Professional Paper No. 56

Series { A, Economic Geology, 89
B, Descriptive Geology, 110
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F, Geography, 55 }

DEPARTMENT OF THE INTERIOR

UNITED STATES GEOLOGICAL SURVEY

CHARLES D. WALCOTT, DIRECTOR

GEOGRAPHY AND GEOLOGY OF A PORTION OF SOUTHWESTERN WYOMING

WITH SPECIAL REFERENCE TO

COAL AND OIL

BY

A. C. VEATCH

WASHINGTON
GOVERNMENT PRINTING OFFICE
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By A. C. Veatch.

INTRODUCTION.

The area discussed in this report comprises the extreme southwest corner of Wyoming and a small portion of Utah. Its northern and eastern boundaries lie, respectively, about 70 miles north of the southern boundary and about 35 miles east of the western boundary of Wyoming. The immediate incentive to this work was the decided economic need of more extended and accurate information regarding the coal fields of the western United States.

Field work was commenced on June 30, 1905, near Evanston, Wyo., with Alfred R. Schultz as chief assistant, Max A. Pishel as geologic aid and helper, and William Longhurst as cook and teamster. Mr. Pishel was appointed in place of a regular camp hand, and rendered considerable scientific assistance. In general, the policy of employing student help in place of regular camp hands is believed to be best for all parties concerned. During the illness of the writer, August 3 to September 3, Carl D. Smith, geologic aid, was added to the party. Field work was closed at Evanston on October 10. Doctor Schultz's efficient aid, both in the field and in the office, has contributed greatly to the results here presented.

METHODS OF FIELD WORK.

As this investigation was primarily economic, concerned principally with coal and oil deposits, it was carried on with special reference to the lines established by United States land surveys rather than as an abstract piece of geologic and geographic mapping. In regions which have been covered by the surveys of the General Land Office the section and its subdivisions are the units of economic interest for everything except lode or vein deposits. All ordinary agricultural entries must conform to these legal subdivisions. Coal lands can be entered only by legal subdivisions, and even placer locations, which in substance include all mineral locations except coal and lode or vein deposits, must in general conform to those subdivisions. Landowners and investors, except those concerned only with lode deposits, are thus primarily interested in the relation of economic deposits and geologic structure to the land lines. Therefore, to be of the greatest economic value and to be immediately available, surveys must be conducted primarily from the standpoint of the lines established by the surveys of the General Land Office.

Geologic mapping of this character, which is concerned principally with the location of deposits with reference to the land lines, does not involve ideally exact surveying. It is merely a matter of finding land corners and of locating the geologic details with reference to them. Were the land surveys ideally exact any method of survey would be applicable. It would be possible to locate corners from known land corners by ordinary road traverse or plane-table work, but, in general, the land surveys are not exact. From a geodetic standpoint the allowable error is large, and the actual error is much larger.

In the search for land corners in any thinly settled region the most satisfactory field method is to pace the section lines and search for corners every half mile. This involves pacing north and south and east and west lines, which is simpler and requires less skill than ordinary meanders. Since the principal lines require no plotting of angles and involve fewer sights, there is consequently less chance of error from these sources. Further, this method permits the work to be constantly checked and corrected with reference to the land corners. In actual field work a man "on line" will often fairly stumble over an obscure corner which he could never discover in any other way, and in fact many corners not known to the local people have thus been found. Meander lines may often be used to supplement this method, but they must in all cases be tied to the land corners, which in general must be located by the rectangular work. Rough triangulation can also be carried on to advantage in connection with the section-line traverses as in ordinary meander or traverse plane-table work. This method, supplemented as the needs of the case may demand, by rough meander and triangulation work, will yield all the economic results possible and a vast amount of purely scientific detail. The maps produced will lack the geographic exactness of those made of areas carefully controlled by triangulation and primary traverses, but the geographic inaccuracies will not seriously affect the geologic conclusions, and the maps will be of greater economic value than maps that have been carefully controlled but not properly tied to the land lines. Work of this character may be conducted to yield geologic results only, or geologic results with enough topographic data to illustrate the geology. When the geologist has any topographic skill the latter is preferable, and all degrees of work are naturally possible between these two extremes.

In preparing for this work copies of all the plats of the Land Office surveys covering this region were obtained, as were profiles and alignment maps of the railroads traversing the area and descriptions of the bench marks established by the Coast and Geodetic Survey and the Geological Survey along and south of the Union Pacific Railroad.

In the field such section lines were paced as were necessary to give the detail and the locations desired, and the geologic and topographic data obtained were plotted on regular blank township plats on the scale of 2 inches to the mile. Lines were not carried as continuous surveys, but only from corner to corner. Having paced a half mile, the geologist hunted for the corner, and when he found it considered it a new zero point. Contours were drawn from aneroid barometer readings based on railroad profiles and on the bench marks of the United States Coast and Geodetic Survey and the United States Geological Survey. Work was carried into the edge of the region buried by the Eocene deposits only so far as was necessary to clearly define the outline of the outcrops of the older deposits. Following the outcrop of these older beds, the party moved almost due north from Evanston to Sage, thence up the valley of Twin Creek and over the Eocene beds between Nugget and Hodges Pass tunnel, here of interest because of the Fossil oil fields, into the Cretaceous exposures in the region of Oyster Ridge. These were followed southward to a point south of Hilliard, where they disappeared beneath the Tertiary. The party then completed the circle to Evanston, where the data collected were carefully considered and the weak and uncertain places in the geologic and topographic maps discovered. The party then went back over the same route and checked, corrected, and to a large degree augmented the results of the work of the first trip.

PREPARATION OF BASE MAP FROM FIELD SHEETS.

The combination of a number of separate plats of the Land Office surveys into a single map is generally attended with many difficulties, for even the best plats show many contradictory details of measurement, and besides there have been many more or less fraudulent surveys. The maps will not check, and the larger the area the greater the difficulty of satisfactory adjustment. It is always necessary to make certain fundamental assumptions in order to get the separate parts of the map together unless the region has been very accurately controlled by primary triangulation and traverse, and this region had not been so controlled. The difficulty of combining and adjusting large-scale maps of this character to a refined polyconic projection is evident. In this case it was felt that with the facts at hand there was no justification for the expenditure of money in endeavoring to plot these data on a polyconic projection. The map is therefore prepared on a square projection, and is presented without claim that it embodies exact geographic accuracy.

The compilation of the base map was effected on the following assumptions and in the manner indicated:

It was assumed that the western boundary of the State was a straight, north-south line and that the southern boundary of the State was a straight east-west line and that the two meet at a plane angle of 90°. No one of these assumptions is absolutely correct. Thus, it is known from the work of the United States Geological Survey that the southern boundary of the State, which is theoretically on parallel 41° north latitude, is, in this region, south of this parallel and is not a straight line.

The western boundary of the State was surveyed by A. V. Richards in 1874, who was supposed to have established marks every mile. It was assumed that these original posts were exactly 1 mile apart and the township boundaries were plotted accordingly. It was, however, found that in T. 21 N., R. 120 W., and T. 22 N., R. 120 W., the actual distance is between three-tenths and five-tenths of a mile greater than called for by the twelve mileposts, and this mismeasurement has resulted in a slight distortion of the sections in T. 20 N., Rs. 120 and 121 W., as explained below.

The fourth standard parallel north was assumed to be exactly parallel with the southern boundary line of the State. This assumption gives the exact irregularity of the townships exhibited by the Land Office plats of this region, and these, as shown by the work of this survey and by the more accurate alignment surveys of the Union Pacific Railroad, were very carefully made.

North of the fourth standard parallel north many difficulties in compilation were encountered because of the inaccurate and in many cases fraudulent character of the land surveys. The fraudulent returns are confined almost wholly to the work of James E. Woods and those associated with him, and affect T. 19 N., R. 120 W. (subdivisions and north and east boundaries), T. 20 N., Rs. 119 and 120 W. (except west boundary), and all the original surveys in the region shown on Pl. III north of the fifth standard parallel north. It appears that the immediate cause of the subdivision of these lands was the proposed building of the Oregon Short Line Railroad. The deputy surveyors followed the preliminary line of the Oregon Short Line survey and established corners within a mile or two of this survey in a very rough and inaccurate manner. Near the State line they appear to have placed three corners in a haphazard fashion in T. 20 N., R. 120 W. At any rate, the original corners discovered by William Newbrough, county surveyor, and marked for the corners on the east side of section 8, are not related to the fifth standard parallel north in the way called for by the original field plats. According to Mr. Newbrough, no original corners have ever been found on the west end of the fifth standard parallel north, although from R. 117 W. eastward there is conclusive evidence that the work of W. O. Downey, the surveyor of this line, was very accurate and reliable. From the data thus far obtained it is believed that the original survey of the fifth standard parallel will be found to be about one-fourth mile north of the corner established by Woods as the corner of secs. 4, 5, 8, and 9, T. 20 N., R. 120 W. In plotting this area the surveys of Rs. 115 and 116 W. between the fourth and fifth standard parallels—surveys which were found to have been very carefully made—were assumed to be correct as shown, and a line was drawn perpendicular to the fourth standard parallel at the point called for in the original plat and the distance to the fifth standard parallel indicated on the original plats measured off. This point on the fifth standard parallel was shown on the alignment maps of the Oregon Short Line Railroad. It was assumed that the north line of T. 21 N. had been correctly connected with the 58-mile post on the State line and that this post was exactly 58 miles[a] from the southwest corner of the State, and a line drawn perpendicular to the State line at this point prolonged 2 miles east. This gave a second point on the Oregon Short Line alignment. The railroad surveys were then plotted between these two known points, and the direction and bearing of all corners found by the railroad survey were copied as given on the alignment maps. From the points thus obtained the section and quarter lines were drawn according to the best data obtainable.

The plats of the resurveys of T. 21 N., R. 115 W.; T. 22 N., Rs. 115 and 116 W., and T. 23 N., Rs. 115 and 116 W., made by Stahle and Van Orsdel in 1903, were not in hand when the field work was being done, but all the work was tied to the new corners established in this resurvey, all of which were found to be correctly placed and well marked. Plats of these resurveys were obtained after return to the office and were carefully checked with the field sheets of this survey.

[a] As already stated, there is some evidence of error in the measurement of the State line.

The compilation in several townships needs special explanation, which is given below:

Adjustments in T. 20 N., Rs. 120 and 121 W.—No original corners were found in T. 20 N., R. 120 W. by this survey except the southwest corner of the township, which was located without difficulty on the line brought up the west side of T. 19 N., R. 120 W. Lines were paced east from this point and then north, and oil stakes were found in the following supposed positions, as shown on the base map: SE. corner, sec. 31; quarter corner, south line, sec. 32; SE. corner, sec. 32; quarter corner, north line, sec. 35; NE. corner, sec. 35; quarter corner, north line, sec. 36; center, sec. 25; quarter, west line, sec. 25; center, sec. 26; quarter, east line, sec. 32; center, sec. 28; quarter, east line, sec. 28; NE. corner, sec. 29; quarter, east line, sec. 20; NW. corner, sec. 20; quarter, north line, sec. 21; center, sec. 8; quarter, north line, sec. 8; center, sec. 5. The distances and directions between these oil-claim corners were found to be approximately correct, and no difficulty was experienced in locating them. The oil stake found by this survey to represent the north center of sec. 8 was connected with corner "A," established by William Newbrough. Corner "A" is a private corner placed on the west side of the Bridger road near the mouth of Spring Creek to assist in finding the three original corners discovered by Mr. Newbrough on the east line of sec. 8. Corner "A" is S. 64° 45′ E. 1,322 feet from the original quarter corner, on the east line of sec. 8. This connection showed that the oil stake supposed to represent the quarter corner on the north line of sec. 8 (which is approximately 1.5 miles east and 5 miles north of the known Government corner at the southwest corner of the township) is approximately 0.25 mile west and 0.05 mile north of the original quarter corner on the east line of sec. 8. With relation to the known corners on the south, the original southeast corner of sec. 8 is thus approximately 0.25 mile too far west and 0.45 mile too far north. In the compilation of the base map the south line of T. 20 N., R. 121 W. and the north line of T. 21 N., R. 120 W. were plotted according to their position with reference to the mileposts on the State line survey given in the original township plats. The three original corners on the west side of sec. 8 were then plotted from the position of the north line of T. 21 N. The space remaining between the north line of T. 19 N. and the southeast corner of sec. 8 was by this plotting 4.15 miles, while that required by pacing was 4.45. The difference is apparently due to errors in the State line measurement, but the method of correcting the discrepancy is not evident with the data at hand, and the map has been left as plotted. The topography has been drawn in this space in exact ratio to it and is therefore relatively correct, but the north-south scale is slightly smaller than that employed in the rest of the map. The section lines have been projected by connecting these original corners on the west line of sec. 8 with the real section corners on the west township line, and with assumed corners, correctly placed, on the east and south township lines, and the remaining positions inferred by the division of distances between known points. In T. 20 N., R. 120 W. there are, therefore, the following errors: The sections indicated are in all probability not those established by the original survey, if indeed, any were then established. The scale employed for the southern four tiers of sections is 0.93 of the scale employed in the remainder of the map.

As the west line of this township is a guide meridian, surveyed by Medary and Grant, who ran the south and west boundaries of T. 19 N., R. 120 W., which have been found to be correct in every respect, this line was assumed to be correct and was projected northward and laid off as described by these surveyors. The accuracy of the other work of these surveyors would indicate that no difficulty should be experienced in finding the corners along this line. The fifth standard parallel was placed in T. 20 N., R. 121 W., as located by Medary and Grant, and this is doubtless its true position instead of that shown in T. 20 N., R. 120 W. and called for by the Woods survey. The lower four tiers of sections in this township are distorted in the same ratio as the lower part of T. 20 N., R. 120 W.

Adjustments in T. 22 N., R. 117 W.—The original survey of Woods in T. 22 N., R. 116 W., appears to have been run only along the valley of Hams Fork. The work was very inaccurate, and the west line of the township was located one-fourth mile too far east. In letting the contract for the resurvey of T. 22 N., R. 116 W., no provision was made for the reestablishment of the west line of the township, which therefore remains one-fourth mile too far east. T. 22 N., R. 117 W., which was probably never surveyed, has been divided regularly, and this error placed in the west tier of sections. This is clearly a hypothetical division and affects the correctness of the agricultural locations shown on Pl. XXVI, which are doubtless actually located in the deep valley west and south of the point shown on the map.

Corners in T. 22 N., R. 118 W.—No original corners were found in this township except the southeast corner of sec. 32, and no others are reported by Mr. Newbrough. Mr. Newbrough has, however, surveyed northward along Rock Creek Valley for the benefit of the lessees and owners, Beckwith, Quinn & Co., and established for their convenience certain reference corners. These reference corners are shown on the base map.

This base map clearly lacks the geographic exactness that would have been possible had it been carefully controlled by primary triangulation and traverse, but the distortion is not sufficient to affect in any way the economic conclusions. As has been shown above, the unit of economic interest is here the section and its subdivisions, and the map is as accurate as it can be made on the scale adopted in regard to the geologic data shown in each section in areas of economic importance.

ACKNOWLEDGMENTS.

For map data.—The maps accompanying this report embody all available data, much of which has been to a greater or less extent corrected or modified by field work. The location of the railroad as shown by the railroad alignment maps has been accepted as correct, but it has been necessary to correct many of the topographic details appearing on these maps. Some of the maps obtained were of assistance only as aids in planning the work, the data they furnished in no way determining or affecting the geographical and geological results. The map data given in the following list is for the most part manuscript material received in the shape of blue-prints or copied from original sheets.

Map data, in addition to field sheets, collected in the preparation of the base map used in Pls. III, XXIII, and XXVI.

Diamond Coal and Coke Company:
- Coal lands of Diamond Coal and Coke Company at mines Nos. 1 and 2, by William Newbrough, March 15, 1904; scale, 1 inch to 600 feet.
- Coal lands of Diamond Coal and Coke Company at mine No. 3, by William Newbrough; scale, 1 inch to 600 feet.
- Town plat of Glencoe, Wyo.; scale, 1 inch to 100 feet.
- Wagon roads of sec. 20, T. 20 N., R. 116 W., Uinta County, Wyo.; scale, 1 inch to 600 feet.
- Map from Kemmerer to Oakley; scale, 1 inch to 600 feet.

William Newbrough:
- Southern Uinta County, Wyo., showing lands covered by tax list of county, March 1, 1905; scale, 1 inch to 2 miles.
- Southern part of Uinta County, Wyo., showing land entries, State and railroad patented land, and oil claims, 1903; scale, three-fourths inch to 1 mile.
- Map of the Shield ranch of Beckwith, Quinn & Co. in Uinta County, Wyo., and Rich County, Utah, 1903; scale, 2 inches to 1 mile. [Gives data from T. 20 N. northward and from west of the State line eastward to Rock Creek.]
- Map of Evanston, Wyo., 1903; scale, 250 feet to 1 inch.
- Road maps: Official maps of county roads made by William Newbrough while county surveyor and filed in county court-house. Scale, 2 inches to 1 mile. Evanston to Hilliard, Hilliard to Altamont, Hilliard to Aspen, Lazeart to Spring Valley (Pioneer Hollow road), Evanston to Fort Bridger, Kemmerer to Fontenelle, Frontier to upper Hams Fork bridge.
- Canal maps: Bear ditch and West Side canals on Hilliard Flat. Chapman canal in T. 16 N., R. 120 W.

Oregon Short Line Railroad Company:
- Alignment, Beckwith to Opal; scale, 1 inch to 2,000 feet.
- Profile, Granger to Border; resident engineer's office, Salt Lake City, Utah, September, 1902; horizontal scale, 1 inch to 260 feet; vertical scale, 1 inch to 3 feet.
- Station plats; scale, 1 inch to 100 feet: Beckwith (December 14, 1904); Diamondville (January 1, 1904); Fossil (August 30, 1903); Kemmerer (October 17, 1902); Nugget (October 14, 1902); Sage (August 30, 1903); Waterfall (April 1, 1903).
- Oregon Short Line in vicinity of Waterfall quarry; scale, 1 inch to 200 feet. January 21, 1902.

Union Pacific Coal Company:
- Outcrops, Piedmont-Kemmerer, Uinta County, Wyo.; scale, 1¼ inches to 1 mile. November, 1900.
- Map of Cumberland mines, buildings, etc., in secs. 19, 30, 31, T. 19 N., R. 116 W., June 1, 1902; scale, 1 inch to 200 feet. [Detailed topographic map with contour interval of 10 feet.]
- Twin Creek mines and buildings; scale, 1 inch to 300 feet.

Union Pacific Railroad Company:[a]
- Map showing track to coal mines at Almy, Wyo.; scale, 400 feet to 1 inch. October 23, 1888.
- Alignment, new line, Hampton, Wyo., to Wyuta, Utah; scale, 1 inch to 2,000 feet.
- Alignment, old line, Leroy to Evanston; scale, 1 inch to 1,000 feet.
- Profile, new line, Antelope to Millis; horizontal scale, 1 inch to 400 feet; vertical scale, 1 inch to 30 feet.
- Profile, old line, Leroy to Millis; horizontal scale, 1 inch to 400 feet; vertical scale, 1 inch to 30 feet.

Union Pacific Railroad Company, land department:
- Map of contested Union Pacific lands, Uinta County, Wyo.; scale, 1 inch to 1 mile. September 27, 1902. Extends north to north line of T. 19 N.
- Plat of oil wells in T. 15 N., R. 118 W., showing approximate location and depth and comparative elevation above Union Pacific well. July, 1904.

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[a] Received in part from chief engineer of Union Pacific Railroad at Omaha, Nebr., and in part from chief engineer of Oregon Short Line (under whose supervision the Union Pacific line west of Green River now comes) at Salt Lake City.

United States Coast and Geodetic Survey:

Bench marks along new line of Union Pacific Railroad. Complete list, with descriptions, on p. 38.

United States General Land Office:

Photographic copies of original township plats for whole area.

United States Geological Survey:

Coalville (Utah) and Hayden Peak (Utah-Wyoming) quadrangles, surveyed 1899-1901 by H. L. Baldwin, Jeremiah Ahern, and W. J. Lloyd. Used on southern edge of base map.

Bench marks. Precise bench marks between Evanston and southwest corner of State. Complete list, with descriptions, given on pp. 39–40.

Wyoming Western Railroad:

Alignment, Moyer Junction to Cumberland; scale, 1 inch to 2,000 feet. 1903.

Profile, Moyer Junction to Cumberland; horizontal scale, 1 inch to 400 feet; vertical scale, 1 inch to 30 feet. January 1, 1904.

For geologic data.—All the coal companies in this region have furnished mine plats and in every way endeavored to further the work. The oil operators have to a limited extent furnished well records, and the railroads have supplied tunnel sections. The sources of these data are specifically acknowledged where they are used in the text. In addition to the assistance thus given, valuable aid was rendered by members of this Survey, particularly by Drs. T. W. Stanton and F. H. Knowlton.

In general.—The Survey is particularly indebted to Mr. William Newbrough, civil engineer and formerly county surveyor of Uinta County; Mr. Frank Manley, chief engineer Union Pacific Coal Company; Mr. Thomas Sneddon, superintendent Diamond Coal and Coke Company; Mr. P. J. Quealy, manager Kemmerer Coal Company; Mr. J. H. Martin, superintendent Rocky Mountain Coal and Iron Company; Mr. A. B. Taylor and Mr. D. H. MacMillan, of the Pittsburg-Salt Lake Oil Company; Mr. Charles O. Richardson, of the Standard Reserve Oil Company; Mr. B. A. McAllaster, land commissioner of the Union Pacific Railroad; Mr. Orlando Curtis; and Mr. Morris Morrison.

CHAPTER I.

HISTORICAL REVIEW OF GEOGRAPHICAL AND GEOLOGICAL EXPLORATIONS.

Until the Mexican cession of 1848 all the area treated in this report except a very small portion north of the forty-second parallel, in T. 23 N., was Spanish or Mexican territory. It then became parts of Cache, Summit, and Green River counties, Utah Territory. In 1868 all the former Mexican territory east of longitude 34° west of Washington and north of latitude 41° N. was made part of Wyoming Territory. In the early maps the meridian 34° west of Washington was placed about 10 miles too far east, and for several years after the organization of the Territory of Wyoming, Evanston is referred to in the reports as in Utah. The small portion of the area that lies north of latitude 42° N. was successively part of Oregon, Washington, and Idaho Territories.

PERIOD OF EARLY EXPLORATION, 1834–1858.

The earliest extended knowledge of the geographic features of this region obtained by white men was doubtless that of the pioneer traders of the Rocky Mountain Fur Company—Gen. William Ashley, Capt. William Sublette, Capt. Robert Campbell, Capt. James Bridger, Louis Vasquez, and their associates—but the first contribution to the world's knowledge of the geography of this general region was that resulting from the explorations of Captain Bonneville in 1834 and 1835. Although Bonneville's explorations were confined largely to regions north and west of this area, he passed across the northern part of it in April, 1835.[a] He collected a large amount of fairly accurate data regarding the country to the south, and his map (fig. 1) is the first to give even the roughest approximation of the principal geographic features of this general region.

In 1837 Capt. James Bridger and Louis Vasquez established on Blacks Fork a trading post named Fort Bridger, and so advantageously was this post situated with reference to the natural central overland route that it became one of the most important points on the emigrant route to Salt Lake and California, and for a time on the Oregon emigrant road. Later it was of importance as a point on the overland stage route. In 1857 it was occupied by the United States Army as a military post, and thus became the natural rendezvous of the scientific expeditions of the second period. Southern Uinta County thus contained during the first period one settlement and was crossed by the main central emigrant trail, by the Oregon emigrant trail leading from Fort Bridger northwestward, and later by the Sublette Cut-off on the Oregon Trail north of Twin Creek, and the early explorations were naturally largely confined to these natural routes of travel.

[a] Irving, Washington, The Rocky Mountains, or Scenes, Incidents, and Adventures in the Far West; from Journal of Capt. B. L. E. Bonneville, Philadelphia, 1837, vol. 2, p. 223. "Capt Bonneville and his party passed by Ham's Fork and reached the Colorado or Green River without accident."

The geographic and geologic contributions of this period are the results of the explorations and records of Frémont in 1843, Clayton in 1847, Stansbury in 1849–50, Egloffstein (Beckwith) in 1854, Lander and Wagner in 1857–58, and Simpson and Engelmann in 1858. Frémont, Stansbury, Simpson, and Beckwith were officers in the United States Army, and their explorations were made largely for military purposes. Beckwith's expedition was undertaken in connection with the early exploratory surveys made by the Government to discover a practicable railroad route to the Pacific Ocean. Lander and Wagner were engaged in "looking out" and constructing

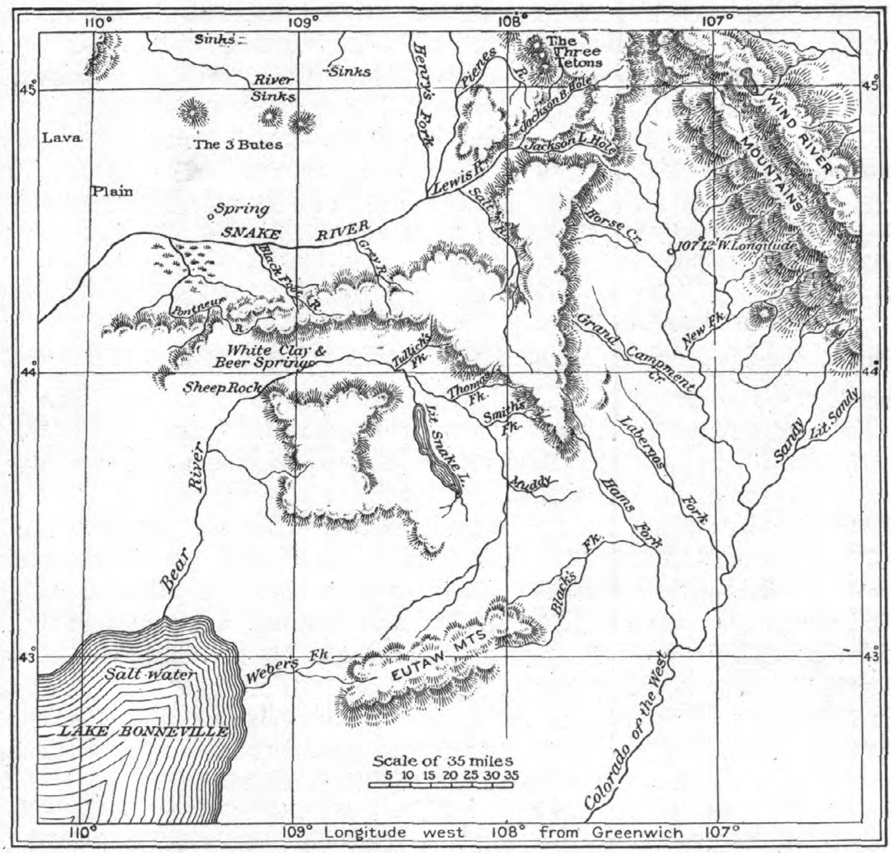


FIG. 1.—Earliest published map of region covered by this report; Bonneville, 1837. A copy of a portion of "A map of the sources of the Colorado and Big Salt Lake, Platte, Yellow-Stone, Muscle-Shell, Missouri; and Salmon and Snake rivers, branches of the Columbia River."

wagon roads under the Interior Department and Clayton was a member of the pioneer band of Mormons which reached Salt Lake on July 19, 1847. The contributions of each of these explorers is discussed in detail in the bibliographic notes given later. The net result of the geographic explorations, as shown in Warren's carefully compiled map in the final report of the Pacific Railroad surveys, was a correct delineation of all the important geographic features of this region. The geologic results were much more meager. Coal beds had been found on Sulphur Creek, and on Little Muddy Creek at Cumberland and Reservoir Gap, and Stansbury had placed on his map the words "Great Coal Basin," extending from the west bank of Bear River, near the present site of Evanston, to Point of Rocks, in Sweetwater County. Oil had been discovered on Sulphur Creek, and probably on the head of Twin Creek. James Hall, to whom the specimens collected by Frémont had been submitted, compared the fossils from the Tertiary beds east of Green River with those from the Cretaceous greensands of New Jersey. He described fresh-water shells from the Eocene beds east of Cumberland as marine species, and tentatively referred them to the Oolitic, as he likewise did the leaves from the Benton Cretaceous. Engelmann, who accompanied Simpson, recognized the three principal divisions of the Tertiary of this region, and correctly assigned the outcrops of the Benton and Bear River formations on Sulphur Creek to the Cretaceous. Meek, however, examined the Bear River fossils collected by Engelmann and regarded them as basal Tertiary, and so started the long discussion of the age of the Bear River beds.

PERIOD OF THE HAYDEN AND KING SURVEYS, 1868-1877.

Shortly after the civil war, which had interrupted the Government exploration of this region, and which was in large measure the cause of the long interval between the first and second periods, two great Government scientific corps began the exploration of the western United States—the King survey, under the auspices of the War Department, and the Hayden survey, under the auspices of the Interior Department. Two other important scientific corps worked in the western United States before the close of this period—the Wheeler survey (Geographical Survey West of the One-hundredth Meridian) and the Powell survey (Geographical and Geological Survey of the Rocky Mountain Region); the first did not touch this area, and although Major Powell visited the Sulphur Creek locality his visit was made mainly to examine the section described by Meek, to which description he added nothing.

The King survey began work in 1867 in California on the famous Fortieth Parallel Survey, which was designed to furnish a complete section across the mountain regions of the western United States between the Pacific Ocean and the east flank of the Rocky Mountains. This survey was carried along the line of the Union Pacific and Central Pacific railroads, which were completed in March, 1869, and greatly facilitated the explorations made during this period. The King survey completed its field work in 1874 on the eastern flank of the Rocky Mountains, having made a geologic and topographic map 100 miles wide along the line of work.

The field work of the King survey in the area discussed in the present report occupied portions of the years 1869, 1871, and 1872. In 1869 the area as far east as the divide between Bear and Green rivers was surveyed. The Gardiner party, with Arnold Hague, geologist, surveyed the "portion lying north of the Union Pacific Railroad, beginning at Echo Canyon and continuing eastward to the Green River divide. They surveyed the valley of Bear River and made highly valuable observations on the coal formation."[a] King "went eastward south of the Union Pacific to Bear River, and thence up Bear River into the Uinta Mountains."[a] In 1871, with headquarters at Fort Bridger, S. F. Emmons carried the work eastward as far as Washakie, in Sweetwater County. In 1872 a general reexamination of the whole

[a] Unpublished letters from Clarence King to Chief of Engineers

region surveyed was made by the geologists of the King survey. Hague reached Evanston in August from a trip into the Bear River plateau, following practically Hayden's route of the preceding year. So far as is shown by the maps and text composing its report the actual exploration made by the King survey in this region appears to have been confined to a hasty examination along the line of the railroad and along Oyster Ridge. The greater portion of the territory—that which lies north and west of these lines of travel—was clearly never seen by members of the King survey.

Members of the Hayden survey worked in this area in 1868, 1869, 1870, 1871, 1872, and 1877. In the fall of 1868, and again in 1869, Hayden examined the country along the route of the Union Pacific Railroad from Cheyenne to Great Salt Lake. In 1870, with headquarters at Fort Bridger, he examined the upper part of Bear River, Muddy Creek, Blacks Fork, and Smiths Fork, and in November again examined the geology along the line of the railroad, particularly in this immediate region. In this year James T. Hodge examined the coal mines at Almy, in connection with his general study of the western coal fields for the Hayden survey. Hayden and Peale, in 1871, "passed up the valley of Bear River, by way of Bear Lake, to Evanston," from which point, after examining the Almy coal mines, Peale proceeded to Fort Bridger and Hayden again reviewed the geology along the railroad.

In 1872 several Hayden parties worked in this area. Meek and Bannister made detailed stratigraphic and paleontologic studies along the railroad, Lesquereux collected leaves from the coal-bearing beds at Almy, and Cope conducted an expedition up Green River to Fontenelle Creek, and thence to the source of that stream, crossed Oyster Ridge divide, and descended Hams Fork to the Union Pacific, and returned to Fort Bridger. He then studied the region between Hilliard and Evanston, collecting fossils in the Wasatch beds near the present railroad bridge over Bear River.

In 1877 Gannett and Peale of the Hayden survey mapped geologically and topographically, on a scale of 4 miles to the inch, with contour intervals of 200 feet, all the area north of the King map. In the same year Wilson visited Evanston for the purpose of connecting his triangulation with the triangulation station of the Fortieth Parallel Survey on Medicine Butte, and White studied the Evanston and Bear River localities.

The Land Office surveys were initiated in this region in January, 1871, when Nathan B. Cook extended the fourth standard parallel through this area to a point near the State line. In the fall of the same year W. O. Downey, starting from a point established by Cook, surveyed the fourteenth guide meridian southward to the third standard parallel, the third standard parallel west to the fifteenth guide meridian, and the fifteenth guide meridian north to the fourth standard parallel. Before the close of this year the exterior boundaries of Tps. 13–16 N., Rs. 119–120 W., were established, and the subdivision of Tps. 13–16 N., R. 120 W., was completed. Land Office surveys continued actively until 1875 and resulted in the survey of the southern boundary of the State in 1873 and the western boundary in 1874, the complete subdivision of the whole area south of the fourth standard parallel, the subdivision of Tps. 17–20 N., Rs. 115 and 116 W., and Tps. 17 and 18 N., Rs.

120 and 121 W., and the complete survey of the fifth standard parallel and of the fifteenth guide meridian as far north as the fifth standard parallel. No surveys were made by the Land Office in this region between 1875 and 1880.

In addition to these parties, H. R. Durkee and William Cleburne, of the Union Pacific Railroad, collected important paleontologic material, and private parties of Prof. O. C. Marsh worked in the Wasatch beds near Evanston for short periods during one or more years in the early seventies.

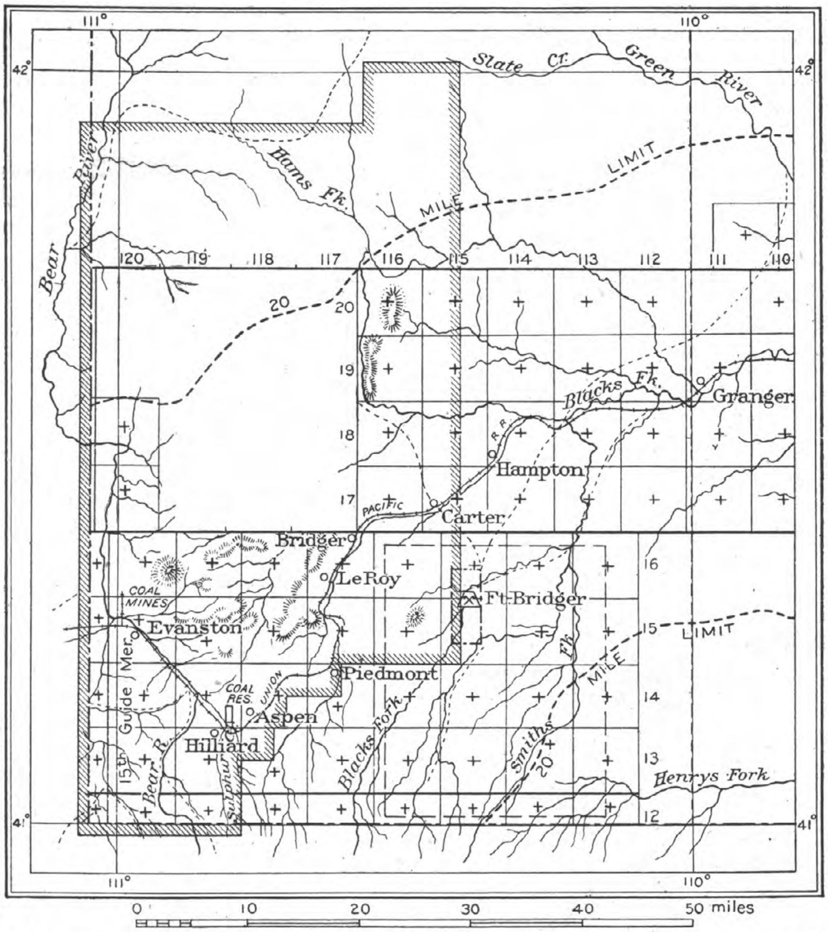


FIG. 2.—Copy of portion of the Land Office map of Wyoming published in 1876, with addition of boundaries of Pl. III, showing extent of surveys of 1871-1874. Townships marked with + were completely subdivided at that time. These surveys are, on the whole, very accurate. The remainder of the area treated in this report was surveyed in 1881-1882. These surveys, with the exception of those of W. J. Boland in Rs. 117-119 W., Tps. 17-19 N., and Rs. 117-118 W., T. 20 N., are entirely fraudulent.

Geographically, the result of surveys of this period was a considerable refinement of the broad outlines of the topography obtained by the explorations of the first period. The Union Pacific Railroad surveys yielded a considerable amount of detailed information concerning the region along the line of the railroad, which, while never published as such, was available in the office of the railroad company, and has been incorporated in many maps, notably, that of the Fortieth Parallel Survey.

The King and Hayden surveys resulted in the production of maps of the whole area on a scale of 1 inch to 4 miles, with contour intervals, in the Hayden maps, of 200 feet and, in the King maps, of 300 feet. The Hayden maps, surveyed by Gannett, covering approximately the area north of the fifth standard parallel, are wonderfully accurate considering the rapidity with which the work was done. They are in marked contrast with the maps of the Fortieth Parallel Survey, made under about the same conditions. Instead of the crude, expressionless topography of the King maps, there are in this Hayden map the broad generalizations of a master hand.

The maps of the Land Office, on a scale of 2 miles to the inch, which cover most of the area mapped by the King survey, were available before the close of this period in manuscript or, on a reduced scale, in the map of Wyoming published by the Land Office in 1876. (Fig. 2.)

The geological results of this period include the preparation of a geological map of the whole area, in part by the King survey and in part by Peale, of the Hayden survey. The line between the work of the two organizations was very near the fifth standard parallel. The Peale map of this area, with the accompanying discussion, was a distinct contribution to geologic knowledge, but that of the King survey, with the exception of the crude and inaccurate representation of the geology along Oyster Ridge and part of Mammoth Hollow, not only contained nothing new, but was misleading.

The period as a whole is most noteworthy for its important paleontologic results. Meek and White made valuable contributions to Cretaceous faunas from a study of collections made near Hilliard, at Carter Oil Spring, near Waterfall, and at Sage. Both made detailed studies of the Hilliard, or old Bear River City locality, and described many species from the Bear River formation, which, because they failed to recognize the structural relations at Bear River City, they regarded as upper Cretaceous or basal Eocene, the word "post-Cretaceous" having been used by White in describing this formation. The Benton Cretaceous was recognized in outcrops near Aspen. Fossils collected in the vicinity of Hilliard from the formation described in the present report as the Frontier were incorrectly referred to the Fox Hills, while fossils from the same beds at Carter Oil Spring were correctly referred to the Benton. Lesquereux made extensive studies of the material collected by himself, Hayden, and Peale near Almy. Cope described vertebrate fossils from the Wasatch formation obtained by Hayden in the vicinity of Evanston in 1871 and by himself in 1872 and 1873.

Thus this region became one of the storm centers of the Laramie-Tertiary-Cretaceous discussion, since it contains the type locality of the Bear River formation, here associated clearly with Cretaceous fossils, the leaf-bearing beds at Evanston on which Lesquereux based some of his conclusions, and, between the two, the type locality of the first vertebrate fossils found in the Wasatch.

Cope also described a large amount of vertebrate material collected from the Green River beds near the present town of Fossil, and Marsh described material collected by his assistants from the Wasatch beds near Evanston.

The economic development during this period included the opening of important mines near Evanston. An attempt was made to develop a mine at the present site of Sage. Some work was done in the vicinity of the Carter and White oil springs, and small amounts of oil were collected and sold. Extensive beds of coal were discovered at Hodges Pass in the formation now called Adaville. Coal was reported by Cope in the present Frontier formation, north of the site of the town of Frontier, and by the Government Land Office surveyors in Tps. 17–20 N., R. 116 W.

PRESENT PERIOD, 1881–1905.

The last work of the several early Government geological organizations in this region was that of the Hayden survey in 1877. In 1879 the United States Geological Survey was created as a successor to and in a way a combination of the four Federal organizations which had been engaged in making topographic and geologic surveys in the region west of the 100th meridian during the second period. It was, however, not until 1881 that any work was done in this area by the United States Geological Survey. In the fall of that year Dr. Lester F. Ward collected fossil leaves at Hodges Pass tunnel, in the lower portion of the beds described in this report as the Adaville formation. In 1885 Dr. C. A. White visited Evanston for the purpose of reexamining the coal-bearing beds at that point and comparing them with the coal-bearing beds of Wales, Utah, which he regarded as of Wasatch age. Doctor White again visited this portion of Bear River Valley in 1891, and, in company with Dr. T. W. Stanton, examined the exposures of the Bear River formation near old Bear River City and north of Evanston. Doctor Stanton then continued the study of the Bear River formation at Waterfall, Sage, and Cokeville. Five years later Doctor Stanton and Dr. F. H. Knowlton, together studying the Laramie beds, examined the exposures at Hodges Pass and Evanston. Edward O. Hills, topographer of the United States Geological Survey, in 1897 and 1898 ran lines of precise levels and established numerous bench marks in the area between and south of Evanston and Hilliard. In 1898 H. L. Baldwin established triangulation stations at Bridger Butte and Medicine Butte in connection with his work in adjoining portions of Utah. Between 1899 and 1901 Messrs. Baldwin, Ahern, and Lloyd surveyed the Coalville and Hayden Peak (Utah-Wyoming) topographic sheets, which extend a fraction of a mile north of the south boundary of the State, from the southwest corner to a point 30 miles east. In 1901–2 E. W. Glafcke ran lines of precise levels and established bench marks east and southeast of Hilliard. In addition to these actual field examinations, members of the Survey studied material collected during the second period and gathered statistics regarding the mineral resources.

