01	1.86	6.36	54.60	.91	33.26	5,355	9,640
								B.	12.2	40.5	43.9	3.41	2.10	5.73	61.77	1.03	25.96	6,055	10,900
								C.	....	46.1	50.0	3.88	2.40	4.99	70.34	1.17	17.22	6,905	12,430
								D.	....	47.9	52.1	....	2.49	5.19	73.18	1.22	17.92	7,175	12,920
56	Prospect of N.W. Griggs in Labarge Ridge.	SE.	12	28	114	3699	10.6	A.	19.6	32.7	42.5	5.16	1.02	6.00	55.47	.97	31.38	5,400	9,720
								B.	10.1	36.6	47.5	5.77	1.14	5.39	62.05	1.09	24.56	6,040	10,870
								C.	....	40.7	52.9	6.42	1.27	4.75	69.01	1.21	17.34	6,715	12,090
								D.	....	43.5	56.5	....	1.36	5.08	73.74	1.29	18.53	7,175	12,920
41	Jones prospect in Mammoth Hollow. Coal weathered.	SW.	17	25	115	3696	16.5	A.	25.6	33.8	37.6	3.02	.41	5.80	49.29	.94	40.54	4,505	8,110
								B.	10.8	40.5	45.1	3.62	.49	4.76	59.03	1.12	30.98	5,400	9,720
								C.	....	45.4	50.5	4.06	.55	3.98	66.21	1.26	23.94	6,055	10,900
								D.	....	47.3	52.7	....	.57	4.14	69.01	1.32	24.96	6,310	11,360
53	Prospect drift in Labarge Ridge. Coal weathered.	NW.	1	28	114	3700	18.1	A.	27.5	31.0	31.8	9.67	.90	5.69	40.46	1.05	42.23	3,665	6,600
								B.	11.5	37.9	38.8	11.81	1.10	4.49	49.40	1.28	31.92	4,475	8,060
								C.	....	42.8	43.9	13.35	1.24	3.63	55.86	1.45	24.47	5,060	9,110
								D.	....	49.4	50.6	....	1.43	4.19	64.46	1.67	28.25	5,840	10,520
55	Surface prospect in Labarge Ridge. Coal badly weathered.	SE.	12	28	114	3694	21.3	A.	32.2	30.8	31.6	5.41	.48	5.87	38.29	.67	49.28	3,515	6,330
								B.	13.8	39.1	40.2	6.88	.61	4.45	48.65	.85	38.56	4,465	8,040
								C.	....	45.4	46.6	7.98	.71	3.38	56.46	.99	30.48	5,185	9,330
								D.	....	49.4	50.6	....	.77	3.67	61.35	1.07	33.14	5,635	10,140
47	Surface prospect in Labarge Ridge. Coal weathered.	NE.	29	27	113	3697	19.3	A.	29.0	31.4	31.7	7.92	1.35	5.43	38.61	.79	45.90	3,420	6,160
								B.	12.0	38.9	39.3	9.81	1.67	4.07	47.85	.98	35.62	4,240	7,630
								C.	....	44.1	44.7	11.16	1.90	3.11	54.40	1.11	28.32	4,820	8,680
								D.	....	49.7	50.3	....	2.14	3.50	61.23	1.25	31.88	5,425	9,770
51	Surface prospect in Labarge Ridge. Coal weathered.	NW.	1	28	114	3695	22.6	A.	35.7	28.9	28.0	7.43	.58	6.31	37.16	.87	47.65	3,245	5,850
								B.	16.9	37.3	36.2	9.60	.75	4.91	48.01	1.12	35.61	4,195	7,550
								C.	....	44.9	43.5	11.56	.90	3.64	57.79	1.35	24.76	5,050	9,090
								D.	....	50.7	49.3	....	1.02	4.11	65.34	1.53	28.00	5,710	10,280

a Samples collected by A. C. Veatch in 1905 in the southern part of Uinta County.

Analyses of samples of coal from the Lincoln County coal field, Wyoming—Continued.

Evanston coals.

No. on Pl. I.	Description.	Location: Quarter.	Location: Sec.	Location: T. N.	Location: R. W.	Laboratory No.	Air-drying loss.	Form of analysis.	Proximate: Moisture.	Proximate: Volatile matter.	Proximate: Fixed carbon.	Ash.	Ultimate: Sulphur.	Ultimate: Hydrogen.	Ultimate: Carbon.	Ultimate: Nitrogen.	Ultimate: Oxygen.	Heat value: Calories.	Heat value: B. t. u.
(a)	Mine No. 5 of Rocky Mountain Coal & Iron Co. Almy bed.	SE.	30	16	120	2325	6.7	A.	14.4	36.8	41.6	7.22	0.21	5.37	59.97	1.15	26.08	5,805	10,450
								B.	8.3	39.5	44.5	7.74	.22	4.96	64.28	1.23	21.57	6,220	11,198
								C.	....	43.0	48.6	8.44	.25	4.41	70.08	1.34	15.48	6,785	12,210
								D.	....	47.0	53.0	....	.27	4.81	76.54	1.47	16.91	7,410	13,330
85	Surface prospect on Fall River. Coal weathered.	NE.	31	38	113	3892	8.7	A.	19.0	39.7	27.8	13.47	2.60	5.26	48.01	1.28	29.38	4,660	8,390
								B.	11.3	30.5	43.5	14.75	2.85	4.70	52.58	1.40	23.72	5,105	9,190
								C.	....	49.0	34.4	16.63	3.21	3.89	59.29	1.58	15.40	5,755	10,360
								D.	....	58.8	41.2	....	3.85	4.67	71.11	1.90	18.47	6,905	12,430
86	Surface prospect on Fall River. Coal weathered.	SE.	31	38	113	3893	4.3	A.	16.5	32.7	37.6	13.25	4.35	5.15	49.38	.99	26.88	4,755	8,560
								B.	12.7	34.1	39.3	13.85	4.55	4.88	51.59	1.03	24.10	4,970	8,950
								C.	....	39.1	45.0	15.87	5.21	3.98	59.14	1.19	14.61	5,700	10,260
								D.	....	46.5	53.5	....	6.19	4.73	70.30	1.41	17.37	6,775	12,190
88	Surface prospect on Snake River. Coal weathered.	NE.	34	40	116	4002	7.9	A.	18.3	23.2	34.4	24.08	.30	4.12	42.03	.57	28.90	3,695	6,650
								B.	11.2	25.2	37.4	26.16	.33	3.51	45.63	.62	23.75	4,010	7,220
								C.	....	28.3	42.2	29.48	.37	2.55	51.42	.70	15.48	4,520	8,130
								D.	....	40.2	59.8	....	.52	3.62	72.92	.99	21.95	6,405	11,530

a Samples collected by A. C. Veatch in 1905 in the southern part of Uinta County.

In analytical work chemists generally recognize that it is not possible to determine the proximate constituents of coal or lignite with the same degree of accuracy as the ultimate constituents. Therefore, in the proximate analyses the air-drying loss, moisture volatile matter, and fixed carbon are given to one decimal place only, and in the ultimate analyses the ash, sulphur, hydrogen, carbon, nitrogen, and oxygen are given to two decimal places. It is also understood that calorific determinations to individual units are not reliable; therefore, in the column headed "Calories" the heat values are given to the nearest five units, and in the column headed "British thermal units" they are given to the nearest tens, a British thermal unit being about one-half the value of a calorie.

The sulphur content of the Frontier coals is low, being generally less than 1 per cent, the lowest being 0.28 per cent and the highest 3.78, and the average of the 23 analyses 0.93 per cent. The ash varies from 1.68 per cent to 14.04 per cent, with an average of 6.12 per cent, and the carbon from 53.94 per cent to 78.19 per cent, with an average of 69.11 per cent.

The Adaville coals fall in part in the bituminous class and in part in the subbituminous class. Their sulphur content is low, varying from 0.49 per cent to 2.10 per cent with an average of 0.94 per cent for all of the samples. The ash is about one-third less than in the Frontier coals, varying from 2.84 to 11.81 per cent, with an average of 4.77 per cent; and the carbon content is equal to that of the Frontier coals, ranging from 47.85 to 67.12 per cent, with an average of 69.12 per cent.

The Evanston coals, like the Adaville, fall in both bituminous and subbituminous classes. They contain more sulphur and ash and a little less carbon than the Frontier and Adaville coals. Their sulphur varies from 0.22 to 4.78 per cent, with an average of 2.52 per cent for five samples, and their ash from 7.74 to 26.16 per cent, with an average of 15.97 per cent, and their carbon from 45.63 to 64.28 per cent, with an average of 53.32 per cent.

The distinction between the Frontier, Adaville, and Evanston coals is largely physical. The two last named generally contain more moisture than the Frontier coals, have a lower calorific value, weather more readily on exposure to the atmosphere, and are lighter in weight. The most marked difference between them is the rapidity with which the Adaville coals weather and the peculiar manner in which the breaks in them occur, the coal seeming to undergo a chemical change, accompanied by a conchoidal or irregular fracture that does not conform in any way with the bedding planes.