Two State officials examined and published geologic reports on portions of this area during this period. Territorial Geologist Louis D. Ricketts visited the oil springs at Carter and Hilliard in 1887 and made a detailed study of the Evanston coal mines in 1889. Prof. Wilbur C. Knight, of the State University, in 1893 collected coal samples at Almy, and in 1898 made a preliminary investigation of the Hilliard, Carter, and Twin Creek oil springs. In 1901–2, after the Spring Valley oil discovery, he again studied this region.

The Coast and Geodetic Survey line of precise levels connecting the Atlantic and Pacific oceans was run through this region along the line of the Union Pacific

Railway in the summer of 1903 by Ralph L. Libby, and numerous bench marks were established.

The survey of the public lands in this area was supposedly completed by W. J. Boland and James E. Woods and associates in 1881 and 1882. Boland surveyed Rs. 117–119 W., Tps. 17–19 N., Rs. 117–118 W., T. 20 N.; Woods surveyed Tps. 19–20 N., Rs. 120–121 W., and all of the townships here considered north of the fifth standard parallel. The surveys made by Woods are wholly fraudulent and inaccurate, and the Land Office is now engaged in resurveying the areas covered by his work. Tps. 22–23 N., Rs. 115–116 W., and T. 21 N., R. 115 W., were thus resurveyed by Edward F. Stahle and John P. Van Orsdel in 1903.

The important geologic results of this period include, besides valuable paleontological contributions by Lesquereux, Cope, and Marsh, based on collections near Evanston and Twin Creek during the second period, and various more or less statistical papers: (1) The determination by Dr. T. W. Stanton of the true stratigraphic position of the Bear River formation at the base of the marine Cretaceous of this region; (2) the determination, again by Doctor Stanton, of the Colorado age of much of the strata mapped as Fox Hills by the early explorers; (3) the publication of a detailed paleontologic report on the Bear River formation by Doctor White, and (4) the publication by Doctor Ward of descriptions of fossil leaves from the Laramie at Hodges Pass.

The knowledge of the geography of the region was advanced by the Land Office surveys of Boland, and to a very limited extent by those of Woods. In the last few years much precise elevation data has been obtained by lines of levels of the Coast and Geodetic Survey run along the Union Pacific Railroad, and of the United States Geological Survey between that line and the southern boundary of the State. The exact position of Medicine Butte, Bridger Butte, the southwest corner of the State, and the southeast corner of Uinta County were determined by the latter organization preparatory to making detailed topographic surveys of this area.

In this period the Almy coal mines reached their maximum development and then declined to the almost total desertion of to-day. Coal mines were opened at Twin Creek and Spring Valley and abandoned, in each case, in a few years. The development of the Benton coals commenced in the early nineties and, receiving impetus both from the high quality of the coal and from favorable treatment by the Oregon Short Line Railroad, has proceeded rapidly, until now there are important private mines at Frontier, Diamondville, Oakley, and Glencoe and railroad mines at Cumberland. The discovery of oil at Spring Valley in 1900 attracted many to this region, but as no large strikes were made the excitement soon died out, leaving a few well-supported, persistent companies to complete the development of a very promising field.

BIBLIOGRAPHY.

The development of the geographic and geologic knowledge of this area, which has been outlined above, is given in detail chronologically in the following list. In the preparation of this bibliography an effort has been made to restrict it for the most part to articles based on original work in this area or containing unpublished material. A few exceptions have been made in cases where the articles seemed to be of particular importance or value from a historical standpoint or as works of reference. Separate editions have, for the most part, been discussed under the date of the first issue.

GEOLOGICAL AND CARTOGRAPHICAL BIBLIOGRAPHY OF THE PORTION OF SOUTHERN UINTA COUNTY, WYO., TREATED IN THIS REPORT.

1837.

1. **Bonneville**, Capt. B. L. E. A map of the sources of the Colorado & Big Salt Lake, Platte, Yellow-Stone, Muscle-Shell, Missouri; & Salmon & Snake Rivers, branches of the Columbia River. [Scale, 23.3 miles to 1 inch. Generalized hachure topography.]

In Washington Irving's The Rocky Mountains, or Scenes, Incidents, and Adventures in the Far West; from the Journal of Capt B. L E Bonneville. Vol. 1, Philadelphia, 1837.

The first map to show any of the geographic features of this region.

1845.

2. **Frémont**, Capt. J. C. Report of the exploring expedition to the Rocky Mountains in the year 1842, and to Oregon and California in the years 1843-44. Washington, 1845.

Published as Senate Doc. No. 174 and House Doc. No. 166, 28th Cong., 2d sess., pp. 130-132. Many subsequent editions.

On August 17, 1843, Frémont crossed Green River near the mouth of Big Sandy and followed the usual emigrant road up Black Fork nearly to Fort Bridger. Here he turned northward along the emigrant's road to Oregon, crossing Muddy Creek (which he describes as "a salt creek") near Carter, and struck Little Muddy Creek, "one of the heads of Ham's Fork, called Muddy," a few miles east of Cumberland Gap. Turning westward up this creek he passed around the big bend of the old Soda Springs road north of Reservoir Gap and then up Little Muddy Creek and over the divide to the headwaters of Bridger Creek, which he names Muddy Creek on his map. He followed this to Bear River bottoms, along which he turned northward.

He collected a few shells in the Wasatch beds east of Cumberland and found leaves in the Frontier formation near Cumberland Gap, both of which he regards as Jurassic. He reports coal beds here and north of Reservoir Gap and describes the variegated Wasatch beds near the head of Little Muddy Creek.

3. **Frémont**, Capt. J. C. Map of an exploring expedition to the Rocky Mountains in the year 1842 and to Oregon and north California in the years 1843–44. [Scale, 1:2,000-000; hachure topography by Charles Preuss.]

In Frémont's Rept. Explg. Exped. to Rocky Mountains, etc., Senate Doc. No. 174, House Doc. No. 166, 28th Cong, 2d sess., 1845.

On edge of map is: Profile of the route from the mouth of the Kansas to the Pacific, horizontal scale 1:3,000,000. [The horizontal distances on profile are not plotted to this scale.]

On this map the parallels are approximately correct, but the meridians are about 10 miles too far east. The general geographic features along the route are well shown and the map is to be regarded as the first important contribution to the detailed knowledge of the interior geography of this area. "Blacks Fork" and an unnamed tributary (Smiths Fork) are represented. Muddy Fork, which is not named, is shown as a tributary of Little Muddy Fork, and the united stream, instead of entering Blacks Fork near Church Buttes, is connected with the lower part of Hams Fork and the whole named "Muddy Fork." The dual character of the head of Bridger Creek is correctly shown, and Twin Creek is indicated but not named. Hills are represented along Bear River close to the east bank south of Twin Creek and a mile or more east of the river from that point to "Smiths Fork."

4. —— [Map of Bear River from Bridger Creek, Wyo., to Soda Springs, Idaho. Scale, 4½ miles to 1 inch.]

In Rept. Expl. Exped. to Rocky Mountains, etc., 1845, p. 132.

On this map Bridger Creek is named "Muddy Creek" The bluffs between Twin Creek and Beckwith ranch house are represented, as is the outlying hill 2 miles north.

5. **Hall**, James. Nature of the geological formations occupying the portion of Oregon and north California included in a geographical survey under the direction of Captain Frémont.

5. **Hall,** James—Continued.

In Rept. Expl. Exped. to Rocky Mountains, etc., by Frémont, House Doc. No. 166, 28th Cong., 2d sess., 1845, pp. 297–298; also Senate Doc. No. 174, 28th Cong., 2d sess., 1845, and many subsequent editions.

Discusses leaves and shells collected by Frémont, "Long. 111°, lat. 41½°, Muddy River" just east of Cumberland, and provisionally refers them to the Oolitic.

6. —— Descriptions of organic remains collected by Capt. J. C. Frémont in the geographical survey of Oregon and North California.

In Rept. Expl. Exped. to Rocky Mountains, etc., by Frémont, House Doc. No. 166, 28th Cong., 2d sess., 1845, pp. 304–307, 309. Pl. I–III; also Senate Doc. No. 174, 28th Cong., 2d sess., 1845, and many subsequent editions.

Describes and figures, from beds, now called the Frontier formation, just east of Cumberland Gap, nine species of plants, eight of them new; and from the Wasatch beds a few miles farther east two new species of shells. Both of these localities he regards provisionally as of Oolitic age.

1848.

7. **Clayton,** W. Latter-Day Saints' Emigrants' Guide; being a table of distances, showing all the springs, creeks, rivers, hills, mountains, camping places, and all other notable places from Council Bluffs to the Valley of the Great Salt Lake. Also, the latitudes, longitudes, and altitudes of the prominent points on the route. Together with remarks on the nature of the land, timber, grass, etc. The whole route having been carefully measured by a roadometer, and the distance from point to point, in English miles, accurately shown. St. Louis, 1848, 24 pp.

An extremely minute description of the wagon road followed by the Mormons in 1847 and for many years after the principal stage road. It passed up Pioneer Hollow, over the divide near Aspen tunnel, crossed Sulphur Creek at the site of Bear River City, and thence ran westward past the Needles into Echo Canyon. Of particular interest is the note regarding the coal and oil spring near the crossing of Sulphur Creek (p. 24).

1850.

8. **Preuss,** Charles. A topographical map of the road from Missouri to Oregon, commencing at the mouth of the Kansas in the Missouri River, and ending at the mouth of the Walla-Walla in the Columbia, in seven sections, from the field notes and the Journal of Capt. J. C. Frémont and from sketches and notes made on the ground by his assistant, Charles Preuss. Section V. [Scale, 10 miles to 1 inch; hachure topography.]

8. **Preuss,** Charles—Continued.

House Com. Rept. No. 145, 30th Cong., 2d sess., vol. 2 [1850].

This map, though on a much larger scale than the map accompanying Frémont's report, adds nothing to the detail there shown. The geographic positions are less accurate than those given in the earlier map.

1852.

9. **Stansbury,** Capt. Howard. Exploration and Survey of the Valley of the Great Salt Lake of Utah. Philadelphia, 1852, pp. 72–79, 225–227, 276, 280.

On his outward journey (August 9–22, 1849) Stansbury followed the usual emigrant road, which crossed Green River at the mouth of the Sandy and followed Black Fork to Fort Bridger. Turning westward he passed up Pioneer Hollow and over the divide near Aspen tunnel to the site of Bear River City. At the ford of Bear River he turned northwestward and followed the east bank of the river to a point near the site of Evanston, where he forded the river and crossed the divide into Lost or Plumber Creek, Utah. On his return he followed the usual emigrant road up Echo Creek, passed the Needles on Yellow Creek, up Needle Creek and across Bear River to the site of Bear River City; thence along the road which passes through the present sites of Aspen and Piedmont to Fort Bridger.

A portion of his account of August 20, 1849 (pp. 77–78), was clearly written after his return home and, making allowances for a faulty memory, it appears that he observed the perpendicular strata at Bear River City and the horizontal Wasatch beds to the west; the former he referred to the Carboniferous, the latter to the Lias, probably because of the earlier reference of beds in this vicinity to the Oolitic by Frémont. He noted the eastward and westward dipping beds on either side of Bear River Valley below Evanston and regarded the whole as indicating an anticlinal axis. Except that the older beds are referred to the Carboniferous, there is no indication that he found coal at this point. In his account of his return trip (pp. 226–280) he describes the Needles, the coal beds near old Bear River City, and the Brigham Young Oil Spring. In his introduction (p. 5) he speaks of "the coal basin of Green River," which is shown on the map (No. 10) as extending from Bear River near Evanston to Point of Rocks in Sweetwater County.

10. —— Map of a reconnaissance between Fort Leavenworth on the Missouri River, and the Great Salt Lake in the Territory of Utah made in 1849 and 1850. [Scale, 1 : 1,000,000; hachure topography. 1852.]

Accompanying Stansbury's Exploration and Survey of the Valley of Great Salt Lake, but in a separate volume.

This map shows a number of points in this area not given on the earlier map of Frémont. The longitude determinations are more nearly correct though the 111th meridian is still too far east in the region of Evanston. Muddy Creek (here named "Muddy Fork") is correctly shown as emptying into Black

10. **Stansbury,** Capt. Howard—Continued.

Fork above the mouth of Hams Fork, but the upper end of Little Muddy has been connected with the lower end of Ham's Fork and the whole labeled "Hams Fork." Details are added to the upper portions of Black and Muddy forks. Smiths Fork, Sulphur Creek, and Yellow Creek are named, and the Needles and Medicine Butte are shown, though the latter is very incorrectly located. Of geological interest on this map is the "Tar Spring" near Sulphur Creek (Brigham Young Oil Spring), the "Copperash Spring" in Pioneer Hollow, and the words "Great Coal Basin," which extend from the west bank of Bear River, near the present site of Evanston, to Point of Rocks on Bitter Creek.

1858.

11. **Marcou,** Jules. American Geology. Letter on some points of the geology of Texas, New Mexico, Kansas, and Nebraska; addressed to Messrs. F. B. Meek and F. V. Hayden, March, 1858, 16 pages.

Page 12: "Professor Heer thinks * * * that the Muddy River coal discovered by Colonel Frémont is of Tertiary age instead of Jurassic as it was pronounced by James Hall." Page 13: "Professor Heer thinks, * * * as to the ferns, no one of Hall's figures is characteristic of the Jurassic period or any other special formation."

1859.

12. **Engelmann,** Henry. Preliminary report on the geology of the country between Fort Bridger and Camp Floyd, Utah Territory, and southwest of the latter place, along Capt. J. H. Simpson's routes, 1858.

Report of the Secretary of War, communicating Simpson's report and map of wagon-road routes in Utah Territory, Senate Ex. Doc. No. 40, 35th Cong., 2d sess., 1859, pp. 45-75.

This is the first important contribution to the systematic geology of this area. The three main divisions of the Tertiary of the Green River Basin are recognized and described as is the unconformity between the Tertiary and Cretaceous. The coal-bearing beds of the Green River Basin, as well as the strata of the Bear River and present Frontier formations on Sulphur Creek, he referred on paleontologic grounds to the Cretaceous, and was therefore the first to prove the existence of Cretaceous in this region.

13. **Lander,** F. W. Preliminary report * * * upon * * * explorations west of the South Pass, for a suitable location for the Fort Kearney, South Pass, and Honey Lake wagon road.

Senate Ex. Doc. No. 36, 35th Cong., 2d sess., 1859, pp. 33

"They (the roads) are very favorable passages of the grand Wasatch mountain chain and principal divide of the American continent near latitude 42°. They are well timbered and abundantly supplied with pure water and excellent building stone. Beds of coal iron, and salt, and a spring of peculiar mineral oil, which, by chemical process, may be made suitable for lubricating machinery, are found in their vicinity." The map shows that in 1847 Lander passed up Twin Creek and over Hodges Pass, and it is believed that he refers to the Twin Creek oil springs.

14. **Simpson,** Capt. J. H. Preliminary map of routes reconnoitered and opened in the Territory of Utah by Capt. J. H. Simpson in the fall of 1858. Scale, 5 miles to an inch.

In Simpson's Report on Wagon Roads in Utah Territory, Senate Ex. Doc. No. 40, 35th Cong., 2d sess., vol. 10, 1859.

This map shows a new road west of Fort Bridger, south of the regular emigrant road. It crossed the divide near the site of Aspen, turned southward up Hilliard Flat at the fork of Sulphur Creek and passed into the present State of Utah in the valley of "White Clay" (Chalk) Creek. This map correctly shows the headwaters of Yellow Creek, incorrectly represented on the maps of the Beckwith survey of 1854 (No. 18). The geographical details north of the road are the same shown on Stansbury's map of 1852, from which it was evidently copied.

15. **Wagner,** W. H. Preliminary map of the central division of Fort Kearney, South Pass, and Honey Lake wagon road, surveyed and worked under the direction of F. W. Lander, superintendent, 1857-58. Department of the Interior. Pacific Wagon Roads. Scale, 1 : 600,000. [Hachure topography.]

In Report on Pacific Wagon Roads, Senate Ex. Doc. No. 36, 35th Cong., 2d sess., 1859.

This is the first map giving any definite information regarding the geography between Green and Bear rivers in the northern part of this area, after the early map of Bonneville (No. 1), to which compilers evidently attached too little weight, and it remained the most accurate map of this region up to the time of the publication of Gannett's maps Nos. 85 95 by the Hayden survey. The true head of Hams Fork is shown on this map for the first time since the early Bonneville map. Rock Creek is correctly shown as flowing southward at the crossing of Sublette's road, but is incorrectly made to empty into Hams Fork.

1860.

16. **Meek,** F. B. Descriptions of new fossil remains collected in Nebraska and Utah by the exploring expeditions under the command of Capt. J. H. Simpson, of U. S. Topographical Engineers (extracted from that officer's forthcoming report).

Proc. Phila. Acad. Sci. for 1860, 1860, pp. 311-315.

Describes, without figuring, new species from the material collected by Engelmann on Sulphur Creek—one from the Oyster Ridge sandstone and six from the Bear River formation.

17. **Meek,** F. B., and **Engelmann,** H. Notice of geological discoveries made by Capt. J. H.

17. **Meek, F. B.,** and **Engelmann, H.**—Cont'd. Simpson, Topographical Engineers, U. S. Army, in his recent explorations across the continent.

Proc. Phila. Acad. Sci. for 1860, 1860, pp. 126-131.

In letter dated April 2, 1860. Meek and Engelmann give brief notes on the collections made by Engelmann in 1858. The fossils from the Frontier formation on Sulphur Creek are regarded as Cretaceous No. 1 or Dakota, and the Bear River fossils from the same locality are considered to indicate an estuary deposit of Eocene age. The fresh-water character of the beds, at present considered Eocene, is recognized for the first time.

1861.

18. **Egloffstein, F. W.** [Map of a railroad route near the 41st parallel] Map No. 1. From the valley of Green River to the Great Salt Lake from explorations and surveys by Capt. E. G. Beckwith, F. W. Egloffstein, topographer for the route. Surveyed in 1854. Scale, 12 miles to 1 inch. [Hachure topography.]

Pacific Railroad Reports, Senatê Ex. Doc., 36th Cong., 2d sess , vol. 11, 1861.

This expedition passed up White Clay Creek (Chalk Creek) and thence almost directly to Fort Bridger. It returned by way of the emigrant road as far as Bear River City, where it turned southwest to the headwaters of Chalk Creek. This map adds some new features to the geography of the southern portion of Uinta County, but is misleading because of lack of care in compilation and unwarranted inferences. The meridians are 10 miles too far east, as in Frémont's map. The headwaters of Yellow Creek have been made to drain into Chalk Creek by way of Tie Creek. Bear River is shown as following Mill Creek and the main channel is not shown at all, although it is described in Beckwith's journal. Smiths Fork is incorrectly made tributary to Blacks Fork at Fort Bridger. Many data are added regarding Cottonwood Creek and Henry's Fork, both of which are named. Muddy Fork is correctly named and Little Muddy is marked "Ham's Fork" and the stream formed by their union made to empty into Blacks Fork at the mouth of Hams Fork, as on Frémont's map, from which this was taken. The name Medicine Butte is applied to the isolated hill between Stove Creek, Bear River, and Sulphur Creek.

19. **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 a railroad route. Compiled by Lieut. G. K. Warren, 1854-1857. Scale, 1:3,000,000. [Hachure topography, with occasional barometric elevations.]

Pacific Railroad Reports, Senate Ex. Doc., 36th Cong., 2d sess., vol. 11, 1861.

This map, though ostensibly a compilation, shows the following new points: Little Muddy (called "Ham's Fork") and Muddy Fork are shown to empty into Blacks Fork at the proper point, and the true

19. **Warren, G. K.**—Continued.

Hams Fork is approximately shown as an unnamed creek emptying into Blacks Fork below the mouth of Muddy Fork. In this respect it differs from the Egloffstein (Beckwith) map accompanying the same report. This map, in point of time of drawing, antedates the Lander map (No. 15), although of later date of publication, and the delineation of the true Hams Fork is evidently based on the Bonneville map (No. 1). This is the most accurate map of this region up to the time of the Land Office map of 1876 (No. 71), which was based on detailed surveys.

1866.

20. **United States General Land Office.** Map of the Territory of Utah to accompany the Annual Report of the Commissioner of the General Land Office. Scale 18 miles to an inch. October 2, 1866.

In maps accompanying Report of the Commissioner of the General Land Office, 1866, pt. 2, No. 18.

This crude compilation shows the territory discussed in this report as parts of Green River, Cache, and Summit counties, Utah, Green River County lying east of the divide between Bear and Green rivers. "Proposed route of Union Pacific Railroad" is shown, and Little Muddy Creek is marked "Hams Fork," though a tributary from the north, roughly in the position of the true Hams Fork, is indicated.

21. —— 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. [Scale, 60 miles to 1 inch.]

In maps accompanying Report of the Commissioner of the General Land Office, 1866, pt. 2, map No. 23.

Shows the greater part of this area as part of Utah and indicates coal on Green River above the mouth of Big Sandy and on Bear River near the present town of Cokeville.

1869.

22. **Hayden, F. V.** Review of leading groups, etc.

[Third Annual] Preliminary Field Report of the United States Geological Survey of Colorado and New Mexico, 1869, pp. 90-92, 98.

Reprinted in First, Second, and Third Ann. Repts. U. S. Geol. Survey Ter. for 1867, 1868, and 1869, 1873, pp 190-192, 198.

Names and briefly describes Green River shales, Bridger group, Wasatch group, and Bear River group. The type locality of the Wasatch group is given as the territory between Aspen and the head of Echo Canyon. The Bear River group, named from old Bear River City, is here made to include the coal-bearing strata at Bear River City, Evanston, and Coalville, and is doubtfully referred to the lower Tertiary.

23. **Hayden,** F. V. Notes on the geology of Wyoming and Colorado Territories, No. 2.

Proc. Am. Philos. Soc., vol. 11, 1869, pp. 45–48.

Account of observations of Hayden in this area in 1868. Refers black shales below Oyster Ridge to Cretaceous No. 2 (Benton). Suggests that Medicine Butte is for the most part composed of strata of the coal series, which he doubtfully regards (p. 46) as of older Tertiary age, but later states (p. 48), in connection with discussion of the fossils found at Coalville that it must be of Cretaceous age

1870.

24. **Hayden,** F. V. Sections of strata belonging to the "Bear River group" near Bear River City, Wyoming Territory.

Proc. Am. Philos Soc, vol. 11, 1870, pp 420–425, pl. xii.

Gives detailed section of Fossil Cut, by H. R. Durkee, afterwards published in Fourth Ann. Rept. U. S. Geol. Survey Wyoming. 1871, pp. 150-152, 153 (No. 29).

25. —— Sun Pictures of the Rocky Mountain Scenery, with a description of the geographical and geological features and some account of the resources of the great West, etc. 150 pages, 30 plates. New York, 1870.

Pages 106–111.

Describes the geology along the line of the Union Pacific Railroad in this area. This was reprinted, with some modifications and additions, in [Fourth Ann.] Rept. U. S. Geol. Survey Terr. for 1870. 1872, pp. 147–156 (No 29).

26. **King,** Clarence. The Green River coal basin.

Rept. U. S Geol. Expl. 40th Par., vol. 3, Mining Industry, 1870, pp. 457, 470, 473.

Uses "Green River Tertiaries" to include all horizontal beds above the folded Cretaceous from the Wasatch Mountains to Green River.

Contains no new data of importance on the area of this report, other than three analyses of Evanston coal.

27. **Meek,** F. B. A preliminary list of fossils collected by Dr. Hayden in Colorado, New Mexico, and California, with brief descriptions of a few of the new species.

Proc. Am. Philos. Soc., vol. 11, 1870, pp. 430–431.

Describes *Ostrea soleniscus*, associated with coal bed at Bear River City, as a Tertiary species, but remarks that it may be Cretaceous. Gives list of five species with descriptions of two new species from the Bear River formation, from "Limestone Hill, Bear River," evidently Fossil Cut.

28. —— Collections from the Bear River estuary beds.

Rept. U. S. Geol. Expl. 40th Par., vol. 3, Mining Industry, 1870, pp. 462–466.

Lists four species from Sulphur Creek and discusses the age of the beds, regarding them as uppermost Cretaceous or lower Tertiary, preferably the latter.

1871.

29. **Hayden,** F. V. [Fourth Annual] Preliminary Report United States Geological Survey of Wyoming and portions of contiguous Territories (being a second annual report of progress), 1871, pp. 40, 45, 52, 147–152, 153.

Perhaps the most important of Hayden's personal reports on this region, embodying, as it does, the most complete published statement of the results of his hasty trips across this area in 1868, 1869, and 1870.

30. **Hodge,** James T. On the Tertiary coals of the West.

[Fourth Annual] Prelim. Rept. U. S. Geol. Survey Wyoming, 1871, pp. 319, 321, 328.

Describes mines at "Evanston, Utah," and gives analysis of coal.

31. **Meek,** F. B. Preliminary paleontological report.

[Fourth Annual] Prelim. Rept. U. S. Geol. Survey Wyoming, 1871, pp. 290, 292–294, 296, 297, 298, 306, 316, 317.

On page 290 refers fossils from light-colored sandstone at Bear River and Coalville to the Cretaceous. Discusses the fossils from the Bear River beds on Sulphur Creek and concludes that they are Tertiary. Lists *Ostrea soleniscus* from the Cretaceous near Bear River, eight species from the Bear River formation from "Limestone Hill, Sulphur Creek, and Bear River City, Utah." Discusses the species described by Hall from east of Cumberland Gap (No. 6), and describes (p. 306) *Cardium pauperculum* n. s. from the "Oil Springs, twenty miles west of Fort Bridger, Wyo. Terr.", and *Goniobasis chrysalis* n. s. from "Bear River, near Sulphur Creek, Utah."

32. —— Descriptions of new species of fossils from Ohio and other Western States and Territories.

Proc. Phila. Acad. Sci. for 1871. 1871, pp. 159, 181–182.

Describes *Campeloma* (*Melantho*) *macrospira* n. s. from "Gilmore, Wyo.," "Bear River near mouth of Sulphur Creek, Utah," "at various localities in the Bear River country," all referring to the locality on Sulphur Creek near old Bear River City.

1872.

33. **Cope,** Edward D. On Bathmodon, an extinct genus of ungulates.

Proc. Am. Philos. Soc., vol. 12, No. 88, Feb. 16, 1872, pp. 417–422.

Describes, from material discovered by Dr. Hayden in Tertiary beds of the Wasatch group near Evanston, *B. radians* and *B. semicinctus*.

34. —— Bathmodon, a new genus of fossil mammals.

Am. Jour. Sci., 3d ser., vol. 3, 1872, p. 224.

Reports *B. radians* and *B. semicinctus* from Tertiary beds of the Wasatch group near Evanston, Utah, obtained by Dr. F. V. Hayden.

35. **Cope,** Edward D. On a new genus of Pleurodira from the Eocene of Wyoming.

Proc. Am. Philos. Soc., vol. 12, No. 89, 1872, pp. 472-477.

Describes the Wasatch group along Bear River in the vicinity of Evanston and lists species found on the north bank of Bear River "11 miles S. E. of Evanston," and in the ridges adjacent. Describes new species of *Notharctus* and *Notomorpha*.

36. —— On the vertebrate fossils of the Wahsatch strata.

[Fifth Ann.] Prelim. Rept. U. S. Geol. Survey Montana, 1872, pp. 350-353.

Describes vertebrates (*Coryphodon radians*, *C. semicinctus*) from material collected by Dr. Hayden "in Wasatch beds near Evanston, Utah," and refers beds to oldest Tertiary.

37. —— [On the age of the Wyoming coal.]

Proc. Phila. Acad. Sci., vol. 24, 1872, pp. 279, 280.

Regards Evanston coal as Cretaceous by analogy with Bitter Creek beds.

38. **Elliott,** Henry W. Profile along the line of the Union Pacific from Cheyenne to Salt Lake Valley, north side. Scale, 1½ inches to the mile. U. S. Geol. Survey Terr., 1870.

Profiles, sections, and other illustrations designed to accompany the first report of the chief geologist of the Survey and sketched under his direction. Dept. Interior, U. S. Geol. Survey Terr., F. V. Hayden, geologist in charge, New York, 1872.

Pls. XVIII and XIX cover this region, showing Wasatch group extending a few miles east of Bridger Station, "Cretaceous clays" between Rock Cut and White Sandstone Cut east of Bear River City, coal east of Bear River City, at Millis, and coal mines at Evanston.

39. **Hayden,** F. V. [Fifth Annual] Preliminary Report United States Geological Survey Montana, 1872.

On page 158 states that coal has been reported in Bear River narrows. Mentions coal beds at Evanston, and states that the coal group is lower Tertiary or upper Cretaceous.

40. **Lesquereux,** L. Fossil flora.

[Fifth Ann.] Prelim. Rept. U. S. Geol. Survey Montana, 1872, pp. 291-293 307-309.

Describes, without figuring, 19 species, 3 new, from below the coal at Evanston (Almy), and 4 from above the coal. These he regards as Eocene.

41. —— An enumeration, with descriptions, of some Tertiary fossil plants from specimens procured in the explorations of Dr. F. V. Hayden, in 1870.

Suppl. to Fifth Ann. Rept. U. S. Geol. Survey Terr. for 1871, 1872, 1872, pp. 10-12, 18.

Describes 17 species, three of them new, from above the coal at Evanston (Almy).

42. **Meek,** F. B. Preliminary list of the fossils collected by Dr. Hayden's exploring expedition of 1871, in Utah and Wyoming Territories, with descriptions of a few new species.

[Fifth Ann.] Prelim. Rept. U. S. Geol. Survey Montana, 1872, pp. 376, 377.

Lists two species from the "Cretaceous between Evanston and Fort Bridger;" 3 species from the Bear River "Tertiary." Concludes that there is a gradual passage of the Cretaceous into the Tertiary at Bear River City and Coalville.

43. **Peale,** A. C. Report of A. C. Peale, M. D., on minerals, rocks, thermal springs, etc.

[Fifth Ann.] Prelim. Rept. U. S. Geol. Survey Montana, 1872, pp. 194-196.

Describes mining and gives section of coals developed at Evanston, Utah.

44. **Thomas,** Cyrus. List of elevations and distances in that portion of the United States west of the Mississippi River.

U. S. Geol. Survey Terr., 1872, 31 pp.

Elevations on Union Pacific in this area stated on page 17. The town of Evanston is not given.

1873.

45. **Bannister,** H. M. Report of a geological reconnaissance along the Union Pacific Railroad.

Sixth Ann. Rept. U. S. Geol. Survey Terr. for 1872, 1873, pp. 519-541.

Summary of results of examination made in summer of 1872 in company with Meek.

46. **Cope,** Edward D. On the short-footed Ungulata of the Eocene of Wyoming.

Proc. Am. Philos. Soc., vol. 13, 1873, pp. 67-70.

Description of genus *Bathmodon* and species *B. radians*, *B. semicinctus*, *B. latipes*, from beds of Green River epoch near Evanston, Utah (now Wyoming), obtained by geological surveys conducted during 1871-72 by Prof. F. V. Hayden.

47. —— On some Eocene mammals obtained by Hayden's Geological Survey of 1872.

Paleont. Bull. No. 12, 1873, p. 3.

Describes *Eohippus* (*Orotherium*) *vasacciense* n. s. from "Green River" (Wasatch) beds near Evanston and Black Butte, Wyo.

48. —— On the extinct Vertebrata of the Eocene of Wyoming observed by the expedition of 1872, with notes on the geology.

Sixth Ann. Rept. U. S. Geol. Survey Terr. for 1872, 1873, pp. 545, 586-589, 625, 626-628.

Describes *Bathmodon*, 3 species, and *Emys*, 2 species, from Green River epoch near Evanston.

49. —— Fourth notice of extinct Vertebrata from the Bridger and Green River Tertiaries.

Paleont. Bull. No. 17, October, 1873, pp. 3-4.

49. **Cope**, Edward D.—Continued.

Describes *Phenacodus primævus* from "Bathmodon bone bed near Evanston, Wyo." Also *Eohippus* (*Orotherium*) *index* from this place. The locality is not given in this article.

50. **Gannett**, Henry. List of elevations principally in that portion of the United States west of the Mississippi River. (2d edition.)

U. S. Geol. Survey Terr. Miscel. No. 1, 1873.

No. 44 is regarded as the first edition. The third edition was published in 1875 and the fourth in 1877. The last only was seen. It contains, on pp. 45 and 109, elevations along the Union Pacific in this area

51. **Lesquereux**, Leo. On the age of certain beds of Wyoming referred to the Tertiary by Professor Hayden, and to the Cretaceous by others.

Am. Jour. Sci., 3d ser., vol. 5, 1873, pp. 308–309.

Corrects Cope's statement that he regarded the Evanston beds as Miocene.

52. —— Lignitic formation and fossil flora.

Sixth Ann Rept. U. S. Geol. Survey Terr. for 1872, 1873, pp. 337–339, 368, 371, 401–403, 410–417.

Describes the beds at Almy and gives sections of strata above coal, with data regarding mining and Hodge's analyses of coal. Lists 38 species and describes 14 species of plants, 2 of them new, from Evanston, concluding that the coal-bearing beds are Eocene.

53. **Meek**, F. B. Preliminary paleontological report, consisting of lists and descriptions of fossils, with remarks on the ages of the rocks in which they were found.

Sixth Ann. Rept. U. S. Geol. Survey Terr. for 1872, 1873, pp. 436, 450–454, 462, 477, 478, 487–488, 493, 494–495.

Gives results of personal examinations during 1872, with detailed sections (p. 451) on Sulphur Creek. Describes 4 new species from this locality and gives lists of species from the Cretaceous coal-bearing beds (Frontier) and the Bear River Estuary beds.

1874.

54. **Cope**, E. D. Review of the Vertebrata of the Cretaceous period found west of the Mississippi River.

Bull. U. S. Geol. and Geog. Survey Terr., vol. 1, No. 2, 1874, pp. 13–16.

Gives some of the details of his explorations in this region in 1872, with lists of Wasatch vertebrate fossils.

55. —— Report on the vertebrate paleontology of Colorado.

Seventh Ann. Rept. U. S. Geol. and Geog. Survey Terr. for 1873, 1874, pp. 441–442.

Discussion, so far as affecting this region, an exact reprint of the foregoing.

56. **Jones**, Capt. William A Map of the Military Department of the Platte. Sheet 3. Wyoming. Compiled under the direction of Capt. William A. Jones, Corps of Engineers, Omaha, Nebr., 1873. Scale, 1:2,000,000, 18.94 miles to 1 inch. [Hachure topography.]

Twin Creek is here named "Washakie Creek."

57. **Lesquereux**, Leo. The Lignitic formation and its fossil flora.

Seventh Ann. Rept. U. S. Geol. and Geog. Survey Terr., 1874, pp. 366, 384–385, 386, 407, 421.

This is largely an argument against the conclusions of Newberry, Cope, and Marsh that the lignitic deposits of the Rocky Mountain region are in part Cretaceous.

Refers to the Eocene (lower American Eocene) the coals of Bear River, to American upper Eocene (or lower Miocene) the coal strata of Evanston, to the middle Miocene the coal basin of Carbon and Washakie group. Lists 40 species from Evanston. Describes *Laurus* (*Tetranthera*) *sessiflora* from shale above the coal.

58. —— On the age of the Lignitic formations of the Rocky Mountains.

Am. Jour. Sci., 3d ser., vol. 7, 1874, p. 556.

Refers the Evanston coal to the upper Eocene.

59. **Newberry**, J. S. On the lignites and plant beds of western America.

Am. Jour. Sci., 3d ser., vol. 7, 1874, p. 400.

Refers to the Cretaceous, the Lignitic beds in Wyoming and Utah at Carbon Station, Rock Springs, Coalville, Hallville, Evanston, Bear River, etc.

1875.

60. **Cope**, E. D. The Vertebrata of the Cretaceous formations of the West.

Rept. U. S. Geol. Survey Terr., vol. 2, 1875, pp. 36–46.

Contains exact reprint of geological discussion and lists of Wasatch fossils published in Nos. 54 and 55

1876.

61. **Engelmann**, Henry. Report on the geology of the country between Fort Leavenworth, K. T., and the Sierra Nevada near Carson Valley.

Report of exploration across the Great Basin of the Territory of Utah in 1859, by Capt. J. H. Simpson, 1876, pp. 287–295, 300.

Section IV, The Green River Basin, does not differ greatly in the discussion of this area from the preliminary report of 1859. The fresh-water character of the Tertiary beds is, however, recognized. Notwithstanding Meek's conclusion to the contrary, the author reiterates his former conclusion that the Bear River beds are Cretaceous. He remarks that the conglomerates and sandstones so common in this region represent different epochs—Tertiary, Cretaceous, Jurassic, and Triassic—and that he has not been able to separate them.

62. **King**, Clarence, and others. Atlas of topographical and geological explorations of the

62. **King**, Clarence, and others—Continued.
fortieth parallel, 1876. Scale, 4 miles to 1 inch; contour interval, 300 feet.

The area described in the present report south of about the center of T. 21 N. is here shown on "Green River Basin, Map II, west half," and "Utah Basin, Map III, east half."

The subdivisions shown are: Upper Coal Measures, Dakota, Colorado, Fox Hills, Laramie, Vermillion Creek, Bridger, and Rhyolite. The map is evidently based on a hasty survey along Oyster Ridge and the Union Pacific Railroad. The rest of the map is conjectural, particularly so the Carboniferous area described north of Bear River Narrows and the region west of the Hilliard shale valley.

63. **Lesquereux,** Leo. A review of the fossil flora of North America.

Bull. U. S. Geol. and Geog. Survey Terr., vol. 1, 2d ser., 1876, p 244.

Divides Tertiary of Rocky Mountains into lower Lignitic (Eocene), Evanston group (upper Eocene or lower Miocene), Carbon group (middle Miocene), Green River group (upper Miocene).

64. —— On the Tertiary flora of the North American lignitic, considered as evidence of the age of the formation.

Eighth Ann. Rept. U. S. Geol. and Geog. Survey Terr. for 1874, 1876, pp. 313–314.

Describes *Ficus pseudo-populus* n. s. from Evanston.

65. —— On some new species of fossil plants from the lignitic formation.

Bull. U. S. Geol. and Geog. Survey Terr., vol. 1, 1876, pp. 387.

Describes *Ficus pseudopopulus* n. s. from Evanston.

66. **Marsh,** O. C. On some characters of the genus Coryphodon.

Am. Jour. Sci , 3d ser., vol. 11, 1876, pp. 425–428, with one page of figs.

Points out that Bathmodon of Cope is really Coryphodon Owen, and describes *C. hamatus* from the vicinity of Evanston.

67. **Meek,** F. B. Report on the paleontological collections of the expedition.

Report of exploration across the Great Basin of the Territory of Utah in 1859, by Capt. J. H. Simpson, 1876, pp. 342, 343–344, 358–359 (Pl. IV, 1bc, 3), 360–364 (Pl. V), 372, 373.

Describes and figures nine species from the Bear River beds on Sulphur Creek, and seven species from the present Frontier formation of the same locality.

68. —— Report on the invertebrate Cretaceous and Tertiary fossils of the upper Missouri country.

Rept. U. S. Geol. and Geog. Survey Terr., vol. 9, 1876, pp. xxx, lvii.

Refers beds at Aspen and sandstone at "old Bear River mine" to the Benton; and by inference the Evanston and Carbon beds to the Tertiary.

69. **Peale,** A. C. Stratigraphy, Cenozoic formations.

Eighth Ann. Rept. U. S. Geol. and Geog Survey Terr. for 1874, 1876, pp. 144–145

Excellent tabular statements of views of different authorities on the Bear River group (Hayden 1869 p. 192, including coal strata at Bear River, Coalville, and Evanston) and Wasatch in this area

70. **Powell,** J. W. Geology of the eastern portion of the Uinta Mountains and a region of country adjacent thereto

U. S. Geol. and Geog. Survey Terr., second division, 1876, pp. 50, 158–159.

Describes Sulphur Creek group, giving as type locality "Sulphur Creek near Hilliard" Repeats Meek's Sulphur Creek section, correlating portions of it with his Point of Rocks, Salt wells, and Sulphur Creek groups.

71. **United States General Land Office.** Territory of Wyoming. Compiled by C. Roeser from the official records of the Land Office and other sources. Scale, 15 miles to 1 inch. 1876.

In "General Land Office Geographical and Political Atlas of the States and Territories of the United States of America in which the Public Land Surveys are now in operation. S. S. Burdett, Commissioner, Washington, 1876."

First publication of the results of the first lot of Land Office surveys in this region. Another map was issued in 1879, on the same scale, based on exactly the same original data but showing more creek names and topographic features.

72. **White,** C. A. Invertebrate paleontology of the Plateau province.

Geology of the Uinta Mountains, Powell, 1876, pp. 97, 98, 99, 100, 101, 105, 117, 118–119, 122–123, 128, 132.

Lists species from the present Bear River and Frontier formations on Sulphur Creek, and describes six new species from this area.

1877.

73. **Cope,** E. D. A contribution to the knowledge of the ichthyological fauna of the Green River shales.

Bull. U. S. Geol. and Geog. Survey Terr., vol. 3, No. 4, 1877, pp. 807–819.

Describes, without figuring, 16 forms from Green River beds near Fossil.

74. **Emmons,** S. F. Green River Basin: Descriptive geology of the Basin region.

Rept U. S. Geol. Explor. 40th Par., vol. 2, Descriptive Geology, 1877, pp. 250–253.

75. —— Utah Basin: From Aspen to Echo City.

Rept. U. S. Geol. Explor. 40th Par., vol 2. Descriptive Geology, 1877, pp. 326–330, 337–338.

In this and the preceding title, areas along Oyster Ridge from Aspen to Evanston and north along Bear River Valley are discussed.

76. **Meek**, F. B. Paleontology.

Rept. U. S. Geol. Explor. 40th Par., vol. 4, Ornithology and Paleontology, 1877, pp. 10-12, 143 (Pl. XIII, 2, 2a), 163-182 (Pls. XVI, XVII).

So far as this report relates to this area it is based wholly on material collected by Engelmann in 1858. *Inoceramus problematicus* is figured and described from Oyster Ridge sandstone near Old Bear River City, as well as many species of Bear River fossils from the same locality.

1878.

77. **Cope**, E. D. Descriptions of fishes from the Cretaceous and Tertiary deposits west of the Mississippi River.

Bull. U. S. Geol. and Geog. Survey Terr., vol. 4, No. 1, 1878, pp. 74-77.

Describes *Priscacara oxyprion* from "a deposit of Green River shales on Bear River, Wyo.," *P. peali* "from Green River formation of Wyoming," *P. clivosa*, and *Dapedoglossus æquipinnis*. All of these except *P. peali*, which came from a point just west of Hams Fork on the old Sublette Trail, came from the vicinity of Fossil.

78. **King**, Clarence. Systematic geology.

Rept. U. S Geol. Explor. 40th Par., vol. 1, 1878, pp. 304, 325-326, 370, 372-373, 375-376, 608.

Gives portion of detailed data already published in Nos. 74 and 75.

79. **Lesquereux**, Leo. The Tertiary flora. Contributions to the fossil flora of the Western Territories, Part II.

Rept. U. S. Geol. and Geog. Survey Terr., vol. 7, 1878, pp. 19, 73-74, 92 (Pl. IX, fig. 2), 138 (Pl. XVII, figs. 21-23), 139 (Pl. XVIII, figs. 1-5), 140-141 (Pl. XVIII, figs. 6-8), 161 (Pl. XXI, fig. 2), 173 (Pl. XXIV, fig. 7), 177-178 (Pl. XXIV, fig. 3), 203-204 (Pl. XXXII, figs. 1-3, Pl. LXIII, fig. 8), 204-205 (Pl XXXIV, figs. 1a, 2), 213-214 (Pl. XXXVI, figs. 1-4, 7), 214 (Pl. XXXVI, figs. 5, 6, 8), 217-218 (Pl. XXXIV, figs. 1c, 1d; Pl XXXV, figs. 8, 9), 219 (Pl. XXXVI, fig. 12), 228-22[illegible] (Pl. XL, fig. 1), 233 (Pl. LIX, fig. 13), 241 (Pl. XLI, fig. 8), 244 (Pl XLII, figs. 4, 5), 279, 281-282, 285-286 (Pl. LIV, fig. 13), 286 (Pl. LV), 289-290 (Pl. LVII, figs. 1-5, Pl LVIII, fig 2), 291-292 (Pl. L, fig. 4; Pl. LVIII, figs. 5-8), 299 (Pl. LIX, figs. 8, 8a), 301 (Pl. LIX, figs. 13, 14), 302 (Pl. LX, figs, 1-1a), 304, 304 (Pl. LX, figs. 20, 21), 305 (Pl. LX, fig. 22).

Gives section at Almy and by inference includes beds of coal at Coalville and on Sulphur Creek in the Lignitic Tertiary. Lists, describes, and figures 28 species of plants from Evanston. Concludes that Evanston beds are distinct from and older than the Carbon beds, but younger than the Bitter Creek beds. Age is provisionally considered Miocene.

80. **White**, C. A. Paleontological papers No. 6. Description of new species of invertebrate fossils from the Laramie group.

Bull. U. S. Geol. and Geog Survey Terr., vol. 4, No. 3, 1878, pp. 714, 715, 716.

80. **White**, C. A.—Continued.

Describes *Acella haldemani*, *Neritina naticiformis* from Bear River beds on Sulphur Creek; *Helix evanstonensis* from the Evanston coal beds, and *Goniobasis endlichi* from Bear River beds, 7 miles northwest of Evanston.

81. —— Paleontological Papers No. 7; on the distribution of molluscan species in the Laramie group.

Bull. U. S. Geol. and Geog. Survey Terr., vol. 4, No. 4, 1878, p. 722.

Includes "Evanston Coal Series" in the Laramie and gives list showing four species common with Judith River beds.

1879.

82. **Bannister**, H. M. Note on the age of the Laramie group or Rocky Mountain Lignitic formation.

Am. Jour. Sci., 3d ser., vol. 17, 1879, pp. 243-245.

Criticises King's statements (No. 78) regarding the Evanston locality.

83. **Gannett**, Henry. Additional lists of elevations.

Bull. U. S. Geol. and Geog. Survey Terr., vol. 5, No. 3, 1879, pp. 443-444, 447, 464.

Gives corrected elevations of stations on Union Pacific Railroad and elevations on preliminary line Evanston, Wyo., to Fort Hall, Idaho.

84. —— [Report on topographic work of Green River division for 1877, with topographic maps.]

Eleventh Ann. Rept. U. S. Geol. and Geog. Survey Terr., 1879, pp. 687, 708-710, Pls. LI, LXII.

Gives brief account of early exploration of that region, and topographic data regarding this area. Topographic maps, scale 5.5 inches to the mile, contour interval 200 feet, afterwards published in No. 95.

85. **Peale**, A. C. Report on the geology of the Green River district.

Eleventh Ann. Rept. U. S. Geol. and Geog. Survey Terr., for 1877, 1879, pp. 533-536, 538, 539, 574-576, 626, 631-632, 639, Pls LII, LIII Q-Q, LXVII.

Discussion, with topographic maps by Henry Gannett, of all the region described in this report north of T. 20 N. The broader structural features of the region—the Meridian anticline, the Rock Creek anticline, and the Absaroka fault—are recognized. Coal is reported near Oakley, at Hodges Pass (called here "Bell's Pass"), and on Twin Creek at Sage. Lists of Bear River fossils are given from east of Waterfall and at Sage.

86. —— The Laramie group of western Wyoming and adjacent regions.

Bull. U. S. Geol. and Geog. Survey Terr, vol 5, 1879, pp. 196-197.

Gives list of Bear River fossils collected near present sites of Waterfall and Sage, also published in No. 85.

87 **White,** C A. Report on paleontological field work for the season of 1877

Eleventh Ann Rept. U S Geol and Geog. Survey Terr., 1879, pp 170-171, 240-250.

Gives detailed results of examinations near Bear River City and Almy in the summer of 1877, with detailed list of fossils

88 —— Contributions to invertebrate paleontology No. 1. Cretaceous fossils of the western States and Territories

Eleventh Ann Rept. U. S. Geol. and Geog. Survey Terr , 1879, pp. 278-279 (Pl. VII, 14a), 289 (Pl III, 2a, b, c), 291 (Pl IX, 3a), 293 (Pl X, 5a), 308-309 (Pl VII, 6a, b, c)

Describes and figures four species from the Hilliard region.

89. **Wilson,** A. D. Report on primary triangulation of 1877 and 1878

Eleventh Ann Rept U S. Geol. and Geog Survey Terr for 1877, 1879, pp 654-655, 661-669.

Reports visiting Evanston, 1877, for the purpose of connecting triangulation with latitude station near Evanston established by Boundary Survey, and with triangulation station on Medicine Butte Gives results of observations, with maps

1880.

90 **White,** C. A Contributions to invertebrate paleontology No 4 Fossils of the Laramie group.

Separate, 1880 (see Am Jour Sci , vol. 25, 1883, p 208).

Twelfth Ann Rept U. S Geol. and Geog. Survey Terr , pt 1, 1883, pp 53-55, 71, 79, 82, 84, 87, 89, 91-93 (Pl XXX), 96, 102 (Pl XXX)

Discusses stratigraphy north of Evanston, Wyo Gives list of invertebrate fossils from ' coal-bearing beds near Evanston" and describes and figures numerous forms from Bear River formation on Sulphur Creek and 7 miles north of Evanston

1881.

91 **White,** C. A Descriptions of new invertebrate fossils from the Mesozoic and Cenozoic rocks of Arkansas, Wyoming, Colorado, and Utah.

Proc U. S. Nat Mus , vol 3, 1881, pp 160

Describes *Helix (Patula) sepulta* n s from coal-bearing series at Evanston, Wyo

1883.

92 **Cross,** Whitman Ores, minerals, etc., in Wyoming

Mineral Resources U S for 1882, 1883, p 759

Reports ' sulphur in Uinta Mountains, Uinta County, undeveloped. 30 miles southwest of Evanston." This is also mentioned in Min Res for 1883 and 1884, p. 864, Min. Res for 1885, p. 497, Min Res for

92 **Cross,** Whitman--Continued

1886, p 645, Min Res for 1887, p 810, and by Knight (No. 129), but without any additional details or facts

93. **Holt,** G L. Holt's new map of Wyoming Compiled by permission, from official records in United States Land Office. Frank and Fred Bond, draftsmen. Engraved and printed by G. W & C B Colton & Co. New York Scale, 12 miles to 1 inch Cheyenne, Wyo , 1883.

See note under No. 96

94. **Lesquereux,** Leo Cretaceous and Tertiary floras Contribution to the Tertiary flora of the western Territories; Part III

Rept. U. S Geol Survey Terr , vol 8, 1883, pp 127-128, 140-141 (Pl XXIII, figs 1-3a), 141-142 (Pl XXXIII, fig 44a), 144 (Pl XXIV, figs 1-2a), 154 (Pl XXVIII, fig 12), 155 (Pl XXVIII, fig 10), 155 (Pl XXXI, fig 12), 159-160 (Pl XXXII, fig 1), 163 (Pl XXXVIII, fig 7, 8), 175 (Pl XXXIV, figs 10, 11), 180 (Pl. XXXVI, figs. 6, 9), 183 (Pl. XXXVIII, fig 13), 197 (Pl XL, figs 6, 7), 199 (Pl XLIV, fig 6), 204 (Pl XL, figs 20, 21), 205, 206-212

Defines Green River group to include Wasatch, Green River, Bridger, Uinta, and White River beds Describes and figures 14 species of plants from Green River beds ' in Randolph County, Utah" (in two places given as Colorado), which Ward and Knowlton regard as meaning the headwaters of Twin Creek in Uinta County

95 **Peale,** A C., and **Gannett,** Henry [Geological and topographical] Map of western Wyoming, southeastern Idaho, and northeastern Utah Scale, 4 miles to 1 inch; contour interval, 200 feet, geology, by A. C. Peale, topography, by Henry Gannett

Twelfth Ann Rept U S Geol. and Geog Survey Terr. 1878, 1883, maps and panoramas

Used in compiling ' Geological map of portions of Wyoming, Idaho, and Utah, scale, 8 miles to 1 inch," and ' General map of area explored and mapped by Dr. F V Hayden, 1869-1880, scale, 41 03 miles to 1 inch," published by Hayden Survey

In the geology the one notable error is the mapping of the inclined Cretaceous between Bell's (now Hodges) Pass and Ham's Fork as Wasatch The geologic subdivisions mapped in this area are Carboniferous, Red Beds (Triassic), Jura-Trias, Jurassic, middle and lower Cretaceous, Fox Hills, Laramie or post-Cretaceous, Wasatch, Green River, Bridger, Quaternary drift.

96. **United States General Land Office.** Territory of Wyoming, compiled from the official records of the General Land Office and other sources under supervision of G P. Strum Scale, 15 miles to 1 inch; 1883

First publication of the results of the Woods and Boland surveys of 1881 and 1882, which were supposed to complete the subdivision of the area under discussion Shows Oregon Short Line Railroad and pro-

96. **United States General Land Office**—Cont'd.

jected road leading south from the site of Hodges Pass tunnel along the crop of the Adaville coal marked "W. I. & C. C. R. R." (Wyoming Iron and Coal Company's Railroad). Bear River is indicated as flowing south.

All the subsequent editions of the Land Office map are, so far as this area is concerned, based on exactly the same original township plats, but vary in detail according to the individual ideas of the compilers. There are also minor changes in the railroad stations and the indication of projected railroads. Editions: 1888, scale, 12 miles to 1 inch; 1892, scale, 12 miles to 1 inch; 1900, scale, 12 miles to 1 inch; 1905, scale, 12 miles to 1 inch.

97. **Ward,** Lester F. Administrative report.

Third Ann. Rept. U. S. Geol. Survey, 1883, pp. 28-29.

Reports making collections around Hodges Pass and at Bell's Fish Cliff in September, 1881.

98. **White,** C. A. A review of the nonmarine fossil Mollusca of North America.

Third Ann. Rept. U. S. Geol. Survey, 1883, pp. 440, 454, 498, Pls. VI, XX, figs. 14, 15; XXVII, fig. 38; XXVII, figs. 29-31.

Figures of fossils from Bear River and Evanston.

99. —— New molluscan forms from the Laramie and Green River groups, with discussion of some associated forms heretofore known.

Proc. U. S. Nat. Mus., vol. 5, 1883, p. 98.

Concludes *Pyrgulifera* Meek, from Bear River beds of southern Wyoming, the same genera as *Paramelania* Smith, a recent form found in Lake Tanganyiki, Africa.

100. **Williams,** Albert, jr. Coal: Wyoming.

Mineral Resources U. S. for 1882, 1883, pp. 87-89.

Yearly production of Central Pacific (Rocky Mountain Coal and Iron Company) and Union Pacific Coal Company mines at Almy from 1869-1870 to 1882. Analysis of Twin Creek coal.

1884.

101. **Cope,** E. D. The Vertebrata of the Tertiary formations of the West.

Rept. U. S. Geol. Survey Terr., vol. 3, 1884, pp. 6-10, 71-77 (Pls. V, VII, VIII, X), 84, 87-98, (Pls. VIII, XIII, XIV), 129, 134-135 (Pl. XXIII, figs. 12-13), 143-144 (Pl. XXXIII, figs. 14-16), 524, 526-530 (Pl. XXIXb, figs. 4-5, Pl. XLVII, fig. 7, Pl. XLVIII, figs. 7-14), 544-549 (Pls. XLV, XLVI, XLVII, figs. 1-6, Pl. XLVIII, figs. 1-6), 634.

Discusses Wasatch beds in this area. Describes and figures vertebrates from the Wasatch (here sometimes called Green River) beds near Evanston and fish from the Green River shales on Twin Creek, near Fossil.

102. **Gannett,** Henry. A dictionary of altitudes in the United States.

Bull. U. S. Geol. Survey No. 5, 1884, pp. 445-449.

Subsequent editions have appeared as Bulls. 76 (1891), 160 (1899), and 274 (1906).

1885.

103. **Emmons,** S. F., Geological sketch of Wyoming.

Geological sketch of the Rocky Mountain division, Tenth Census U. S., vol. 13, 1885, pp. 86-88.

104. **Ward,** Lester F. Synopsis of the Flora of the Laramie group.

Sixth Ann. Rept. U. S. Geol. Survey, 1885, pp. 422, 441, 443-514, 541, 551, 553; Pl. XXXVII, figs. 6-7; Pl. XXXIX, fig. 8; Pl. XLVI, fig. 12; Pl. XLVII, fig. 7.

Gives lists of species from Evanston beds and discusses (p 541) and figures material from Hodges Pass. Same figures, with detailed descriptions, appear in No. 112.

105. **White,** Charles A. The genus Pyrgulifera Meek, and its associates and congeners.

Am. Jour. Sci., 3d ser., vol. 29, 1885, pp. 277-280. (See No. 99.)

106. **Williams,** Albert, jr. Coal: Wyoming.

Mineral Resources U. S. for 1883 and 1884, 1885, pp. 102-114.

Gives yearly production of two companies at Almy from 1869-1870 to 1884, and Twin Creek mines for years 1882 to 1884.

Analyses of Almy and Twin Creek coals.

1886.

107. **Ashburner,** Charles A. Coal: Wyoming.

Mineral Resources U. S. for 1885, 1886, pp. 71-73.

Products of Union Pacific mines at Almy from 1869 to 1885, Central Pacific mines at Almy from 1870 to 1885, Twin Creek mines from 1882 to 1885.

108. **Aughey,** Samuel. Annual Report Territorial geologist of Wyoming for year 1885, 1886.

On p. 35 refers to oil seeps near "old Bear City and at and near Bridger," but states that he has explored this district" too imperfectly to venture a description."

109. **Stowell,** S. H. Petroleum.

Mineral Resources U. S. for 1885, 1886, p. 154.

Note on Twin Creek oil field, which was personally visited by Mr. Stowell in summer of 1885, with analysis of oil.

110. **White,** Charles A. Relation of the Laramie molluscan and fresh-water Eocene fauna to that of the succeeding fresh-water Eocene and other groups.

Bull. U. S. Geol. Survey No. 34, 1886, pp. 9-12, 23, 29, 30 (Pl. II, fig. 21).

Discusses age of Evanston coal beds and concludes that they are basal Wasatch.

1887.

111. **Chisolm,** F. F. Coal: Wyoming.

Mineral Resources U. S for 1886, 1887, pp. 375-377.

Analysis of Almy coal. Yearly production of

111. **Chisolm,** F. F.—Continued.

Union Pacific mines at Almy 1869-1886, Central Pacific mines at Almy 1870-1886, Twin Creek mines 1883-1885.

112. **Ward,** Lester F. Types of Laramie flora.

Bull. U. S. Geol. Survey No. 37, 1887, pp. 27 (Pl. X, figs. 7-8), 27 (Pl. XI, fig. 1), 30 (Pl. XIV, fig. 1), 49-50 (Pl. XLVI, fig. 11), 53-54 (Pl. XXV, fig. 4).

Describes and figures five species of plants from Hodges Pass, four of them new.

1888.

113. **Bailey,** Gilbert E. [Economic geological map of Territory of Wyoming. Scale, 12 miles to 1 inch.]

An 1888 edition of the Land Office map of the Territory of Wyoming, showing coal fields, oil fields, and mineral districts, and indorsed "Geological features from surveys by Gilbert E. Bailey, E. M., Ph. D., late geologist of Wyoming." In this area are shown "Evanston coal field," "Bear River coal field," "Hams Fork coal field," and "Sublette coal field." The outlines of these coal fields are much more accurate on this map than on Storrs's map (No. 170).

114. **Chisolm,** F. F. Coal: Wyoming.

Mineral Resources U. S. for 1887, 1888, p. 380.

Production of Union Pacific mines at Almy 1869-1887; Central Pacific, 1870-1887; Twin Creek, 1882-1885.

115. **Lesquereux,** Leo. Recent determinations of fossil plants from Kentucky, Louisiana, Oregon, California, Alaska, Greenland, etc., with descriptions of new species.

Proc. U. S. Nat. Mus., vol. 11, 1888, pp. 37-38.

Describes specimens in the National Museum which Frémont collected in 1843 on Little Muddy Fork, near Cumberland Gap, and which were originally described by Hall in 1845. He is more positive of the Oolitic character of this material than Hall (Nos. 5, 6).

116. **Ricketts,** Louis D. Annual Report of Territorial geologist of Wyoming for 1887, 1888.

Pages 9-10, 22-24, 41-43.

Gives data regarding coal mines at Almy and Twin Creek based largely on the "Mineral Resources of the United States." Discusses the oil springs at Carter and Hilliard, evidently from actual study in the field, and the oil spring on Twin Creek from report.

117. **White,** C. A. [Administrative Report Mesozoic division of Invertebrate paleontology.]

Seventh Ann. Rept. U. S. Geol. Survey, for 1885-1886, 1888, pp. 118-119.

Reports that in August, 1885, he studied the coal at Evanston and concluded that it belongs to the Wasatch group (No. 110).

1889.

118. **Ward,** Lester F. The geographical distribution of fossil plants.

Eighth Ann. Rept. U. S. Geol. Survey, for 1886-1887, pt. 2, 1889, pp. 906-908.

118. **Ward,** Lester F.—Continued.

Mentions Frémont collection on Little Muddy Creek east of Cumberland, the collection of the Hayden parties at Evanston, the material obtained by Ward at Hodges Pass, and the material described by Lesquereux from "Randolph Co., Utah."

1890.

119. **Chisolm,** F. F. Coal: Wyoming.

Mineral Resources U. S. for 1888, 1890, pp. 392-394.

Yearly coal production of two companies at Almy from 1869-1870 to 1888, together with number of men employed in 1888.

120. **Ricketts,** Louis D. Annual Report of Territorial geologist of Wyoming [for 1888 and 1889], 1890.

Pages 6-12, Table No. 4, pp. 51, 63, 65, Pl. I.

Contains detailed description of Almy mines, with sections of coal seams, based on examination made in September, 1889.

1891.

121. **Clark,** W. B. Correlation papers—Eocene.

Bull. U. S. Geol. Survey No. 83, 1891.

122. **Scudder,** Samuel H. Administrative Report for 1889-1890.

Eleventh Ann. Rept. U. S. Geol. Survey, pt. 1, 1891, p. 123.

Reports that he visited Fossil in 1889 in search of fossil insects, but that "little was obtained."

123. **White,** C. A. Correlation papers—Cretaceous.

Bull. U. S. Geol. Survey No. 82, 1891, pp. 153.

1892.

124. **Chisolm,** F. F. Coal: Wyoming, Uinta County.

Mineral Resources U. S. for 1889 and 1890, 1892, p. 264.

Gives production of the two companies at Almy from 1869-1870 to 1890.

125. **Earle,** Charles. Revision of the species of Coryphodon.

Bull. Am. Mus. Nat. Hist., vol. 4, 1892, p. 151.

126. **Stanton,** T. W. The stratigraphic position of the Bear River formation.

Am. Jour. Sci., vol. 43, 1892, pp. 98-115.

Discussion of field examination of the Bear River formation at Bear River City, on Bear River 7 miles north of Evanston, at Waterfall and Sage, and other points outside of this area, which resulted in the important determination that the Bear River formation is the lowest rather than the highest member of the fossiliferous Cretaceous of this region.

127. **White,** C. A. Administrative Report of division of Mesozoic invertebrates.

Thirteenth Ann. Rept. U. S. Geol. Survey, for 1891-1892, pt. 1, 1892, pp. 140-141.

127. **White**, C. A.—Continued.

Reports that he and Mr. T. W. Stanton worked in southwest Wyoming on the "so-called Bear River Laramie in July and August, 1891."

128. —— On the Bear River formation, a series of strata hitherto known as the Bear River Laramie.

Am. Jour. Sci., vol. 43, 1892, pp. 91-97.
Historical review in connection with Stanton's article (No. 126).

1893.

129. **Knight**, Wilbur C. Notes on the mineral resources of the State.

Bull. Wyo. Exp. Station No. 14, Oct. 1893, pp. 130, 137-139, 146-148, 154, 169, 197-198.
Contains data regarding sulphur (see No. 92), oil and coal in southern Uinta County, for the most part compiled. Gives data regarding Red Canyon and Almy, Twin Creek, and Hams Fork mines.

130. **Marsh**, O. C. Restoration of Coryphodon.
Am. Jour. Sci., 3d ser., vol. 46, 1893, p. 321, Pl. VI.
Gives historical data regarding finding of Coryphodon near Evanston and plate showing restoration of *C. hamatus*.

131. **Parker**, E. W. Coal: Wyoming, Uinta County.

Mineral Resources U. S. for 1891, 1893, pp. 354-355.
Gives yearly production of two companies at Almy from 1869-1870 to 1891.

132. —— Coal: Wyoming, Uinta County.

Mineral Resources U. S. for 1892, 1893, pp. 548-549.
Gives yearly production of two companies at Almy from 1869-1870 to 1892.

133. **Stanton**, Timothy W. The Colorado formation and its invertebrate fauna.

Bull. U. S. Geol. Survey No. 106, 1893, pp. 45, 56-57 (Pl. II, fig. 1, Pl. III, fig. 12), 67 (Pl. VIII, fig. 7), 68-69 (Pl. VIII, fig. 11), 89-91 (Pl. XX, figs. 1, 2), 99-100 (Pl. XXII, fig. 10), 101-102 (Pl. XXIII, figs. 1, 2), 110 (Pl. XXV, fig. 1), 123-124 (Pl. XXVII, figs. 7, 8), 128 (Pl. XXVIII, figs. 4, 5), 130, 149.
Describes and figures all the species found, up to that time, in the beds called in this paper the "Frontier formation," and called the "Fox Hills" by the early geologists.

1894.

134. **Hewitt**, G. C. The coal fields of Wyoming.
Mineral Resources U. S. for 1893, 1894, p. 414.
Gives brief note on Hams Fork and Bear River (Almy) fields. Regards coal as Laramie.

135. **Parker**, E. W. Coal: Wyoming, Uinta County.

Mineral Resources U. S. for 1893, 1894, p. 410.
Gives yearly production of two companies at Almy from 1869-1870 to 1893.

1895.

136 **Knight**, Wilbur C. Coal and Coal Measures of Wyoming.

Sixteenth Ann. Rept. U. S. Geol. Survey, pt. 4, 1895, pp. 208, 210-211, 212.
Gives tables by Slosson and Colburn (No. 138) and states that coal-bearing rocks are found at "Henrys Fork, Almy, Twin Creek, Hams Fork and Coalville [Cokeville]. The last four localities are probably in the same coal field, which belongs to the lower Cretaceous, and has been known as the Bear River group." This erroneous conclusion is probably based on a misinterpretation of the facts collected by Dr. Stanton (126).

137. **Parker**, E. W. Coal: Wyoming.

Sixteenth Ann. Rept. U. S. Geol. Survey, pt. 4, 1895, pp. 216-217.
Coal statistics for Uinta County for 1893 and 1894. Annual coal production for Uinta County from 1869 to 1894.

138. **Slosson**, Edwin E., and **Colburn**, L. C. The heating powers of Wyoming coal and oil.

Univ. of Wyo. Special Bull., Jan., 1895, pp. 7-11.
Gives tests and analyses of three samples of coal from Hams Fork and four from Almy.

139. **White**, C. A. The Bear River formation and its characteristic fauna.

Bull. U. S. Geol Survey No. 128, 1895. 108 pp., 11 plates.
Contains figures and descriptions of the Bear River fossils found at Hilliard, north of Evanston, at Waterfall and Sage. Embodies material given in Nos. 125 and 127

1896.

140. **Darton**, N. H. Catalogue and index of contributions to North American geology, 1732-1891.

Bull. U. S. Geol. Survey No. 127, 1896, pp. 1041-1095.

141. **Knight**, Wilbur C. [Petroleum fields of Wyoming.]

Nineteenth Ann. Rept. U. S. Geol. Survey, pt. 3, 1896, pp. 704, 706.
Condensed from paper in American Manufacturer. Gives among oil fields of State Sulphur Creek, Carter, Twin Creek, and Fossil. As the last two are the same, it is evident that he had not at this time visited this area. The Sulphur and Twin Creek oil is regarded as Laramie? and the last as Wasatch?

142. **Parker**, E. W. Coal: Wyoming.

Seventeenth Ann. Rept. U. S. Geol. Survey, pt. 3, 1896, pp. 537-538.
Coal statistics for Uinta County for 1894 and 1895. Yearly production of coal for Uinta County, 1869 to 1895.

1897.

143. **Knight,** Wilbur C. The petroleum fields of Wyoming.

Mineral Industry for 1896, 1897, pp. 442-450. Essentially the same as No. 138.

144. **Parker,** E. W. Wyoming: Coal.

Eighteenth Ann. Rept U. S. Geol. Survey, pt. 5, 1897, pp. 629-630.

Coal statistics of Uinta County for 1895 and 1896. Yearly coal production for Uinta County from 1869 to 1896.

145. **Stanton,** T. W., and **Knowlton,** F. H. [Administrative report on explorations in Wyoming by Stanton-Knowlton party in 1896.]

Eighteenth Ann. Rept. U. S. Geol. Survey for 1896-1897, 1897, pp. 63-64.

146. **Stanton,** T. W., and **Knowlton,** F. H. Stratigraphy and paleontology of the Laramie and related formations in Wyoming.

Bull. Geol. Soc. Am., vol. 8, 1897, pp. 148-149.

Gives short discussions of Evanston and Hodges Pass localities, which the authors visited in 1896. Concludes that Wasatch is unconformable on coal-bearing beds. Flora upper Laramie. Suggests that Hodges Pass material represents downward continuation of the Evanston beds.

1898.

147. **Knight,** Wilbur C. The building stones and clays of Wyoming.

Eng and Min Jour., vol. 66, 1898, pp. 546-547.

Reports sandstone quarry and brickyard at Evanston.

148. **Knowlton,** F. H. A catalogue of the Cretaceous and Tertiary plants of North America.

Bull. U. S Geol. Survey No. 152, 1898.

149. **Parker,** E. W. Coal: Wyoming.

Nineteenth Ann. Rept. U. S. Geol Survey, pt. 6, 1898, pp. 540, 541.

Coal statistics for Uinta County for 1896 and 1897. Yearly coal production for Uinta County from 1869 to 1897.

1899.

150. **Knight,** Wilbur C., and **Slosson,** E. E. The oil fields of Crook and Uinta counties, Wyoming.

Bull School of Mines, Univ. Wyoming, Petroleum Series, No. 3, 1899, pp. 11-25, 30-31, 1 map, 3 cross sections.

A hasty reconnaissance yielding in this area inaccurate and erroneous conclusions.

151. **Matthew,** W. D. A provisional classification of the fresh-water Tertiary of the West.

Bull. Am. Mus. Nat. Hist., vol. 12, 1899, pp. 33-34.

Gives location of type specimens of vertebrates from the Wasatch beds at Evanston, Wyo.

152. **Parker,** E. W. Coal: Wyoming.

Twentieth Ann. Rept. U. S. Geol. Survey, pt. 6, 1899, pp. 505, 506.

Coal statistics for Uinta County for 1897 and 1898; yearly coal production for Uinta County from 1895 to 1898.

153. **Baldwin,** H. L. [Triangulation stations, Utah-Wyoming.]

Twentieth Ann. Rept. U. S Geol. Survey, pt. 1, 1899, pp. 275-277.

Describes and gives longitude and latitude of triangulation stations at Medicine Butte and Bridger Butte, established in 1898. (See No. 161 for corrected values.)

1900.

154. **Gannett,** Henry. Boundaries of the United States and of the several States and Territories, with an outline of the history of all important changes of territory. (Second edition.)

Bull. U. S. Geol. Survey No. 171, 1900, p. 130, Pls. L, LII, LIII.

First edition published as Bull. U. S. Geol. Survey No. 13, 1885.

155. **Knight,** Wilbur C. A preliminary report on the artesian basins of Wyoming.

Bull Wyo. Univ. Exp. Station No. 45, 1900, pp. 146, 157, 160, 225-228, 245-246. Sec. XI, geologic map.

156. —— University of Wyoming reconnaissance geological map of Wyoming. Scale, 12 miles to 1 inch [1900].

Accompanying Bull Wyo. Exp. Station No. 45, 1900.

Modified in this area from King and Hayden maps, and on the whole, though very crudely drawn, a distinct advance on the geological cartography of this region. Shows the following subdivisions. Carboniferous, Triassic, Jurassic, Cretaceous, Tertiary, Eruptive The latter is a limited area south of Sage, evidently based on one of the outcrops of the Fowkes formation in Dry Hollow.

1901.

157. **Knight,** Wilbur C. The petroleum fields of Wyoming.

Eng. and Min. Jour., vol. 72, 1901, pp. 358-359, and map.

Contains map showing limited areas marked Hilliard, Carter Spring Valley and Twin Creek fields. Records one pumping well in the Carter field (?) and one pumping well in the Spring Valley field The Twin Creek oil is regarded as Laramie, the Carter as Laramie? and the Spring Valley as Bear River?.

158. **Parker,** E. W. Coal: Wyoming.

Twenty-first Ann. Rept. U. S. Geol Survey, pt. 6, 1901, pp. 515, 516.

Coal statistics for Uinta County for 1898 and 1899; yearly coal production for Uinta County from 1895 to 1899.

159. **Parker,** E. W. Coal: Wyoming, Uinta County.

Mineral Resources U. S. for 1900, 1901, pp. 455–456. Coal statistics for 1899 and 1900. Coal production 1895 to 1900.

160. **Warman,** P. C. Catalogue and index of the publications of the United States Geological Survey, 1880–1901.

Bull. U. S. Geol. Survey No. 177, 1901, pp. 851–855.

161. **Wilson,** H. M., **Renshawe,** J. M., **Douglas,** E. M., and **Goode,** R. U. Results of primary triangulation and primary traverse, fiscal year 1900–1901.

Bull. U. S. Geol. Survey No. 181, 1901, pp. 195, 196, 202.
Gives recomputed longitude and latitude values for Medicine Butte, Bridger Butte, and southwest corner stone of Wyoming. (See No. 153.)

1902.

162. **Gannett,** Henry. Origin of certain place names in the United States.

Bull. U. S. Geol. Survey No. 197, 1902.
Second edition published as Bull. No. 258, 1905.

163. **Hay,** Oliver Perry. Bibliography and catalogue of the fossil Vertebrata of North America.

Bull. U. S. Geol. Survey No. 179, 1902. 868 pages.

164. **Knight,** Wilbur C. Petroleum in Wyoming.

Proc. Wyoming Industrial Convention, 1902, pp. 42–43, 47, with small-scale text map.
Essentially the same as No. 157.

165. —— The petroleum fields of Wyoming, III. The fields of Uinta County.

Eng. and Min. Jour., vol. 73, 1902, pp. 720–722, 4 figs.
Presents geologic cross section of Hilliard, Spring Valley, and Carter and Twin Creek oil fields. Names Hilliard and Frontier formations

166. **Oliphant,** F. H. Petroleum: Wyoming.

Mineral Resources U. S. for 1901, 1902, p. 563.
Records discovery at Spring Valley and action of General Land Office.

167. **Parker,** E. W. Coal: Wyoming.

Mineral Resources U. S. for 1901, 1902, p. 448.
Coal statistics for Uinta County for 1900 and 1901.

168. **Quealy,** P. J. Coal mines and mining.

Proc. Wyoming Industrial Convention, 1902, pp. 90–91.
Gives data regarding phenomenal development of coal mines at Diamondville and Kemmerer.

169. **Storrs,** L. S. The Rocky Mountain coal fields.

Twenty-second Ann. Rept. U. S. Geol. Survey, pt. 3, 1902, pp. 444–446, Pl. XXX.
Discusses briefly "Hams Fork, Almy, and Sublette's coal fields," evidently from compiled data.

170. **Storrs,** L. S. Northern Rocky Mountain coal fields, showing Cretaceous coal-bearing areas. Scale, 40 miles to 1 inch.

Twenty-second Ann. Rept. U. S. Geol. Survey, pt. 3, 1902, Pl. XXX.
Shows "Hams Fork field" and "Sublette field" and indicates Evanston and Bear River fields. Evidently a compilation. On the whole much less accurate than No. 113.

171. **Weeks,** F. B. North American geologic formation names; bibliography, synonymy, and distribution.

Bull. U. S Geol. Survey No. 191, 1902, 448 pp.

172. —— Index to North American geology, paleontology, petrology, and mineralogy for 1892–1900, inclusive.

Bull. U. S. Geol. Survey No. 189, 1902, pp. 336–337.
Index to accompany bibliography for same period published as Bull. No. 188, which is a combination of the yearly bibliographies published as Bulls. No. 130 (1892–1893), 135 (1894), 146 (1895), 149 (1896), 156 (1897), 162 (1898), and 172 (1899), with additions for the year 1900.

173. —— Bibliography and index of North American geology, paleontology, petrography, and mineralogy for the year 1901.

Bull. U. S. Geol. Survey No. 203, 1902, pp. 44.

1903.

174. **Hufford,** V. Map of the oil field, Uinta County, Wyo. [Scale, 4 miles to 1 inch.]

Pacific Oil Reporter, vol. 4, June 6, 1903, pp. 13–14.
A crude compilation of Government land plats showing claims of certain companies.

175. **Knight,** Wilbur C. Coal fields of southern Uinta County, Wyo.

Bull. Geol. Soc. Am., vol. 13, 1903, pp. 542–544.
Names Frontier and Hilliard formations, the former containing the coals worked at Frontier, Diamondville, and Cumberland, and the latter including the shales extending from these coal-bearing beds to the coal-bearing beds containing the Adaville and Twin Creek coals.

176. **Pacific Oil Reporter.** The oil fields of Wyoming.

Pacific Oil Reporter, vol. 4, June 6, 1903, pp. 2–19.
Description of southern Uinta County field, with numerous half-tones and sketch map, by V Hufford.

177. **Richardson,** Charles O. Uinta County, Wyo., oil fields, Spring Valley district. Copyright, April 19, 1903, by Chas. O. Richardson. [Scale, 5 miles to 3 inches. Hachure topography.]

Covers area Tps. 13–17 N., Rs. 114–121 W. and is a very careful and faithful copy of the original township plats with some minor additions. It is decidedly the most accurate published map of this area.

177. **Richardson,** Charles O.—Continued.

A broad belt of color extends northeast and southwest across the map, presumably showing valuable oil territory. In margin is given diagram showing "Approximate log of the Union Pacific oil well near Spring Valley," etc.

178. **Warman,** P. C. Catalogue and index of the publications of the United States Geological Survey, 1901 to 1903.

Bull. U. S. Geol. Survey No. 215, 1903, pp. 232–233.

179. **Weeks,** F. B. Bibliography and index of North American geology, paleontology, petrology, and mineralogy for the year 1902.

Bull. U. S. Geol. Survey No. 221, 1903, p. 200.

1904.

180. **Hayford,** John F. Precise leveling from Red Desert, Wyoming, to Owyhee, Idaho.

Rept. Supt. U. S. Coast and Geodetic Survey for 1904, Appendix 6, 1904, pp. 401–430.

Gives results, with description of bench marks of line run through this area along the Union Pacific Railroad by Ralph L. Libby in May-July, 1903.

181. **Oliphant,** F. H. Petroleum: Wyoming.

Mineral Resources U. S. for 1902, 1904, pp. 563, 565. Analyses of Spring Valley petroleum by Dr. F. Salathe and Wilbur C. Knight.

182. **Parker,** E. W. Coal: Wyoming.

Mineral Resources U. S. for 1902, 1904, pp. 445–446

Coal statistics for Uinta County for 1901 and 1902.

183. —— Wyoming: Coal.

Mineral Resources U. S. for 1903, 1904, pp. 536–537.

Coal statistics for Uinta County for 1902 and 1903.

184. **Schmeckebier,** L. F. Catalogue and index of the publications of the Hayden, King, Powell, and Wheeler surveys.

Bull. U. S. Geol. Survey No. 222, 1904.

185. **Weeks,** F. B. Bibliography and index of North American geology, paleontology, petrology, and mineralogy for the year 1903.

Bull. U. S. Geol. Survey No. 240, 1904, p. 243.

1905.

186. **Hayford,** John F. Precise leveling from Red Desert, Wyoming, to Seattle, Wash., 1903–1904.

Rept. Supt. U. S. Coast and Geodetic Survey for 1905, 1905, p. 203.

Gives corrected elevations of bench marks in this region described in No. 180.

187. **Parker,** E. W. Wyoming: Coal.

Mineral Resources U. S. for 1904, 1905, pp. 575–576.

Coal statistics for Uinta County for 1903 and 1904. Coal products for Uinta County from 1900 to 1904, inclusive.

188. **Potter,** Albert F. Grazing lands, western United States (general location and area). [Scale, 37 miles to 1 inch. Portion of Land Office base of United States.]

Accompanying Grazing on the Public Lands. Extracts from the report of the Public Land Commission, Senate Doc. No. 189, 58th Cong., 3d sess., 1905. Reprinted as Bull. U. S. Forest Service, No. 62, 1905.

Represents the whole area west of Oyster Ridge except a narrow strip along Twin Creek as "winter range only." The map shows no irrigated land in this area.

189. **Schuchert,** Charles, and others. Catalogue of type and figured specimens of fossils, minerals, rocks, and ores in the department of geology, United States National Museum. Part I. Fossil Invertebrates.

Bull. U. S. Nat. Mus. No. 53, pt. 1, 1905, 704 pp.

190. **Trumbull,** L. W. A preliminary report upon the coal resources of Wyoming.

Bull. Univ. of Wyoming School of Mines No. 7, 1905, pp. 9–13, 41, 47, 87–92.

Abs. Mining Mag., vol. 13, 1906, pp. 246–248.

Production, analyses (given in No. 135), and short descriptions of Uinta County field with view of Kemmerer Coal Company's mine at Frontier.

191. —— A map of Wyoming showing the coal-bearing areas, 1905. Scale, 34.3 miles to 1 inch.

Accompanying Bull. Univ. of Wyoming School of Mines No. 7, 1905.

Map roughly shows "Cretaceous" and "Cretaceous covered with Tertiary" and certain unshaded areas for the most part clearly pre-Cretaceous. In southern Uinta County largely the same as No. 156, from which it was evidently compiled.

1906.

192. **Veatch,** A. C. Coal and oil in southern Uinta County, Wyoming.

Bull. U. S. Geol. Survey No. 285, 1906, pp. 331–353, Pls. X–XII.

Preliminary statement of results discussed in the present paper.

193. —— Age and type localities of the supposed Jurassic fossils collected north of Fort Bridger, Wyoming, by Fremont, in 1843.

Am. Jour. Sci., 4th ser., vol. 21, 1906, pp. 457–460.

194. **Veatch,** A. C., and **Schultz,** A. R. Map of coal fields of southern Uinta County, Wyoming. [Scale 1 inch to 5 miles.]

Bull. U. S. Geol. Survey No. 285, 1906, Pl. X.

195. —— Geologic map of southern Uinta County, Wyoming, showing economic data relating to oil, underground water, and copper. [Scale 1 inch to 5 miles.]

Bull. U. S. Geol. Survey No. 285, 1906, Pl. XI.

CHAPTER II.

GEOGRAPHY.

LOCATION.

With relation to political subdivisions the area discussed in this report is in the southern part of Uinta County, Wyo. Its northern and eastern boundaries lie, respectively, about 35 miles east of the western boundary of the State and 70 miles north of the southern boundary, and on the south and west sides it includes an inconsiderable portion of Utah. With relation to the globe, it extends roughly from latitude 41° to 42° N., and from longitude 110° 24′ to 111° W. of Greenwich. (See index map on Pl. III.) Precise knowledge regarding the location of several points in and near this area has been obtained by the United States Geological Survey in connection with its work on the Coalville and Hayden Peak (Utah-Wyoming) topographic sheets, and the values determined for certain points, together with descriptions of triangulation stations, are given below:

Geographic positions in southern Uinta County, Wyo.

[From observations by United States Geological Survey.[a]]

Locality.	Latitude.			Longitude.		
	°	′	″	°	′	″
Medicine Butte [b]	41	21	09.90	110	54	26.39
Bridger Butte	41	17	50.40	110	27	49.07
Milepost 314, south boundary Wyoming	40	59	51.43	110	01	49.65
Uinta-Sweetwater county line (initial point on south line of Wyoming)	40	59	51.30	110	02	54.85
Milepost 315, south boundary Wyoming	40	59	51.29	110	02	58.92
Southwest corner stone of State	40	59	53.48	111	02	56.67

[a] Twentieth Ann. Rept. U. S. Geol. Survey, pt. 1, 1899, pp. 272, 273, 275, 277; Bull. U. S. Geol. Survey No. 181, 1901, pp. 195, 196, 198, 202.