In making comparisons with coals in other fields, only 11 analyses (Nos. 3570, 3572, 3693, 3698, 3699, 3891, 4299, 4300, 4301, 4302, and

4303), together with the samples of the coals collected in mines in Uinta County, should be taken as representative of the coals in their unaltered condition. Comparison of these analyses with others made by the United States Geological Survey fuel-testing plant on the samples collected in other parts of the Rocky Mountain region shows that the coals of Benton age found in Lincoln County are equal to many of the best, and are much better than some of those from Montana, Colorado, Utah, and New Mexico, which are about equivalent to the Adaville and Evanston coals. The coals of Benton age in Lincoln County may be said to be well up in the group of the best bituminous coals of the Rocky Mountain region. The high quality of these coals in part of Lincoln County is due not to igneous intrusions, as is often held by local opinion, but to regional conditions; and they are, therefore, apt to be uniform over large areas. From the preliminary tests thus far made some of the coals of Benton age rank as fairly good coking coals, and will probably in the near future be developed for their coking properties.

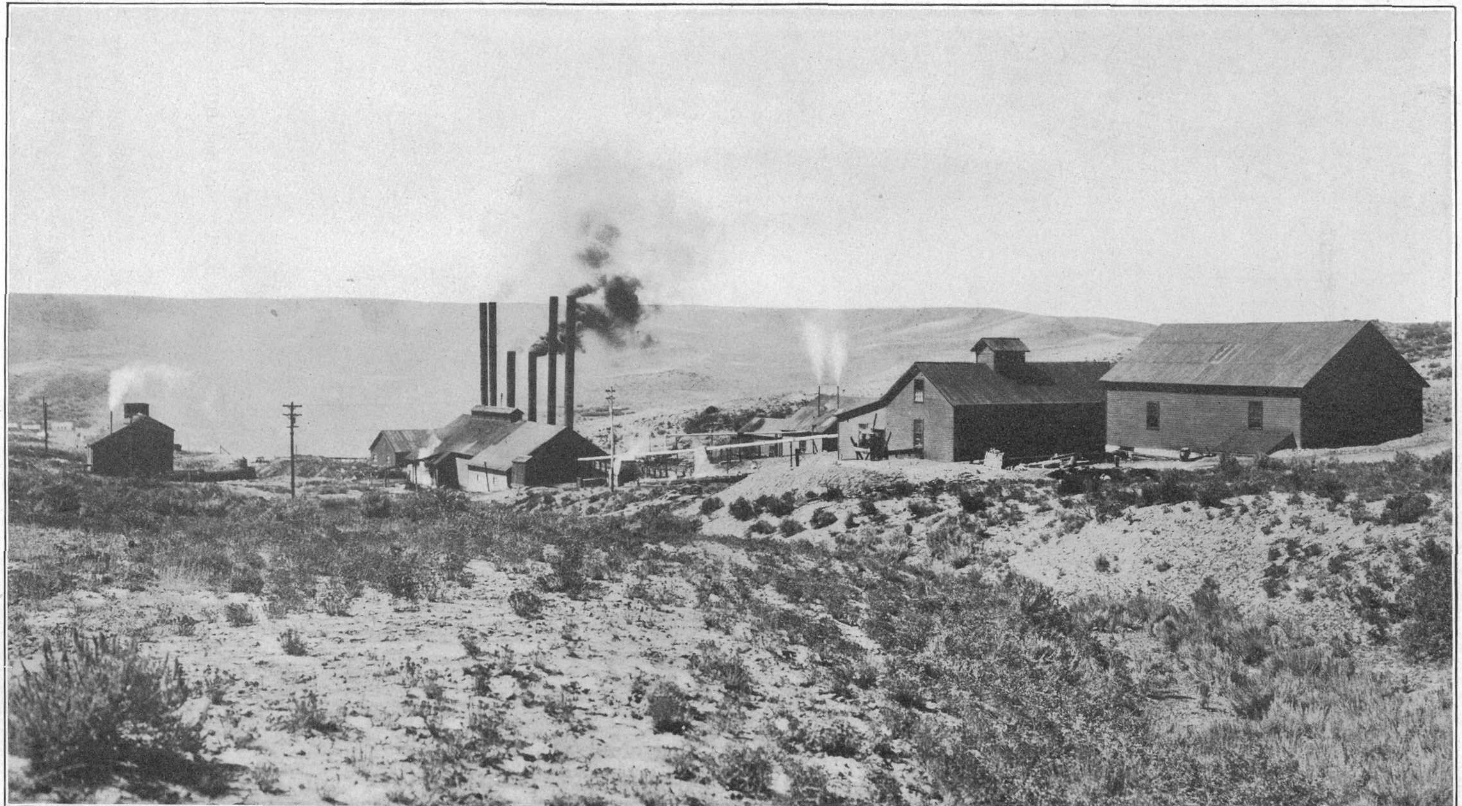
MINING DEVELOPMENT.

No active mining is carried on within the area surveyed in 1906. The coal fields are still in a prospecting stage, and in only a few localities has even prospecting been carried on systematically. At present these coals are scarcely known north of Kemmerer and are but little developed. In a few localities enough coal is taken from shallow pits to supply ranches in the immediate vicinity, but except for this and for surficial prospecting no work on them is being carried on in the area.

In the Fall River coal field no mining has been done, and practically no prospecting has disclosed the position of the coal beds. It is highly probable that they extend under a large portion of the Green River basin, but their outcrop is of very small extent, as the Tertiary covering has been removed in only a few localities. Until drill holes have been put through the Tertiary cover the position, distribution, and thickness of these beds can only be inferred.

On the Adaville coals very little mining and prospecting has been done. Up to the last few years J. M. Wright mined, about 1 mile south of the south boundary of the area (see I in the table on p. 101), enough coal for ranch use and opened 18 feet of coal without exposing the bottom or top of the coal bed. Farther south, in Uinta County, coal has been mined at six different mines—the Twin Creek, Adaville, St. Albans, Foelter, Lazeart, and Carleton—but at present it is being taken only from the Lazeart mine.[1]

[1] Veatch, A. C., Bull. U. S. Geol. Survey No. 285, 1906, pp. 331-335; Prof. Paper U. S. Geol. Survey No. 56, 1907.



FRONTIER COAL MINE, FRONTIER, WYO.

In the Labarge Ridge field coal is at present taken from two mines, the Saley and the Griggs. At the Saley mine (No. 44) a drift has been opened 180 feet along the strike of the coal bed, and coal is mined for ranch use as demanded and sold at the mine for $1.50 to $2 a ton. At the Griggs mine (No. 56) a slope 125 feet long has been opened and coal is taken out by ranchers whenever needed, each rancher doing his own mining and taking as much of the coal as is needed. Coal was also mined from some of the other prospects east of Labarge Ridge, but at present most of these are neglected.

Throughout the northern part of the field very little prospecting and practically no mining has been done on the coals in the Frontier formation. Coal is not mined anywhere in the Greys River field, and it is mined at only one locality (No. 64) in the McDougal field. Sam Smith has recently opened a 20-foot drift in a 6-foot 2-inch coal bed and has sold several loads to people living in Green River basin. Coal for ranch use is also mined in the Kemmerer coal field by Wright & Holden at Nos. 23 and 40, respectively. Farther south a little coal was mined by the Kemmerer Coal Co. at Nos. 5 and D in 1904, but since that time no further development work has been carried on. The same company in 1897 opened the Frontier mine (Pl. X), which lies 5 miles south of the south boundary of the region mapped and is working the Kemmerer group of coals (second and third beds from the top). (See fig. 8.)

The average daily output (of 10 hours) in 1906 was 350 tons. Three beds of coal occur in the Kemmerer group. Between the main Kemmerer bed and bed A, stratigraphically 35 feet lower, alternating bands of sandstone and shale are found. About 10 feet stratigraphically below bed A is the top of another bed (B), which is about 6½ feet thick, with a parting 17 inches below the top. The intervening material between bed A and bed B is too soft to allow bed B to be worked, and no coal has thus far been taken from it.

FIGURE 8.—Section of Kemmerer coals in Frontier formation (SE. ¼ NW. ¼ sec. 12, T. 21 N., R. 116 W.).

OIL.

HISTORICAL SKETCH.