[b] The value of this point given by A. D. Wilson, of the Hayden survey, is: Latitude 41° 21′ 6.5″, longitude 110° 54′ 42.5″. Elevation 8,769 feet. The elevation, corrected according to revised elevation of Evanston, is 8,742 feet—Eleventh Ann. Rept. U. S. Geol. Survey Terr., 1877–1879, p. 661.

Medicine Butte.—Station is situated on butte of same name (also called "Almy Mountain"), a few miles east of Almy, and about 6 miles north of Evanston, Wyo.

Station mark: Copper bolt cemented in limestone rock on the summit.

Reference point: A rock monument, 3.8 feet distance, the true azimuth of which is 173°.

Bridger Butte.—This station is at the northeast corner of the butte locally known as Bridger Butte, about 4 miles west of the site of the abandoned Fort Bridger.

Station mark: Copper bolt cemented in rock set in ground.

Milepost 314 (Sweetwater County).—This point was occupied as an aid in marking a point on meridian 33° west of Washington, it being the three hundred and fourteenth milepost on the Utah-Wyoming line. It lies on high rolling ground about three-eighths of a mile west of Burnt Fork Creek.

Station mark: Aluminum tablet cemented in 500-pound water-worn granite bowlder.

Uinta-Sweetwater county line.—On the State line between Wyoming and Utah, about on meridian 33° west of Washington (the old Naval Observatory), that meridian being, according to statute, the line dividing Uinta County, Wyo., on the west, from Sweetwater County, Wyo., on the east. It falls on ground gently sloping to the north, and was established by measuring 312.14 feet eastward from milepost 315 on the line to milepost 314, and the point marked by a bronze tablet cemented in a water-worn granite bowlder. The bowlder weighs about 1,200 pounds, and projects 6 inches above ground, with a light-red surface measuring 1½ by 2 feet. It was established in the field from preliminary computations, and is 7.63 feet too far east. Elevation about 8,000 feet above sea.

This position is as near to the thirty-third meridian west of Washington as could be determined from the incomplete data at hand. It is based on positions of certain stations near Salt Lake in the transcontinental belt of triangulation run by the United States Coast and Geodetic Survey, furnished in 1896 for use of the Geological Survey before the final adjustment of the whole belt was complete. The longitudes given were west of Greenwich, and in changing them to Washington longitudes the difference between Washington and Greenwich was taken as 77° 03′ 0.60″ west, being the value given in all editions of the American Ephemeris prior to 1896.

Milepost 315.—On the Utah-Wyoming State line, and supposed to be 1 mile west of milepost 314, but in reality 32 feet greater. It stands on the side of a hill facing north and about 312 feet west of the county line between Uinta and Sweetwater counties, which line was established by measurements from this milepost and also from milepost 314.

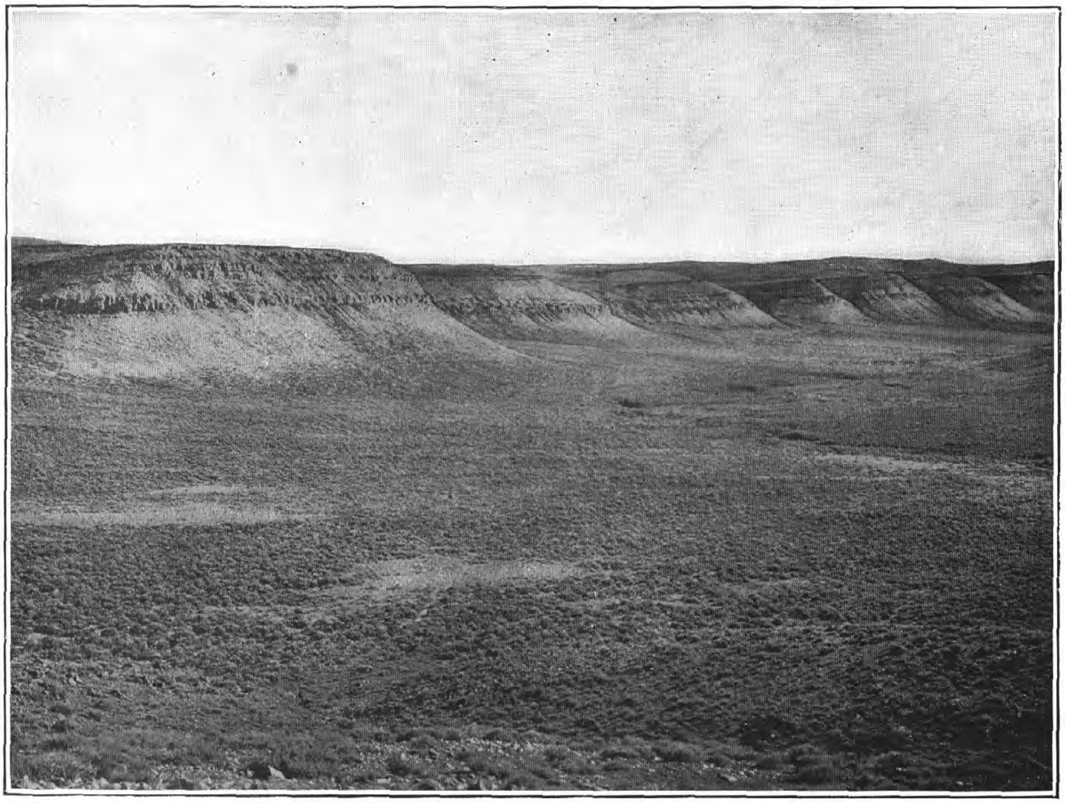
Station mark: Aluminum bolt cemented in top of 500-pound water-worn granite bowlder, marked
S. G.
"U. △ S."

Wyoming, southwest corner.—This is the stone originally set by A. V. Richards. It is a cut sandstone (red) projecting 5 feet above ground, with rocks piled 3 feet high around the base. It is also a bench mark on the level circuit from Evanston, Wyo., via Hilliard, Mill City, Weber River to Coalville, thence to Evanston.

TOPOGRAPHY AND DRAINAGE.

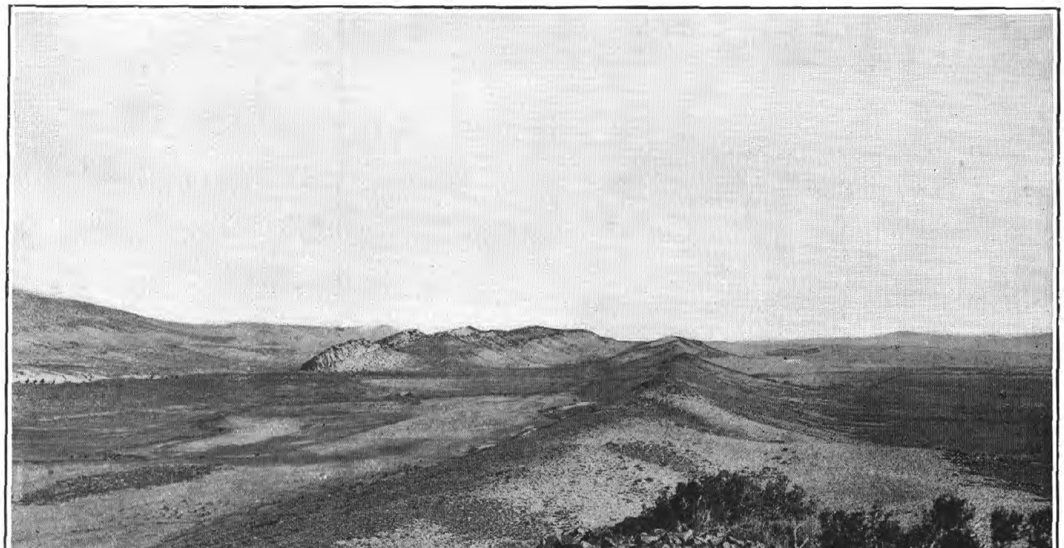
This area has an elevation ranging from 6,200 to 8,750 feet. It lies north and east of prominent mountain ranges, and on the line of the southern extension of two other ranges, which, though geologically passing through it, are of very little topographic importance because they are so deeply buried by Tertiary deposits. On the south the Uinta Mountains, an east-west range, rise to a height of over 12,000 feet. Forty miles to the west this Uinta uplift joins the north-south Wasatch Range, which is from 8,000 to 12,000 feet high. The Wyoming and Salt River ranges north of this area have elevations ranging from 7,000 to 10,000 feet. To the east is the great plain-like Green River basin, whose mean elevation is somewhat less than 7,000 feet.

The divide between the Green River and Great Salt Lake drainages separates this area into an eastern and a western half, but although the waters to the east flow directly into Green River, the streams to the west, with one exception, join Bear River and flow over 100 miles away to the north, around the northern end of the Bear River and Wasatch ranges, and then 100 miles to the south to Great Salt Lake, which they enter at a point only 50 miles west of Evanston. The Eocene deposits which characterize the Green River basin extend beyond this modern divide to the Wasatch Mountains, and this area thus lies in the southwest corner of the old Green River basin. In places the mantle of nearly horizontal Tertiary deposits laid down in this old Green River basin has been worn away and the underlying, highly inclined older beds have been exposed. The difference in the dip of these two series has resulted in the production of two very unlike types of topography.



A. TERRACE AND ESCARPMENT TOPOGRAPHY OF NEARLY HORIZONTAL EOCENE BEDS.

Five miles east of Kemmerer, Wyo., E. ½ sec. 14, T. 21 N., R. 115 W. The strata exposed in the face of the escarpment belong to the Green River Eocene.



B. HOGBACK TOPOGRAPHY OF INCLINED PRE-EOCENE BEDS.

Near Hinshaw ranch, sec. 22, T. 16 N., R. 118 W. On extreme left is hill of horizontal upper Wasatch or Knight. The pronounced thick white sandstone capping the second hogback is the Lazeart sandstone, which marks the base of the Adaville formation. On the extreme right, in the distance, is Oyster Ridge, and between is Mammoth Hollow, underlain by Hilliard shales.

CHARACTERISTIC TOPOGRAPHIC TYPES.

The upper horizontal beds produce relatively flat table-like forms, some of them bounded by escarpments of considerable length (Pl. I, *A*), and in some places where the beds dip gently in one direction the harder layers produce bench after bench in regular succession. The creek and river systems have the dendritic form that is characteristic of streams which flow over nearly horizontal rocks, and their branches show no regular arrangement. On the other hand, where the older rocks are exposed the steeply dipping harder layers produce long ridges with corresponding valleys of the same trend, the hills and valleys showing a parallel arrangement quite different from the irregular distribution of the hills and valleys of the younger series. So striking is this difference that a mere glance at the topographic features of a hill will do much to inform the observer whether or not it is underlain by the younger or older rocks.

As shown on the geologic map (Pl. III), the older rocks are exposed in two belts extending through this area, an eastern and a western one. The eastern belt, except that portion in the immediate vicinity of Hilliard, lies for the most part east of the Green River-Great Salt Lake divide, and extends from near Hilliard through Cumberland and Kemmerer and northward beyond this area. On the east side of this eastern belt there is a series of pronounced hogbacks, produced by the harder beds of the Aspen and Frontier formations, the most conspicuous of which is Oyster Ridge. This line of elevations lies on the west side of an anticline, which to the north rises and produces the Meridian and Wyoming ranges. West of these hogbacks, having the same trend, there is a broad valley, known as Mammoth Hollow, beyond which on the west lie the hogbacks of the Adaville formation (Pl. I, *B*) and of West Oyster Ridge, and, in the extreme northern part of the area, Absaroka Ridge, a southern extension of the mountain ranges to the north. The western belt lies west of the topographic divide, and is separated from the eastern belt by the central Tertiary plateau area. It extends from the point where Yellow Creek crosses the State line northward along the east side of Bear River Valley beyond the limit of the map. In it are exposed disturbed beds which represent the southern extension of the lines of disturbance that produced the Salt River Range to the north, and although there are in this western belt important elevations, like the Tunp Range, Bridger Hill, the Cockscomb, and Medicine Butte, they lack the continuity necessary to constitute a mountain range. Along the western edge of this western belt of older rocks, where Bear River cuts out a strip of northeastern Utah along the Wyoming-Utah boundary line, there is a rugged area of folded Carboniferous rocks, 2 or 3 miles wide and 15 miles long, rising 1,500 feet or more above Bear River bottoms, known as the Crawford Mountains. This is geologically the southern extension of the Sublette Range, although not at present connected with it topographically.

The divide between the Green River and Interior basins where it is crossed by the Union Pacific Railroad has been called Aspen Divide. Farther north it is part of the Aspen Plateau; still farther north it is crossed by the Oregon Short Line at Hodges Pass; and north of that point and for some distance beyond this area it is a part of Hams Fork Plateau. At the old crossing of the Union Pacific Railroad this divide has an elevation of approximately 7,500 feet. Toward the south it rises rapidly, merging into foothills of the Uinta Mountains, beyond the area studied. To the north, in the Aspen Plateau, it reaches elevations of over 8,000 feet, but at Hodges Pass it lowers to a little over 7,100 feet, north of which point it again rises and passes out of this area at an elevation of about 7,800 feet.

Immediately west of this hydrographic divide, which is for the most part located on relatively horizontal Tertiary deposits, there is a disconnected line of elevations, in places towering above the hydrographic divide. This line of elevations, distinctly connected geologically, represents the remnants of an old mountain chain, which in the geologic past was one of the important divides of this region. The remnants of this chain are found to-day in the Tunp Range along Rock Creek, 7,500 to 8,500 feet high, which distinctly rises above the present divide on Hams Fork Plateau, north of Hodges Pass tunnel; in Bridger Hill, 8,100 feet high; the Cockscomb, 8,000 feet; and Medicine Butte, 8,750 feet, which is perhaps the most striking landmark of the whole region (Pl. XIII, *A*.) The present divide is situated where there was then a deep depression, now filled with Tertiary deposits. It is not in any way connected with the structural mountain chains revealed by geologic study. A detailed knowledge of the geology and the geologic history is, however, necessary to understand fully these changes, and their complete elaboration must be held in abeyance until after the geological discussion.

The streams tributary to the Green River basin include Muddy Creek, Little Muddy Creek with its important branch Albert Creek, from the southern part of Mammoth Hollow, and Hams Fork. These are all tributary to Blacks Fork. The flow of all these streams except Hams Fork is very small, sufficient only for the irrigation of limited spots near the headwaters. Hams Fork, a clear mountain stream that contrasts sharply with the muddy creeks to the south, rises in the mountains just north of this area. It furnishes water to irrigate portions of the adjacent bottom lands (Pl. II), is utilized to float mine timbers down from the mountains to the mines at Frontier and Diamondville, and furnishes the water supply for the towns of Frontier, Kemmerer, Diamondville, Oakley, and Glencoe. It is second in importance only to Bear River. North of this Blacks Fork drainage, in the extreme northeast corner of the area here considered, are the headwaters of Slate Creek, another tributary of Green River.

Bear River, the master stream of this region, rises in the Uinta Mountains about 15 miles south of the State line, enters the area at an elevation of 7,800 feet, and leaves it at an elevation of 6,200 feet. It flows northward through bottom lands, which are generally about a mile wide, but which reach a width of 3 miles near the southern boundary of the State and perhaps as much at a point just west of the Crawford Mountains in Utah. The bottoms are almost entirely absent where the river passes through a narrow gorge just above the Union Pacific Railroad bridge, and again at the Narrows, 18 miles below Evanston. The river furnishes water to irrigate a large portion of the adjacent bottom and terrace lands and a portion of Hilliard Flat—an area extending southward from Hilliard to Bear River and representing a former course of the river—and is also the source of the water supply of Evanston. This town has a gravity system with an intake about 7 miles above its site.

With the exception of Twin Creek, the tributaries of Bear River in this area are of little importance. Yellow Creek, which joins it at Evanston, furnishes water sufficient only for the irrigation of very limited spots, as does Sulphur Spring Creek, just north of Evanston. Little Bridger Creek in its upper portion carries running water, but in dry seasons it flows but a short distance beyond its junction with Bridger Creek. Twin Creek receives considerable water from its principal tributary, Rock Creek, and this is used to irrigate a portion of the Bear River bottoms near Beckwith. The headwaters of Twin Creek yield but little water, only sufficient to irrigate relatively small areas of grass at a few points (Pl. II). Twin Creek is interesting topographically because of the great variation in the width of its valley. Where it has excavated the soft Tertiary beds in the region of Fossil it has a broad amphitheaterlike valley, 2 miles wide. This contracts to a narrow gorge where it crosses the southern extension of the Tunp Range, but again expands to a broad valley in the Tertiary deposits to the west. It is contracted by the Bear River hogback at Sage, and again by the Carboniferous rocks 2 miles to the west.

Along nearly all these streams there are several terraces. At Evanston four were observed in a height of 200 feet above the river. Southwest and west of Hilliard and in the region of Kemmerer, pronounced gravel-covered terraces occur 400 feet above the present stream level (see pp. 99–100).

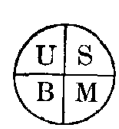
ELEVATIONS.

On the topographic base the approximate elevations in a large part of this area are indicated by contours. The elevations at the railroad stations and of the bench marks of the United States Coast and Geodetic Survey and the United States Geological Survey are given in figures, as are the elevations of railroad stations where there are no Government bench marks. Descriptions of the bench marks are given below.

RESULTS OF THE PORTION OF THE TRANSCONTINENTAL LINE OF PRECISE LEVELS BETWEEN WYUTA, UTAH, AND CARTER, WYO., BY UNITED STATES COAST AND GEODETIC SURVEY.[a]

The elevations in the following list are based upon precise lines of levels connecting Cheyenne, whose elevation was determined by interlocking precise circuits described in Appendix 3, United States Coast and Geodetic Survey for 1903, and the Pacific Ocean. The elevations are given in meters and in the reduction to feet the value of 1 meter has been taken as 3.280833 feet.[b] The leveling through this area was done by Mr. Ralph L. R. Libby, in 1903. The bench marks established are of two types:

1. A copper bolt set horizontally in stone or brick, flush with the surface, and marked on the head



Bench is intersection of cross lines.

[a] Ann. Rept. U. S. Coast and Geodetic Survey for 1904, 1904, pp. 405, 409 413–414, 419–420, 423–424; Ann. Rept. U. S. Coast and Geodetic Survey for 1905, 1905, p. 203.

[b] Ann. Rept. U. S. Coast and Geodetic Survey for 1893, p. 265.

2. Red sandstone post, 3 feet long and 6 inches square, projecting 6 inches above the ground, the top dressed and lettered

U S
□
B M

Bench is bottom of square hole.

WYUTA, UTAH, TO CARTER, WYO., ALONG TRACK OF UNION PACIFIC RAILROAD.

	Feet.
Wyuta, a square cut in stone culvert, 200 yards west of station sign, 25 feet south of Union Pacific Railroad tracks	6,731.374
Evanston, elevation of top of rail in front of railroad station	6,743.9
Evanston, in front yard of Pacific Hotel, in corner of yard, west of walk, about 19 feet south of south rail of south track; an iron post, established by United States Geological Survey	6,743.526
Evanston, in south part of court-house grounds, 6 feet north of south fence, nearly in line with east face of court-house; a tablet set in the top of a stone post, established by United States Geological Survey	6,752.244
Evanston, in stone corner post on southeast corner of railroad station, in east face, a few inches from the corner and 4 feet from the ground; copper bolt	6,747.930
Knight, elevation of top of rail in front of railroad station	7,085.3
Knight, 100 yards east of station and in line with front of section house, 150 paces south of mail stand and Union Pacific Railroad tracks; red sandstone post	7,060.581
Altamont, elevation of top of rail in front of railroad station	7,224.6
Altamont, near west entrance of "Aspen tunnel," south of tracks, opposite a point on the track halfway between station and section house, about 100 yards from track, near the right-of-way fence; red sandstone post	7,218.020
Spring Valley, elevation of top of rail in front of railroad station	7,009.1
Spring Valley, 100 feet west of water tank, 40 feet north of Union Pacific Railroad tracks; red sandstone post	7,010.686
Leroy, elevation of top of rail in front of railroad station	6,708.3
Leroy, 200 yards east of section house, in Union Pacific right of way south of tracks, 2 feet from fence, and nearly opposite the roadway that leads up the hill on the other side of the tracks; red sandstone post	6,693.176
Bridger, elevation of top of rail in front of railroad station	6,628.3
Bridger, 200 feet northwest of milepost 914, in the right of way, 80 feet north of Union Pacific Railroad tracks and north of station sign, 6 feet from fence; red sandstone post	6,628.209
Bridger, 3 miles east of; in culvert at mile-pole 911; a square cut in top stone on arch north of tracks	6,580.520
Carter, elevation of top of rail in front of railroad station	6,496.6
Carter, west of station and opposite mile-pole 904; a square cut in the south-southeast base stone of water tank	6,498.272
Carter, on west side of roadway leading up the hill, 400 feet north of Union Pacific Railroad tracks, 5 feet west of a telephone pole; red sandstone post	6,500.887

RESULTS OF SPIRIT LEVELING BY UNITED STATES GEOLOGICAL SURVEY IN AND ADJACENT TO AREA OF PLATE III.

The elevations in the following list are based upon bronze tablet in top of stone post stamped "6752 EVAN," at the south side of the court-house yard in Evanston, 6 feet north of property line and on south extension of east line of court-house. The elevation of this is now accepted as 6,752.244 feet above mean sea level, which is the adjusted elevation by the completed transcontinental precise-level line of the United States Coast and Geodetic Survey.

The leveling between and south of Evanston and Hilliard was done in 1897-98 by Edward O. Hills, levelman, and that lying east and southeast of Hilliard was done in 1901–2 by E. W. Glafcke, levelman.

The standard bench marks are now stamped with the letters "EVAN" in addition to figures showing elevation, most of them 26 feet less than the former stamping, which was based upon railroad datum.

The standard bench marks are of two types:

1. Iron posts: These are hollow, wrought-iron posts 4 feet 3 inches in length, 3.5 inches in outer diameter, split at the bottom and expanded to 10 inches to prevent the easy subsidence of the post or malicious disturbance. The reduced height is 4 feet. In the top is riveted a bronze tablet 3.9 inches in diameter, one-fourth inch thick, marked "U. S. Geological Survey B. M.," with figures showing the elevation of the top of the bench mark. These posts are buried in the earth, with only 1 foot of their length projecting above the surface. The intersection of the cross on the tablet is taken as the bench mark.

2. Tablets: Metal tablets fastened with Portland cement into rock or masonry structures, lettered in same way as the one just described.[a] The bench mark is the intersection of the cross lines.

EVANSTON SOUTHEAST TO HILLIARD, THENCE SOUTH VIA BEAR RIVER TO MOUTH OF WEST FORK.

	Feet.
Evanston, in front of Union Pacific Railroad station; top of rail	6,743.3
Evanston, south side of court-house yard; 6 feet north of property line and south of east line of court-house, in top of stone post, bronze tablet stamped "6752 EVAN"	6,752.244
Evanston, in front yard at Depot Hotel, iron post stamped "6744 EVAN"	6,743.523
Evanston, 3 miles southeast of; west side of Union Pacific Railway track, 1 foot east of wire fence, opposite milepost 952, iron post stamped "6842 EVAN"	6,841.639
Evanston, 6 miles southeast of; west side of old grade of Union Pacific Railroad, 1 foot east of fence, 200 yards south of point where bench comes down to grade, iron post stamped "6942 EVAN"	6,941.765
Evanston, 9 miles southeast of, east side of old Union Pacific Railroad, outside of fence corner, at old side track, iron post stamped "7046 EVAN"	7,045.985
Hilliard, 0.75 mile northwest of, south side of old grade of Union Pacific Railroad, iron post stamped "7179 EVAN"	7,179.063
Hilliard, 75 feet northwest of post-office; 600 feet northwest of old Union Pacific depot, iron post stamped "7246 EVAN"	7,245.524
Hilliard, 2 miles south of; opposite Bell's ranch, about one-half mile south of first cabin on west side of road, iron post stamped "7333 EVAN"	7,333.067
Hilliard, 5 miles south of post-office; east side of road opposite Robinson's ranch, iron post stamped "7491 EVAN"	7,491.349
Hilliard, 8 miles southwest of post-office; 0.1 mile from Goodman's ranch, corner of fence, 900 feet southwest of original Mill Creek channel, iron post stamped "7609 EVAN"	7,608.747
Hilliard, 11 miles southwest of post-office; 450 feet below Goodman road ford, east side of Bear River, at point where Hilliard Flat ditch reached height of east bank, iron post stamped "7773 EVAN"	7,772.676

ALONG YELLOW CREEK VALLEY NORTH FROM BOUNDARY TO EVANSTON.

Evanston, 21.5 miles south of; 150 feet west of old Emigrant road crossing of Yellow Creek, 5.5 miles northeast of southwest corner of Wyoming, iron post stamped "7218 EVAN"	7,217.590
Evanston, 16.5 miles south of; 8 feet west of wagon road along Yellow Creek, 100 feet west of creek, 1.5 miles north of J. Johnson's ranch, iron post stamped "7056 EVAN"	7,055.846

[a] Figures showing the lettering on these tablets are given in Eighteenth Ann. Rept. U. S. Geol. Survey, 1896–97, pt. 1, 1897, Pl. IV; also in Prof Paper U. S. Geol. Survey No. 46, 1906, p. 334.

	Feet.
Evanston, 13.5 miles south of; 5 feet from wagon road, 200 yards west of sheep bridge and ford across Yellow Creek, 100 feet south of road fork, iron post stamped "7009 EVAN"	7,008.836
Evanston, 10.25 miles southwest of; 20 feet northwest of northwest corner of Wright's ranch house, west of Yellow Creek, 0.5 mile west of south group of Needle Rocks, iron post stamped "6892 EVAN"	6,891.661
Evanston, 9 miles southwest of; about 3.75 miles southwest of Yellow Creek bridge, 0.25 mile northwest of Needle Rocks, iron post stamped "6869 EVAN"	6,868.629
Evanston, 5.75 miles southwest of; 15 feet west of wagon road, 150 feet southwest of bridge across Yellow Creek, iron post stamped "6747 EVAN"	6,747.371
Evanston, 2.5 miles southwest of; 1 mile east of Yellow Creek, 30 feet south of forks of road, iron post stamped "6816 EVAN"	6,815.648

YELLOW CREEK SOUTHWEST TO SOUTHWEST CORNER OF WYOMING.

Evanston, 23.25 miles south of; 2.5 miles north of southwest corner of State of Wyoming, 10 feet north of old Emigrant road, about 1.75 miles southwest of Yellow Creek crossing, summit of divide between Yellow Creek and Chalk Creek, iron post stamped "7507 EVAN"	7,506.677
Evanston, 24 miles south of; 2 miles north of southwest corner of State of Wyoming, 12 feet west of old Emigrant road, at junction with another road running north and crossing divide to west of emigrant crossing of divide, 1½ miles east of Chalk Creek, 4 miles northeast of Porcupine Mountain, iron post stamped "7069 EVAN"	7,068.914
Wyoming, at southwest corner of; 27 miles south of Evanston, in top of State corner stone, a red sandstone monument 12 by 12 inches square, bronze tablet stamped "7150 EVAN SLAK"	7,149.747

HILLIARD EAST TO ASPEN, THENCE SOUTHEAST ALONG MUDDY CREEK TO DIVIDE WEST OF MOUTH OF WEST FORK OF BLACK FORK OF GREEN RIVER.

Aspen, 500 feet west of old Union Pacific station; 56 feet north of old grade, top of cut bank, large sandstone with large mound of rock alongside, bronze tablet stamped "7387 EVAN".	7,386.661
Aspen, 3.25 miles southeast of; 60 feet north of road, 400 feet west of gate to Mouselander's Meadow, near top of small divide, sandstone ledge with mound of rock alongside, aluminum tablet stamped "7581 EVAN"	7,580.627
Aspen, 9.80 miles southeast of; top of first divide going over into East Muddy Creek, 0.75 mile southeast of ford, 40 feet east of road, west slope of divide, large bowlder with mound of rock alongside, aluminum tablet stamped "8299 EVAN"	8,299.215
Beeksteads corrals, 3.80 miles southeast of; 25 feet south of road, 400 yards north of old sawmill site, north side of creek, large bowlder, aluminum tablet stamped "8906 EVAN." (Could not be found to re-mark)	8,878.879
Divide between Muddy Creek and Blacks Fork, top of, 10 feet south of road, 300 feet west of intersection of road to Piedmont, 100 feet east of Bigelow's ditch, in large bowlder, aluminum tablet stamped "9214 EVAN"	9,213.763

PINE GROVE NORTHWESTWARD TO PIEDMONT.

Piedmont bench, 20 feet south of top of; 300 feet east of west edge of road, 75 feet east of crossing of Bigelow ditch No. 2; iron post stamped "7910 EVAN"	7,910.339
White dip pens, 300 feet east of cabin, at forks of road; 3.40 miles southeast of Piedmont, iron post stamped "7310 EVAN." (Not re-marked)	7,283.200
Piedmont, 75 feet east of old section house, 275 feet east of old station; 200 feet west of old grade of Union Pacific Railway, iron post marked "7048 EVAN"	7,048.277

PIEDMONT WEST TO ASPEN.

Piedmont, 3.1 miles west of; on county road to Aspen, 15 feet south of road, at northwest corner of Easton's pasture fence; iron post stamped "7125 EVAN"	7,125.000
Piedmont, 6.5 miles west of; 300 feet south of old railroad grade, 20 feet north of county road, top of divide between Piedmont and Aspen, iron post stamped "7490 EVAN"	7,489.615

CLIMATE.

The location of this section in the central part of the western mountain region, at an elevation of 6,000 to 8,000 feet, gives it a semiarid and semiboreal climate. That the climatic conditions here may be readily understood, the more salient features have been arranged in tables, with similar data from Salt Lake, Utah, and Des Moines, Iowa. Salt Lake was chosen as representing a well-known locality in the semiarid region noted for its agricultural products. Des Moines was chosen as a representative point in the great agricultural section west of the Mississippi, well within the belt where irrigation is not required. These three points are in about the same latitude and have the following relative elevations: Des Moines, 861 feet; Salt Lake, 4,366 feet; Evanston, 6,750 feet. As shown by the tables, the length of the growing period at Evanston is about one-half that at Des Moines and less than one-half that at Salt Lake. The maximum yearly temperature at Evanston ranges from 7° to 10° lower than that at Salt Lake and from 3° to 17° lower than that at Des Moines. The minimum yearly temperature at Evanston is from 10° to 34° below that at Salt Lake and from 2° to 21° below that at Des Moines. The average rainfall at Evanston is but 2 inches less than that at Salt Lake, but the short length of the growing season very greatly restricts the agricultural possibilities.

First and last killing frosts and length of growing period at Evanston, Wyo., Salt Lake, Utah, and Des Moines, Iowa.

[Compiled from reports of United States Weather Bureau.]

Year and station.	Last in spring.	First in autumn.	Length of growing period in days.
1898 Salt Lake	May 4	October 1	150
1898 **Evanston**	**June 4**	**September 10**	**98**
1898 Des Moines	April 4	October 4	193
1899 Salt Lake	May 3	October 24	174
1899 **Evanston**	**June 7**	**August 21**	**75**
1899 Des Moines	April 16	September 29	166
1900 Salt Lake	April 14	October 7	176
1900 **Evanston**	**May 28**	**September 17**	**112**
1900 Des Moines	April 4	October 8	187
1901 Salt Lake	April 27	November 3	190
1901 **Evanston**	**June 15**	**September 2**	**79**
1901 Des Moines	April 20	October 4	167
1902 Salt Lake	April 10	November 2	206
1902 **Evanston**	**Every month in year.**		
1902 Des Moines	April 5	October 14	193
1903 Salt Lake	April 13	October 30	200
1903 **Evanston**	**May 29**	**September 9**	**103**
1903 Des Moines	May 3	October 18	168
1904 Salt Lake	April 8	October 18	193
1904 **Evanston**	**June 25**	**August 21**	**57**
1904 Des Moines	April 21	October 21	183
1905 Salt Lake	April 1	October 10	192
1905 **Evanston**	**May 30**	**September 14**	**107**
1905 Des Moines	April 18	October 12	177
Average for period 1898-1905:			
Salt Lake	April 18	October 20	185
Evanston	**June 6** [a]	**September 4** [a]	**90**
Des Moines	April 15	October 11	179

[a] In these averages the year 1902 has been omitted. They are therefore somewhat too high.

Extremes of temperature for each month of the year at Evanston, Wyo., Salt Lake, Utah, and Des Moines, Iowa, expressed in degrees Fahrenheit.

[Compiled from Reports of United States Weather Bureau.]

Year and station.	January. Maximum.	January. Minimum.	February. Maximum.	February. Minimum.	March. Maximum.	March. Minimum.	April. Maximum.	April. Minimum.	May. Maximum.	May. Minimum.	June. Maximum.	June. Minimum.
1898 Salt Lake	48	−3	60	16	63	11	83	27	80	32	96	33
1898 **Evanston**							**74**	**23**	**70**	**24**	**89**	**29**
1898 Des Moines	43	2	48	−7	67	13	90	25	87	38	92	54
1899 Salt Lake	51	−16	51	−10	67	7	80	30	83	25	96	34
1899 **Evanston**	**38**	**−17**	**42**	**−30**	**53**	**1**	**68**	**10**	**78**	**18**	**84**	**20**
1899 Des Moines	51	−16	58	−24	65	−1	82	13	84	41	90	54
1900 Salt Lake	57	20	55	10	72	26	78	30	89	40	101	47
1900 **Evanston**	**45**	**0**	**38**	**−15**	**60**	**12**	**67**	**18**	**77**	**24**	**88**	**31**
1900 Des Moines	54	−10	45	−10	68	−4	80	28	89	35	91	50
1901 Salt Lake	51	4	55	15	65	25	79	25	88	43	90	40
1901 **Evanston**	**45**	**−14**	**50**	**−16**	**53**	**−2**	**68**	**4**	**79**	**25**	**80**	**20**
1901 Des Moines	57	−3	44	−8	66	4	84	28	88	36	98	42
1902 Salt Lake	43	−4	62	12	28	21	78	32	88	35	98	42
1902 **Evanston**	**48**	**−21**	**50**	**−4**	**42**	**−10**	**67**	**11**	**76**	**18**	**85**	**26**
1902 Des Moines	58	−16	56	−9	71	2	89	23	88	44	90	43
1903 Salt Lake	53	15	42	−4	65	11	80	25	86	33	91	54
1903 **Evanston**	**43**	**−10**	**40**	**−34**	**52**	**−11**	**69**	**8**	**76**	**19**	**82**	**33**
1903 Des Moines	49	−3	46	−13	74	15	78	29	83	31	92	43
1904 Salt Lake	48	7	66	6	63	19	78	30	83	36	92	44
1904 **Evanston**	**42**	**−8**	**49**	**−20**	**49**	**−6**	**70**	**18**	**72**	**22**	**80**	**24**
1904 Des Moines	50	−18	47	−9	63	8	74	26	85	38	87	52
1905 Salt Lake	57	14	58	−4	64	15	74	25	83	34	90	45
1905 **Evanston**	**51**	**−9**	**48**	**−38**	**55**	**7**	**65**	**15**	**74**	**21**	**79**	**29**
1905 Des Moines	45	−15	63	−26	77	11	82	21	80	38	90	51
Extremes for period 1898-1905: Salt Lake	57	−16	66	−10	72	7	83	25	89	25	101	33
Evanston	**51**	**−21**	**50**	**−38**	**60**	**−11**	**74**	**4**	**79**	**18**	**89**	**20**
Des Moines	58	−18	63	−26	77	−4	90	13	89	31	98	42

Year and station.	July. Maximum.	July. Minimum.	August. Maximum.	August. Minimum.	September. Maximum.	September. Minimum.	October. Maximum.	October. Minimum.	November. Maximum.	November. Minimum.	December. Maximum.	December. Minimum.	Year. Maximum.	Year. Minimum.
1898 Salt Lake	97	49	97	58	90	36	76	30	74	10	47	6	97	−3
1898 **Evanston**	**90**	**32**	**88**	**41**	**86**	**27**	**66**	**16**	**63**	**−6**	**42**	**−13**	**90**	**−13**
1898 Des Moines	97	54	99	51	94	45	85	26	69	−2	46	−10	99	−10
1899 Salt Lake	97	51	91	46	91	46	73	30	63	28	59	9	97	−16
1899 **Evanston**	**89**	**35**	**82**	**27**	**82**	**28**	**70**	**11**	**59**	**11**	**45**	**−23**	**89**	**−30**
1899 Des Moines	91	52	95	56	99	26	91	27	70	20	52	−5	99	−24
1900 Salt Lake	99	53	94	52	88	32	76	27	68	28	56	2	101	2
1900 **Evanston**	**92**	**34**	**87**	**32**	**82**	**18**	**66**	**10**	**58**	**0**	**43**	**−19**	**92**	**−19**
1900 Des Moines	95	54	92	61	92	40	87	33	71	11	54	−2	95	−10
1901 Salt Lake	101	49	95	56	86	39	85	36	67	29	59	11	101	4
1901 **Evanston**	**92**	**31**	**88**	**38**	**79**	**19**	**74**	**25**	**58**	**7**	**47**	**−14**	**92**	**−16**
1901 Des Moines	109	59	95	56	93	36	83	30	67	13	47	−18	109	−18
1902 Salt Lake	96	43	98	52	92	35	81	36	70	21	58	15	98	−4
1902 **Evanston**	**88**	**28**	**89**	**29**	**83**	**19**	**74**	**18**	**61**	**−2**	**50**	**−12**	**89**	**−21**
1902 Des Moines	93	54	94	50	83	35	77	31	72	24	50	−7	94	−16
1903 Salt Lake	96	46	98	48	92	37	77	32	70	17	45	14	98	−4
1903 **Evanston**	**87**	**29**	**90**	**28**	**83**	**18**	**70**	**12**	**62**	**−10**	**49**	**−3**	**90**	**−34**
1903 Des Moines	94	55	92	50	84	39	82	29	69	10	55	−9	94	−13
1904 Salt Lake	97	51	94	46	92	38	83	28	66	26	55	7	97	6
1904 **Evanston**	**86**	**33**	**87**	**27**	**85**	**24**	**73**	**20**	**61**	**9**	**51**	**−20**	**87**	**−20**
1904 Des Moines	93	54	91	49	89	38	86	28	71	13	58	−6	93	−18
1905 Salt Lake	97	53	96	55	91	37	81	25	61	18	44	7	97	−4
1905 **Evanston**	**87**	**35**	**88**	**36**	**85**	**22**	**73**	**−3**	**65**	**−7**	**47**	**−15**	**88**	**−38**
1905 Des Moines	94	54	94	58	88	50	85	24	64	3	57	1	94	−26
Extremes for period 1898-1905: Salt Lake	101	43	98	46	92	32	85	25	74	10	59	2	101	−16
Evanston	**92**	**28**	**90**	**27**	**86**	**18**	**74**	**−3**	**68**	**−10**	**51**	**−23**	**92**	**−38**
Des Moines	109	52	99	49	99	26	91	24	72	−2	58	−18	109	−26

Rainfall data for each month of the year at Evanston, Wyo., Salt Lake, Utah, and Des Moines, Iowa.

[Compiled from Reports of United States Weather Bureau.]

Year and station.	January.		February.		March.		April.		May.		June.		July.		August.		September.		October.		November.		December.		Year.	
	Precipitation.	Rainy days.	Precipitation	Rainy days.	Precipitation.	Rainy days.	Precipitation.	Rainy days.	Precipitation.	Rainy days.	Precipitation.	Rainy days.	Precipitation.	Rainy days.	Precipitation.	Rainy days.	Precipitation.	Rainy days.	Precipitation.	Rainy days.	Precipitation.	Rainy days.	Precipitation.	Rainy days.	Precipitation.	Rainy days.
	In.		*In.*		*In.*		*In.*		*In.*		*In.*		*In.*		*In.*		*In.*		*In.*		*In*		*In*		*In.*	
1898 Salt Lake	0 58	9	0.38	3	1.71	11	1.30	5	4.19	14	1.45	6	0.18	4	1.35	4	0.15	2	1.57	4	1.95	8	1.28	9	16.09	79
1898 **Evanston**	....	....	....	....	....	....	.80	4	2.83	13	1.29	6	.22	2	.97	5	.50	4	1.94	7	2.10	4	.50	2	....	....
1898 Des Moines	1.59	9	.82	7	1.35	7	2.64	11	4.22	12	6.85	13	1.86	7	1.09	5	1.91	9	3.56	10	1.87	10	.57	6	28.33	106
1899 Salt Lake	.84	8	2.98	14	2.93	16	.81	5	2.59	10	.96	4	.42	6	1.06	3	T	0	2.85	12	1.52	6	.61	11	17.57	95
1899 **Evanston**	1.48	7	2.10	10	5.12	13	1.83	4	2.09	11	.18	8	.51	4	.73	5	.04	1	2.87	0	.87	0	1.75	7	19.59	65
1899 Des Moines	.29	5	.57	4	1.04	8	2.22	9	6.71	16	3.53	10	3.20	9	3.53	9	1.17	3	.56	5	1.76	7	2.12	9	26.73	94
1900 Salt Lake	.44	4	1.30	9	.33	2	2.91	14	.44	4	.08	3	.32	3	.72	3	1.44	4	1.99	7	1.40	8	.16	1	11.53	62
1900 **Evanston**	.30	1	1.33	9	.11	1	2.28	14	.85	8	.80	1	.37	8	.52	3	1.60	6	1.80	6	2.13	8	.85	2	11.48	62
1900 Des Moines	.20	3	.50	6	3.07	7	3.82	10	4.76	14	4.89	7	5.15	12	8.02	9	3.66	9	3.08	7	.96	7	.35	7	38.46	98
1901 Salt Lake	.95	5	1.77	12	2.48	9	.87	6	4.27	7	.49	2	.31	2	1.22	11	.66	1	.98	5	.92	5	1.16	14	16.08	79
1901 **Evanston**	.53	4	1.82	5	.86	5	1.28	6	1.97	6	.22	2	.82	2	1.00	7	.13	1	1.82	10	.75	2	1.81	7	13.01	57
1901 Des Moines	1 01	5	1.11	6	3.02	11	2.26	6	1.40	5	2.41	9	1.72	4	.67	7	2.60	8	2.14	5	.40	1	1.03	9	19.77	76
1902 Salt Lake	.80	5	1.17	8	1.22	12	3.69	9	.33	8	.37	4	.56	4	.15	2	.05	2	.52	4	1.24	8	1.31	9	11.41	75
1902 **Evanston**	.57	8	.73	5	1.24	9	1.86	7	1.25	10	.76	2	1.08	6	.21	3	1.00	3	.40	6	.58	5	.84	6	10.52	65
1902 Des Moines	91	6	.52	7	1.15	10	1.55	6	4.69	14	7.27	17	5.95	13	7.82	13	5.03	8	3.70	8	1.65	9	1.77	10	42.01	121
1903 Salt Lake	2 11	11	.82	9	1.35	5	1.11	8	3.55	9	.74	2	.14	1	.43	5	.84	7	.81	6	2.21	8	.51	6	14.62	77
1903 **Evanston**	2.14	6	.80	6	.44	2	1.22	7	1.51	8	.19	5	1.18	5	.05	1	.76	8	.87	8	1.62	7	.30	4	11.08	67
1903 Des Moines	.20	5	1.12	6	1 00	11	1.64	9	10.64	20	3.06	12	3.62	10	6.72	13	1.62	12	1.32	6	.31	2	.09	3	31.43	109
1904 Salt Lake	1.45	12	2.25	14	3.99	18	2.20	7	3.08	8	.27	4	.59	4	.28	6	.12	2	1.18	8	.00	0	.90	8	16.31	91
1904 **Evanston**	.53	6	1.56	10	2.60	14	1.13	5	2.88	7	.80	6	.47	4	1.91	9	.05	1	1.23	6	.00	0	.53	3	13.69	71
1904 Des Moines	1.22	8	.22	6	1.20	10	5.48	9	3.16	9	2.08	10	6.94	11	2.60	7	1.95	10	1.50	10	.06	1	2.02	6	28.43	97
1905 Salt Lake	.65	8	1.22	10	2.62	15	1.70	16	2.74	12	.23	13	.62	2	.58	3	2.07	10	.24	4	.73	4	.83	8	14.23	89
1905 **Evanston**	.27	4	.45	4	1.72	11	1.71	9	.86	11	.32	3	.84	3	.71	8	1.48	7	.30	3	.15	1	.32	3	9.18	67
1905 Des Moines	1.08	12	1.06	9	2.16	10	3.29	11	4.44	15	5.73	12	4.53	10	5.21	13	3.47	10	3.64	8	2.34	5	.55	5	37.50	120
Average for period 1898–1905:																										
Salt Lake	.99	7	1.49	9	2.09	11	1.83	8	2.66	9	.59	4	.40	3	.72	5	.67	4	1.27	6	1.24	6	.85	8	14.85	80
Evanston	.80	4	1.22	7	1.70	8	1.47	7	1.75	9	.47	4	.65	4	.72	5	.70	4	1.34	6	1.02	3	.80	4	12.64	65
Des Moines	.81	6	.74	6	1.75	9	2.87	9	5.00	13	4.48	11	4.12	8	4.45	10	2.68	9	2.44	7	1.17	8	1.06	7	31.57	103

COMMON PLANTS AND ANIMALS.

As shown by the climatic table, the general conditions here are essentially semiarid, and the common vegetation is that which is characteristic of the semiarid regions of the West—the never ending sagebush (*Artemisia*) and its associated plants. The general character of the vegetation of this country is well shown in the views accompanying this report. In Pls. I, *A*, and V, *B*, the most evident plant is the sagebush, but there is a sparse amount of grass between the individual bushes. Pl. XXII, *B*, shows, in addition to the sagebush, a few clumps of hawthorn bushes, and, in the foreground, near the head of a deep ravine where there is a little water seep, a clump of quaking aspen, or "quakin' asp." In Pl. I, *B*, a few clumps of greasewood show in the foreground, and on the second pronounced hogback and the hill to the extreme left there are a few clumps of rock cedar. Rock cedar is well shown also in Pl. XIII, *B*.

In the extreme southeast corner of this area, in the foothills of the Uinta Mountains, there is some small timber representing the northern extension of the evergreen forests of the Uinta Mountains, and again in the northern extremity of the area, along Rock Creek and on Absaroka Ridge, there are occasional outliers of the forests which cover the mountains to the north.

The economic value of this natural vegetation at present may be briefly summarized as follows: Along Bear River and Hams Fork and near important springs there are patches of wild grass which is occasionally cut for hay. A sparse amount of grass, sufficient with the sagebush for a relatively poor range, is found over the hills. It is reported that this hill grass was formerly abundant, but with the overstocking of the range and the introduction of sheep it has been almost destroyed. If properly protected it would, however, in most of the area, recover its former value. Rock cedar grows sparingly over much of the area and is cut for fence posts and firewood. Quaking aspen is found in limited spots, generally near the head or on the sides of deep valleys, where there are spring seepages, and cottonwood occurs on some of the waterways. These trees have been largely cut away and only a few small poles remain. Logs and timbers, except those shipped in by rail, are obtainable only in the Uinta Mountains or in the southern extension of the Salt River and Wyoming ranges.

The large game has been for the most part killed or driven out of this area. A few deer and antelope were, however, seen by this party in the summer of 1905. Sage chickens or sage grouse are common, and at times ducks are abundant along the waterways. Fish are common in Hams Fork and Bear River, and a few small trout were seen in Rock Creek. Rabbits, both common and jack, gophers, kangaroo rats, and badgers are everywhere, and coyotes are by no means rare. Several beaver and two new beaver dams were seen on Hams Fork, a family of mink was observed near the Cumberland reservoir, and two porcupines were encountered in the Crawford Mountains

IRRIGATION AND CROPS.

Because of the small amount of rainfall the land in this area is of value for farming only when irrigated. The amount of water available for irrigation is, however, very limited. It is practically all appropriated, and, with the exception of

IRRIGATED AND IRRIGABLE LANDS IN A PORTION OF SOUTHWESTERN WYOMING

BY A. C. VEATCH, 1906

Scale
0 1 2 3 4 5 6 7 8 9 10 miles

Irrigation canals and ditches

Areas irrigated in 1905

Areas which will probably be irrigated

certain evident areas in the bottom lands which will undoubtedly be irrigated, there seems little chance of greatly increasing the reclaimed area. The land now irrigated, as well as all that which can probably be irrigated with the water now in sight, is shown on Pl. II. From this map it will be seen that the irrigable lands represent an extremely small proportion of the whole—roughly about 6 per cent, or 132 square miles out of 2,027 square miles. Of this amount only about one-half is now irrigated. The possible irrigation of Yellow Creek Valley is indicated, not because water is available under present conditions, but because it seems practicable to irrigate this area by building storage reservoirs on the headwaters of Bear River. Whether this would prove a remunerative undertaking could be determined only after an exhaustive examination. There appears to be no important difficulty in the way of leading the water over the low divide crossed by the Emigrant road. Similarly water may perhaps be obtained to irrigate the whole of Hilliard Flat and a portion of the lowland along Willow Creek to the east. A storage reservoir built at the Narrows, where there is a favorable dam site, would supply water to irrigate the lower part of Dry Hollow, but the area reclaimed would be rather small and there would be some difficulty in determining and assessing for the good which might accrue to the farmers in Bear River bottom below the dam site, who do not now have sufficient water during the irrigation season.

The very short length of the growing period at this place, as shown in the climatic tables on page 41, ranging from fifty-seven [a] to one hundred and twelve days in the last eight years, restricts the crops which it is possible to raise on these irrigated lands. The common crops are wild-grass hay, alfalfa, oats, and potatoes. Wheat has been raised at a few points, and in 1905 experiments were being conducted with sugar beets.

GRAZING.

The products of these irrigated areas are for the most part utilized in feeding stock. The area is in greater part agriculturally valuable only as grazing land, and as a whole is distinctly a stock-raising country, in which most of the farming is only a necessary accessory to stock raising. The free range has here, as at other points in the West, had an important influence on stock raising, and the gradual introduction of sheep has here, as elsewhere, proved a serious menace to the horse and cattle men, resulting in a great overstocking and serious depreciation of the range. Many stock men have recently acquired large holdings of railroad lands, [b] and by posting trespass notices have practically preempted to themselves the intervening Government sections, since it is considered practically impossible to use the Government sections without trespassing upon the odd sections purchased from the railroad. It is thus held locally that the purchase of a number of sections of railroad lands gives the buyer exclusive control of almost twice that much range. Beyond the northern limit of the railroad grant the old plan of controlling the free range by acquiring the water has been tried to some extent. In this area beyond the railroad lands the larger stock men have agreed on certain division lines of the range. Thus it was stated that Bridger and Cottonwood creeks, on which there are a number of important

[a] In 1902 the minimum temperature for all the summer months was below 32° F.
[b] The Union Pacific Railroad was granted every odd section of land for 20 miles on each side of the track in this area.

springs and very good grazing, are controlled by certain cattle and horse interests and that no sheep are allowed on them. This area is open Government land, on which no entries of any kind have been made.

Although the winters are severe, this whole area is regarded as an all-year range for cattle and horses. The sheep men use it for the most part only in the spring during the lambing season and for a limited time in the autumn.

RESOURCES.

As has been pointed out above, this section is to be regarded as essentially a stock-raising country, with a fair to poor range and very severe winters. The range, never very good, has been seriously impaired by overstocking. Farming in this region is limited in area and in number of crops by the climatic conditions, and is for the most part a mere accessory to stock raising. At the coal-mining towns the writer found oats and hay, the only important agricultural products of this region, being shipped in from the outside. The agricultural value of the land ranges from 50 cents to $1 per acre for grazing land and is about $10 per acre for bottom land with good water rights. The railroad facilities are as good as those in many other parts of the West where lands with good water rights are worth much more, and the values represent the true low farming worth of this land. The great wealth of this section is in its coal fields, which are described at length in the chapter on economic geology, page 113.

TOWNS AND VILLAGES.

The first settlement in this general region was at Fort Bridger, where a trading post was established on Blacks Fork by Capt. James Bridger and Louis Vasquez, of the Rocky Mountain Fur Company, in 1837. Here there was abundant water for irrigation and good broad bottoms covered with natural grass. The locality was chosen after many years trapping in this section and was, therefore, located on the natural routes of travel. It thus became an important point on the early Emigrant road to Salt Lake and California and later on the overland stage route. During the early Utah troubles, "the Utah invasion," it was occupied by the United States Army and continued a military post for many years. At the time of the building of the Union Pacific Railroad it was the principal settlement in this general region, and it remains to-day one of the most important agricultural localities in Uinta County.

With the building of the Union Pacific Railroad in 1868–69 many new settlements were established. A number of these were only temporary construction camps, like old Bear River City; others have persisted to this day. The principal town was naturally built at the site of Evanston, where there was an ample water supply and a considerable area of bottom land and, most important of all, very valuable coal deposits, which for many years supplied the fuel for the greater part of the transcontinental railroad line west of Evanston. Railroad shops were naturally built at this point, and Evanston quickly became an important town. At the zenith of its coal development there was in Evanston and the near-by tributary coal towns, Almy and Red Canyon,[a] a population of over 5,000. When extensive coal mining at the neighboring coal mines ceased, as it did about 1900, Evanston was so firmly established that even the cessation of the industry which made it did not rob it of its supremacy. It is still the business center of this section, has two banks, a new stone Federal building, and Carnegie library, two brick school buildings, and the State asylum for the insane. It is a division point on the railroad, with large shops and railroad ice houses, which are filled each winter from Bear River. The present population is approximately 2,750.

Hilliard was the second town of importance in this region immediately after the construction of the railroad. A large timber flume was constructed by the Hilliard Lumber Company up Hilliard Flat into the foothills of the Uinta Mountains, beyond the State line, and large sawmills erected. The building of the Aspen cut-off has left this town without a railroad, and its present population is but a few families. For years a considerable territory along the railroad has been supplied with charcoal from this point, and there are still several charcoal kilns operated here, the product of which is hauled by wagons to Altamont.

At Carter a small settlement sprang up, as this was the railroad point for Fort Bridger and for a considerable territory to the north. A stage line now runs south from this point to Fort Bridger and Henry's Fork and north to Cumberland. Trade naturally tributary to this point has been cut off by the building of the Oregon Short Line, and the settlement is now of much less importance than formerly.

With the building of the Oregon Short Line in 1881–82 settlements were made at Hams Fork, Fossil, and Twin Creek. Hams Fork was the early shipping point for the upper Hams Fork basin, but has been abandoned since the growth of Kemmerer. Twin Creek was a coal-mine town of several hundred which had no excuse for existing after the abandonment of the mines, and there is nothing there to-day to indicate a town but a few stone and brick foundations. A town was also built at Adaville mine, but was soon abandoned. Fossil, from a combination of causes, has developed into a town of perhaps 100. The railroad must maintain a tank at this point to supply water for the extra engines needed to help heavy freights over the Hodges Pass divide. It is a natural shipping point, and was boomed slightly by the attempts to develop the Fossil oil field during the last excitement. Sillem is another coal settlement which has entirely disappeared. This antedated the railroad, and all the bricks used in the construction of coke ovens, which still remain, are reported to have been hauled 40 miles from Evanston. The only houses at this point now are the railroad buildings at the station of Sage.

The valuable coal beds which outcrop just west of Oyster Ridge have caused several towns to be built along it in the last ten years—Diamondville, Oakley, Frontier, Kemmerer, Glencoe, Cumberland No. 1, and Cumberland No. 2. All these towns except Kemmerer are coal-mining towns—"company towns"—pure and simple. Their population varies with the demand for coal and the energy with which the mines are worked, but was reported on January 1, 1906, as follows:

[a] These two towns really formed a continuous settlement, but were separate post-offices, because their mines were operated by different companies, who were thus individually benefited by the postal regulations.

Population of coal towns in Uinta County, Wyo.

Diamondville	840
Oakley	500
Frontier	1,200
Glencoe	[a] 450
Cumberland No. 1	1,300
Cumberland No. 2	1,000

Kemmerer is something more than a coal town. It has natural advantages of location similar to those of Evanston, and is second in importance only to that place, although its population on January 1, 1906, was only about 700. It is a division point on the railroad, with extensive yards and a roundhouse. It has a bank and hotel, built of local sandstone, a large school, and several large mercantile establishments.

With the building of the Aspen cut-off in 1900, the Union Pacific Coal Company opened a mine at Spring Valley and built a regular company mine town. This mine was abandoned in the spring of 1905 and all the company buildings were removed. The town now consists of three or four buildings besides the station and section house of the railroad company.

In southern Uinta County there are thus two important towns, Evanston and Kemmerer, favorably located and containing considerable railroad improvements, which, though owing their present importance largely to coal mining, are yet something more than coal towns. The other principal settlements of the region at present—Frontier, Diamondville, Oakley, Glencoe, and the two Cumberlands—are regular coal-mining towns, and will when the mines are abandoned suffer the fate of Twin Creek, Spring Valley, and Almy.

[a] In summer of 1905 the population of Glencoe was between 50 and 100, but the mine was then shut down.

CHAPTER III.

STRATIGRAPHIC GEOLOGY.

INTRODUCTION.

The oldest rocks exposed in this area are of Pennsylvanian or Upper Carboniferous age. From this time until late Cretaceous there was no profound disturbance. The strata, so far as can be seen, are entirely conformable and the series is complete, but the absence of beds found in other portions of the Rocky Mountains suggests that there were land periods during this interval, produced by broad orographic movements without pronounced deformation in this area. In late Cretaceous time the vast thickness of beds deposited during the Carboniferous, Triassic, Jurassic, and Cretaceous periods was profoundly faulted, folded, and eroded. This period of disturbance was succeeded by one of shallow fresh-water deposition, during which a series of beds, coal-bearing and conglomeratic near the base, were deposited on the eroded edges of the older rocks. This second epoch of deposition was closed by a period of volcanic activity, when beds of volcanic ash were deposited in parts of this area. This volcanic activity culminated in orographic movements, acting here along lines of disturbance determined by the initial late Cretaceous revolution, and the deposits of the second series were faulted, folded, and eroded, though by no means so profoundly as the first. In the succeeding deposition thick beds containing fresh-water and land forms accumulated to a large degree in lake basins. After these beds had been laid down there was a long epoch of erosion, which was succeeded by a time when an extensive gravel sheet was spread over this region by water action. From this gravel-covered plain the present topographic features have been developed in late Quaternary time almost solely by erosion. This erosion, as pointed out in the discussion of topography (pp. 34–35), has in places cut away the younger beds, and thus enabled geologists to examine the older strata and to determine the succession and relation of the beds underlying this region. These strata are given in the accompanying table, and are treated in detail, beginning with the oldest, in the succeeding discussion.

CARBONIFEROUS.

WEBER QUARTZITE.

The oldest rocks in this area occur along Rock Creek. They consist of gray and white quartzitic sandstones, often considerably brecciated, and are exposed along the rather uneven crest of a sharp, and in places overturned, anticline.

The field work of Doctor Schultz in 1906, northward of this area, showed these beds to be underlain by Mississippian limestone, and the stratigraphic position of this quartzitic sandstone is, therefore, that of the Weber quartzite, which has been recognized as such in the near-by section at Cokeville by Mr. F. B. Weeks. Indeed, the reference of this quartzitic sandstone to the Weber is entirely due to Mr. Weeks's suggestion in the matter, which carries great weight because of his intimate knowledge of the Paleozoic section of this portion of the Rocky Mountain region.

PARK CITY FORMATION.[a]

Overlying the Weber quartzite at this locality, and in an earlier report[b] included with it, is a series of very arenaceous thin-bedded limestones which, from its stratigraphic position, approximately represents the upper coal measures limestone of the Fortieth Parallel Survey. No fossils were found in these beds other than a few *Lingula*, which occur in the uppermost layers. The best exposure of this formation occurs near the mouth of Sheep Canyon immediately west of the locality shown in Pl. V, *B*. The thickness of the formation was not accurately determined in this section, but on the east side of Absaroka Ridge, 12 miles north of the north end of Pl. III, Doctor Schultz in the summer of 1906 found it to be 1,000 feet thick.

WOODSIDE FORMATION.[a]

The Woodside formation consists of red sandstones and sandy shales, typically exposed in Sheep Canyon and along the road on Rock Creek just north of Sheep Canyon. The formation is here about 500 feet thick and is limited below by the sandy limestones just described and above by the fossiliferous limestones of the Thaynes formation (Pl. IV, section C). These beds were not seen at the western end of Watercress Canyon, 3½ miles above Sheep Canyon, because they have here been cut out by a slight fault (Pl. IV, *B*). This formation was found by Doctor Schultz in the summer of 1906 on the east side of Absaroka Ridge, where it has a thickness ranging from 300 to 500 feet.

THAYNES FORMATION.[a]

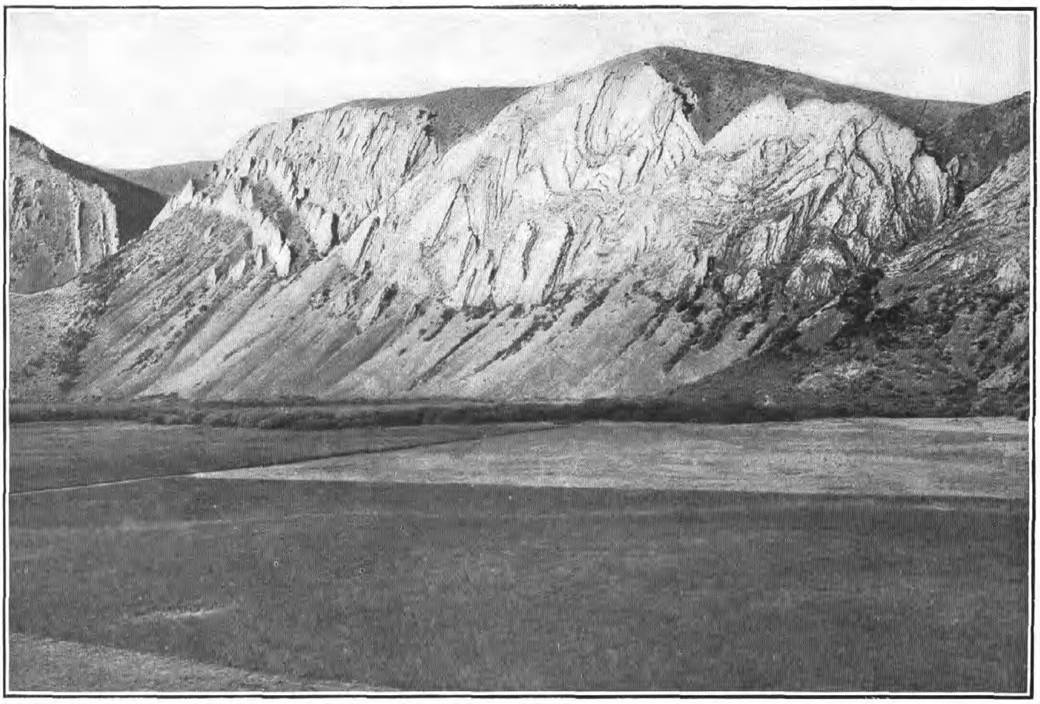
The Thaynes formation is composed of very fossiliferous gray limestones and thin-bedded yellow sandstones and is here exposed on the east and west sides and around the southern end of a steeply southward-pitching anticline, which is in places somewhat overturned (Pl. IV, section C, and Pl. V).

The same beds were found on the east side of Absaroka Ridge and in a limited, very much disturbed exposure northwest of Reservoir Gap on Muddy Creek (Pl. III and Pl. IV, section E).

---

[a] This formation, as well as the Woodside and Thaynes, has been named by Mr. J. M. Boutwell from a locality near Park City, Utah, where it is extensively exposed and where it has been exhaustively studied by Mr. Boutwell in connection with an investigation of the Park City mining district. A preliminary report on the stratigraphy of this Park City area, in which this formation is named and found, will be published in the Journal of Geology, vol. 15, 1907. A complete report will subsequently be published by the Survey as a professional paper.

[b] Bull. U. S. Geol. Survey No. 285, 1906, p. 334. "Gray to white sandstones sometimes calcareous and often brecciated." The expression "sometimes calcareous" refers only to the upper portion of the beds described or to the portion here separated as the Park City formation.



A. EAST SIDE OF ROCK CREEK AT PORTER RANCH, 1 MILE NORTH OF NUGGET STATION, WYOMING.

Thin-bedded fossiliferous limestone. These beds here occur on the eastern flank of a slightly overturned anticline. The view also shows the vegetation of this region, the barren uplands covered sparingly with sagebrush, the willow fringe along Rock Creek, and in the foreground the irrigated meadow of wild grass partially mowed.

B. EAST SIDE OF ROCK CREEK, NORTH SIDE OF SHEEP CANYON, 3 MILES NORTH OF NUGGET STATION, WYOMING.

Thin-bedded fossiliferous limestone. The vertical limestone in the center yielded the fossils listed from Sheep Canyon. The Woodside red beds occur just below this layer to the left. Note the hillside covered with sage and haw bushes.

OUTCROPS OF THAYNES FORMATION.

FOSSILS.

The fossils collected at several localities have been studied by Doctor Girty, who has furnished the following list of species from the Rock Creek region:

Two miles southeast of Nugget station, in SE. ¼ SW ¼ sec. 15, T. 21 N., R. 118 W.

Near top of formation.

Aviculipecten weberensis.
Aviculipecten curtocardinalis.
Edmondia aff. E. nebraskensis.
Bakewellia ? sp.

Hill immediately northeast of Nugget station.

Near top of formation.

Lingula sp.
Aviculipecten parvulus.
Aviculipecten occidaneus.
Aviculipecten sp.
Aviculipecten ? (Amusium ? sp.)
Myalina permiana.
Myalina sp.
Schizodus ovatus.
Myacites inconspicuus ?
Sedgwickia concava.
Naticopsis sp.
Bakewellia ? sp.

Three miles north of Nugget station in Sheep Canyon, in NW. ¼ NW. ¼ sec. 28, T. 22 N., R. 118 W.

At base of formation.

Aviculipecten parvulus.
Aviculipecten near curtocardinalis.
Aviculipecten near A. interlineatus.
Aviculipecten weberensis.
Myalina permiana ?

Six and one-half miles north of Nugget station on hill west of Watercress Canyon.

A. About 600 feet from base of formation.

Aviculipecten curtocardinalis.
Aviculipecten sp.

B. 950 feet from base of formation.

Seminula ? sp.
Aviculipecten parvulus ?
Aviculipecten 2 sp.
Bakewellia ? sp.

C. 1,550 feet from base of formation.

Aviculipecten weberensis ?
Bakewellia ? sp.
Schizodus sp.
Sedgwickia concava.

D. 1,850 feet from base of formation.

Aviculipecten sp.
Myalina permiana.
Bakewellia ? sp.
Schizodus ovatus.

Seven and one-half miles north of Nugget, at fork of Rock Creek cut, in center of sec. 32, T. 23 N., R. 118 W.

Pugnax, near P. utah.
Terebratula (N. gen.?) n. sp.
Aviculipecten curticardinalis.
Aviculipecten parvulus.
Myalina permiana.

Ten miles north of Nugget, on Rock Creek, in sec. 29, T. 23 N., R. 118 W.

Aviculipecten sp.
Myalina permiana.

In addition to this material a small lot, collected by Mr. Schultz, supposedly near the northwest corner of sec. 3, T. 21 N., R. 118 W., was found to contain *Aviculipecten curtocardinalis*, *Myalina permiana*, and *Aviculipecten* sp., together with characteristic Jurassic forms found in the Twin Creek formation. A fault had been located near this point on the field maps and it was supposed at first that the fossils were perhaps collected on both sides of a faulted zone, more complex than had been originally supposed.[a] A careful consideration of the field notes made at this point, together with those covering adjacent sections, has led to the conclusion that this supposed fault is merely an overturned syncline, and in view of the possibility that material collected in the Thaynes formation just west of the point given on the label was mixed with that found in the Twin Creek beds, it has not been thought advisable to show on the sections the complexity of faulting which this association, if correct, would involve. The following material has been identified by Doctor Girty from localities near Cumberland reservoir and in Absaroka Ridge.

Seven miles west of Cumberland, in NW. ¼ sec. 30, T. 19 N., R. 117 W.

Aviculipecten curtocardinalis.	Myalina permiana.
Aviculipecten sp.	

East side of Absaroka Ridge, in SW. ¼ NW. ¼ sec. 16, T. 23 N., R. 116 W.

Lingula sp.	Aviculipecten occidaneus.
Aviculipecten weberensis.	Schizodus ovatus.
Aviculipecten curtocardinalis.	Goniatites ? sp.

Doctor Girty adds the following discussion of this material:

All these collections belong to the same faunal group and clearly represent the horizon which is called Permo-Carboniferous in the account of the geology of the fortieth parallel. This fauna is to a considerable extent undescribed. *Aviculipecten curtocardinalis*, *Aviculipecten weberensis*, *Aviculipecten parvulus*, *Aviculipecten occidaneus*, *Sedgwickia concava*, and *Myacites inconspicuus* have been described from these beds, and *Myalina permiana* and *Myalina aviculoides* identified, probably incorrectly, from them. It will be clear from consulting the foregoing lists that all or nearly all of these species have been found in Mr. Veatch's material, and there can be no question that they indicate an extension into Wyoming of the Permo-Carboniferous of the Wasatch Range, which in its extension toward the southwest is probably to be correlated with the Permian of Walcott's Grand Canyon section.

Several of these characteristic fossils are shown on Pl. VI.

This is the first time that this fauna has been recognized in this region. Doctor Peale, in 1877, collected from these beds on the hill immediately west of the mouth of Sheep Canyon, and the material was referred to Dr. C. A. White, who reported[b] the following Jurassic forms, which caused Doctor Peale to map this outcrop as Jurassic:

Eumicrotis curta?	Myacites?
Myalina whitei?	Aviculopectén idahoensis?
Modiola (Volsella)?	

These are all doubtful identifications, and both Doctors Stanton and Girty are of the opinion that the original specimens were Permo-Carboniferous forms.

[a] The character of the fault supposed to exist at this point, as represented before reports on these collections were received, in Pl. XII, Bulletin No. 285, would not bring up the Thaynes formation at this point.

[b] Eleventh Ann. Rept. U. S. Geol. and Geog. Survey Terr. for 1877, 1879, pp. 575, 626.

Stems of *Pentacrinus* are common throughout these beds, and as they closely resemble *Pentacrinus asteriscus*, which has been repeatedly published as a characteristic Jurassic form, care must be taken not to confuse them. Five-sided crinoid stems are more common in this region in the Thaynes formation than in the Twin Creek beds.

UNDIFFERENTIATED CARBONIFEROUS.

IN ABSAROKA RIDGE.

On the east side of Absaroka Ridge a small area has been indicated on Pl. III as undifferentiated Carboniferous. The area so colored probably contains outcrops of Park City formation and Woodside formation, but they are not separated here, as this section was not studied in detail.

IN CRAWFORD MOUNTAINS.

Crawford Mountains consist of a very rugged mass of cherty limestones, and represents in its broader features a somewhat broken anticline. The exposures in the Crawford Mountains and their northern extension, the Beckwith Hills, were not examined in detail, because not connected with any of the economic problems studied in this area.

They were crossed on horseback in two places, and the western border was skirted rapidly. Fig. 3 shows the general outline of the main mountain mass, whose northern extension only is shown on the geologic map of this area (Pl. III). Fig. 4 is a rough section prepared in riding hastily across the mountain about on the line A--A of fig. 3. On this line a few fossils were collected, approximately in sec. 8, T. 11 N., R. 8 E., which have been examined by Dr. George H. Girty, who reports:

> Chonetes aff. C. geinitzianus.
> Streblopteria sp.
> Gasteropod indet.
>
> This collection is hardly ample enough to determine the horizon with much accuracy. It is clearly of upper Carboniferous age, and I suspect well up in the series, because smooth *Chonetes*, of which *C. geinitzianus* is an example, usually appear only in the upper part of the Pennsylvanian.

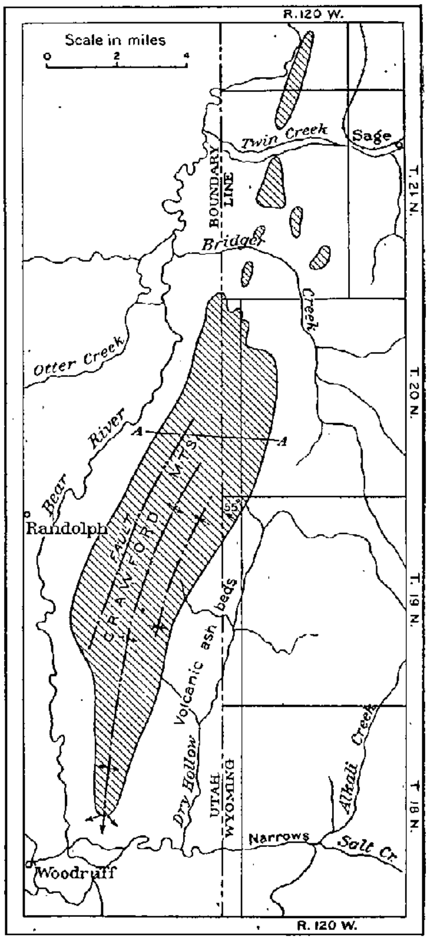


FIG. 3.—Sketch map showing Pennsylvanian (Upper Carboniferous) rocks (shaded areas) in the vicinity of Crawford Mountains, Utah-Wyoming.

The rock is predominantly a very cherty gray to blue-black limestone, entirely too cherty, where seen, to be of much value for building stone or for lime burning. At the southern end of the ridge the main anticline plunges down very abruptly at an angle of about 60°. The eastern termination of this outcrop against the Tertiary and Cretaceous is for the most part sharp and is believed to indicate a large fault. At one point, due west of sec. 30, T. 19 N., R. 120 W., a small outcrop of very fossiliferous Bear River formation was seen in contact with the Carboniferous, and while the exposure was not sufficient in itself to prove whether the relation was one of faulting or unconformity, other lines of evidence indicate conclusively that it is due to faulting (Pl. IV). It seems probable that this fault is the southern continuation of the large fault observed by Stanton[a] in the Cokeville section, which there likewise brings the "Permo-Carboniferous" and Bear River beds together.

Crawford Mountains are structurally to be regarded as the southern continuation of the Carboniferous beds exposed around and north of Cokeville in the Sublette Range. The general lithological character and the fossils collected indicate that the

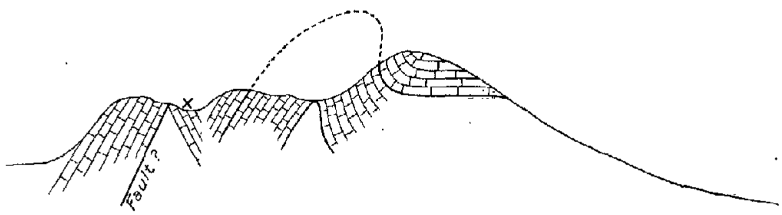


FIG. 4.—Sketch cross section of northern part of Crawford Mountains about on line AA, fig. 3. Cross shows where fossils were collected.

beds exposed contain representatives of the Park City and Thaynes formations. No exposures of the Woodside were noted, but this is believed to be due to the fact that the Woodside beds are inclined to weather down, and hence might not be noticed in a hasty reconnaissance. No outcrops of the Weber quartzite were noted in the Crawford Mountains. In a preliminary report on this region this group of limestone was placed in the columnar section below the white quartzitic sandstones which are now referred to the Weber. This was based on the report by Doctor Girty that the fossils collected in the Crawford Mountains appeared older than the typical "Permo-Carboniferous," and the Crawford Mountain limestones were hence inferred to belong below the sandstones. The identification of the sandstone with the Weber precludes such a reference, and Doctor Girty's studies of collections made by Mr. F. B. Weeks from adjoining areas show that the fossils collected in the Crawford Mountains may occur in the true "Permo-Carboniferous."

A phosphate pit was noted in these beds near the mouth of Twin Creek, and Mr. Weeks finds in the Cokeville section that the phosphatic horizon occurs between the calcareous beds, which he regards as roughly equivalent to the Park City and just below very fossiliferous "Permo-Carboniferous" limestones and sandstones.

Hayden observed this ridge in 1871 and described it as follows:[b]

> About 5 miles below the village of Randolph, on the east side of Bear River, there is one of the ruggedest walls of Carboniferous limestone I have seen on the trip. The rocks seem to rise up from the

[a] Am. Jour. Sci., 3d ser., vol. 43, 1892, p. 111.
[b] [Fifth Ann.] Rept. Prelim. U. S. Geol. Survey Montana for 1871, 1872 p. 158.

river bottom almost vertically, the summits are weathered into jagged points, and the sides of the wall, from summit to base, are gashed with dry canyons or gulches, which form splendid cross sections of the strata. The trend of the ridge is about northeast and southwest; the dip northwest, 60° to 70°. The limestone is usually pure, light-gray color, full of fossils, mostly in a fragmentary condition. Still these fossils show most clearly that the limestones are of Carboniferous age. This range of mountains, as it might properly be called, forms a very singular exhibition of the dynamic forces that have produced the remarkable folds in the older sedimentary rocks. It may be called an oblong quaquaversal, or an isolated puff or bulge in the crust. The entire range is not over 8 miles in length and not over 2 or 3 miles wide. The limestones bend down from the summits like the steep, flexible, convex roof of a house. About 3 miles above Randolph, at the bend of the river, the limestone ridge breaks off suddenly. On the south end the strata seem to be inclined at a greater angle, in some instances passing a vertical. A fragment has been cut off at the south end, where a stream has at some period very remote in the past made its way through. This section shows the strata clearly, and as well the way they flex down around the end of the range.

This account, which in the main is correct, apparently escaped the notice of both Emmons and Peale, who afterwards described portions of this ridge. Emmons, on the geologic map accompanying the report of the fortieth parallel, shows the limestone bordering the Narrows on the north and gives the following description of it: [a]

On the east side [of Bear River], from the Narrows northward beyond the limits of our map, heavy dark-blue limestones come down to the water's edge in steep, precipitous slopes, which present a rugged, broken surface cut through by deep rough canyons. The formation rises some 2,000 feet above the river, extending to the eastward in irregular undulating ridges until concealed beneath the Tertiaries. At the Narrows the limestone falls off abruptly, the beds standing nearly vertical, and on the west side of the river the Vermilion Creek beds come close up to the limestones. The river, which has run due north for a long distance, is curiously deflected on reaching the limestone, and takes a due west course for 5 or 6 miles, then, bending sharply to the north again, hugs closely the flanks of the hills. But little opportunity was afforded for the examination of this somewhat isolated body of limestone, and it has been referred to the Upper Coal Measures limestone, on no paleontological or direct stratigraphical evidence, but solely from its relative position with regard to the Silurian and Cambrian bodies on the west side of Bear River Plateau.

It should be pointed out in this connection that the last outcrop of the limestone is 6 miles west of the Narrows, as shown in fig. 3. It can hardly be held that Bear River is "deflected due west on reaching this limestone."

Peale,[b] after quoting Emmons, states that on his map he has colored the limestone Carboniferous to agree with the King map. He, however, materially corrects the areal boundaries given by Emmons, who included in the "Carboniferous" certain strata mapped by Peale as "Jura Trias" (Beckwith formation of the present report). On his cross section at the mouth of Twin Creek Peale marked the Carboniferous limestone "Jura Trias" evidently by mistake.

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[a] Rept. U. S. Geol. Explor. 40th Par., vol. 2, 1877, p. 338.

[b] Eleventh Ann. Rept. Geol. and Geog. Survey Terr. for 1877, 1879, p. 576, Pl. LXVII; geologic map of portion of western Wyoming, southeastern Idaho, and northeastern Utah accompanying Twelfth Ann. Rept. U. S. Geol. and Geog. Survey Terr., 1883

TRIASSIC.

NUGGET FORMATION.

The group of yellow, pink, and red sandstones, bounded below by the gray fossiliferous limestones of the Thaynes formation and above by the dark-colored fossiliferous shales and limestones of the Twin Creek formation, have been named the Nugget formation, from Nugget station on the Oregon Short Line, at and near which these beds are well exposed. Along Twin Creek, in the vicinity of Nugget, this formation is about 1,900 feet thick and shows two distinct members, a lower, brightly colored red-bed member, 600 feet thick, and an upper light-colored sandstone member. The upper member is a thin-bedded sandstone, the individual layers of which are perforated with holes at right angles to the bedding planes, but are otherwise without a suggestion of organic life. This sandstone is light yellow in fresh exposures, and weathers to a dark brown. It forms a rugged topography, with characteristic dark-brown talus slopes.

In Absaroka Ridge these two divisions are not distinct, though the beds have the same general features as the yellow and reddish tabular sandstones on Rock Creek.

These beds have been regarded as probably in whole or part Triassic, because of their position above Upper Carboniferous limestones and below beds containing Jurassic fossils.

JURASSIC.

TWIN CREEK FORMATION.

The fossiliferous marine Jurassic, to which has been given the local name Twin Creek formation, from the excellent exposures on that creek between Sage and Fossil, here consists for the most part of dark, calcareous shales and thin-bedded shaly limestones, though occasionally showing lighter colored sandstone layers. These are sharply limited above by the thick red beds which mark the base of the Beckwith formation. The thickness of the Twin Creek beds north of Twin Creek on two carefully measured sections was found to be 3,500 and 3,800 feet, respectively. Doctor Stanton has identified the following fossils from this locality:

Two miles west of Nugget, in NW. ¼ sec. 6, T. 21 N., R. 118 W.

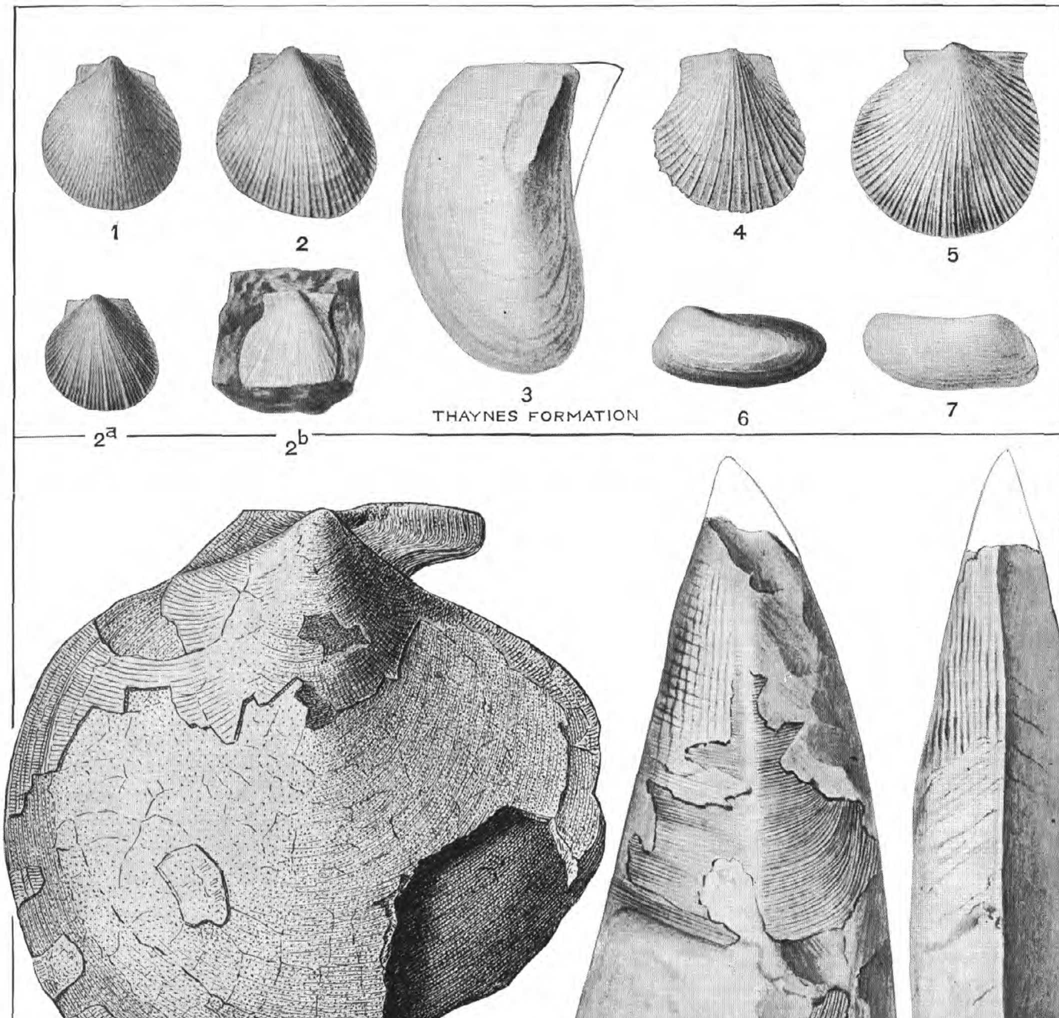
Sandstone near base of formation.