The occurrence of oil in southwestern Wyoming has been known for nearly three-fourths of a century. Many of the early trappers and fur traders, who built Fort Bonneville and the trading post at Fort Bridger, knew the location of the oil springs and visited them in their annual trapping tours. The first published account of oil in southwestern Wyoming resulted from an examination made by the Mormons in 1847 on their pioneer journey across the great plains. The discovery of the oil springs on Hilliard Flat, the Carter oil spring, and those in the Fossil syncline near Fossil, have been chronicled by Veatch.[1]

A few miles southwest of the Carter oil spring, in sec. 7, T. 14 N., R. 118 W., oil was found by the Oregon Short Line Railroad in 1900 and 1902, while constructing the Aspen tunnel, and a considerable oil seepage was encountered along a fault plane about 1,600 feet from the west portal of the tunnel. The oil springs along the east front of Absaroka Ridge north of Kemmerer were probably referred to in Lander's report of 1859,[2] in which he makes the general statement that in the mountains along the divide in latitude 42° north there are "beds of coal, iron, and slate and a spring of peculiar mineral oil which by chemical process may be made suitable for lubricating machinery." No further description of the spring is given and its exact location is not known. Later geologic reports do not mention oil springs north of the Fossil locality. A brief description of the oil springs in Uinta County is given in the Wyoming reports by W. C. Knight and E. E. Slosson.[3] The oil discovery in the vicinity of Spring Valley and the developments in Uinta County from 1900 to 1905 are described by A. C. Veatch.[4] Since 1905 prospecting and development work have continued in the region about Spring Valley. The Pittsburg-Salt Lake Oil Co. has filed proof of labor on most of its property, and the people interested in oil are holding their locations. During the last three months of 1907 the Pittsburg-Salt Lake Oil Co. shipped seven cars of refined oil and two cars of gasoline.

North of Kemmerer no prospecting for oil was carried on during the oil excitement in Uinta County. Oil discoveries have been reported, however, from several localities along the east front of Absaroka Ridge and from Green River basin east of Meridian Ridge and Thompson Plateau. Considerable excitement was caused in the summer of 1907 by the discovery of oil east of Labarge Ridge in T. 27 N., R. 113 W. Numerous placer claims were staked in the country between Labarge Ridge and Green River, and plans were outlined to prospect the region by churn and diamond-drill borings.

---

[1] Veatch, A. C., Bull. U. S. Geol. Survey No. 285, 1906, pp. 342–344.

[2] Lander, F. W., Preliminary report upon explorations west of South Pass for a suitable locality for the Fort Kearney, South Pass, and Honey Lake wagon route; S. Doc. No. 36, 35th Cong., 2d sess., vol. 10, p. 33.

[3] Bull. No. 3, Petroleum series, School of Mines, Univ. Wyoming, 1899.

[4] Bull. U. S. Geol. Survey No. 285, 1906, pp. 342–353; Prof. Paper U. S. Geol. Survey No. 56, 1907, pp. 139–162.

OCCURRENCE AND SOURCE.

LABARGE RIDGE.

The Labarge oil field lies along the east base of Labarge Ridge and extends from Labarge Creek northward to the vicinity of South Piney Creek in T. 28 N., R. 113 W. The greater portion of the area forms a plain sloping gently eastward toward Green River.

The oil-bearing shale of Uinta County does not outcrop in the Labarge Ridge locality. The oil, however, as in Uinta County, is believed to come from the Aspen formation of Benton age. None of the natural oil springs in Uinta County occur along the outcrop of the shale that supplies the oil in the Spring Valley wells, and no trace of oil has been seen anywhere along the outcrop of the Aspen formation. The springs are all in the region of profound disturbance along the Absaroka fault and its associated secondary faults. The oil springs of Hilliard Flat, the Carter oil spring, and the seepage near the west end of the Aspen tunnel are located along a secondary fault, but those on Twin Creek lie along the line of the main fault. The oil observed at all these springs has probably been forced up from the oil-bearing shale along the fault line, through the water which has penetrated along the fault contact.

East of Labarge Ridge no outcrop of Aspen formation was seen. The oil springs observed resemble those in the vicinity of Fossil in that the strata around the springs are of Tertiary age. The Wasatch strata here lie on an anticline dipping about 5°, that may represent the southern continuation of the anticline at the north end of Labarge Ridge. It is believed that the oil comes from the Aspen formation, which here lies from 2,000 to 4,000 feet below the surface. Part of the oil that makes its escape into the valley where the oil prospects are located may have been collected along the low anticlinal crest in the fairly waterlogged beds of the Wasatch group.

Whether the oil-bearing sands in this locality are dry like those at Spring Valley, or whether there is sufficient water present to float the oil and make it accumulate on the crests of anticlines, can not be determined until drill holes are put down. If the rocks are saturated drilling should be done along the anticlinal axis east of Labarge Ridge; if they are dry the conditions in the Labarge oil field are manifestly unfavorable for the accumulation of oil in commercial quantities.

ABSAROKA AND SALT RIVER RANGES.

North of Hams Fork oil indications have been observed at several places along the east base of the Absaroka and Salt River ranges, near the fault line. Oil was observed on the water along some of the streams tributary to Fontenelle Creek. In Pomeroy Basin oil was observed on the water in a number of marshes, in quaking asp groves, and in low depressions. Gas is said to escape about 12 miles north of Kemmerer, along Mammoth Hollow, and to be readily perceptible on a damp morning by its rank odor. Indian tradition has it that many years ago oil used to flow from a spring near this same locality, but no trace of this spring was seen during the writer's work. However, owing to the heavy covering of talus and timber in this vicinity, as well as to the numerous springs that rise on the mountain sides or flow from snowbanks near the crest of the range, traces of oil are not so readily seen or recognized as in the southern part of the county. In the northern part of the field examined in 1906, about 2½ miles west of Snake River, along the north line of T. 39 N., R. 116 W., oil having a distinct odor was observed on the water and in footprint depressions.

One of the most favorable localities for oil prospecting is in the vicinity of Wright's ranch, in T. 23 N., R. 116 W., where the oil-bearing shale lies from 2,500 to 4,000 feet below the surface along the center of the syncline. Almost as favorable a locality is that along Fontenelle Creek, near the north end of the Lazeart syncline. The depth to the oil-bearing shale in the center of the syncline is such that wells could be readily sunk, and test holes in this region may yield results. Similar conditions exist in the synclinal trough that crosses Little Greys and Snake rivers in the northern part of the field.

Although no prospecting, drilling, or development work has been done north of Kemmerer on the oil-bearing Aspen and Bear River formations to determine whether they contain as much oil as the beds at Spring Valley, their occurrence throughout this region east of the Absaroka and Salt River ranges and east of the Wyoming Range is certain. They extend from Spring Valley to Snake River, and it is not improbable that they contain about as much oil throughout this area as they do south of it. The distribution is given on Plate I. No oil was observed along the outcrop. This fact, however, proves nothing, as any oil near the surface may have escaped or have settled toward the synclinal axis, so as not to be noticeable on the surface.

UINTA COUNTY.

In the vicinity of Spring Valley,[1] where the Aspen formation has been developed, the oil is found in sandy layers in shale from top to base of the formation. Failure to obtain oil in this locality has been recorded in three types of wells—(1) those not deep enough to reach the oil-bearing beds; (2) those which on account of irregularities of the sandy layers in the Aspen formation fail to produce

[1] Veatch, A. C., Bull. U. S. Geol. Survey No. 285, 1906, pp. 342-353; Prof. Paper U. S. Geol. Survey No. 56, 1907, pp. 143-144.

oil, although oil is present in adjacent wells; (3) those located on the outcrop of the shale, particularly near the lower or eastern edge, where the bed is less than 500 feet thick. Although in general no oil is found along the outcrop of the oil-bearing shale, it is found in increasing quantity down the dip. The oil problem in the Spring Valley locality, as well as in much of the territory north of that place, is well set forth in the following statement:[1]

> The oil-bearing beds are entirely dry when the oil is pumped out of the wells; no water follows. Water occurs in the overlying Wasatch beds and in the sandstones of the Frontier formation and is also reported in a sandstone several hundred feet below the main oil sands, as in the Jager well and the Consolidated Oil Co. well. The occurrence of large quantities of water in the Bettys well and the Baker well has been regarded by some as affecting the oil situation, but the water-bearing beds here are in no way connected with the oil-bearing strata. The anticlinal theory, according to which oil accumulates by floating upon water on the flanks or crests of anticlines, does not seem to apply to this field, for one of the essential factors in the theory—the water in the oil-bearing sand—is not present. The absence of water in the oil-bearing sands, together with the fact that springs do not occur along the outcrops of the beds and the irregularity shown in the position of the oil-bearing sands in adjoining wells, suggests that the oil has been formed from the shale in which it is found and that the oil-bearing shales represent local sandy layers more or less perfectly surrounded by shale in which the oil has accumulated. * * * In the absence of water, oil tends to move down the dip and, so far as the continuity of the porous beds will allow, to collect in the troughs of the synclines. This is apparently the case in this field and the position of this syncline and the depth of the oil-bearing shale at its lowest point then become matters of considerable economic importance.

Because of the rising and pitching of the Lazeart syncline, the oil-bearing shale in the synclinal trough lies at varying depths below the surface along the axis, and in part of the trough lies at a depth that is practically prohibitive of development work. However, the softness of the beds suggests that the pressure of the superincumbent rocks may be great enough practically to close the pore space so that the maximum accumulation of oil may be found, not on the axis but on the limb of the syncline between the axis and the outcrop. In the vicinity of the fault, where the oil beds lie at great depth, the oil leakage may be partly cut off by the same cause and the oil may be stored on the limb of the syncline. If the above-outlined conditions are true, prospecting in much of this field should be restricted to the shallow portions of the synclinal basin and to the region between the axis of the syncline and the outcrop of the oil-bearing shale on the west flank of the Meridian anticline.