Camptonectes pertenuistriatus H. and W.
Gervillia montanaensis Meek.
Pinna kingii Meek.

Two and one-half miles west of Nugget station, in NE. ¼ sec. 1, T. 21 N., R. 116 W.

Near top of formation.

Pseudomonotis? sp.
Mytilus whitei Whitfield.
Camptonectes pertenuistriatus H. and W.
Trigonia quadrangularis H. and W.
Cyprina iddingsi Stanton.
Lyosoma sp.
Nerinea sp.



1. Aviculopecten curtocardinalis Hall & Whitf. (After Hall and Whitfield.)
2, 2a, 2b. Aviculopecten occidaneus Meek. (After Meek.)
3. Myalina permiana (Swallow). (*After Hall* and Whitfield.)
4. Aviculopecten parvulus Hall & Whitf. (After Hall and Whitfield.)
5. Aviculopecten weberensis Hall & Whitf. (After Hall and Whitfield.)
6. Myacites inconspicuus Meek. (After Meek.)
7. Sedgwickia concava M. & H. (After Hall and Whitfield.)
8. Trigonia quadrangularis Hall & Whitf.
9. Camptonectes bellistriatus (Meek). (After Stanton.)
10. Cucullæa haguei Meek. (After Stanton.)
11, 11a. Pinna kingii Meek. (After Meek.)
12, 12a. Pleuromya weberensis Meek. (After Meek.)

(Specimens 1, 3, 4, 5, 7 from southeast of Salt Lake City, Utah; 2, 2a, 2b, 6, 11, 11a, 12, 12a from Weber Canyon, Utah; 8 from 2½ miles west of Nugget Station, Wyoming; 9 from Bighorn Mountains, 10 miles from Yellowstone National Park, Wyoming.)

FOSSILS CHARACTERISTIC OF THAYNES AND TWIN CREEK FORMATIONS.

Eleven miles northwest of Nugget station, in sec. 18, T. 23 N., R. 118 W.

Camptonectes sp.
Pentacrinus asteriscus M. and H.
Pseudomonotis sp.

The above three lots are from the marine upper Jurassic.

Material collected in the northwest corner of sec. 3, T. 21 N., R. 118 W., by Mr. Schultz, and already mentioned (p. 50), yielded:

Pentacrinus asteriscus M. and H.
Ostrea sp.
Cucullæa haguei Meek?

Typical Twin Creek beds were found in the northeast corner of the area mapped and are believed to occur on the western side of Absaroka Ridge, though this area was not studied in great detail. Some of the typical fossils of this formation are shown on Pl. VI.

BECKWITH FORMATION.

DEFINITION AND DISTRIBUTION.

The Beckwith formation, which directly overlies the Twin Creek, has been so named from its occurrence and extensive development on leased State lands now forming part of the Beckwith ranch, situated just east of Beckwith station on the Oregon Short Line. It is here and throughout the west side of this area composed of two rather distinct members, a lower red-bed member, composed of interbedded sandy clays, sandstones, and conglomerates 2,500 feet thick; and an upper member, composed of rather light-colored interbedded sandstones and clays. The sandstones are commonly rather light yellow and the clays vary from yellow to light pinkish red. The lower part is well exposed east of Beckwith station, at the Cockscomb, and in the vicinity of Fowkes Canyon. The upper member is well exposed at the Narrows, north of Fowkes Canyon, and on the east side of Dry Hollow. The upper member has a thickness of 3,000 feet or more.

In the eastern belt of older rocks these two phases merge; in the area along the west side of the great fault just west of Hilliard these beds, while having a predominant reddish cast, are all light in color. The conglomerates, which near Beckwith are deep red, are here white to yellow. These reddish beds are exposed along the whole of the eastern side of the eastern belt just east of the Cretaceous exposures, and for the most part form the crest of the pronounced anticline which skirts this region on the east. These beds here reach a total thickness of 4,000 feet.

AGE AND TIME EQUIVALENTS OF THE BECKWITH FORMATION.

This formation is lithologically distinct from the very fossiliferous, dark-colored beds which overlie and underlie it, and compared with them is essentially unfossiliferous. Doctor Stanton has found marine Jurassic fossils at two points in beds which are regarded as in the lower part of the Beckwith formation. At old Bear River City, just west of the great fault line and east of the principal conglomerate bed at this point, Doctor Stanton found *Belemnites densus* M. and H., *Trigonia quadrangularis* H. and W., *Myacites* (*Pleuromya*) *weberensis* Meek?[a] In the exposures north of this point this horizon appears to be distinctly underlain by the characteristic unfossiliferous Beckwith beds, and unless it represents a portion of the Twin Creek which has been faulted up—and this is not regarded as probable—it is distinctly in the Beckwith formation. This fossil-bearing layer is here about 1,600 feet below the Bear River formation and 2,400 feet below the Aspen shales. South of Rockport, on Weber River in Utah, Doctor Stanton 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 formation and 3,500 feet or more below the lowest observed black shales with fish scales, representing the Aspen formation, which here, in the absence of the Bear River, is the base of the known Cretaceous.[b]

The lower part of the Beckwith formation is thus clearly upper Jurassic, and the remainder probably contains time equivalents of the lower Cretaceous and Dakota beds, if these occur in this area.

RELATION OF THE BECKWITH FORMATION TO THE "DAKOTA" OF THE FORTIETH PARALLEL SURVEY.

Some of the conglomerate beds in the Beckwith formation, together with conglomerates clearly Wasatch, have been segregated by members of the King survey and mapped as Dakota in the southern part of this area along the base of the Uinta Mountains. The separation of the Dakota here is evidently based on the assumption that wherever a coarse conglomerate is encountered between the fossiliferous Jurassic and the Cretaceous it must be the Dakota. The basis of subdivision was thus in part a lithologic one, but a stratigraphic corroboration was in general required. On the Weber River, above Rockport, the lower 400 feet of a 2,400-foot group terminated above by fossiliferous Cretaceous, has been mapped as Dakota;[c] on Chalk Creek both the mapping and description indicate that a portion of the Wasatch conglomerate has been included in the Dakota with the conglomerate beds in the Beckwith; at the Needles, where the Beckwith beds strike east of north but contain no pronounced conglomerates and where there are large outcrops of almost vertical Wasatch conglomerates which strike a little west of north, there is, it is stated, "a conglomerate similar to, though coarser than, that on Chalk Creek, having a vertical position and strike a little west of north," which is regarded as Dakota. The conglomerate here mentioned is clearly Wasatch. On Medicine Butte the conglomerate in the Beckwith has been mapped by the King survey as Laramie, and at Bear River City conglomerate of the same age has been mapped as Fox Hills. These data are adduced here merely to show the lack of the strikingly unique lithological character which the Dakota beds were supposed by the King survey to possess. Regarding the value of the assumption that any pronounced conglomerate beds occurring between the fossiliferous Jurassic and the fossiliferous Cretaceous are in this region Dakota, and that the Dakota as thus determined has a thickness

[a] Am. Jour. Sci., 3d ser., vol. 43, 1892, p. 103.

[b] Bull. U. S. Geol. Survey No. 106, 1893, p. 44.

[c] Compare statement of King (Rept. Explor. 40th Par., 1878, pp. 303 and 304) with section given by Stanton in Bull. U. S. Geol. Survey No. 106, p. 44. This section is given in the present paper on p. 104.

of from 200 to 500 feet, it should be pointed out that conglomerate beds having the character of these Dakota beds occur in many parts of the Beckwith formation and have an extreme vertical range of perhaps 3,000 feet. Doctor Stanton has shown that the Dakota conglomerate of the King survey south of Rockport, Utah, is between 1,800 and 2,500 feet below the base of the Colorado, which is here the local base of the marine Cretaceous so far as known at present. East of Beckwith, Wyo., the first pronounced conglomerate in the Beckwith formation is 3,000 feet below the base of the Bear River, and perhaps 8,000 feet below the base of the Aspen (Colorado) formation. Just west of the Narrows, on Bear River, a very striking conglomerate is developed at least 2,000 feet above a pronounced red conglomerate, which occurs in the same group of red beds in which the conglomerate east of Beckwith is developed. The most pronounced conglomerate in the section at Bear River City is at least 1,600 feet below the Bear River and 2,400 feet below the Aspen, which is here tentatively regarded as the base of the Colorado. Doctor Stanton has repeatedly expressed the view that the Dakota sandstone mapped by the King survey in this region is not the time equivalent of the Dakota sandstone of the eastern region, and it would certainly be undesirable to separate the different conglomerates of the Beckwith, situated as they are at different horizons, and call them Dakota.

CRETACEOUS.

The exact base of the Cretaceous in this region is not known. The lowest fossiliferous Cretaceous beds are clearly near the base of the Upper Cretaceous, and the Dakota, as well as the Cretaceous beds which Darton has found beneath the Dakota in eastern Wyoming, if they exist in this region, are thus inferred to be represented in the upper part of the Beckwith formation. The top of the Cretaceous is likewise in doubt, involving, as it does in other parts of the Rocky Mountains, rather conflicting lines of stratigraphic and paleontologic evidence. In the present discussion the Cretaceous is made to terminate with the great dynamic revolution which interrupted the period of relative quiescence in this area, which extended without important interruption from the earliest Carboniferous to late Cretaceous time. These disturbances produced important folds and faults, involving the movement of these sediments through thousands of feet. This known portion of the Upper Cretaceous series has the enormous thickness of over 20,000 feet. Its fossils indicate that it contains the time equivalents of the Benton, Niobrara, Montana, and Laramie groups of the eastern section, but the natural lithologic subdivisions do not correspond with these faunal subdivisions and do not agree with those east of the Rocky Mountains. There is in this section an entire new member—the Bear River formation—characterized by brackish- and fresh-water forms, which, although attaining a great thickness, is essentially of local development.

BEAR RIVER FORMATION.[a]

DEFINITION AND DISTRIBUTION.

The Bear River strata everywhere throughout this area overlie the Beckwith beds and contrast very markedly with them in lithological aspect. The nonfossiliferous light-colored sandstones and clays of the upper Beckwith are succeeded by the dark-colored, very fossiliferous shales of the Bear River, containing thin beds of sandstone and limestone and impure beds of carbonaceous material. The outcrops of these very fossiliferous beds on Sulphur Creek, near the old overland stage route and later on the line of the Union Pacific Railroad, early attracted attention and large collections of fossils were made from this locality, which is variously described as "Limestone Hill, Bear River;" "Bear River City, Utah;" "Gilmore, Wyo.;" "Sulphur Creek, Utah;" "mouth of Bear River, Utah;" Sulphur Creek near Bear River, Wyoming," and "Mellis, Wyo."

This was for some time the only known locality of the Bear River formation, and is naturally to be regarded as its type locality. The name was perhaps 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,[b] although the location of these beds near Bear River may have also influenced the selection of the name. White, in 1877, collected Bear River fossils "7 miles north of Evanston," at the locality now known as Shell Hollow. In the same year Peale collected Bear River fossils near Waterfall and at Sage and found extensive outcrops of the same beds to the north associated with the folds of the Wyoming and Salt River ranges. To this day the Bear River beds have not been recognized anywhere in this continent beyond this limited stretch extending from Bear River City northward through the Wyoming and Salt River ranges to the northeast corner of Idaho.

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[a] Synonymy and usage of Bear River formation:

$=$"Brackish water deposits on Bear River," Meek, 1860, Proc. Phila. Acad. Nat. Sci. for 1860, pp. 312-313.

$<$Bear River group (or Coal group), Hayden, 1869, [Third Ann.] Prelim. Rept. U. S. Geol. Survey Colorado and New Mexico, 1869, p. 92; Bull. U. S. Geol. and Geog. Survey Terr., vol. 1, No. 2, 1874, p. 2; Eighth Ann. Rept. U. S. Geol. and Geog. Survey Terr. for 1874, 1876, pp. 144–145. This includes, besides true Bear River beds, coal-bearing strata at Bear Town, Coalville, and Evanston, belonging to the Frontier, Hilliard, and Evanston formations.

$=$Bear River Estuary beds, Meek, 1870, Rept. Expl. 40th Par., vol. 3, p. 462.

$=$The Estuary formation on Bear River, Engelmann, 1876, Simpson's Rept. Explor. Great Basin, pp. 291–292.

$<$Point of Rocks group, Powell and White, 1876, Geol. Uinta Mts., pp. 100–101.

$=$Bear River fresh or brackish water beds, Meek, 1877; Rept. U. S. Geol. Explor. 40th Par., vol. 4, pt. 1, 1877, p. 163.

$<$Laramie, White, 1878, Bull U. S. Geol. Survey Terr., vol. 4, No. 4, p. 721; King, Atlas of 40th Par. Survey, 1876, Rept. U. S. Geol. Explor. 40th Par., vol. 1, 1878.

$=$ and $<$Post-Cretaceous or Laramie, Peale, 1879, Eleventh Ann. Rept. U. S. Geol. and Geog. Survey Terr. for 1877, 1879, pp. 630–631; Bull. U. S. Geol. and Geog. Survey Terr., vol. 5, 1879, pp. 196–197, Geol. map of western Wyoming, southeastern Idaho, and northwestern Utah accompanying Twelfth Ann Rept. U. S. Geol. and Geog. Survey Terr., 1883; here referring only to true Bear River beds.

$=$Bear River Laramie, White, 1883, Third Ann. Rept. U. S. Geol. Survey, p. 430 and in titles of plates 6-8.

$\equiv$Bear River formation, Stanton and White, 1892, Am. Jour. Sci., 3d ser., vol. 43, pp. 91–115.

$\equiv$Bear River formation, White, 1895, Bull. U. S. Geol. Survey No. 128.

NOTE.—In this and the several synonym tables following the symbols used have the following meanings:

$\equiv$ Equal to in every respect.

$=$ Equal in a general way.

$>$ Less than.

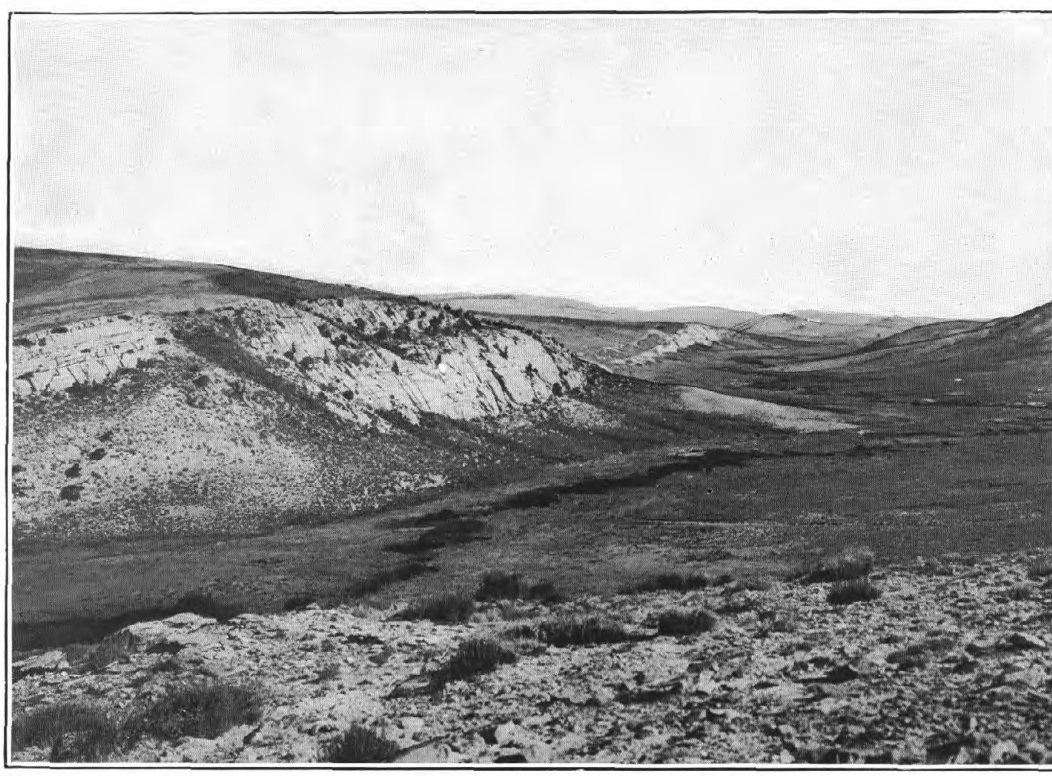
$<$ Greater than.

$\nleq$ Not equal to.

[b] [Third Ann.] Prelim. Rept. U. S. Geol. Survey of Colorado and New Mexico, 1869, pp. 91–92.

A. "FOSSIL CUT," A NOTED LOCALITY OF THE BEAR RIVER FORMATION.

Just west of old Bear River City on Sulphur Creek, sec. 29, T. 14 N., R. 119 W., Uinta County, Wyo. Alternate strata of very fossiliferous shale and dark-colored shaly limestone. The apparent eastward dip is due to position of strata on upper flank of an overturned syncline. The true angle of dip is about 135°. The flexing of the beds to the west at the surface is due to hill creep, and *does not* indicate an "anticlinal fold," as has been repeatedly suggested.



B. LAZEART SANDSTONE AT LAZEART MINE, UINTA COUNTY, WYO.

View north, showing typical exposures. Note *fringe* of willows along creek and rock cedar on face of sandstone exposure.

OUTCROPS OF BEAR RIVER FORMATION AND LAZEART SANDSTONE AT THE TYPE LOCALITIES.

The Bear River strata on Sulphur Creek at the type locality are on the upper side of an overturned syncline on the west side of Absaroka fault. (Pl. IV, sec. K; Pl. VII.) On account of their overturned character these beds apparently dip eastward and appear to be above the Millis coal, which has the same dip and is apparently the western continuation of the westward-dipping coal just east of old Bear River City. These strata were thus thought to indicate a syncline. This natural misinterpretation of the structural relations here led to the assignment of the Bear River beds to a much higher stratigraphic position than they really occupy, and this reference was apparently corroborated by the nonmarine character of the fauna, which naturally suggested their reference to that great catch-all, the Laramie. This misconception prevailed until 1891, when Dr. T. W. Stanton, by a series of careful paleontologic studies at old Bear River City, at a point 7 miles north of Evanston, near Waterfall, at Sage, and on Smiths Fork, determined the true stratigraphic position of these beds.[a] The outcrops studied by Doctor Stanton were either greatly disturbed or incomplete, and his correct conclusion in this matter is a marked evidence of his stratigraphic acumen.

The work of this party during the summer of 1905 merely added to the existing knowledge many areal details and showed conclusively, from many complete exposures with very simple structural relations, the correctness of his conclusions.

FOSSILS.

The fossils in this formation have been described and figured in detail in Doctor White's bulletin on the "Bear River formation and its characteristic fossils."[b] A few very abundant and typical forms are shown on Pl. VIII, and these will serve the purpose of those who are interested in these fossils merely as guides in stratigraphic studies.

The localities in this area from which type specimens have been obtained, together with lists of the species, are given below.

List of types of Bear River fossils obtained in this area.

Between Millis and Old Bear River City, on Sulphur Creek, in sec. 29, T. 14 N., R. 119 W.

[Species marked † were first described from this locality.]

† Unio belliplicatus Meek.
† Unio vetustus Meek.
† Corbicula durkeei (Meek).
† Corbula pyriformis Meek.
† Corbula engelmanni Meek.
† Rhytophorus (Melampus) priscus Meek.
† Tortacella haldemani White.
Limnæa nitidula Meek.
† Physa usitata White.
† Neritina naticiformis White.
† Pachymelania (Goniobasis) cleburni White.
† P. chrysalis Meek.
† P. chrysalloidæ White.
† P.? macilenta, White.
† Pyrgulifera humerosa Meek.
† Campeloma macrospira Meek.
Campeloma? sp. Meek (=Viviparus couesi White).

[a] Am. Jour. Sci., 3d ser., vol. 43, 1892, pp. 98-115.
[b] Bull. U. S. Geol. Survey No. 128, 1895, 108 pp., 11 pls.

Seven miles north of Evanston, Shell Hollow, in sec. 7, T. 16 N., R. 120 W., sec. 12, T. 16 N., R. 121 W.

[Species marked † were first described from this locality.]

Corbicula durkeei (Meek).
Pachymelania (Goniobasis) cleburni White.
P. chrysalloidea White.
P? macilenta White.
Pyrgulifera humerosa Meek.
† Goniobasis (Lioplax?) endlichi White.
† Viviparus couesi White.

Sage, sec. 7, T. 21 N., R. 119 W.

† Modiola pealei White.
† Corbulomya tauschii White.
† Neritina stantoni White.
Pachymelania chrysalis Meek.
P. turricula White.

Waterfall, sec. 28, T 21 N., R. 115 W.

Corbula engelmanni Meek.

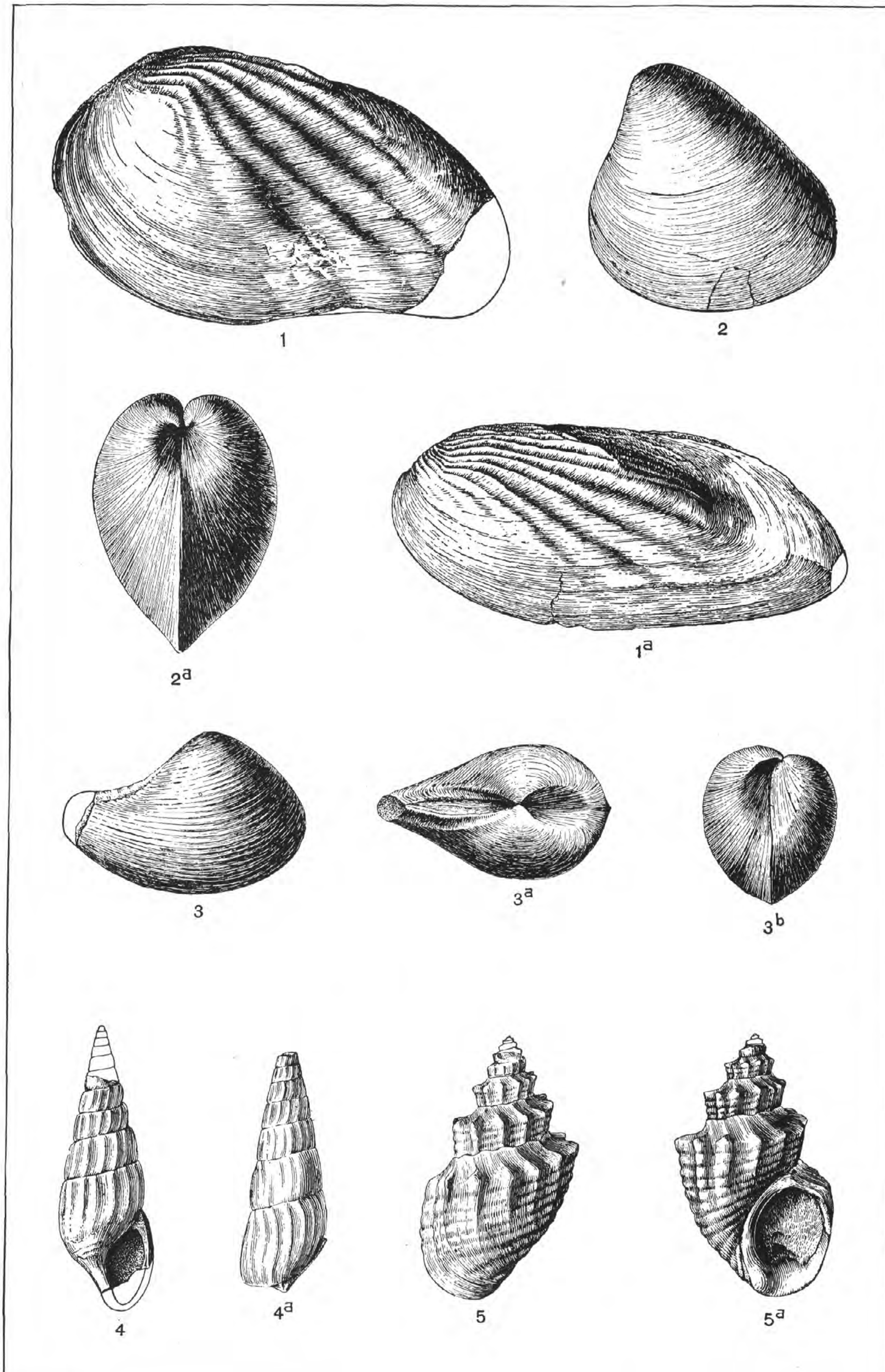
No attempt was made by this party to collect extensively from the Bear River beds. The commoner fossils were readily recognized, and the mapping is based on these. Small lots were, however, collected and forwarded to the National Museum from SW. ¼ sec. 5, T. 22 N., R. 119 W.; 750 feet west of center of south line of sec. 20, T. 23 N., R. 115 W.; 7 miles north of Evanston; sec. 20, T. 18 N., R. 118 W.; just west of the Utah-Wyoming line due west of the northwest corner of sec. 30, T. 19 N., R. 120 W. The last material is of particular interest because found in contact with the Pennsylvanian limestone of the Crawford Mountains. The exposure is not good, and it was not possible to make a detailed examination, but the relation is probably a fault contact analogous to that shown by the strata at Cokeville.[a]

One collection, from beds immediately in contact with the Beckwith formation, 3 miles east of Cumberland, and hence at the very base of the Bear River formation, shows, according to Doctor Stanton, a distinct marine facies, and this, with the collection made by Doctor Stanton at Sage in 1891, brings up the question of the position of the Bear River formation with relation to the horizons recognized in the Cretaceous section east of the Rocky Mountains.

Before taking up this question a further word is needed regarding the relation of the Bear River to the overlying beds. Where exposed in the eastern belt of older strata from near Hilliard to beyond this area, this formation is overlain by the Aspen beds, a series of dark-colored sandy shales containing a few ammonites and abundant fish scales. This weathers into small splintery fragments, quite different from the ordinary Bear River formation, and has produced long rounded hills of a peculiar silver-gray color. In the western belt of older rocks exposed along and just east of the State line these Aspen beds do not occur. The highest beds of the known Cretaceous series, with the possible exception of certain layers near and north of Sage, clearly belong to the Bear River formation. At Sage Doctor Stanton reports:[b]

Above the coal there is a considerable thickness of sandstones interstratified with argillaceous and siliceous shales, none of which yielded any fossils. In a thin bed of sandstone, 15 or 20 feet below

[a] Am. Jour. Sci., 3d ser., vol. 40, 1892, p. 111 fig. 3.
[b] Am. Jour. Sci., 3d ser., vol. 43, 1892 p. 108.



1, 1a. Unio belliplicatus Meek.
1, 2a. Corbicula durkeei Meek.
3, 3a, 3b. Corbula pyriformis Meek.
4, 4a. Pachymelania cleburni White.
5, 5a. Pyrgulifera humerosa Meek.

(Copies of White's figures of specimens from Sulphur Creek, Wyoming, and 7 miles north of Evanston, Wyo.)

FOSSILS CHARACTERISTIC OF BEAR RIVER FORMATION.

the coal, *Modiola multilinigera*,[a] *Barbatia coalvillensis*, and a few other species of the Colorado Cretaceous were found. Four hundred or 500 feet east of (below) this there are exposures of sandstones and calcareous shales containing Bear River fossils, interstratified with thin seams of coal, on some of which excavations have been made.

The outcrops at this point are not over 750 feet long and 50 feet wide, and the relations of the beds are entirely concealed by the overlying Quaternary and Tertiary deposits. Very limited exposures of the sandstones associated with the coal were seen just north and south of Sage. East of Beckwith *above* the coal bed, which is either the extension of the Sage coal or a higher horizon, a number of characteristic Bear River forms were found by Doctor Schultz. This paleontologic evidence, together with the fact that these beds contain marine forms and do not in any way resemble the characteristic Aspen[b] outcrops a few miles to the east, has led to the representation of these exposures as Bear River on the geologic map and the accompanying cross sections. This gives to the Bear River at this point a thickness exceeding 5,000 feet. It is clearly over 3,000 feet thick, as shown by the sections around and north of the Narrows and Stanton's studies near Cokeville, and at neither of these points was the top of the formation seen. On the eastern side of the area this formation is thinner. It is over 1,000 feet thick north of Hams Fork and decreases southward to 800, and it may be as low as 500. This rapid decrease in the thickness of this formation to the east has an important bearing on the topographic relations of this region at the time of its deposition.

RELATION OF BEAR RIVER FORMATION TO HORIZONS IN THE CRETACEOUS SECTION EAST OF THE ROCKY MOUNTAINS.

Although the true stratigraphic position of the Bear River formation with relation to the other beds of this region was determined by Stanton, the question of its relation or equivalence to other members of the Mesozoic is still but partially solved. White[c] after considering this question concluded from the fragmentary plant material collected that it was Upper Cretaceous rather than Lower Cretaceous or Jurassic. This and its position below the Benton has led to the rather persistent suggestion that it might be the time equivalent of the Dakota.

In this connection the marine species found on Little Muddy Creek 3 miles southeast of Cumberland, on the line between secs. 3 and 4, T. 18 N., R. 116 W., are of interest. 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. Doctor Stanton lists the following species:

Cardium sp.
Mactra sp.
Corbula sp. Related to C. pyriformis Meek.
Liopistha (Psilomya)? sp.
Lunatia sp.

The whole assemblage of forms is unfamiliar, but the horizon is clearly Upper Cretaceous.

[a] In 1893 Dr. 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 U. S. Geological Survey Bull. No. 128, p. 33.

[b] The Aspen is of uniform lithologic character throughout the eastern part of this area, and its extension many miles to the southwest is shown in the Chalk Creek and Rockport sections. These facts give the lithologic argument just offered more weight than it would otherwise have.

[c] Bull. U. S. Geol. Survey No. 128, 1895, pp. 20-24.

The restricted development of this formation, combined with the great thickness of the beds and the relatively complete faunal isolation indicated by its fossils, makes it of peculiar interest in the consideration of the geographic conditions at this early time. The beds along the northern part of the Uinta Mountains and the west face of the Rockies show an apparently conformable series from the Jurassic through the Cretaceous, yet this formation seems to be entirely absent from these sections. The rapid thinning of the Bear River formation to the east suggests a barrier even nearer than the Rocky Mountains, and its absence to the south shows the importance of the Uinta uplift at this early time.

ASPEN FORMATION.

Outcrops of the characteristic dark-colored, splintery, somewhat arenaceous shales containing abundant fish scales, which overlie the Bear River formation, are recorded in the reports of Hayden, Bannister, Emmons, and King[a] near Aspen station (named from Quaking Asp Divide or Quaking Asp Ridge) on the old line of the Union Pacific Railroad. These outcrops were even at this early date correctly referred to the Benton or Colorado. The name Aspen is thus historically appropriate for this group of dark-colored shale beds, bounded below by the Bear River and above by the coal-bearing Frontier formation.

The same beds were seen by Mr. Emmons near the present town of Cumberland, and described by him as follows:

> In the little circular valley just west[b] of the ridge at this point are exposed some clayey beds, too much disintegrated to show a definite structure; but as they are succeeded on the east by the same sand-rocks, dipping 25° to the eastward, with a strike of north 15° east, they have been colored as belonging to the Colorado series. The overlying striped red and white clays of the Vermilion series form a semicircular wall to this valley on the east, dipping eastward at an angle of 3° to 4°.

The sandstone described as dipping 25° eastward belongs to Wasatch, and the main anticlinal crest, which is here eroded down to the Beckwith beds, occurs a little farther east.

The Aspen beds are exposed along the east side of this anticline wherever not covered by the Tertiary from Aspen northward beyond the limit of the map. The same beds are also exposed west of the fault line (Absaroka fault) in the vicinity of Old Bear River City. Identical beds in the same stratigraphic position occur to the southwest on Chalk Creek and at Rockport in Utah (see p. 103). These beds contain the oil-bearing layers encountered in the wells near Spring Valley, and Knight recognized that the "Spring Valley oil sands" occur immediately below the Frontier formation, but did not recognize the identity of these beds with the formation whose outcrops are described by the early explorers as Benton or Colorado shale. He therefore presents a table showing an unnamed formation, No. 4, between his Frontier and his Benton, No. 5. Knight's[c] formations No. 4 and No. 5 are the same,

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[a] F. V. Hayden, [Fourth Ann.] Prelim. Rept. U. S. Geol. Survey of Wyoming for 1870, 1871, p. 149, H. M. Bannister, Sixth Ann. Rept. U. S. Geol. Survey Terr., 1872-1873, p. 538; S. F. Emmons, Rept. Explor. 40th Par., vol. 2, 1877, pp. 253, 326; Clarence King, Rept. Explor. 40th Par., 1878, vol. 1, p. 326. The Emmons statement is apparently based entirely on the Bannister account, although no credit is given. If the map in the Geologic Atlas had followed the Bannister account as closely as the text, it would have been more nearly correct.

[b] Should be east, as shown by map in accompanying atlas.

[c] Knight, Wilbur C., Eng. and Min. Journal, vol. 73, 1902, p. 721.

the one referring to the beds encountered in the wells and the other to their surface exposures. The Aspen formation ranges in thickness from 1,600 to 2,200 feet, but its average thickness is about 1,800 feet.

FRONTIER FORMATION.

DEFINITION AND DISTRIBUTION.

The Frontier formation was named by Knight in a paper presented to the Geological Society of America in December, 1901.[a] It was defined as essentially a coal-bearing formation containing a marked sandstone layer and characterized by the presence of *Ostrea soleniscus*,[b] a very long slender oyster, shown on Pls. IX, X. The name Frontier was taken from the coal town of that name, near which these beds are well developed. The pronounced sandstone layer or group of sandstone layers, occasionally conglomeratic and containing numerous specimens of the elongate oyster mentioned, produces a pronounced ridge, which was named Oyster Ridge by Hayden[c] in 1872. This name was adopted by the King survey and used on the maps and reports of that organization. This group of sandstones has therefore been named the Oyster Ridge sandstone member of the Frontier formation, and has been shown by a distinct color on the geological map. At several places minor sandstones or oyster-bearing ridges occur above the Oyster Ridge sandstone, notably about Cumberland, where they immediately overlie the important Kemmerer coal bed, and again east of Crow Creek. These low ridges for the most part mark the divide between the hogbacks of the Frontier formation and the broad valley produced by the Hilliard shale, and have been accepted as the top of the Frontier formation. Where this ridge is absent, the top of the Kemmerer group of coal beds is accepted as the top of the Frontier formation. This dividing line is approximately 600 feet above the base of the Oyster Ridge sandstone, which is generally about 200 feet thick. Beneath the Oyster Ridge sandstone there are other sandstone layers, which produce pronounced ridges, but these, except near the northern extremity of the map, are definitely separated from, and not readily confused with, the main Oyster Ridge sandstone. The total thickness of this formation ranges from 2,200 to 2,600 feet. It is exposed along the east side of Mammoth Hollow throughout this area, and on the west side north of Hams Fork and between Little Muddy and Clear creeks. It outcrops west of the great Absaroka fault from the Evanston-Fort Bridger road south to Sulphur Creek.

FOSSILS.

INVERTEBRATES.

Engelmann,[d] in 1858, collected fossils from this formation on Sulphur Creek in strata Nos. 12 and 5 of Meek's section,[e] and in the sandstone at the bend of Sulphur

[a] Eng. and Min. Jour., vol. 73, 1902, p. 721; Bull. Geol. Soc. Am., vol. 13, 1903, pp. 542–544.

[b] Although *O. soleniscus* is common throughout this formation, it is not characteristic of it, as Knight asserts. It occurs abundantly in this region in the Hilliard formation, at horizons 3,000 to 3,800 feet above the top of the Frontier.

[c] [Fourth Ann.] Prelim. Rept. U. S. Geol. Survey of Wyoming for 1871, 1872, p. 149.

[d] Engelmann, H., S. Ex. Doc. No. 40, 35th Cong., 2d sess., 1859, pp. 51-52, accompanying Captain Simpson's report on the wagon roads in Utah Territory.

[e] Sixth Ann. Rept. U. S. Geol. Survey Terr for 1872, 1873, p. 451. Republished by Stanton, Am. Jour. Sci., 3d ser, vol. 43, 1892, p 102 See p 101 of present report

Creek (now called Rock Cut). From the specimen of *Inoceramus*, which he compared with *I. cripsii* Mantell, but which was afterwards identified as *I. labiatus* Schl., he established the occurrence of the Cretaceous in this region. This locality was visited by many of the earlier geologists, and because of their writings has become a locality of particular interest to the geological student.

The following lists, prepared from the publications of Meek, White, and Stanton, give the forms listed or described from this point, together with additional geographic and stratigraphic data.

Rock Cut, 1 mile southeast of Hilliard, in sec. 2, T. 13 N., R. 119 W.

Horizon of Oyster Ridge sandstone.

[Where species are marked *, figures of specimens from this locality have been published; species marked † were first described from this locality.]

*Ostrea soleniscus Meek.
Cyrena securis Meek (=†Cyrena erecta White.)
*†Placunopsis? hilliardensis White.
Volsella (Brachydontes) multilinigera Meek.
Cardium curtum M. and H.
Cardium pauperculum (=Cardium subcurtum Meek).
Corbula dubiosa White.
*Neritina incompta White.
Turbonilla (Chemnitzia) coalvillensis Meek.

"Between Evanston and Fort Bridger" (probably near Hilliard).[a]

Inoceramus (like I. problematicus).
Cardium curtum M. and H.

At Carter Oil Spring, in sec. 31, T. 15 N., R. 118 W.

500 feet below Oyster Ridge sandstone.

†Cardium pauperculum Meek.

Near Old Bear River City, in secs. 28, 29, T. 14 N., R. 119 W.

Horizon of Oyster Ridge sandstone and a horizon whose position can not be determined exactly but which is thought to be near the Oyster Ridge sandstone.

Ostrea cf. glabra (probably Ostrea coalvillensis Meek).
*†Anomia concentrica Meek (Oyster Ridge sandstone).
*†Ostrea soleniscus Meek (Oyster Ridge sandstone).
* Inoceramus labiatus Schloth. (*I. problematicus.) (No. 12 Meek's section.)
*†Barbatia (Trapezium) micronema (Meek) Oyster Ridge sandstone.
*†Cyrena securis Meek (No 12 Meek section).
*†Cyrena (Corbicula) æquilateralis (Meek) (No. 12 Meek section).
*†Donax cuneata Stanton (No. 12 Meek section).
* Corbicula subtrigonalis ? M. and H. (No. 12 Meek section).
Neritina (Velatella) patelliformis Meek (No. 12 Meek section).
Pugnellus fusiformis (Meek) (No. 12 Meek section).

West side of Bear River,[b] *sec. 31, T. 14 N., R. 119 W.*

Near base of formation.

Ostrea ———?
Volsella (Brachydontes) multilinigera Meek.
Nucula ———?
Barbatia coalvillensis White.
Cardium trite White ?.
Cyrena securis Meek.
Tellina ? modesta Meek.
Tellina (Arcopagia?) utahensis Meek.
†*Corbula dubiosa White.

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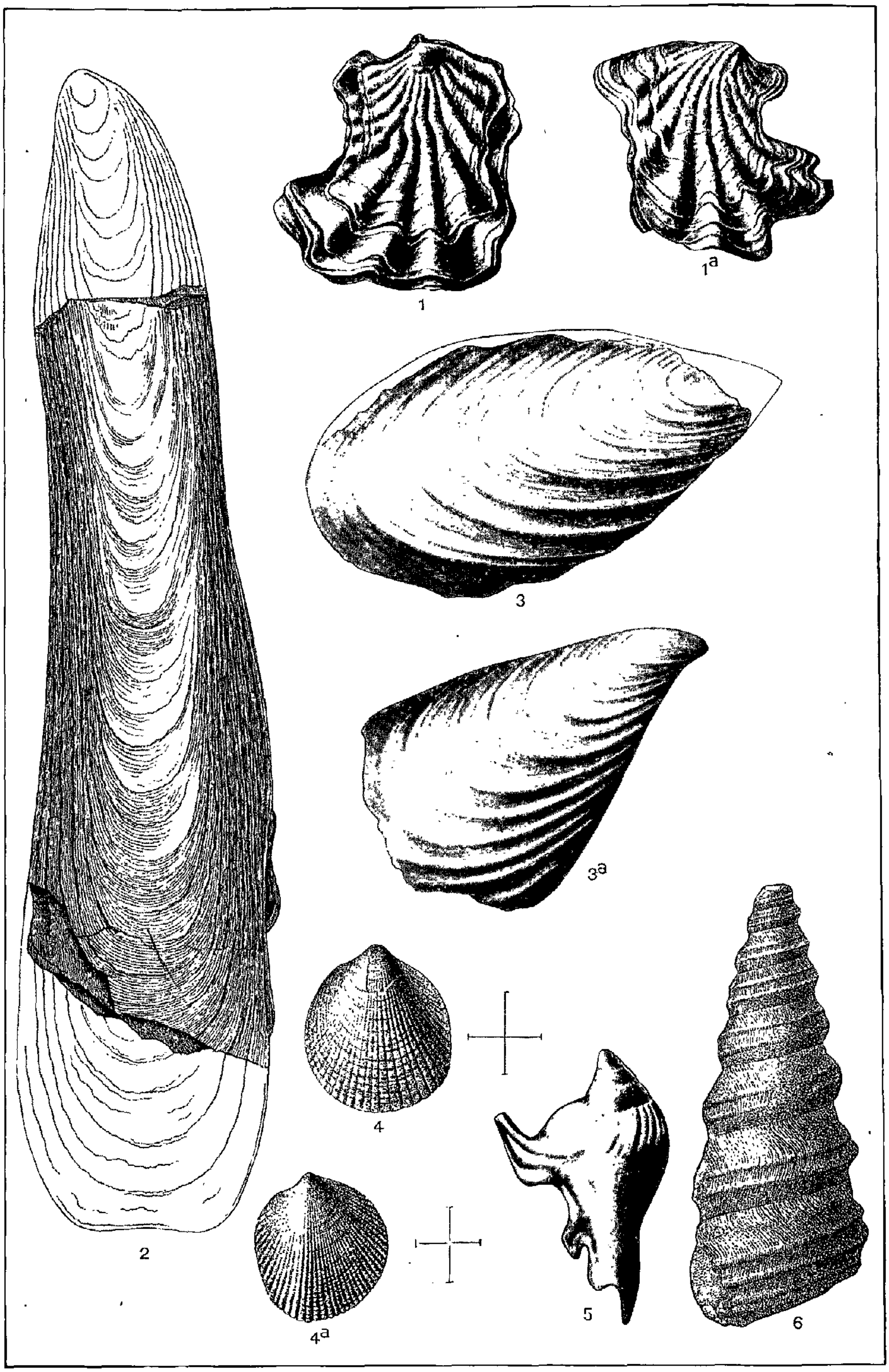
[a] Meek, [Fifth Ann.] Prelim. Rept. U. S. Geol. Survey Terr. for 1871, 1872, p. 376.