In Uinta County the wells of the Pittsburg-Salt Lake Co., in sec. 10, T. 14 N., R. 118 W., developed an oil-bearing bed in the lower part of the Bear River formation.[2] The oil is black and more like a lubricating oil than that of the Aspen formation. Although the

---

[1] Veatch, A. C., Geography and geology of southwestern Wyoming: Prof. Paper U. S. Geol. Survey No. 56, 1907, p. 158.

[2] Veatch, A. C., idem, p. 159.

Bear River formation extends throughout this area, lying conformably below the Aspen formation in a narrow belt along its east side, nothing further was learned about these oil-bearing beds. At no point within this field have wells been drilled to test the oil-bearing properties of either the Aspen or the Bear River formation.

QUALITY OF THE OIL.

All the oil from springs in Uinta and Lincoln counties is dark and heavy and may have been derived from the oils of the Aspen formation by the evaporation of the more volatile portions. Slosson [1] gives the gravity of the Carter oil as 21.5° Baumé and that of the Fossil or Twin Creek oil as 19.7° Baumé. The gravity of the Fossil oil is given by the Union Pacific Railroad [2] as 26.75° Baumé. The results of analyses of the Spring Valley petroleum and of a sample collected from a shallow well about 3 feet square and 6 feet deep, sunk near the center of a drain about 4 miles east of Labarge Ridge, are given below. This shallow well contained more than a foot of dark-colored heavy oil. Considerable oil was taken from this pit during the summer by visitors. The oil was also used by the ranchers in Green River basin as machine oil and proved highly satisfactory. It did not rise to the surface, but appeared to drain into the soil that filled the valley; at several points oil was encountered by sinking shallow wells a few feet into this soil.

Tests of oil from well of Pittsburg-Salt Lake Oil Co. in sec. 22, T. 15 N., R. 118 W., 1 mile north of Spring Valley.

[By C. F. Mabery, Cleveland, Ohio, 1906.]

Temperature (°C.) at which gas was given off on distillation.	Percentage.	Gravity (°Baumé).	Nature of product.
50–150	21.3	65	Gasoline.
150–305	39.7	44	Burning oil.
305–350	16.4	36	Gas oil.
350–380	15.4	37	Oil partly cracked.

Residue, 7.2. Specific gravity, 0.81,=44° B. The oil begins to crack at 350°; of course this product is really gas oil. The distillates at 305°–350°, 350°–380°, and the residue contain much paraffin. These oils become solid when cooled in tap water with paraffin, so the yield is large. We refined some of the burning oil, not, however, with reference to flash or complete absence of color; it refines very easily, and gives a very fine grade of burning oil. Of course the proportions of products will be somewhat different on a refining scale (1,000 barrels)—probably larger, rather than smaller, than is given on the small scale. This petroleum is different from any of the numerous specimens that I have previously examined from Wyoming. A large amount of very light gasoline can be separated by strong cooling. With respect to the large proportion of gasoline and of burning oil, also of paraffin, this petroleum is one of the most valuable that I have ever examined. It is a nonsulphur oil; percentage of sulphur, 0.03.

[1] Slosson, E. E., Bull. No. 3, Petroleum series, School of Mines, Univ. Wyoming, 1899, p. 31.

[2] Mineral resources U. S. for 1885, U. S. Geol. Survey, 1886, p. 154.

Test of oil from shallow pit east of Labarge Ridge, Green River basin, in sec. 34, T. 27 N., R. 113 W.

[By David T. Day, U. S. Geol. Survey, Jan. 8, 1908.]

Temperature (°C.) at which gas was given off on distillation.	Percentage.	Specific gravity.	Nature of product.
Below 150	Trace.	....	
150–300	34	0.891	Suitable for burning.

Specific gravity of the original oil, 0.9435=18.75° Baumé. The oil was collected from seepage into a shallow well. It had evidently suffered oxidation, as shown by the considerable amount of resins contained. These resins made it difficult to completely separate water from the oil. The distillation was, therefore, slow and somewhat unsatisfactory. There is no indication of sulphur in the oil, no quantitative test being obtained by oxidation, and there is no odor of sulphur.

The specific gravity of the oil suitable for burning was so high that this portion was treated with sulphuric acid to determine whether the oil consisted of hydrocarbons of the paraffin (Pennsylvania) series. The amount absorbed by sulphuric acid was not abnormally large, and left a pleasant-smelling, refined product. The examination of the residue not distilling below 300° was extremely interesting. In addition to an oil soluble in cold alcohol, probably plain paraffin hydrocarbons, it gave a considerable amount soluble in boiling alcohol, which should have consisted entirely of paraffin wax, but did consist to a large extent of resins entirely absorbed by strong sulphuric acid, and giving evidence of being terpenes. The portion insoluble in boiling absolute alcohol, which should consist ordinarily of asphalt, gave, instead of the usual hard black asphalt, a soft sticky material characteristic of the transition stage of resins into asphalt.

While the oil has suffered too much oxidation to be interesting from the refiner's standpoint, it is extremely interesting scientifically, on account of the effects of the oxidation, showing, as given above, the intermediate stage between oil and ordinary hard asphalt.

GOLD.

A little time was given to the study of the gold placers along Snake River and its tributaries and to an examination of some of the claims which have recently been staked on Horse Creek east of Wyoming Range and have caused considerable gold excitement in the Green River basin. A preliminary report has been published.[1]

GOLD IN THE ROCKS.

The gold thus far reported lies in the northern third of the area, on the east side of the Wyoming Range, in sedimentary rocks (Beckwith formation) of Jurassic age. The only prospecting that has been done is in the vicinity of Horse Creek in T. 34 N., Rs. 114 and 115 W., where numerous claims have been staked, but no development work except a few shallow pits opened on both sides of the creek has been done. Some of these pits were visited but showed no indications of gold. It is reported locally by persons interested in the claims that several assays of the rock are high in gold and silver.

[1] Schultz, A. R., Gold development in central Uinta County, Wyo., and at other points on Snake River: Bull. U. S. Geol. Survey No. 315, 1906, pp. 71–88.

Among the best claims reported is that of Wesley Vickrey, on which the rock was said to assay as high as $66 a ton in gold and $18 a ton in silver. This claim was not visited, nor were any samples seen by members of the party while on Horse Creek. Two samples, however, sent by Mr. Vickrey from his 40-foot tunnel show no traces of gold and only a trace of silver, though both show considerable iron sulphide or pyrite in streaks and as small vein fillings.

The samples were assayed through the kindness of Prof. R. J. Holden by W. B. Martin, of the Virginia Polytechnic Institute, Blacksburg, Va., under the direction of Dr. Barlow. Mr. Martin reports as follows:

Sample No. 1: Gold, none; silver, trace (0.07 ounces per ton)=4 cents a ton.
Sample No. 2: Gold, none; silver, trace.

The Jurassic rocks of the field consist of bluish-gray shale and limestone and some gray and yellow sandstone interbedded with dark-gray shale. They lie on the west side of the anticline fold, and dip 30–45° W. (See Pl. I.) On the north side of Horse Creek the strike turns abruptly and continues approximately N. 40° W. along the trend of the stream, which here follows the outcrop of the Aspen formation. The Jurassic beds are slightly brecciated and contain numerous small seams of calcite. Some of the rock shows considerable pyrite, and in many places iron stains are associated with calcite cavities. The claims are by no means restricted to the Jurassic outcrop but cover the Bear River and Aspen outcrops as well. In neither of these sedimentary beds was there any evidence of gold. In several localities, however, fine gold particles or flakes have been reported as disseminated through the Aspen shale in very small quantities. It is said that two assays of this shale showed traces of gold.

PLACER DEPOSITS.

OCCURRENCE AND CHARACTER.

Gold was observed at various points on Snake River and its tributaries. It occurs either in the gravels forming the terraces along the streams or in the deposits of bowlders, gravel, and sand filling the channels or forming the beds of the streams.

Interesting examples of terrace formation are seen on both sides of Snake and Fall rivers at points where valley expansion permits their preservation. At several places along Snake River above the canyon terraces carrying 10 to 15 feet of horizontally stratified pebbles and bowlders occur 50 to 100 feet and even 200 feet above the river. The terraces slope gently toward the center of the valley and their slopes are strewn with water-worn rock fragments similar to the material found in the river bed. The material consists chiefly of quartz, with some granite, schist, shale, slate, and sandstone, and here and there some volcanic material, which no doubt is derived from the upper Snake in the vicinity of the Yellowstone National Park. Snake River, between the canyon and the mouth of Fall River, occupies in many places a wide shoal bed and in autumn exposes extensive bars of shingle and cobblestone, among which the river winds in several channels. Many of the terraces along Fall River, below the canyon, extend back one-quarter to one-half mile from the present channel, whose bed is paved with water-worn pebbles similar to those in the Snake River channel, the granites and schists coming from the Gros Ventre Mountains several miles to the northeast. Near the lower end of Fall River, where the stream cuts across two anticlines of low dip and the eroded sandstone and shale produce riffles in the stream, several flakes or scales of gold were found in the sands accumulated near the water's edge. Whether these gold flakes occur in the gravel farther up Fall River above the canyon and along its tributaries heading in the Gros Ventre Mountains was not determined. Numerous small streams that emerge from the mountains can be utilized in sluicing operations or for generating power to run a concentrating plant.

As early as 1862 prospectors were trying to extract gold from the gravels of upper Snake River. Some of the first workings on the Snake above the grand canyon, in Jackson Hole north of Gros Ventre River, are described as follows by Frank H. Bradley,[1] in his report on the Snake River expedition in 1872:

> A considerable excitement was stirred up a few years since by reported discoveries of placer gold in large quantities on the upper Snake, and many prospectors visited this region. A small hydraulic operation was undertaken near this point; but the gold was too fine and in too small quantities to pay, and the whole region was entirely abandoned after a few months. The coarse gold found on the lower part of the Snake appears to have entered the river below the canyon, which is still to the southward of us.

In 1878 Orestes St. John [2] found on the terraces along Snake River in the vicinity of Bailey Creek indications of old placer workings that had been opened in 1870 by a party of miners associated with Jeff Stantiford. The enterprise was, however, discontinued on account of trouble with the Indians. In recent years considerable prospecting, but very little development work, has been done along Snake and Fall rivers. Claims have been staked on the gravel terraces along the greater portion of Snake River and along Fall River below its canyon, but only assessment work has been done.

The placer-gold deposits along Snake River may be classed as stream placers and bench placers. The stream placers consist of deposits of bowlders, gravel, and sand that form bars, banks, fills, and shoals in or adjacent to the streams, filling the channels and forming the stream beds. Many of the bars, banks, and fills are only tem-

[1] Sixth Ann. Rept. U. S. Geol. and Geog. Survey Terr., 1873, p. 266.
[2] Twelfth Ann. Rept. U. S. Geol. and Geog. Survey Terr., pt. 1, 1883, p. 196.

porary and change more or less during every heavy storm. The bench placers are in the old stream deposits, at present represented by the terrace remnants that mark the former much higher level of the stream. None of the stream-placer deposits are at present worked, and the only bench placers mined systematically are those of A. J. Davis, on the east bank of the river north of the mouth of Bailey Creek, and of Hoffer & Rosencrans at Pine Bar, on the south side of Snake River at the mouth of Pine Creek, 1½ miles below the mouth of Bailey Creek.

BAILEY CREEK MINING CAMP.

The placer workings on the Davis claim are on a low terrace along the east side of Snake River, extending half a mile north from the mouth of Bailey Creek. They are in the vicinity of those opened by Stantiford in 1870. There are two distinct terraces here, and Mr. Davis is at present working parts of both. The very fine flour or flake gold occurs all through the gravel but is much more abundant in some streaks than in others. Mr. Davis, who has been mining in Idaho for 40 years and has been working this bar for several years, makes the following statement concerning the gold placers:

I always found, in working the high bars of the river, that they contain from one to two and sometimes three pay streaks, with fine gold scattered throughout the gravel both above and below the pay streaks. Most all of these high bars have streaks of pay. Sometimes in old eddies or whirlpools the deposits do not seem to have any regular pay streaks. The gold in these places seems to be deposited uniformly and the entire deposit pays well.

The gold-bearing sand and gravel in my richest pay streak at the Davis diggings or Bailey Creek mining camp average from 3 to 7 feet in thickness and lie on a bed of white cement rock or clay. The gold in this pay streak runs from 9 cents to $3 per cubic yard. The average height of the bar or bank that is here worked is 20 feet. From the top of the lower pay streak to the top of this bank is a 13-foot sand and gravel bed which averages 3 cents to 25 cents in gold per cubic yard. The width of the pay streak is about 500 feet and extends beyond the limits of my workings, which are about 900 feet at this place. South of the "machine" near the central ditch the pay streak is considerably wider. Six hundred feet north of the central ditch the gravel bank is 30 feet high, the pay streak wider, and the entire bank runs higher in gold values. The gold is saved in undercurrent boxes, whose bottoms are covered with burlap held in place by two board strips nailed to each side of the box. A perforated screen is placed on top of the board strips and burlap and extends over the whole length of the box. The gold and iron bearing sand and gravel are run over this screen. The gold and magnetic sand fall through on the burlap, where they are held and finally delivered to the receiving box, while the light sand and gravel pass on out of the box. These boxes are set at half-inch grade to the foot. The first box delivers its sand and iron to the receiving box for the burlap tables. The receiving box is placed on a level under the screen box and across the mouth of the sluice, so that the sluice can deliver its sand into the receiving or head box for the table. The burlap tables are 16 feet in length, 36 inches in width, with a burlap covering, the same as in the sluice box, with a board strip on each side of the table to hold the burlap firmly against the bottom. These tables are set snug up against the receiving box and 1 foot apart, so as to leave walking space between the tables and permit working about them. From 4 to 8 tables are run on each side of the screen box that carries the bowlders, coarse sand, and gravel through to the tailing pile. These burlap tables are set on half-inch grade to the running foot the same as the sluice box and deliver their sand and water into the tailing box at the lower extremity. The sluice box delivers the undercurrent sand into the receiving or head box at the head of the tables. The sand and water is here divided according to the number and size of tables used. The average amount of water used is from 700 to 900 inches and is divided in the receiving box so that it runs 1 inch in depth over the 16 tables. The balance escapes through the sluice box and carries the bowlders and gravel into the tailing pile.

The concentrates on the tables are swept off twice a day for six days. The burlap is then taken up and washed in the concentrate box and replaced by fresh burlap. The concentrates thus accumulated from the tables are worked in a churn which holds 200 pounds of concentrate and run by water power generated in the sluice box. The concentrates are put in the churn and 1 ounce of quicksilver, 1 quart of concentrated lye, and enough water to make a good pulp are added. This pulp is then churned for an hour or more until the gold is thoroughly amalgamated. The sand is then taken out and run over a small table with riffles to hold the quicksilver. The sand and iron pass over the riffles to a strip of burlap below and are very easily saved. The riffles on the tables are produced by tacking strips of board one-half inch thick, 4 inches apart, across the top of the table. The trick in saving this gold is to separate the sand from the gravel and then divide this sand and water into small sheets—say 1 inch deep—over the table so as to give the gold a show to lie on the "twills" of the cloth, and the cloth is swept off once or twice a day to keep the small fibers or little grass roots from rotting the burlap. In running gravels to the machine I find it a great help to turn a small head of clear water away from the groundsluice water and bring it into the head of the first undercurrent box so as to thin the muddy water and let the gold and sand settle more readily on the screen.

Water for hydraulicking is brought in a ditch from a point some distance up Bailey Creek and is used to break down the gravel, wash out the gold and fine particles, and sluice through the flume. Sometimes the gravel is shoveled into sluice boxes. Large bowlders are piled up in rows between the boxes so as to retain as much grade as possible and still work the lower pay streaks.

The gravel on these terraces, as shown by the workings for the last few years, runs from 3 cents to $3 a cubic yard. Pay streaks that run $2 to $3 a cubic yard are very thin and rare. The average aggregate run of the pay streaks and the comparatively barren gravel is 7 to 10 cents a cubic yard. Only one piece of coarse gold, said to be about half the size of a tenpenny nail, has thus far been found.

During 1905 several hundred dollars' worth of gold was taken from this area. In 1905 a little placer gold was reported[1] from Jackson Hole, near the western boundary of the State.

Four samples of black-sand concentrates collected by the writer from the Davis diggings were examined by David T. Day, who says:[2]

These samples consist largely of magnetite—No. 1, apparently not much concentrated, containing 1 ounce of magnetite to 4½ ounces of the original material. They are all rich in gold but contain no platinum. The percentage of gold was not determined, but they will all range from $30 to $100 a ton and probably more. This gold could easily be extracted by means of shaking tables of the Pinder, Wilfley, Woodbury, or Deister type, but it is doubtful whether very much can be taken out by other means, certainly not by sluice boxes, as you have probably already found.

[1] Mineral Resources for 1905, U. S. Geol. Survey, 1906, p. 341.

[2] Personal communication.

Mr. Day found the effective operation of the concentrate tables named to be comparatively independent of the fineness of the gold. In many sands they saved 95 to 98 per cent of the total assayed value of gold as fine as 200 mesh. A brief description of these tables and additional data on the black sands of the Pacific slope has been given by Day and Richards.[1]

Four additional samples of gold-bearing gravel at the Bailey Creek mining camp were furnished through the kindness of Mr. Davis. Concerning these samples Mr. Day reports:

The samples of black sand collected from the Snake River gravel at Bailey Creek mining camp, Davis diggings, Lincoln County, Wyo., have been carefully tested and examined.