[b] White, Eleventh Ann. Rept. U. S. Geol. and Geog. Survey Terr. for 1877, 1879, p. 248. The field sheets of our party in 1905 shows no outcrop of the Frontier at this point, though its presence is clearly suggested to the west by the Bear River and Aspen formations, and it is inferred that Doctor White found some point of exposure in the area colored Wasatch which was overlooked by this party. [The outcrop is on the bank of Bear River and shows thickness of nearly 150 feet T W S.]



1, 1a. Ostrea sannionis White. (After White.)
2. Ostrea soleniscus Meek. (After White.)
3, 3a. Inoceramus labiatus Schlotheim. (After Meek.)
4, 4a. Cardium pauperculum Meek. (After Stanton.)
5. Pugnellus fusiformis (Meek). (After Stanton.)
6. Glauconia coalvillensis (Meek). (After Stanton.)

(Specimens 1, 1a, 6 from Coalville, Utah; 4a, 5 from Huerfano Park, Colorado; 2, 3, 3a, 4 from Bear River City, Wyo.)

FOSSILS COMMON IN FRONTIER FORMATION.

Doctor Stanton in 1896 collected *Ostrea coalvillensis* Meek and *Inoceramus fragilis* H. and M., "just above the Diamondville coal near Kemmerer." [a]

Several small lots of shells collected by this party from the Frontier formation at different points in this area have been identified by Doctor Stanton. The lists of species are given below in their stratigraphic order:

Fossils collected from Frontier formation.

U. S. Geol. Survey lot No.	Locality.	Position with reference to Oyster Ridge sandstone.	Species.
3366	SW. ¼ sec. 32, T. 19 N., R. 117 W	Not known [a]	Inoceramus labiatus Schl.
3380	Center north line sec. 32, T. 19 N., R. 117 W.	do. [b]	Cardium sp. Tellina modesta Meek. Tellina? isonema Meek. Mactra emmonsi Meek.
	Sec. 29, T. 19 N., R. 116 W. (see Pl. XXIV).	720 feet below	Unio sp.,[b] related to U. vetustus Meek.
	Sec. 8, T. 18 N., R. 117 W.	700 feet below.	Unio sp.,[b] related to U. vetustus Meek.
3374	SE. ¼ sec. 8, T. 18 N., R. 117 W	650-700 feet below	Ostrea sp. Inoceramus labiatus Schl. Unio sp.
3373	1,000 feet east of center of west line sec. 19, T. 22 N., R. 115 W. Sandstone just below Willow Creek coal.	500 feet below	Ostrea sp. Inoceramus sp., apparently undescribed but related to I. erectus Meek.
3371	Center east line sec. 31, T. 15 N., R. 118 W., near Carter Oil Spring.	500 ± feet below	Cardium pauperculum Meek. Corbula sp. Cyrena? sp. Spirorbis? sp.
3357	SW. ¼ sec. 33, T. 19 N., R. 117 W., 5 miles west of Cumberland.	250? feet below	Unio sp.,[b] related to U. vetustus Meek.
	NE. ¼ sec. 32, T. 20 N., R. 116 W	200 + feet below	Unio sp., related to U. vetustus Meek.
3370	NW. ¼ sec 28, T. 23 N., R. 116 W., and 1,000 feet north of SW. corner sec. 16, T. 23 N., R. 116 W.	Oyster Ridge sandstone.	Corbula nematophora Meek. Glauconia coalvillensis (Meek). Admetopsis subfusiformis Meek.
3378	Sec. 31, T. 15 N., R. 118 W., just west of Carter Oil Spring.	Oyster Ridge sandstone?	Meretrix? sp. Donax cuneata Stanton? Anatina sp. Mactra emmonsi Meek. Pugnellus fusiformis (Meek).
3375	Sec. 31, T. 15 N., R. 118 W., just west of Carter Oil Spring.	Same as 3378.	Ostrea soleniscus Meek. Mactra sp.
3369 3372 3377	Near center of sec. 33, T. 15 N., R. 118 W., 1½ miles southwest of Spring Valley.	Oyster Ridge sandstone.	Ostrea soleniscus Meek. Inoceramus n. s. Same as No. 3373.
3387	1,400 feet west of NE. corner sec. 31, T. 19 N., R. 116 W.	Shell layer, top of Oyster Ridge.	Ostrea sp. Cardium pauperculum Meek. Corbula nematophora Meek? Gyrodes sp. Fasciolaria? utahensis Meek. Pyropsis? sp.
3385	Frontier, Wyo., immediately above Kemmerer coal.	500 feet above base of Oyster Ridge sandstone.	Ostrea soleniscus Meek. Anomia sp. Modiola sp. Inoceramus labiatus Schl.? Corbula subtrigonalis M. and H.
3376	Center north line sec. 1, T. 21 N., R. 116 W. Sandstone above Kemmerer coal. On parting between Frontier and Hilliard formations.	500-600 feet above base of Oyster Ridge sandstone.	Inoceramus n. s. Same as No. 3373.
3389	Center north line sec. 13, T. 22 N., R. 116 W. On parting between Frontier and Hilliard formations.	600 feet above base of Oyster Ridge sandstone.	Ostrea sannionis White. Lima sp. Cardium sp. Mactra sp. cf. M. formosa M. and H.

[a] In greatly faulted region east of Absaroka fault; may be as high as Oyster Ridge sandstone.

[b] Doctor Stanton says: "This undescribed species is a simple form that might occur anywhere in the Cretaceous and on to the present time. Its resemblance to a Bear River species suggests a low horizon in the Upper Cretaceous."

Doctor Stanton adds the following notes:

Lots No. 3366, 3380, 3374, 3371, 3378, and 3387 indicate horizons that may be correlated with the Fort Benton.

The species of No. 3370 indicate a low horizon in the Colorado group.

Lot No. 3389 is from the horizon of the Third Ridge of the Coalville, Utah, section, which is believed to be in the lower part of the Montana group.

[a] Bull. Geol. Soc. Am., vol. 8, 1897, p. 149.

The line between the Montana and Colorado was drawn by Doctor Stanton, after considerable hesitation, in the Coalville, Utah, section, just above the second ridge[a] (see section, p. 103), with the remark that there was a promising field for a study of this question in western Wyoming, along the uplift of Oyster Ridge and west of it. Numerous specimens of *Inoceramus exogyroides* were found 3,000 feet above the horizon of No. 3389, which occurs at the top of the Frontier formation. These show not only that the Frontier formation belongs to the Colorado, but strongly suggest that the lower half of the Hilliard is also Colorado.

PLANTS.

The plants collected by Frémont in 1843 "on Muddy River, longitude 111°, latitude 41.5°," and described by James Hall,[b] who doubtfully referred them to the Jurassic, came from the Frontier formation on the south bank of Little Muddy Creek, about 1 mile east of the present town of Cumberland. A portion of this material found its way into the National Museum and was examined by Lesquereux, who, while presenting a list in which the age is given as "Jurassic?"[c] makes the following positive statement regarding its age, which is much more conclusive than that of Hall:[d]

> The specimen representing fig. 4, of Pl. II, of Hall, is part of an ovate leaf, lanceolate pointed above and dentate on the borders, the secondaries entering the teeth. The figure is really that of a dicotyledonous leaf, but the specimen is not in the lot!
>
> What seems to me to be conclusive of the Oolithic age of the plants is the number of fragments of small ferns referable to the genus *Thyrsopteris*, of which Heer has described a number of species from the Jurassic in Jura Flora of Siberia, Pls. I, II; also in Portugal flora, and which are also described as *Hymenophyllites leckenbyi* in Zigno, Pl. IX, figs. 3-5, and Pl. XI, figs. 1, 2. Pl. I, fig. 4, of Hall, is like *Cycadopteris heterophylla* Zigno, and fig. 3 of Pl. II is like *C. heerii* Zigno. Those small ferns, mixed upon small specimens, are really Oolithic type.

A collection of plants was made during the summer of 1905 from what was afterwards determined, by a careful consideration of the accounts of Frémont and Hall, to be from exactly the same horizon as that yielding the above collection. This material came from the southern part of sec. 29, T. 19 N., R. 116 W., 1 mile east of Cumberland, at a point stratigraphically 1,200 feet below the base of Oyster Ridge sandstone and near the base of the Frontier formation. Its stratigraphic position is shown in Pl. XXIV, p. 116. Dr. F. H. Knowlton, to whom this material was referred, reports:

> Gleichenia. Two or three species, well preserved.
> Equisetum? sp. Peculiar, probably new.
> Aralia, cf. A. saportana.
> Dewalquea, near D. insignis.
> Peculiar radiate plant of unknown affinity.
>
> This is extremely interesting material, as it is evidently from the same locality or horizon as that at which Frémont obtained a small collection in 1842, which was worked up by James Hall, who referred the beds to the Jurassic. The ferns here called *Gleichenia* were named *Pecopteris* by Hall, but they seem indistinguishable from this modern genus. The age, so far as I am able to fix it, is the lower part of the Upper Cretaceous, about in the position of the Turonian, possibly a little lower.

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[a] Bull. U. S. Geological Survey No. 106, 1893, pp. 38, 39, 41.
[b] Rept. Explor. Exped. to Rocky Mountains in the year 1842, and to Oregon and north California in the years 1843-44, 1845, pp. 130-132, 297-298, 304-307, 309, Pls. II and III.
[c] Proc. U. S. Nat. Mus., vol. 11, 1888, 1889, p. 11.
[d] Ibid., p. 38.

A collection made by Doctor Schultz from sec. 8, T. 18 N., R. 117 W., 2 miles southwest of Cumberland Reservoir, from beds thought in the field to be in the Frontier formation and at or near the horizon just recorded, was reported on by Doctor Knowlton as follows:

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

Two explanations suggest themselves for these apparently conflicting data. The last collections may have come from a limited outlier of the Wasatch beds, which are exposed to the west, or they may have come from a horizon comparable to that which yielded the supposed Laramie[a] at Coalville and which from data obtained in this region I am inclined to regard as Colorado rather than Montana and as probably the upper part of the Frontier formation. The first hypothesis is not regarded as probable. Doctor Schultz is positive that the fossils were collected from a bed in the Frontier formation and suggests that they may have come from a horizon slightly higher than the Frémont leaf bed. This would lend weight to the second suggestion.

AGE OF THE FRONTIER FORMATION.

Because of the prevailing sandy character of the formation and the pronounced sandstone beds which it contains, it was referred to the Fox Hills by nearly all the early geologists. This reference was accepted until the careful work of Stanton on the Colorado formation[b] showed that these beds were for the most part clearly Colorado. The work of this season has furnished additional evidence of the correctness of Doctor Stanton's conclusions. The discovery of numerous specimens of *Inoceramus exogyroides* 3,000 feet above the top of this formation conclusively proves its Benton age and indicates that the Colorado-Montana line is rather higher than drawn by Doctor Stanton.

HILLIARD FORMATION.[c]

DEFINITION AND DISTRIBUTION.

In a paper read before the Geological Society of America[d] in 1901, Prof. Wilbur C. Knight proposed the name Hilliard for the group of dark-colored shales overlying the coal-bearing Frontier formation and underlying the coal-bearing Adaville formation, saying:

> 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 as the east portal of the Oregon Short Line tunnel as a typical section.

[a] Bull. U. S. Geol. Survey No. 106, 1893, p. 42.

[b] Stanton, T. W., The Colorado formation and its invertebrate fauna: Bull. U. S. Geol. Survey No. 106, 1893.

[c] Synonymy and usage of Hilliard formation:

≡ Sulphur Creek formation, Powell (at type locality), Geology Uinta Mountains, 1876, p. 50.

< or ≨ Sulphur Creek formation, Powell (at other points), Geology Uinta Mountains, 1876, pp. 50, 154, 157. Atlas Geology Uinta Mountains, 1876.

≡ Hilliard formation, Knight, Eng. and Min. Jour., vol. 73, 1902, p. 721; Bull. Geol. Soc. Am., vol. 13, 1903, p. 543.

[d] Bull. Geol. Soc. Am., 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."

In the summer of 1905 the writer, not knowing of these earlier definitions, mapped this group of shales in the field under the name "Moyer formation," the name being taken from Moyer Junction on the Oregon Short Line Railway between Kemmerer and Hodges Pass tunnel on the section which Knight chose as a typical section.

The Hilliard beds at the type locality were mentioned by Prof. J. W. Powell in 1876 in the following words:[a]

Sulphur Creek group.—This group of black shales can be well seen in the hills near Hilliard station on the Union Pacific Railroad. Here Sulphur Creek cuts through them for several miles. In Professor Meek's "Section on Sulphur Creek near Bear River," his "No. 1" is the summit of the group. The locality does not present a good type, from the fact of the great displacements to which the beds have been subjected. Their relation to underlying beds can not be determined with certainty.

Powell's interpretation of the stratigraphy of Meek's Sulphur Creek section (see p. 102) was altogether incorrect. He regarded the strata exposed from near Millis to east of Old Bear River City as an unbroken section of conformable beds in which the beds to the west (the Bear River formation) are at the top and the Sulphur Creek (Hilliard) beds at the base. With this interpretation of the structure at the type locality it is not surprising that the beds called Sulphur Creek in the Uinta Mountain section are probably not at the same horizon as the beds at the type locality. Part of the beds in the Uinta Mountain section referred to the Sulphur Creek by Powell are undoubtedly Aspen, and from the list of fossils given by White from the "Sulphur Creek group"—none of them from the type locality— it may be inferred that Powell applied the name Sulphur Creek group to any pronounced exposure of Cretaceous black shales regardless of its stratigraphic position. On account of this confusion it has been considered advisable to employ Knight's name rather than Powell's.

This formation consists of dark-colored sandy shales, containing a few sandstone layers and limited below by the coal-bearing Frontier beds and above by the coal-bearing Adaville beds. Its ready weathering has produced a great depression known as Mammoth Hollow. It has a thickness ranging from 6,500 to 6,800 feet in most of the area, but on Hilliard Flat it appears to be not over 5,500 feet thick.

West of Frontier this formation contains a series of pronounced white sandstone lentils having an individual thickness of 50 to 100 feet and occurring through about 800 feet of strata. These sandstone lenses have a longitudinal outcrop of only about 5 miles. No trace of them is seen to the south, and to the north they change abruptly into a low clay ridge covered with large oysters (Pl. X). This formation is not known to be coal bearing, but future discoveries are by no means improbable. In the Baker well (p. 150) a coal bed was encountered 920 feet above the Kemmerer coal, but this occurred near the line between the Wasatch conglomerates and the Hilliard beds and is regarded as more probably belonging to the Evanston formation than to the Hilliard. The surface exposures of this formation are confined for the most part to Mammoth Hollow. It is also exposed in a narrow band on Sulphur Creek near Hilliard and its occurrence is inferred, on paleontologic grounds, in a

[a] Geology Uinta Mountains, 1876, p. 50. On p. 51 Powell states that the type locality of the Sulphur Creek group falls without the area described, which in connection with the Atlas clearly shows that he regards Sulphur Creek near Hilliard as the type locality.

limited area just west of Altamont. Because of the soft character of the beds, good exposures are rare. The best occur on Sulphur Creek near Hilliard, along the railroad from Moyer to Glencoe Junction, and on Hams Fork.

FOSSILS.

Fossils were found only near the center of this formation at the horizon of the sandstone lentils exposed on Hams Fork, from 3,000 to 3,800 feet above the base of the formation. This group of sandstone lentils is very pronounced on Hams Fork, but extends only about 2 miles northward, to a point where it is replaced by a clay ridge covered with very large *Ostrea soleniscus* (Pl. X), in no way suggesting the sandstone layers, though grading directly into them. These fossils have been identified by Dr. T. W. Stanton.

Fossils from horizon of sandstone lentils in Hilliard formation.

U. S. Geol. Survey lot No.	Locality.	Species.
3383	Upper Hams Fork bridge, sec. 27, T. 22 N., R. 116 W	Inoceramus exogyroides M. and H. (Pl. XI).
3388	do	Ostrea sp. Inoceramus sp. (Fragments of thick-shelled forms, probably I. exogyroides.) Tellina? sp. Mactra sp. cf. M. formosa M. and H.
3390	One-half mile northwest of above, in sec. 22, T. 22 N., R. 116 W	Cardium sp. Mactra sp. Corbula subtrigonalis M. and H. Corbula sp.
3367	SW. corner sec. 33, T. 23 N., R. 116 W	Ostrea soleniscus Meek (Pl. X).
3368	NE. corner sec. 3, T. 22 N., R. 116 W	Ostrea soleniscus Meek.
	Hams Fork station [a]	Inoceramus erectus Meek.? Cardium. Cyprimeria. Anomia.
3379	2 miles southwest of Altamont, Wyo.[b]	Inoceramus umbonatus M. and H. Cardium sp. Mactra sp. Corbula sp.

[a] Collected by Doctor Stanton in 1896 (Bull. Geol. Soc. America, vol. 8, 1897, p. 149), and thought, from geographic position, to be from this horizon

[b] This outcrop occurs in a badly faulted region, and the stratigraphic relation can not be determined. The area has been colored Hilliard on the geologic map because of the occurrence of *Inoceramus umbonatus*.

Doctor Stanton gives the following notes regarding the paleontologic aspects of this material:

No. 3383. This species is known elsewhere only from the upper part of the Colorado group at about the horizon of the Niobrara, and may be said to be characteristic of the base of the Niobrara or the top of the Benton.

No. 3379. *Inoceramus umbonatus* occurs in the same horizon with *I. exogyroides*.

No. 3388. Judging from the *Mactra*, I should think this lot came from the Montana group, though its horizon may be as low as the top of the Colorado.

No. 3390. These fossils are believed to have come from the Montana group.

AGE OF THE HILLIARD FORMATION.

The forms *Inoceramus umbonatus* and *I. exogyroides* are highly specialized types and belong to the class of fossils which are of the greatest stratigraphic value because of their unique characteristics and limited time range. Of *Inoceramus umbonatus*, Doctor Stanton says:[a]

> In this country the species has been found only at or near the original locality (20 miles below Fort Benton, on the Upper Missouri, from the Fort Benton group, or No. 2 of the Cretaceous series), and in the Austin limestone of Texas.[b] Dr. C. Schlüter (Palæontographica, vol. 24, p. 272) regards involute specimens as belonging to *I. involutus* and retains the name *I. umbonatus* for those (including *I. exogyroides*) in which the beaks are not coiled. He states, however, that as all three forms are associated in the same strata both in Europe and America, it will probably be found that the greater or less amount of coiling in the beaks is not an essential specific character. It should be stated that *I. involutus* occurs in Germany, in Schlüter's "Emscher Mergel," and in equivalent strata in other parts of Europe, at the base of Senonian, where it is associated with *Ammonites texanus* and *Ammonites tricarinatus*. The relative position of these analogous if not identical forms, therefore, is not very different on the two continents. * * * Larger collections will probably show that *Inoceramus exogyroides* is identical with *I. umbonatus*.

Of the two forms collected in southwestern Wyoming, *I. umbonatus* alone is entirely typical. It does not distinctly aid, however, in fixing the age of the different formations, since it was obtained from a stratum in a greatly faulted area whose stratigraphic position could not be determined. The specimens of *I. exogyroides* show some varietal characteristics, as may be seen by comparing the figures given on Pl. XI, with the original figures of Meek, but these differences are not regarded by Doctor Stanton as sufficient to justify their reference to a new species.

These forms east of the Rocky Mountains are limited, according to Doctor Stanton, to a horizon at the top of the Benton and to the Niobrara and its equivalents. They have not before been found west of the Rocky Mountains and are believed to conclusively fix the horizon at which they are found. The Colorado group at this point thus reaches the enormous thickness of over 8,000 feet, including, as it does, the Aspen formation, the Frontier formation, and the lower 3,800 feet of the Hilliard formation.

No fossils were found in the upper 3,000 feet of the Hilliard formation, but from the occurrence of fossils regarded as near the top of the Montana, about 300 feet above the top of this formation in the Adaville, it is believed that the upper part of the Hilliard is Montana and that the thickness of the Montana in this section may be as much as 3,000 feet.

ADAVILLE FORMATION.

DEFINITION AND DISTRIBUTION.

The group of strata immediately overlying the Hilliard shales 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.

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[a] Bull. U. S. Geol. Survey No. 106, 1893, pp. 82, 83.

[b] Since the above was written this species has been found in the upper part of the Benton shale in Montana and elsewhere and in the Niobrara of southern Colorado.—T. W. Stanton.

The Adaville formation consists of yellow, gray, and black carbonaceous clays, with irregularly bedded brown and yellow sandstones. These beds do not weather so readily as the Hilliard and rise distinctly above the area underlain by the latter formation. Mammoth Hollow is here a monoclinal valley bounded on the east by the hogbacks of the Frontier formation and on the west by the hogbacks of the Adaville formation. In the vicinity of the Hinshaw ranch there are two distinct hogbacks on the west side of Mammoth Hollow (Pl. I, *B*), an outer one formed of dark-brown sandstone and an inner one capped by a white sandstone. The sandstone layer forming the first hogback, which is here the topographic boundary of the Hilliard shale valley, was initially regarded as the upper limit of the Hilliard beds. The overlying white sandstone was, however, found on further examination to represent better the base of the lithological group containing the Adaville coal beds, and it has therefore been defined as the base of this formation whenever present. This white sandstone is not characteristically developed north of Hodges Pass tunnel. It is exposed in the east portal of the tunnel and from Adaville south. It attains in places a thickness of over 200 feet and has been named the Lazeart sandstone lentil of the Adaville formation, from its typical exposure near the Lazeart coal mine (Pl. VII).

The Adaville formation outcrops in a narrow belt just west of Mammoth Hollow, between Hams Fork and Little Muddy Creek and between Clear Creek and Lazeart coal mine. A very limited outcrop shows in the side of a little stream valley just south of Carlton coal mine near Hilliard. Throughout the area it is unconformably overlain by the Wasatch beds and in some places by the Green River. Its relation to the Evanston can be inferred only from the general stratigraphy of the region. Its maximum thickness in the section along the Oregon Short Line is between 4,000 and 5,000 feet.

FOSSILS AND TIME RELATIONS.

Fossils have thus far been collected only in the lower part of this formation at Hodges Pass and Adaville. In 1881 Dr. Lester F. Ward made large collections of fossil plants from Hodges Pass tunnel and described and figured the following species (Pl. XII):[a]

† Dryophyllum bruneri Ward. (=D. subfalcatum Lx.)[b]
† Dryophyllum falcatum Ward.
† Alnus grewiopsis Ward.
† Nyssa buddiana Ward.
Cinnamomum lanceolatum (Ung.) Heer.

Doctor Ward says regarding this locality:[c]

> The coal formation was reached before leaving Hams Fork to enter the pass, and continues some 5 miles west of the divide, the strata dipping to the west and representing an immense thickness of coal deposits. Fossil plants were found at nearly all horizons above the coal bed, and at two places they were exceedingly abundant, yielding specimens of superior perfection and interest.

[a] These were figured in the 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 †

[b] Knowlton, F. H., Bull. U. S. Geol. Survey No. 152, 1898, p. 91.

[c] Third Ann. Rept. U. S. Geol. Survey, 1883, pp. 28-29.

In the Sixth Annual Report he gives the following additional data:[a]

The plant beds occurred in the ridge through which the tunnel was being excavated. The place was then known as Hodges Pass, and my specimens are so labeled. * * * The ridge through which the tunnel was being constructed contained fossil plants at nearly all points. The rock consists of a coarse, very arenaceous limestone, or calcareous sandstone, the leaves being either scattered without much stratification through the mass and lying at various angles to one another, often much crumpled or folded, or else in matted layers upon one another in parallel planes, and sometimes so abundant that the rock seems to consist almost wholly of them. In either case it was difficult to obtain perfect specimens. The impressions are very distinct, being of a dark color upon the light matrix and showing the presence of the silicified leaf substance. Notwithstanding the coarseness of the material, the finer details of nervation are often clearly exhibited. At first sight this flora seemed to be exceedingly monotonous, owing to the prevalence of certain lanceolate or linear willow-shaped forms, but a close study of these reveals considerable variety and the presence of several species and two or three genera. With these, however, occur numerous less abundant forms, which lend considerable diversity to the flora of this locality. 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.

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, 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:

Sections 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

Doctor 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.

[a] Sixth Ann. Rept. U. S. Geol. Survey, 1885, p. 541.

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1a

1, 1a. Inoceramus exogyroides Meek and Hayden, from sandstone lentil in Hilliard formation on Hams Fork, sec. 27, T. 22 N., R. 116 W.

FOSSILS FROM HILLIARD FORMATION.

Of a few leaf fragments which were collected just south of the Carlton mine near Hilliard and which came from about the same horizon, Doctor Knowlton says:

> Four specimens, one of which seems to be a species of *Populites*. This specimen is very poor, but if it is really a *Populites*, the age should be Dakota. It is too imperfect to be of much value.

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.[a] A section of this tunnel, furnished by the railroad company and given in fig. 8 on page 133, 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 still 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.

DEPOSITS OF THE PERIOD BETWEEN THE KNOWN CRETACEOUS AND THE KNOWN EOCENE.

So far as our observations have shown, all the older rocks in this area are conformable—the sedimentary succession appears essentially unbroken from the Carboniferous sandstone exposed on Rock Creek to the top of the Adaville coal-bearing bed. The next deposits—the Evanston formation—are separated in time from the Adaville formation by a long period of folding, faulting, and erosion. The Evanston beds rest upon Beckwith and Bear River beds, indicating an unconformity of over 20,000 feet. These Evanston beds are conformably overlain by a series of sandstone, clays, and conglomerates—the Almy formation—and this in turn by beds of volcanic ash—the Fowkes formation—both of which are included in the Wasatch group of Hayden. The period of deposition of these two lower Wasatch beds is separated from that of the upper Wasatch beds, or Knight formation—the "Coryphodon beds" of the vertebrate paleontologists—by a period of faulting and folding, and by erosion, amounting in the aggregate to several thousand feet. There is thus isolated by pronounced periods of orographic movement and erosion a group of beds over 6,000 feet thick, apparently conformable and certainly not interrupted by any such periods of movement as preceded and succeeded them. The unconformity at the base of this series amounts to over 20,000 feet; that at the top to perhaps 5,000 feet, but this is of much less relative significance than the figures indicate, because the movements of the second disturbance were along the lines of weakness produced by the first. The physical break between this group and the known

[a] 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.

Cretaceous beds is thus greater than the break between it and the known Eocene, and on purely physical grounds this group would seem to belong rather to the Eocene than to the Cretaceous. The evidence from a paleontological standpoint is by no means satisfactory, and is in some respects conflicting. On the one hand, the paleontologists have regarded the Evanston beds as Laramie and referred them to the Cretaceous; on the other, they have called them Wasatch and referred them to the Eocene. The Almy beds have been separated by some observers from the Evanston, and by others included with them. The phenomena observed here suggest in many respects the relations observed in the Denver and Arapahoe deposits of the Denver region, described by Cross[a] and Eldridge, and the Livingston beds of Montana, described by Weed[b] and Peale, and the decision of the question involves the determination of the dividing line between the Cretaceous and Eocene in the Rocky Mountains. It has therefore seemed best to present the data regarding this group entirely separate from the discussion of the known Cretaceous and Tertiary and as occupying a debatable ground between the two.

EVANSTON FORMATION.

DEFINITION AND DISTRIBUTION.

The coal-bearing beds which outcrop in the bluffs on the east side of Bear River just north of Evanston first attracted attention about the time of the building of the Union Pacific Railroad. Important coal mines were then opened, and geologists naturally found the names "Evanston beds,"[c] "Evanston coal series,"[d] and "Evanston coal-bearing strata"[e] convenient geographic designations. Numerous well-preserved fossil plants were found by the Hayden survey associated with these coals, and these were studied by Lesquereux, who referred to these beds as the Evanston group.[f] Although none of these geologists defined an Evanston formation, the formation here described consists of the same beds to which the geographic term was applied by White and Lesquereux, and it thus seems appropriate to retain for it the name Evanston.[g]

The Evanston formation is typically exposed in the vicinity of Almy. It contains an abundant flora, which has been regarded as upper Laramie, and its correlation with the Denver beds is tentatively suggested.[h] It is regarded as separated from the lower Laramie, represented by the upper part of the Adaville formation, by a pronounced period of faulting and erosion, which is inferred on stratigraphic grounds, not by actual contact of the two formations. In lithologic aspect it is

[a] Mon. U. S. Geol. Survey No. 27, 1896.

[b] Bull. U. S. Geol. Survey No. 105, 1893.

[c] Emmons, S. F., Rept. Explor. 40th Par., vol. 2, 1877, p. 337.

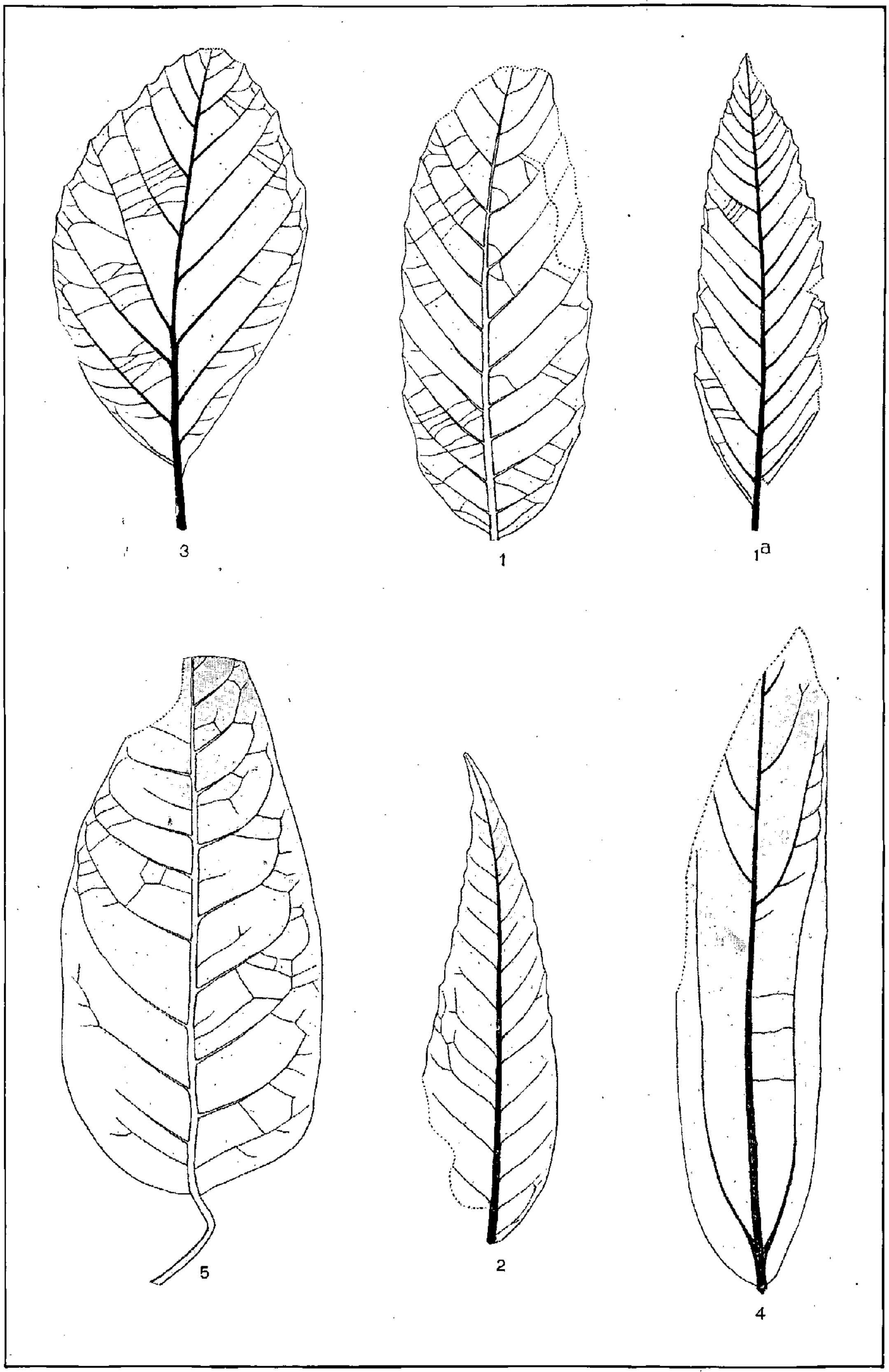
[d] White, C. A., Bull. U. S. Geol. Survey Terr., vol. 4, No. 4, 1878, p. 721; Eleventh Ann. Rept. U. S. Geol. and Geog. Survey Terr., 1879, p. 240.

[e] Bannister, H. M., Am. Jour Sci., 3d ser., vol. 17, 1879, p. 244.

[f] Bull. U. S. Geol. Survey Terr., vol. 1, 2d ser., 1876, p. 244.

[g] Veatch, A. C., Bull. U. S. Geol. Survey No. 285, 1906, pp. 332.

[h] Knowlton, F. H., Bull. U. S. Geol. Survey No. 105, 1893, p. 62. "As the localities of Carbon and Evanston, Wyo., are still open to question as to their age, it has been thought best to keep up the distinction by placing them in a separate column. They were regarded by Lesquereux as belonging to his Upper Lignitic, and therefore possibly belong to what has since been differentiated as the Denver group, to which they have been referred in the above tabulation." Bull. U. S. Geol. Survey No. 152, 1898, pp. 117, 123, 129.



1, 1a. Dryophyllum bruneri Ward.
2. Dryophyllum falcatum Ward.
3. Alnus grewiopsis Ward.
4. Cinnamomum lanceolatum (Ung.) Heer.
5. Nyssa buddiana Ward.

(Copies of Ward's figures of specimens from west end of Hodges Pass tunnel, Uinta County, Wyo.)

FOSSIL LEAVES FROM ADAVILLE FORMATION.

very similar to the Adaville, consisting of yellow, gray, and black carbonaceous shales and irregular brown and yellow sandstone beds, but differs from the Adaville in containing pronounced conglomerate beds below the upper coals, suggesting the initiation of the conditions which produced the overlying conglomerates. The coals are much dirtier and less persistent than those found in the Adaville beds. The upper limit of the Evanston is fixed by the pronounced sandstones and conglomerates which mark the base of the Almy. Because of the irregular character of the beds composing both the Evanston and Almy formations, it is difficult to determine the exact line of parting at every point, though it may be inferred within relatively small limits. This difficulty is well shown in Pl. XIII. The Evanston is characterized by coal and by dark-colored clays and by a relatively small proportion of sandy and conglomeratic material, while the Almy is more predominantly arenaceous and conglomeratic, and in places shows a reddish tinge not seen in the Evanston.

The Evanston formation is exposed in three limited areas near Evanston:

1. It extends in a narrow belt along the foot of the hills from a point 1 mile north to a point about 7 miles north of Evanston. This is the Almy exposure.

2. It outcrops again in secs. 26, 27, 34, and 35, T. 17 N., R. 120 W., around the Michigan-Wyoming Oil Company's oil well.

3. It is exposed on the east side of the Medicine Butte-Needles fault in the river bluffs and railroad cut just north of the insane asylum at Evanston and on the south side of Medicine Butte north of the Evanston-Cumberland road.

OUTCROPS IN THE VICINITY OF ALMY.

The bluff on the east side of Bear River north of Evanston represents the eroded remnant of the westward-facing fault scarp of an eastward-tilted block. It owes its present topographic importance to the basal sandstones and conglomerates of the Almy formation which have thus been exposed. The topographic aspect of this feature is well shown in Pl. XIII, *A*. This bluff has been examined by all the geologists who have worked in this region, and their almost unanimous opinion regarding the relation between the Almy and Evanston beds is of particular interest. Detailed sections of the coal beds have been prepared by Peale and Ricketts, and these are given in part in fig. 9, page 135. Lesquereux and Bannister have prepared sections of the bluff behind mine No. 1, represented by the pronounced hill point in Pl. XIII. These sections, although made very near the same point, show considerable differences and are referred to here to emphasize the irregular character of the bedding of these two series.

Section of hill behind mine No. 1, Almy, Wyo.[a]

[By H. M. Bannister, 1872.]

	Feet.
1. Coarse, pebbly conglomerate, with some intercalated sandstones and clays	50
2. Yellowish and gray sandy clays, or soft, decomposing sandstone	70
3. Massive gray sandstone	6
4. Yellowish and gray sandy shales or soft sandstone	8
5. Coarse grayish sandstone weathering brown	25
6. Reddish and yellowish sandy clays or shales	100

[a] Bannister, H. M., Sixth Ann. Rept. U. S. Geol. Survey Terr. for 1872, 1873, pp. 539-540.

		Feet.
7.	Coarse grayish-brown sandstone and conglomerate	15
8.	Reddish and ash-colored sandy clays or shales	100
9.	Massive light-grayish sandstone	12
10.	Yellowish sandy clays	15
11.	Coarse, pebbly, reddish-gray sandstone	15
12.	Soft grayish sandstone, passing downward into decomposing reddish conglomerate	52
13.	Yellowish sandy clays, some sandstone at base	50
14.	Sandstone and conglomerate	25
15.	Gray and yellowish-gray sandstones and sandy shales	45
16	Coarse sandstone and conglomerate	8
17.	Sandy clays or shales, some parts reddish	50
18.	Conglomerate passing into coarse sandstone	16
19.	Yellowish sandy clays or soft sandstone	32
20.	Conglomerate	22
21.	Yellowish or reddish sandy shales or clays	50
22.	Conglomerate	13
23.	Yellowish sandstone and sandy clays	50
24.	Coarse conglomerate	140
25.	Yellowish and whitish sandstone with some sandy clays	170
26.	Dark-grayish sandstone and shales	22
27.	Light-colored sandy clays or shales	12
28.	Grayish-buff sandstone	10
29.	Grayish sandy shales with apparently some carbonaceous seams near base	150
30.	Reddish and gray sandstone	12
31.	Grayish shales or sandy clays	150
32.	Reddish and gray sandstone	4
33.	Light-colored sandy shales, perhaps some sandstone	45
34.	Light-gray or whitish sandstone	14
35.	Dark and light-colored sandy shales	60
36.	Dark grayish-brown sandstone	20
37.	Dark-grayish shale with some carbonaceous layers and perhaps some thin seams of coal near base	100
38.	Hard reddish sandstone	5
39.	Soft argillaceous sandstone, some harder layers	20
40.	Coal	4½
41.	Dark clay	4
42.	Hard, impure coal—"rock coal"	2
43.	Coal	9½
44.	Hard, impure coal—"rock coal"	4½
45.	Coal	10
46.	Shale and clay	10
47.	Coal	5½
48.	Shaly clay, about	20
49.	Iron ore (ferruginous sandstone)	3
50.	Clay	15
51.	Coal	1

Still above the highest member of this section we could see from 500 to 700 feet of sandstones and sandy clays or shales, which we did not examine closely. In fact, the whole of the upper part of the section is only valuable to give an idea of the alternations and the general character of the whole series. The sandstones afforded in no instance any trace of animal or vegetable remains, and the exposures of the softer beds were such as to give no evidences of any fossil contents, being generally slopes more or less covered with débris. The dip was throughout nearly northeast, varying perhaps a little to the eastward. Its angle averaged from 17° to 20°. The first fossils found in place were seen in No. 32, which contained impressions of large leaves of dicotyledonous trees. About this horizon also we picked up a fragment of sandstone containing the cast of a *Helix*, which, however, might, judging from its appearance, have come from bed No. 30. Farther down, bed No. 34 also contained leaf impressions, and in No. 35 we found imperfect casts of bivalve shells resembling *Unio*. In No. 37, below its middle, we found a 2-foot band exposed in a prospecting trench almost entirely made up of small fresh-water shells, *Cyclas*, *Physa*, etc., all crushed together and almost unrecognizable, except as to genus.

Comparative section of hill back of mine No. 1. Almy, Wyo [a]

[By Leo Lesquereux, 1872.]