Sample No. 5 (our No. 1133), reported "to be an average sample of the pay streak from the bottom to the top, 20 feet in depth," gave on assaying:

	Ounces per ton.
Gold	35.64
Silver	4.25
Platinum	None.

Sample No. 6 (our No. 1134), reported to be "concentrates of sample 5, from which all gold has been extracted by the churn process," weighed 137 grams and was run over the Wetherill magnetic separator, giving the following results:

	Grams.
Magnetite	57
Ilmenite	48½
Garnet	12½
Garnet and olivine	5
Tailings (consisting of three-fourths zircon and one-fourth quartz)	19

An assay gave the following results:

	Ounces per ton.
Gold	8.75
Silver	1.14

Sample No. 7 (our No. 1135), "concentrates from which gold has been taken out and concentrates buried for five years," weighed 101 grams and was run over the Wetherill with the following results:

	Grams.
Magnetite	62
Ilmenite	28
Garnet	9
Olivine	5
Tailings (consisting principally of zircon with some garnet)	14

An assay gave the following results:

	Ounces per ton.
Gold	29.98
Silver	1.15

Sample No. 8 (our No. 1136), "is a sample of pay streak showing gold content." This gave on assaying:

	Ounces per ton.
Gold	107.41
Silver	10.56
Platinum	4.54

[1] Useful minerals in the black sands of the Pacific slope: Mineral Resources U. S. for 1905, U. S. Geol. Survey, 1906, pp. 1175–1246.

From the above assays it will be seen that much of the gold is not saved by the churn process. Often from one-fourth to one-half, or even more, of the gold in the gravel escapes. No platinum has thus far been detected at the Davis diggings by the churn process, yet, as will be seen from sample No. 8, the gravel contains 4.54 ounces to the ton and will yield good returns in addition to the gold.

PINE BAR MINING CAMP.

The terrace at the mouth of Pine Creek, on the south fork of Snake River, has been worked during the last two years by Ivan L. Hoffer and L. M. Rosencrans. The terrace or old bar at this point is 1 mile long, one-twelfth to one-eighth mile wide, and from 40 to 50 feet above the water level of Snake River. The methods employed are much the same as those at the Davis diggings. The water for hydraulicking is brought from a point some distance up Pine Creek in a ditch across the bench. The water is used to break down the gravel, wash out the gold, and sluice through the flume. Sometimes the gravel is shoveled into the sluice boxes. Large bowlders are piled up in rows between the boxes so as to retain as much of the grade as possible and still work the lower pay streaks. The fine material drops through a series of steel-punched screens near the lower end of the sluice and is diverted at right angles through a distributing box to a series of inclined tables about 4 feet wide and several feet long, covered with canvas or burlap, on which the gold and concentrates readily settle. About four-fifths of the gold and heavy concentrates are caught on the first few feet of the tables and are swept into a tray every few hours by diverting the pulp and turning on clear water. In order to catch the gold that may have escaped from the tables several boxes are placed in the path of the water between the tables and the river and the material collected in these boxes is run over the tables a second time. The concentrates and gold are stored until a sufficient amount is accumulated and are then placed, with quicksilver, lye, and warm water, in a small churn, or grinding pan, which is run by water power from the sluice box. The gold amalgamates readily after a few hours of grinding and is then run into bars or sheets ready for the market.

Mr. Hoffer informed the writer that on this bar there is about 8 feet of overlying gravel that contains about 15 very fine colors to the cubic foot, followed by 32 feet of gold-bearing gravel to water level, without striking bedrock. So far only the upper 12 feet of this gold-bearing gravel, which is supposed to be better than that lower down, has been worked.

The following figures, furnished by Mr. Hoffer, give the run of gold in colors for the first 12 feet of gravel in two different places.

Colors of gold in upper gravel at Pine Bar diggings.

Depth in feet.	Colors per cubic foot.	
	A.	B.
1	7,200	6,300
2	23,400	3,600
3	8,100	16,200
4	106,200	11,700
5	8,100	11,700
6	22,500	4,500
7	3,600	5,400
8	17,100	900
	196,200	60,300

The tests were made on one-thirtieth cubic foot of gravel carefully measured and the results per cubic foot were obtained by multiplying these values by 30. About 1,000 to 1,200 colors make 1 cent value. Thus it will be observed that this 8 feet of gravel, both tests being averaged, yields from 12 to 14 cents a cubic yard. Including the upper 8 feet, the value for 16-foot depth averages about 7 cents a cubic yard. Working to a depth of 20 feet or more should slightly raise this value. In a few places small streaks running up to $2 a cubic yard have been cut. Most of these streaks occur on top of the gold gravel immediately below the overlying 8 feet of comparatively barren material.

PLATINUM IN AURIFEROUS GRAVELS OF SNAKE RIVER.

The experiments of David T. Day, of the United States Geological Survey, at Portland, Oreg., on the heavy placer concentrates of the Pacific slope, to determine their value in other metals and minerals besides gold, included a number of samples of Snake River concentrates, nearly all of which yielded from a trace to an appreciable amount of platinum, but Day doubts whether many of the results were obtained from representative samples. The subject is interesting and well worthy of close and intelligent investigation. It may prove, however, that in the present state of the platinum market the platinum along Snake River is too thinly scattered to be of much value, unless much of it is combined with the concentrates and has passed unnoticed. The actual content of magnetite and similar heavy residues in these gravel beds, as nearly as has been determined, is from 0.25 to 0.33 per cent of the gravel, and when the visible free gold is properly amalgamated out the residue will not assay more than $5 in gold to the ton.

The gravel containing the gold and platinum is generally well worn and small, affording ideal conditions for dredging, and with a large enough plant and intelligent handling may be made to pay. The possible margin of profit, however, working for the gold content alone, would be small and unattractive, unless associated gold or platinum not saved by ordinary methods can be recovered. That platinum in metallic form is associated with the gold in these gravel beds can not be questioned, for although it can rarely be seen in panning it invariably shows in cleaning amalgam.

SOURCE OF GOLD.

The source of the Snake River fine flour or flake gold is unknown. Its fineness and the abrasion marks on some of the pieces suggest that the particles have been carried some distance. From the evidence gathered it seems likely that the gold was derived from the older rocks of the Teton and Gros Ventre ranges or from the region of the later intrusives of the upper Snake Valley. Some of the gold farther down on Snake River[1] below the canyon was undoubtedly derived from the Caribou Range south of Snake River, where the older rocks are known to carry gold-bearing quartz veins and other ore bodies containing gold. The old bars and benches containing the gold were built in much the same manner as those now forming in the river, and some of the gold particles have been worked over and over again by the river.

The thickness and value of the pay streaks is no doubt dependent on the local conditions under which they were deposited. The gradient of the stream as well as the volume of the water, its turbidity, and the time during which it flowed in the same channel would affect the distribution, thickness, and richness of the pay streaks. Unlike other gold placers, those of Snake River do not increase in gold values as bedrock is approached, for the gold is generally more plentiful in the gravel banks between present and former high and low water marks than at the deeper horizons.

IRON.

Little prospecting for iron has been done and very little is known concerning it. Small specimens of good hematite ore were shown to the writer by several ranchers and range riders who claim to have picked it up from the surface along some of the valleys in Wyoming and Hoback ranges. According to reports, a miner some years ago opened a prospect pit in Hoback Range in the vicinity of upper Fall River canyon and struck a good bed of iron ore. The exact location of this pit is not known, and as the work has been abandoned for some time no information concerning it was obtainable. Samples reported to have come from this locality were determined by the writer to be good hematite ore. Several pebbles of hematite were also picked up from the valley fill at several points along Fall River.

[1] Schultz, A. R., Gold developments in central Uinta County, Wyo., and at other points on Snake River: Bull. U. S. Geol. Survey No. 315, 1906, pp. 71-88.

In the vicinity of Sheep Creek, a tributary of Greys River, on the north side of Sheep Creek canyon in the SW. ¼ sec. 11, T. 33 N., R. 116 W., a bed of iron-bearing rock, between beds of whitish sandstone, was observed in rock of Pennsylvanian age. The beds were seen only in the walls of the canyon, where they form part of the west anticline of the Wyoming Range. Farther north they are concealed by the overlying rock. No attempt was made to trace them, and it is not known whether they occur farther north, where rocks of this horizon again come to the surface.

On the north bank of Sheep Creek the following section was measured:

Section on north bank of Sheep Creek, Uinta County, Wyo.

	Feet.
Sandstone, bluish gray.	
Conglomerate, composed largely of pebbles of hematite	4
Shale, iron bearing	6
Sandstone, whitish.	

The conglomerate consists of large and small pebbles of hematite, some of which are 1½ to 2 inches long and others are as small as a grain of sand. Many of the smaller particles are coated with two or more layers that readily chip off in concentric shells and show them to be concretions with centers of hematite. The cementing material is largely iron oxide, and in places the cement and coating is grayish green in color. The general appearance of this conglomerate and the hematite pebbles is shown in Plate XI, and the iron content of the shale, conglomerate, and hematite pebbles is reported by W. T. Schaller as follows:

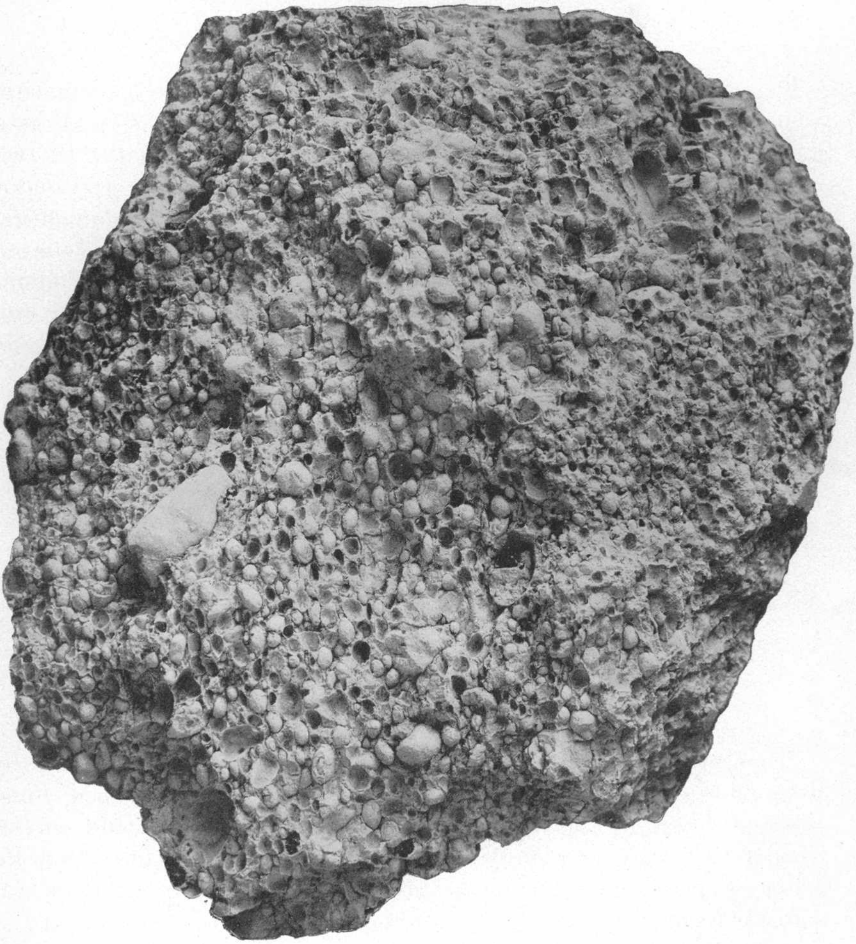
Analysis of iron ore from Sheep Creek canyon, Lincoln County, Wyo.

	Shale.	Conglomerate.	Hematite pebbles in conglomerate.
SiO_2	60.48	27.87	8.99
Fe_2O_3 (as total iron)	16.18	49.73	86.34
P_2O_5	.10	.06	.03
S	.04	.08	.04
Fe (as metal)	11.33	34.81	60.44

COPPER.

Prospecting for copper has been carried on over a large part of the area, but in no place has extensive or systematic work been done. Small surface pits have been dug, miners' cabins built, and entries opened for considerable distances at various places on Absaroka Ridge, Thompson Plateau, Meridian Ridge, Wyoming Range, and Hoback Range, but most of these have been abandoned and are of very little value. In many of the prospect pits copper and traces of gold are reported to have been found but not in sufficient quantities to make mining profitable.

A. PEBBLE OF HEMATITE. (NATURAL SIZE.)



B. IRON-BEARING CONGLOMERATE. (NATURAL SIZE.)

Many of the smaller pebbles are coated with concentric layers and resemble concretions.

Copper is more abundant in the Salt River Range, where most of the prospecting at the present time is carried on. Near the head of Salt River prospectors have opened a fair showing of copper and are making preparations for mining. As the region lies some distance west of the area mapped, the locality was not visited. The copper-bearing rock may be a northward continuation of the beds containing the copper deposits just east of Rock Creek, a few miles north of Nugget station, on the Oregon Short Line Railroad. These rocks were examined in 1905 by A. C. Veatch,[1] who says:

> The Beckwith red beds, wherever exposed along the Rock Creek-Needles anticlinal in the western part of this area, have been extensively prospected for copper, but at only one locality have copper-bearing minerals been found. This place, well named the Cockscomb, is about 25 miles north of Evanston and 5 miles from Bear River. The red beds are here involved in an overturned anticline, and at three places along the axis of this anticline copper carbonates have been found in a gray sandstone containing considerable vegetable matter. The prospects are all shallow surface pits, and there is no evidence that surface work will yield returns. Deep prospecting alone might yield values, but, notwithstanding the favorable structural conditions, only a very sanguine operator would attempt to develop this locality.
>
> About 25 miles north of this locality, in the valley of Rock Creek, tributary of Bear River, and 6 miles north of Nugget station on the Oregon Short Line Railroad, copper carbonates have been found in a brecciated sandstone which occurs just below the "Permo-Carboniferous" red beds. These beds here form a rather flat-topped anticline with very steeply dipping flanks. The western flank appears to be somewhat faulted at the point of the change in dip from the slightly inclined beds of the crest of the anticline to the highly dipping beds of the flank. The copper carbonates have been found along and just east of this structural break. The main group of openings here are horizontal tunnels in the slightly dipping beds. The same amount of labor in shafts along the probable fault line would be more likely to yield results.

Gale has also examined similar copper deposits in this general region.[2]

PHOSPHATE.

GEOLOGIC POSITION OF THE PHOSPHATE ROCK.

During the last few years it has been found that the upper Carboniferous (Permian?) rocks of this general region contain a variable percentage of phosphoric acid. A description of the phosphate-bearing rocks and what was known regarding their distribution in 1907 was given by F. B. Weeks and W. F. Ferrier.[3] Later and more detailed information regarding their occurrence and distribution was set forth in the reports of Hoyt S. Gale and R. W. Richards [4] and of Eliot Blackwelder.[5] No prospecting has been done directly for phosphate in this field, but the rocks in which the phosphate occurs in Bear River valley were observed at places throughout the area.

---

1 Prof. Paper U. S. Geol. Survey No. 56, 1907, p. 163.

2 Gale, H. S., Geology of the copper deposits near Montpelier, Bear Lake County, Idaho: Bull. U. S. Geol. Survey No. 430, 1910, pp. 112-121.

3 Bull. U. S. Geol. Survey No. 315, 1907, pp. 449-473.

4 Bull. U. S. Geol. Survey No. 430, 1910, pp. 457-535.

5 Bull. U. S. Geol. Survey No. 470, 1911, pp. 452-481.

Some prospecting for coal and graphite has been carried on along the outcrop of the phosphate beds, but thus far their importance as a phosphate-bearing formation has not been known.

In this report the phosphate beds are not mapped separately, but their approximate location may be inferred, as they occur in the middle part of the Park City formation, approximately 300 feet stratigraphically above the contact of the Weber quartzite and the Park City formation. (See p. 44.)

Prospecting for phosphate should be made along the horizon indicated.

PROSPECTING.

For the benefit of the prospector the following general description of the phosphate-bearing formation is given:[1]

The phosphate series consists of alternating layers of black or brown phosphatic material, shale, and hard blue or gray compact limestones. The limestones are in the main very fossiliferous, containing well-preserved forms of Rhynchonella, Chonetes, Omphalotrochus, and Productus, which are apparently the characteristic fossils of this horizon. The shales contain Lingula and lamellibranchs.

The phosphate series is in places about 90 feet thick. The beds vary in thickness from a few inches to about 10 feet, but where of this extreme width are in general broken by thin layers of shaly material poorer in P_2O_5. At the base the series begins with limestone, and as a rule 6 to 8 inches of soft brown shale overlies this basal limestone. Above is the main phosphate bed, 5 to 6 feet thick. This is almost entirely oolitic in structure and high in P_2O_5. Several other beds, varying in thickness from a few inches to about 10 feet, separated by 6 inches to 2 feet of limestone or shale, occur in the series. The beds of extreme thickness, as already mentioned, contain seams of shaly material, itself phosphatic, too thin to be separated from the pure oolitic material in mining. All the sections that have been examined show one and some of them two beds which are of commercial value. The other beds are not of sufficient thickness nor of a grade which will pay to mine at present.

The phosphate series is overlain by a coarse-grained, locally brecciated limestone, for the most part in massive outcrops. Above this limestone is sometimes found 100 feet or more of nearly white limestone, but as a rule it is succeeded by a series of blue and gray limestones containing large spirifers and Productus. Next above is a series of red sandstones and shales containing brachiopods and lamellibranchs. Still higher in the section is a considerable thickness of blue, gray, and greenish limestones, which form the upper part of the upper Carboniferous series, and in the Montpelier region there are siliceous limestones and red sandstones containing ammonites and other fossils of Lower Triassic age.

The Park City formation in many localities in this field where examined is divisible into three members. The upper member consists of a massive bed of chert and cherty limestone, the lower member of gray limestone and cherty limestone, and the middle member of phosphate rock, shale, and limestone bands, the thickness of the three members aggregating 300 to 500 feet. The rock phosphate varies in color from coal black to dull gray.

[1] Weeks, F. B., and Ferrier, W. F., Bull. U. S. Geol. Survey No. 315, 1907, pp. 452–453.

LOCAL OCCURRENCES.

The brown and black phosphate beds on Fontenelle Creek are approximately 50 feet thick and have been mistaken for coal at many places along the outcrop. All the early prospecting along the phosphate bed was done in the hope of locating important coal beds of Carboniferous age. Even now it is not generally known that this bed is economically important, not for its coal possibilities but for its phosphate content. The only prospects that were open when the survey was made are those along Absaroka Ridge, those on the southeast flank of Thompson Plateau north of Labarge Creek, and those on the north bank of Snake River in the NE. ¼ sec. 32, T. 39 N., R. 116 W.

Black material in the north bank of Snake River above the Snake River Canyon in the NE. ¼ sec. 32, T. 39 N., R. 116 W., has long been reported as a coal exposure and has been considered by the inhabitants as a possible source of coal for local use. Here, however, as at other places farther south, the deposit consists of approximately 60 feet of shale, representing the phosphate rock. Regarding these deposits F. H. Bradley,[1] who visited the locality in 1872, says:

> Just opposite these springs in the lower part of the sandstones as they reappear on the west side of the anticlinal there are exposures of two or three heavy beds of black calcareous shale and friable clay with some harder bituminous sandstones, which appear from short distances precisely like coal outcrops. Fragments of teeth and bones, probably belonging to amphibians, occur at these layers. Above them are some thick beds of chert.

The phosphate bed here as elsewhere in this region occurs near the base of the Park City formation and overlies the Weber quartzite, as in Absaroka Ridge in T. 23 N., R. 116 W. As the reconnaissance mapping was not carried north of the grand canyon of Snake River and as no examinations were made of the north end of the Wyoming Range in the vicinity of Snake River, the distribution of the phosphate beds is not known. The structure of the range in this locality becomes much more complicated, and considerable time would be required to work out the details. However, the phosphate beds probably cross to the south side of Snake River on both the east and the west sides of the sharp fold forming the north crest of the Wyoming Range in the vicinity of Snake River. The west exposure extends along the east side of Snake River and Bailey Creek, but the east limb is cut out within a short distance to the south by the overthrust fault along the east face of the Wyoming Range.

Farther east, in T. 38 N., R. 115 W., on the south side of Fall River the phosphate series comes in again on both the east and the west flank of the anticlinal fold which forms the west part of the Hoback

---

[1] Hayden, F. V., Sixth Ann. Rept. U. S. Geol. and Geog. Survey Terr., 1872, p. 268.

Range and which crosses Fall River near the mouth of Hoback Canyon. North of Fall River the phosphate beds outcrop in the summit of Astoria Mountain and lie in a synclinal basin high above the level of Fall River. The distribution of the phosphate beds in the Hoback Range is very irregular, owing to the numerous folds and complex structure, necessitating much more detailed examination than could be given.

One of the supposed coal prospects on the phosphate beds was opened in sec. 27, T. 24 N., R. 116 W., on a little creek northwest of Walter Wright's ranch near the east base of Absaroka Ridge. This prospect consists of a series of shallow openings or surface diggings showing good indications of phosphate. The bed was not fully prospected and very little is known regarding the thickness, quality, or quantity of the phosphate at this locality. A short distance farther south, on the crest of Absaroka Ridge, in the SE. ¼ sec. 9, T. 23 N., R. 116 W., several shallow openings were made in these same beds by sheep herders who were apparently looking for coal, but no bed of coal seems to have been encountered in any of the diggings, although all of them showed the black phosphate rock which was considered by the prospectors to be coal.

A sample of rock taken by the writer from one of the prospects in sec. 9, and analyzed for phosphate by W. H. Waggaman, of the Bureau of Soils, Washington, D. C., yielded P_2O_5 15.5 per cent and $Ca_3(PO_4)_2$ 33.9 per cent. Another sample collected from a ledge of phosphate in sec. 7, T. 24 N., R. 116 W., Wyoming, by Forest Ranger Wright and analyzed by J. G. Fairchild in the laboratory of the Geological Survey gave P_2O_5 11.5 per cent and $Ca_3(PO_2)_2$ 25.2 per cent.

Southeast of Thompson Plateau, in the SE. ¼ sec. 22, T. 27 N., R. 114 W., where some prospecting for graphite has been carried on, a drift 87 feet long has exposed 10 feet of carbonaceous phosphatic shale. Examination proved that there is no graphite present in this rock, although the place is known locally as the "graphite pits."

A sample of this dark carbonaceous shale was collected at random by the writer and examined by E. C. Sullivan, of the United States Geological Survey, who found that the loss of moisture at 120° C. was 5 per cent, the loss on ignition 31 per cent, and the carbonaceous matter 26 per cent. An analysis for the phosphate content made by W. H. Waggaman, of the Bureau of Soils, gave P_2O_5 14.1 per cent and $Ca_3(PO_4)_2$ 30.9 per cent. This same phosphate bed occurs throughout the area here mapped, but no additional samples were collected.

UNDERGROUND WATER.

Throughout most of the area an abundance of surface water may be obtained from the mountain streams, which thus far have furnished the main domestic supply. However, several strata are of probable importance as sources of underground water. The sandstones and conglomerates of the Wasatch group (Almy and Knight formations) are sufficiently porous to make them readily absorb and transmit water, and they have yielded flowing wells in Uinta County. The sandstones of the Adaville, Frontier, Beckwith, and older formations may be important water bearers, but thus far no wells have been sunk to show whether they are water bearing or not. The suggestion that they may possibly contain water is based on their physical character and the fact that they have yielded water in Uinta County, where the supply is much more meager than it is farther north.

Throughout the area the underground water is derived from the rain and snow that falls on the local surface, the source of supply for the various water-bearing beds being in the Salt River, Wyoming, Hoback, and Gros Ventre mountains. The heavy conglomerate beds along the east flank of the Wyoming and Hoback ranges, as well as on the south flank of the Gros Ventre Mountains, are favorably located to absorb and transmit water to distant points in the Green River basin. In the area east of Meridian Ridge and of the Wyoming and Hoback ranges these beds dip for the most part gently eastward and may therefore give rise to artesian conditions over parts of the Green River basin. The most favorable artesian conditions are found in the Fossil syncline and in the area east of the mountains in the great Green River syncline. Good water may also be obtained from the various water-bearing beds along the synclinal folds in the older rocks. In some places along the low depression in these folds flowing water may be obtained in considerable quantities.

BUILDING STONE.

None of the rocks in this area have been quarried for building, although they are present in abundance. Sandstone of considerable value for building occurs in the Frontier formation, and some of it has been shipped from the area south of this field. Many of the sandstones and limestones in the older formations would make excellent building material.

CLAY.

At present none of the clays in this region are utilized industrially. In Mammoth Hollow there is an abundance of residual clay, which has been used for making brick at places south of this field. Kilns were built at Glencoe but have been abandoned for several years. It is reported that certain beds of clay associated with some of the coal beds have been tested and found to make good fire brick; thus far, however, very little is known regarding their value.

SALT.

Salt springs occur at several places in the Salt River Range. Salt springs and salt deposits, as well as beds of rock salt, have been found in Bannock County, Idaho, and in Lincoln County, Wyo., along the State line. In both of these localities salt has been produced for many years. The salt-producing area in Wyoming lies south of Star Valley on the route from Smoot, in upper Star Valley, to Thomas Fork. The salt developments are located on Salt Creek in the SW. ¼ sec. 26, T. 29 N., R. 119 W., about 8 miles northeast of Green's ranch or the head of Thomas Fork. The brine springs in this part of Wyoming are similar to those along the Idaho-Wyoming border described by C. L. Breger.[1] It is highly probable that in various parts of the Salt River and Wyoming ranges rock salt similar to that discovered in 1902 on lower Crow Creek, a tributary to Salt River in eastern Idaho, will be found. A brief description of the sodium salts of Wyoming has been published.[2]

[1] Breger, C. L., The salt resources of the Idaho-Wyoming border, with notes on the geology: Bull. U. S. Geol. Survey No. 430, 1910, pp. 555–569.

[2] Schultz, A. R., Deposits of sodium salts in Wyoming: Bull. U. S. Geol. Survey No. 430, 1910, pp. 570–589.

INDEX.