	Feet.
Conglomerate	40
Hard yellow, fine-grained micaceous sandstone	32
Conglomerate, topped with coarse sandstone	37
Fine-grained and intermediate layers of coarse-grained sandstone	32
Conglomerate (lower banks)	27
Bituminous clay	10
Shale and clay banks, mostly covered	145
Sandstone in bank	11
Alternating beds of shale and shaly sandstone	106
Shaly sandstone, very hard, sometimes in bank, with dicotyledonous plants	11
Argillaceous shale, with ferruginous concretions and remains of plants	96
Coal	5
Clay and shale	12
Coal	7
Clay	3
Main bed of coal, with four bands of slate	26
Shale and clay	8
Coal	5
Clay and shale	15
Iron ore	3
Clay and shale	15

It should be noted that in essentially the same section one observer reports the first pronounced conglomerate to be 400 feet above the coal and the other 800 feet. A detailed section was made by Mr. Pishel across this hill, along the line shown by the dips on Pl. XIII, *B*, to determine the total thickness of the Almy, and it is different from both of these sections, but the general results agreed more nearly with the Bannister record.

Detailed sections farther north show like dissimilarities. In sec. 18 pronounced conglomerates were observed 225 feet beneath the main coal beds, and suggest the condition observed in the railroad-cut section at Evanston.

The minor lithologic differences of these beds are clearly of less importance than the general relation between the Evanston and Almy. Lesquereux,[b] Bannister,[c] and Cope[d] all concluded that the two formations are entirely conformable. Emmons and King, of the Fortieth Parallel Survey, considered the conglomerate

[a] Lesquereux, Leo, Rept. U. S. Geol. Survey Terr., vol. 7, 1878, Tertiary Flora, p. 19. The lower part of the section was compiled by Professor Lesquereux from the report of Dr. A. C. Peale, Fifth Ann. Prelim. Rept. U. S. Geol. Survey Montana, 1871, 1872, p. 195.

[b] Sixth Ann. Rept. U. S. Geol. Survey Terr. 1872, 1873, p. 338. "The conformability of the strata is especially remarkable at Evanston and easily recognized along the hills facing the river. * * * If, as it has been supposed, this conglomerate formation was more recent and had covered strata of different groups, this alternance of conglomerate with sandstone strata in perfect accordance with the soft bituminous clay beds which they overlie is unexplainable."

[c] Sixth Ann. Rept. U. S. Geol. Survey Terr. 1872, 1873, p. 541.

[d] Seventh Ann. Rept. U. S. Geol. and Geog. Survey Terr. for 1873, 1874, p. 441, Rept. U. S. Geol. and Geog. Survey Terr., vol. 2, 1875, pp 36–40.

and coal-bearing beds a unit and mapped the whole as Laramie.[a] White likewise considered the Evanston and Almy beds as belonging to the same formation, but referred them both to the Wasatch.[b] Stanton, in 1892, followed White in combining the Evanston and Almy, and referred both to the Wasatch group,[c] but in 1896 expressed the view that the Evanston beds represent the upper part of the Adaville and that the Evanston and Almy, are perhaps not conformable.[d] This supposed unconformable relation was apparently inferred from the unconformable relation of the Adaville and Wasatch beds at Hodges Pass. Examinations by this party in the summer of 1905 led to the conclusion that the Evanston and Almy beds are conformable. Additional evidence of their relation was obtained in the extensive cuts then being made by the railroad company just east of Evanston.

The greatest thickness of the Evanston formation was found in the Almy region, along the section running east from the southeast corner of sec. 13, T. 16 N., R. 121 W. In the bed of the river at this point there are several impure carbonaceous beds of Evanston age, and between these and the Almy conglomerates 1,600 feet of strata occur. North of this the Evanston beds are observed in contact with the Bear River formation. These Bear River beds for the most part dip eastward, and when viewed from a distance the two are apparently conformable. However, many discordant details of dip and evidences of unconformity are seen on more detailed examination. The difference between the Almy and Evanston beds is not very marked just east of this Bear River outcrop; the conglomerates of the Almy largely disappear and a conglomeratic layer shows in the Evanston below the coal horizon. The thick coal beds of the Almy mines are much thinner in this section and apparently die out entirely a short distance to the north. The areal boundaries here are therefore somewhat uncertain. The Evanston is 600 feet thinner in the center of sec. 18 than half a mile to the south, and it is inferred that it gradually pinches out along the Bear River outcrop, as shown on the geologic map. On the north end of this Bear River outcrop pronounced reddish beds, apparently the middle Almy, rest directly on Bear River strata, indicating that the pinching out is progressing along this line and affects the Evanston and Almy beds alike. On the western side of the Bear River outcrop at this point are limited exposures of highly inclined strata, in part upper Almy and in part lower Fowkes. The exact relation between these different beds is by no means evident. The rough agreement of the dip of the Bear River and Evanston beds at the southern end of this exposure appeared to the early observers to corroborate the supposed position of the Bear River formation near the top of the Laramie, although Doctor White questioned their truly conformable relation. When Doctor Stanton determined the true stratigraphic position of the Bear River in 1891, he suggested

[a] In Rept. Explor. 40th Par., vol. 2, p. 330, Emmons says: "On the east side of Bear River Valley, a short distance north of Evanston, the bluffs are formed of a series of coarse sandstones not differing greatly in lithological habit from some of the beds of the Vermilion Creek series. They are, however, more compact in general, and dip from 13° to 15° to the northeast." King clearly did not regard the conglomerates as sufficiently separate to consider them Eocene, for he says: "At Evanston these coal-bearing Laramie beds dip at angles of from 16° to 25°, whereas the Vermillion Creek Tertiaries are nearly horizontal over them." (Rept. Explor. 40th Par., vol. 1, 1878, p. 373.)

[b] Bull. U. S. Geol. Survey No. 34, 1886, pp. 9-12. Seventh Ann. Rept. U. S. Geol. Survey, 1888, pp. 118-119.

[c] Am. Jour. Sci., 3d ser., vol. 53, 1892, p. 113.

[d] Bull. Geol. Soc. America, vol. 8, 1897, pp. 148-149.

that there was possibly a fault just east of this Bear River outcrop. This view was adopted when the locality was first seen, in the summer of 1905, but when the work was reviewed on the return trip (see p. 3), in the light of the knowledge of the general relations of the whole region, the relation was considered largely one of unconformity. A fault here is not impossible, and it would be difficult to prove conclusively from the surface exposures that a fault does or does not occur to the east of the Bear River exposures. Indeed, considering the numerous small faults found in the Almy mines, a small fault here would be quite probable, and such a fault would, with a supposition of initial unconformity, assist in the explanation of the relations observed at the north end of the Bear River outcrop. The suggestion that this fault could be of the magnitude required by the supposition that the Evanston beds are the top of the Adaville, as suggested by Doctors Stanton and Knowlton, is, however, quite contrary to the structural relations found in this area, and is believed to border on the impossible. Such a fault would have a throw of over 15,000 feet, a length of but a few miles, and would connect with no other structural features of the same magnitude in this region. On the west side of the Rock Creek-Needles anticline, which is for the most part capped with Beckwith beds, none of the undoubted Cretaceous beds above the Bear River are exposed in this area. Everywhere the Bear River and older beds are unconformably overlain by the Almy and Fowkes, which are shown throughout the Almy exposures to conformably overlie the Evanston. The Evanston and Bear River beds at this point are involved in the minor folds and faults on the western slope of this anticline, and the upper beds of the known Cretaceous series normally lie many miles to the west, in the synclinal trough whose axis is near Echo City, Utah. If the faults west of the Rock Creek-Needles anticline are of such a magnitude as a Bear River and upper Adaville contact would involve—about 15,000 feet—one would expect some portions of the other beds of the marine Cretaceous series between the Bear River and Adaville to be exposed in this region along the State line. None were seen at any point, but everywhere there is a marked unconformity between the Bear River-Beckwith beds and the Evanston-Almy beds.

The exposures just discussed are regarded as strongly suggestive of a marked time interval between the Adaville and Evanston and as indicating an essentially unconformable relation between the Evanston and the known Cretaceous series.

OUTCROPS NEAR THE MICHIGAN-WYOMING WELL.

More direct, and hence more conclusive, evidence of the unconformable relation between the Evanston and older beds is found in secs. 26, 27, 34, 35, T. 17 N., R. 120 W., near the Michigan-Wyoming well. Here there is a limited outcrop of coal-bearing beds resting directly on the Beckwith beds and entirely surrounded by them. This outcrop is situated on the crest of a pronounced anticline in the Beckwith beds, and owes its preservation from erosion to a slight irregularity in the crest of this anticline, partly structural and in part due to erosion. It lies midway between two large faults, and with reference to the neighboring beds of the same age is on an upraised block. East of the eastern fault there is a considerable folded area of Almy beds, which farther east are unconformably overlain by the upper Wasatch or Knight. Beyond the western fault are the lower layers of the Fowkes formation, which overlie the Almy and Evanston beds, 3 miles to the southwest, at the type locality. An attempt was made to prove that these coal-bearing beds were Bear River rather than Evanston, but without success. A narrow strip of Bear River outcrops along the east side of this anticline (see geologic map, Pl. III) and extends southward to Whitney Canyon. It was traced for a short distance south of Whitney Canyon to a point within a quarter of a mile of the coal-bearing beds, where it pinched out. These Bear River beds are extremely fossiliferous and in every way the same as the Bear River beds exposed in Shell Hollow and at the Narrows. No Bear River fossils were found anywhere in connection with the coal-bearing beds, which are lithologically identical with the Evanston beds and differ decidedly from the typical Bear River. An analysis of a sample of coal from the mine opened by the Michigan-Wyoming Oil Company showed that the coal was of exactly the same type as the Almy coal, differing slightly from the Adaville coal and very markedly from the older Cretaceous coals.

OUTCROPS AT THE RAILROAD CUT EAST OF EVANSTON.

During the summer of 1905 the Union Pacific Railroad made improvements in its track alignment just east of Evanston, which involved extensive grading in the hill just north of the insane asylum. An unusually complete section of the Evanston and Almy beds was thus exposed. The following section has been prepared by Doctor Schultz:

Section of Evanston and Almy beds in railroad cut just east of Evanston.

	Feet.
Almy:	
1. Sandstone and conglomerate	35
2. No exposures	106
3. Drab-colored shale	4
4. Indurated calcareous clay	4
5. Clay	.7
6. Dark, compact conglomerate; small pebbles	17
7. Yellow indurated sandy clay	40
8. Alternating bands of hard and soft sandy shale	20
9. Hard indurated blue clay	40
10. Indurated reddish clay interlaminated with soft layers	22
11. Sandy shale	12
12. Sandy bluish clay	24
13. Coarse, light-colored conglomerate, also exposed in river bank	16
Evanston:	
14. Bluish-gray shale with leaves and invertebrates	13
15. Soft yellowish-gray sandstone	16
16. Drab-colored clay	70
17. Bluish clay with bands of bituminous matter	25
18. Coal seam	.5
19. Blue shale	1
20. Bituminous shale	.5
21. Blue shale	2
22. Coal seam	.5
23. Indurated bluish gray clay	13
24. Coal seam	.3
25. Bluish-black clay	2
26. Blue clay	11

Evanston—Continued.	Feet.
27. Coal seam	1.5
28. Bluish clay	3
29. Compact sandy shale	6
30. Impure coal; upper 7 inches good coal, the remainder poor with bands of good coal 1 to 2 inches thick	9
31. Blue shale, very brittle	16
32. Bituminous shale, with bands of poor coal varying in thickness from one-half to 2 inches	3
33. Sandy shale	5.5
34. Coarse light-colored conglomerate	17
35. Bluish clay	5
36. Coal seam; poor grade of coal	.7
37. Bluish gray clay, with a few thin bands of bituminous material	35
38. Blue-gray clay	80

The strike of the beds here is N. 10° to 15° E. and the dip from 12° to 16°. This cut shows that the Evanston and Almy beds are conformable in every respect, and corroborates the conclusions reached in the Almy exposures regarding the relation of these two series. The section is particularly interesting in showing the closely related lithological character of the upper Evanston and lower Almy, and notably the occurrence of pronounced conglomerate beds in the midst of the coals, corresponding to the conglomeratic sandstones observed beneath the coal in the northern part of the Almy exposures, and clearly showing that the Almy conglomerates do not indicate the beginning of a new series of events, but rather the culmination of one already begun, and that they therefore have no significance as indicating an unconformity between the Evanston and Almy. There is a limited exposure of the beds Nos. 13 and 14 in the river bluff just west of the cut which shows some distortion by slipping.

OUTCROPS AT SOUTH END OF MEDICINE BUTTE.

At the south end of Medicine Butte, in sec. 2, T. 15 N., R. 119 W., and on the strike of the exposures in the railroad cut, there is a limited outcrop of the Evanston formation which is reported to be coal bearing. The overlying conglomerates may be traced from this point to the railroad cut. The Evanston and Almy beds along this line are separated from the exposures in the Almy locality by a pronounced fault (Pls. XIII, *A;* XV, *A;* IV, section J). Just south of this Medicine Butte outcrop the displacement of the Evanston beds is about 5,000 feet, with the upthrow to the east. Bannister, in 1872, suspected that the structure at this point was rather complex. He says:[a]

> We also visited the hills on the north side of Bear River, northeast of Evanston, which we found to be composed of very similar strata to those in the upper part of the Almy section, viz, alternations of coarse sandstones, conglomerates, and sandy clays. There seems to have been a considerable disturbance here besides the mere tilting of the beds, and from the altered direction of the strike, which is here nearly north and south, we were led to suspect a considerable lateral displacement with faulting, which might very possibly cause the appearance of the same beds in both these hills, and those about Almy, although at first sight these would appear much higher in geological position. We did not attempt, however, to work out the geological structure to any great extent, as it would have required more time and labor than we were well able to give for that purpose.

[a] Sixth Ann. Rept. U. S. Geol. Survey Terr. for 1872, 1873, p. 540-541.

POSSIBLE EVANSTON BEDS IN THE BAKER WELL NEAR SPRING VALLEY.

A series of borings just west of Spring Valley suggests the possible extension of the coal-bearing beds of the Evanston formation in that region or the occurrence of coals in the lower Wasatch beds. In the Baker well (Pl. XIV and p. 150) a coal bed 6 feet thick was found in a series of conglomerates at a depth of 230 feet, intimately associated with the lower Wasatch beds. This record receives partial corroboration from two near-by diamond-drill borings. In one the dark Hilliard shales were encountered at a depth of 55 feet, while in another the red clays and sandstones of the Eocene extend to a depth of 158 feet or more. Coal was also found in diamond-drill boring No. 2, a little farther east, above red clays which are regarded as Wasatch or Evanston and which have been so considered by the Union Pacific Coal Company in the cross sections given on Pl. XXIV (p. 116).

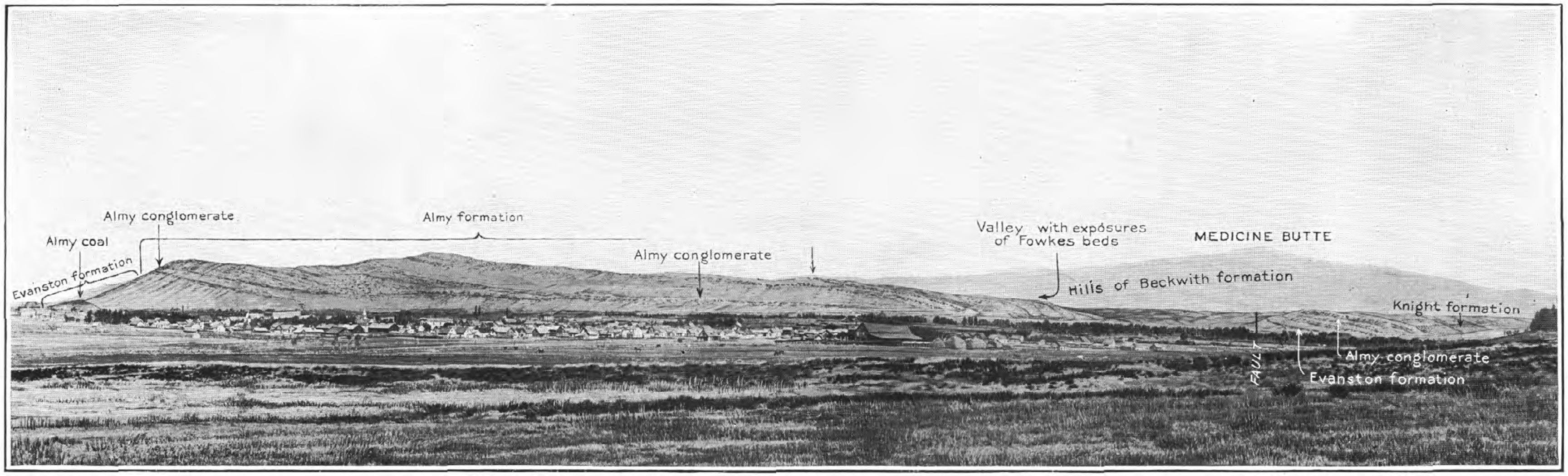
FOSSILS.

PLANTS.

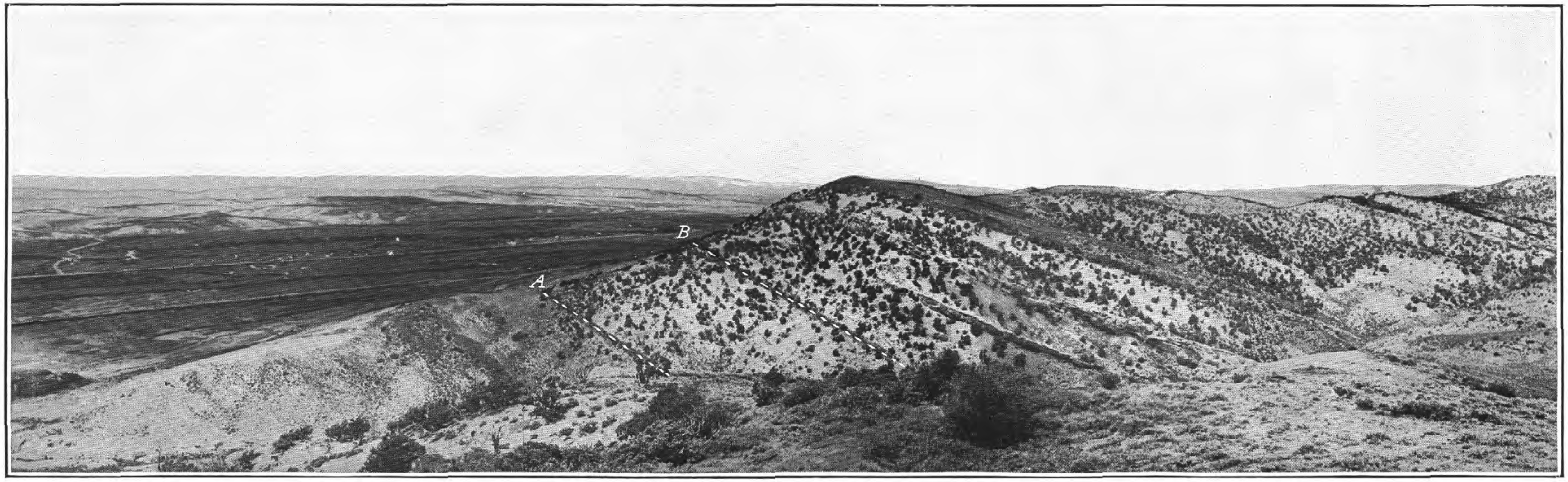
This formation is noted from a paleontologic standpoint principally for the large number of fossil plants obtained from it. These plant remains were first studied by Professor Lesquereux, who published numerous preliminary reports on them in the Annuals of the Hayden Survey,[a] and finally a detailed report accompanied by numerous plates.[b] Great difficulty would be experienced in preparing satisfactory lists of species from these publications, since in several cases species mentioned in the annual reports as from Evanston are not so described in the final report, and a number of new species established in the annual reports are not mentioned again. Some of the species figured and described in the final report from certain localities are given in the catalogue of types in Lesquereux's own handwriting as being from entirely different localities, and in view of the manifest carelessness and resulting confusion in this work the only way of obtaining lists that will be of scientific importance is by a study of the original collections together with the additional collections made since that time. Dr. F. H. Knowlton has very patiently worked over all the collections of Laramie and related plants in the United States National Museum, which are supposed to contain practically all the material studied by Lesquereux, and has very kindly prepared the following list, showing the species obtained from Evanston and the stratigraphic place or range of each.

[a] [Fifth Ann.] Prelim. Rept. U. S. Geol. Survey Montana for 1871, 1872, pp. 291-293, 307-309, 314, Supplement to the Fifth Ann. Rept. U. S. Geol. Survey Terr. for 1871, 1872, pp. 10-12, 18; Sixth Ann. Rept. U. S. Geol. Survey Terr. for 1872, 1873, pp. 401-403, [Seventh] Ann. Rept. U. S. Geol. and Geog. Survey Terr. for 1873, 1874, pp. 384-385.

[b] Rept. U. S. Geol Survey Terr., vol. 7, Tertiary Flora, 1878.



A. AT EVANSTON, WYO.



B. DETAIL OF PROMINENT HILL AT LEFT OF VIEW *A*.

The line of parting between Evanston and Almy formations lies between the points *A* and *B*. Upper beds are conglomeratic Almy; lower, Evanston. Slack pile at foot of hill in foreground marks site of old mine No. 2. The hills across the irrigated bottom of Bear River are composed of nearly horizontal strata belonging to Knight formation.

RELATIONS OF EVANSTON AND ALMY FORMATIONS AT THE TYPE LOCALITY.

Preliminary list of plants from the Evanston formation at Almy, with their known geologic range, by Dr. F. H. Knowlton.

[Species first described from this locality are marked †.]

Species.	Stratigraphic distribution.								
	Montana.	Laramie.	Arapahoe.	Ceratops beds.	Denver.	Livingston.	Fort Union.	Eo-lignitic.	Green River.
Betula stevensoni Lesq		×							
†Carpites evanstonensis Kn									
†Carpites utahensis Lesq									
†Cassia concinna? Heer									
Cinnamomum lanceolatum (Ung.) Heer		×?							
Cissus tricuspidata Lesq		×							
Cyperus chavannesi? Heer		×							×?
†Diospyros woodeni Unger									
†Ficus nervosa Newb									
Ficus pseudo-populus Lesq									×
?Fraxinus denticulata Heer		×				×			
Hicoria antiquorum (Newb) Kn					×?		×		
Juglans crossii Kn		×?			×	×?			×
Juglans rugosa Lesq	×?	×			×	×	×		
Laurus primigenia Ung	×?	×	×		×?				
Laurus socialis Lesq		×	×		×	×			
Leguminosites? arachioides Lesq					×		×		
?Magnolia Lesleyana Lesq		×						×	
†Malapœnna sessiliflora (Lesq.) Kn									
Palmocarpon palmarum (Lesq.) Kn		×		×	×				
Phragmites œningensis Al. Br.[a]		×							×
†Quercus negundoides Lesq									
?Populus cuneata Newb							×		
Populus speciosa Ward							×		
?Rhamnus oboratus Lesq		×?							
†Rhus evansi Lesq									
Vitis bruneri Ward		×							
Vitis olriki Heer		×			×?				
Total	2	15	2	1	8	4	5	1	4

[a] Poor; wide range.

Small lots of leaves were collected by this party in the summer of 1905 below the coal at mines Nos. 6 and 7 and from strata No. 14 in the Evanston railroad cut. Dr. F. H. Knowlton has furnished the following report on these collections:

Mine No. 6, Almy.

Dryophyllum subfalcatum? Lesq.

Appears to be this species, but the leaf is poor and without margin. If correctly determined, should be Laramie or same age as beds at Hodges Pass.

Mine No. 7, Almy.

Betula stevensoni Lesq.
Laurus socialis? Lesq.
Laurus primigenia Unger.
Populus speciosa Ward.
Populus cuneata? Newb.
Cissus? sp.
Corylus? sp.

This belongs to the upper part of the Laramie; is about the same position as the plant beds at Carbon.

Union Pacific Railroad cut just east of Evanston.

(No. 14 of section on p. 82.)

Sequoia sp.
Carpites n. sp. Described in manuscript from Carbon.
Cissites tricuspidata (Heer) Lesq.
Leguminosites arachioides Lesq.
Vitis bruneri Ward.

This is of the same age as the last—namely, upper part of the Laramie, and similar to the beds at Carbon.

INVERTEBRATES.

The invertebrates from this formation have been listed and described by Dr. C. A. White, who visited this locality in 1877 and 1885 and who studied the collections made by the other Government parties at this point. The species reported are given in the following list:

Species from the Evanston beds at Almy, listed by Dr. C. A. White.[a]

[Where species are marked * figures of specimens from this locality have been published; species marked † were first described from this locality.]

*† Pisidium saginatum White.
Sphærium formosum M. and H.
Planorbis cf. convolutus M. and H.
Bulinus longiusculus M. and H.
Bulinus disjunctus White.
†* Helix evanstonensis White.
Macrocyclis spatiosa (?) M. and H.
Columna teres M. and H. (Meek?)
* Hydrobia recta White.
Cypris ——?
Goniobasis nebrascensis M. and H.
* Helix (Patula) sepulta White.[b]

A collection from bed No. 14 of the Evanston railroad cut has been studied by Dr. T. W. Stanton, who furnishes the following report:

3381. *Union Pacific Railroad cut 1 mile south of Evanston.*

Sphærium formosum M. and H.
Columna teres M. and H.
Planorbis sp. a.
Planorbis sp. b.
Goniobasis tenuicarinata M. and H.
Bulinus disjunctus White.
Campeloma multilineata M. and H.

This lot is referred to the upper Laramie, though it may possibly be as late as the Fort Union.

AGE AND TIME RELATIONS OF THE EVANSTON FORMATION.

The Evanston formation was considered by the geologists of the early Government expeditions as Laramie. Later Doctor White, after studying in detail its invertebrate fauna and comparing it with that found at Wales, Utah, concluded that these beds were undoubtedly Wasatch. Ward[c] and Knowlton[d], because of its flora, have regarded it as essentially the same as the Carbon beds, but, as the stratigraphic position of the Carbon beds has never been determined,[e] this correlation does not lead very far. Knowlton reported that the leaves collected in 1905 are "upper Laramie." As early as 1893 he suggested the possibility of their representing the

[a] Eleventh Ann. Rept. U. S. Geol. Survey Terr. for 1877, 1879, p. 242; Bull. U. S. Geol. Survey No. 34, 1886.
[b] Proc. U. S. Nat. Mus., vol. 3, 1881, p. 160.
[c] Sixth Ann. Rept. U. S. Geol. Survey, 1885, pp. 443-514.
[d] Bull. U. S. Geol. Survey No. 105, 1893, pp. 58-60.
[e] Bull. Geol. Soc. America, 1897, vol. 8, pp. 149-150.

Denver beds, and again, in 1898, doubtfully referred this locality to the Denver.[a] Dr. T W. Stanton regards the invertebrates as Laramie or Fort Union, and the question thus becomes involved in the larger one of the true age of the Fort Union, which has been regarded both as Upper Cretaceous and Eocene. The paleontologic collections made at this locality do not prove conclusively that the beds are Upper Cretaceous, or, on the other hand, show that they are basal Eocene. If a final study of the fauna shows conclusively that these beds are of the same age as the Denver beds, the weight of evidence afforded by the dinosaurian remains found in the Denver beds, which Marsh regarded as proving their Cretaceous age, must be considered. The stratigraphic evidence strongly suggests that the line between the Eocene and the Cretaceous should be drawn at the base of the Evanston, and certainly shows no reason for drawing it between the Evanston and the Almy. On the whole, the Evanston formation may be tentatively regarded as Eocene.

WASATCH GROUP.[b]

The Wasatch group was named by Hayden in 1869.[c] In 1870[d] he published a more complete description, from which the following extracts have been taken:

We have passed the western rim of the Bridger Basin and near Quaking Asp summit enter on the borders of the great valley of Salt Lake. The geological character of the country is essentially changed. Instead of the brown and light-gray sands and clays of the Bridger group we have the curiously variegated beds of the Wasatch group, which present almost every variety of shade of color from white and yellow to a deep brick-red, the red and purple tints so predominating that they give a singularly curious aspect to the scenery. * * * From Aspen station to Wasatch, at the head of Echo Canyon, these red beds are not so conspicuous along the immediate line of the road, but in the distance they can be seen on either side. * * * The tunnel at the head of Echo Canyon is cut through the reddish and purplish indurated sands and clays of what I have called the Wasatch group. * * * As we descend Echo Valley we emerge from the canyon around "Pulpit Rock" and shoot our way with wonderful rapidity down the picturesque valley of the Weber. We shall observe that as we descend the Echo

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a Bull. U. S. Geol. Survey No. 152, 1898, pp. 117, 123, 129.

b Synonymy and usage of Wasatch group.

=Third series [of the Tertiary of the Green River basin], Engelmann, Sen. Ex. Doc. No. 40, 33d Cong., 2d sess, 1859, pp. 45-75.

≡Wasatch group, Hayden, 1869, [Third Ann] Prelim. Field Rept. U. S. Geol. Survey Colorado and New Mexico, p 91, Hayden, 1870, Sun Pictures of the Rocky Mountains, pp. 106, 107, 111, 113-114, Hayden, 1871, [Fourth Ann.] Prelim. Rept. U. S. Geol. Survey Wyoming for 1870, 147, 155, 156.

≡Vermilion Creek group, King, Atlas Geol. Explor. 40th par., 1876, Marsh, Am. Jour. Sci., vol. 9, 1876, p. 428, Emmons, U. S. Geol. Explor. 40th par., vol. 2, 1877, pp. 203, 225, 329, 855; King, U. S. Geol. Explor. 40th par., vol. 1, 1878, pp. 360-377.

≡Wahsatch beds, Wahsatch group, Cope, Am. Jour. Sci., 3d ser., vol. 3, 1872, p. 224, [Fifth Ann.] Prelim. Rept. U. S. Geol. Survey of Montana, etc., 1872, pp. 350, 352; Proc. Am. Philos. Soc., vol. 12, 1872, p. 473.

=Wahsatch beds proper, Cope, Rept. U. S. Geol. Survey Terr., vol. 3, 1884, p. 9.

<Green River epoch, Green River beds, Green River formation, Green River strata, Cope, Proc. Phil. Acad. Nat. Sci. vol. 24, 1873, p. 279, Sixth Ann. Rept. U. S. Geol. Survey Terr. for 1872, 1873, pp. 589, 625, 627, 628; Seventh Ann. Rept. U. S. Geol. and Geog. Survey Terr., 1874, p. 441. Here used to include both Wasatch and Green River (see following usage).

<Wasatch group, Cope, Rept. U. S. Geol. Survey Terr., vol. 3, 1884, p. 7; vol. 4, 1889, table following p. 43, which includes both the Wasatch and Green River groups.

<Green River beds, Comstock, Rept. Recon. of Northwest Wyoming in 1873, by W. A. Jones, 1875; table following p. 103, 123 Includes both Wasatch and Green River beds.

>? Coryphodon beds, Marsh, Am. Jour. Sci., 3d ser., vol. 12, 1876, pp. 401-402; Am. Jour. Sci., 3d ser., vol. 14, 1877, p. 354; Proc. Am. Assoc. Adv. Sci., vol. 26, 1878, table facing p. 211, 230; Mon. U. S. Geol. Survey, vol. 10, 1886, pp. 6, 7. In this region Coryphodon remains have been found only in the upper Wasatch or Knight formation

>? Wahsatch, Osborn, Bull. Am. Mus. Nat. Hist., vol. 7, 1895, p. 73 Here used as an exact synonym of Coryphodon beds.

c [Third Ann.] Prelim. Field Rept. U. S. Geol. Survey of Colorado and New Mexico for 1869, 1869, p. 90.

d Sun Pictures of the Rocky Mountains 1870, pp. 106, 107, 111, 113-114.

Canyon the more rugged picturesque scenery is exhibited on our right hand, and as we descend the Weber the same lofty perpendicular walls, weathered here and there into all sorts of fantastic forms, continue to the "Narrows," where the Weber River makes a bend to the left and the conglomerates disappear. This formation, which in some respects is the most remarkable one which I have ever seen in the West, must have a thickness of 3,000 to 5,000 feet. The conglomerate portion above must be 1,500 to 2,000 feet in thickness. I have included in this group all the variegated beds which we have observed west of Carters station, and we have noticed especially that some shade of red has prevailed in the clays and sands as well as in the conglomerates of this group. Some of the sandstones in the upper portion of Echo Canyon are noticeable for their deep yellow hue. I have called this series of beds the Wasatch group.

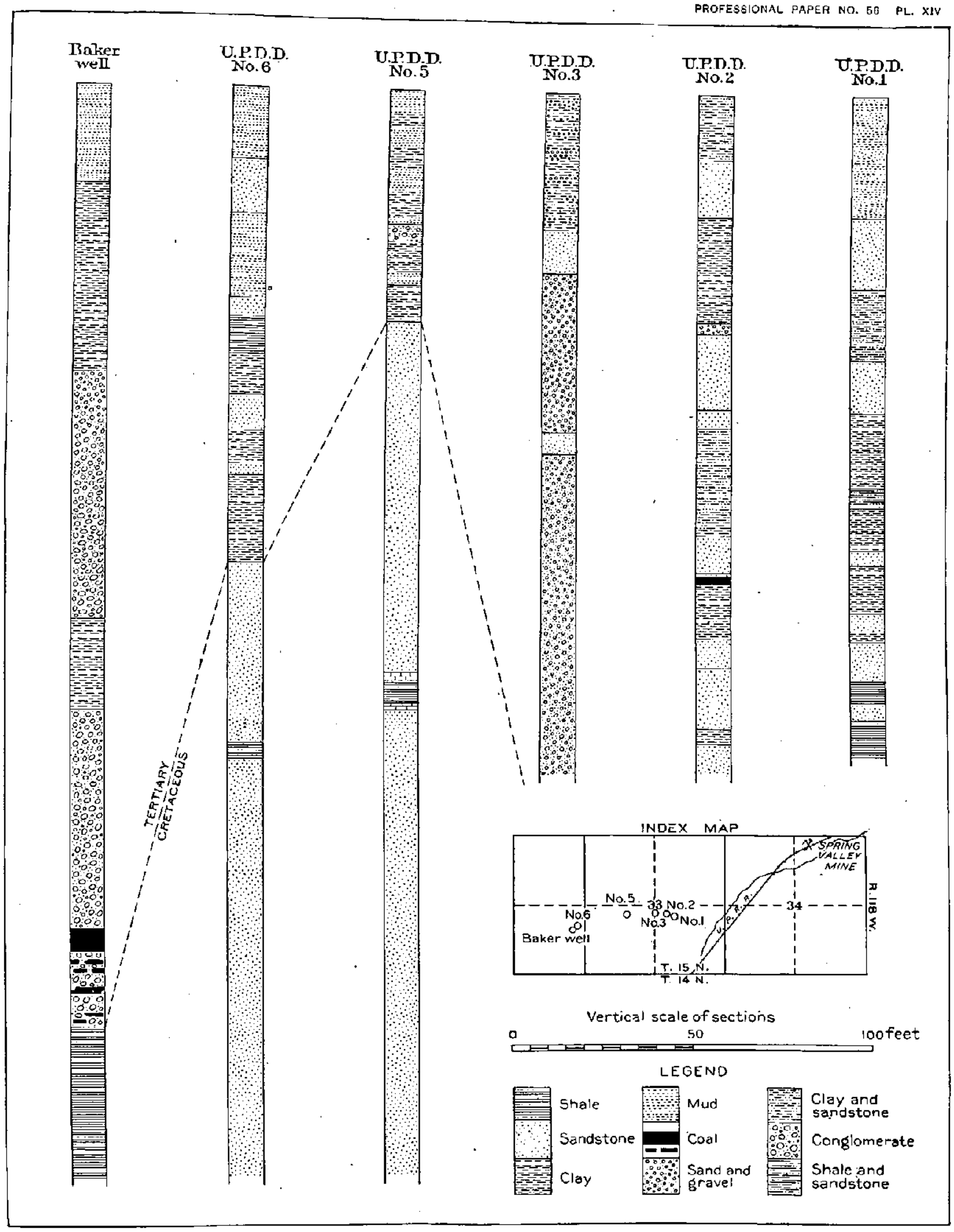
The type locality of the Wasatch group of Hayden thus extends from Carter, Wyo., to the Narrows on Weber River, 7 miles below Echo City, Utah, and some 10 to 15 miles east of the crest of the Wasatch Mountains. The name is derived from Wasatch station, on the Union Pacific Railroad, in Summit County, Utah, situated about midway between Carter and the Narrows.

It has been suggested,[a] and is very generally held, that the Wasatch group was named by Hayden from the Wasatch Mountains, but there is apparently no basis for this supposition in this original description or in any other by Doctor Hayden. The group is extensively and typically developed in the vicinity of Wasatch station, and the name in this respect is an entirely appropriate one.

SUBDIVISIONS.

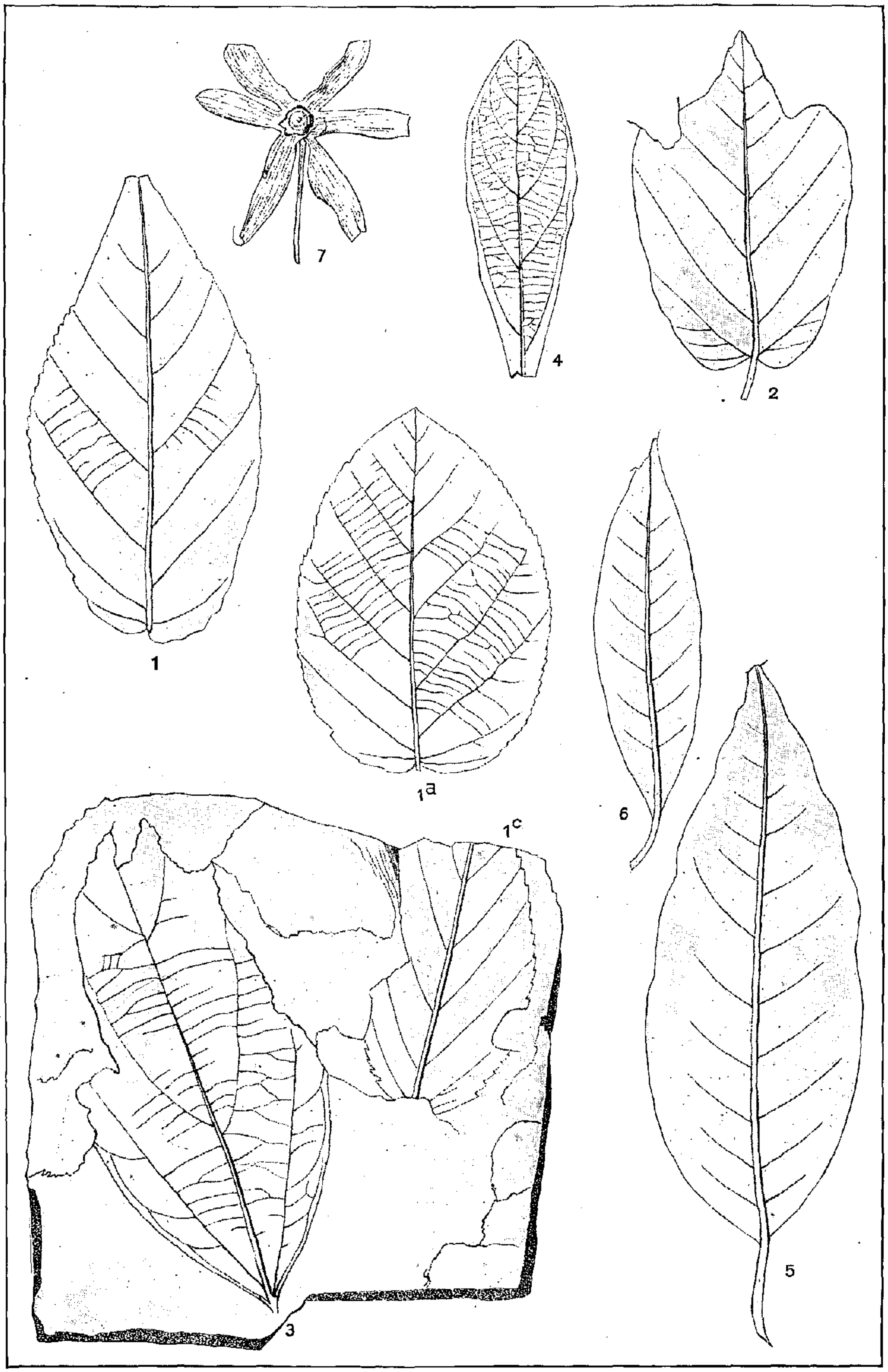
In the Wasatch group as thus defined by Hayden the field work of the season of 1905 showed three divisions: (1) A basal member composed of reddish-yellow sandy clays, in many places containing pronounced conglomerate beds, which has been named the Almy formation; (2) a great thickness of light-colored rhyolitic ash beds containing intercalated lenses of white limestones with fresh-water shells and leaves—the Fowkes formation; and (3) a group of reddish-yellow sandy clays with irregular sandstone beds closely resembling (1) lithologically and separated from (1) and (2) by a pronounced period of folding and erosion. The last group has been called the Knight formation and is the horizon of the Coryphodon remains found in this vicinity. The Almy and Fowkes formations belong, with the Evanston, in the conformable series separated on the one hand by a pronounced period of folding and erosion from the Laramie beds, and on the other from the Coryphodon Wasatch beds by a period of folding and erosion of great magnitude though of much less importance than the one between the Adaville and the Evanston. The fossils from the Almy and Fowkes have, without exception, been considered Eocene, but the formations are treated with the Evanston because of their very intimate stratigraphic relation to it and the stratigraphic isolation of the Evanston, Almy, and Fowkes from the beds above and below. Whether it can ever be conclusively proved from the limited paleontologic data available that the line between the Cretaceous and Eocene should be drawn in this section between the Evanston and Almy, so that one great physical break will be thrown into the Cretaceous and the other secondary physical break into the Tertiary, is very doubtful. Stratigraphic geologists will, in the absence of very positive paleontologic data to the contrary,

[a] Clark, W. B., Bull. U. S. Geol. Survey No. 83, 1891, p. 139; Geikie, Archibald, Text Book of Geology, 4th ed., 1903, p. 1243



SECTIONS OF DRILL HOLES WEST OF SPRING VALLEY, WYO., SHOWING COALS IN TERTIARY BEDS.

From records of Union Pacific Coal Company.



1. 1a, 1c. Betula stevensoni Lesq.
2. Quercus negundoides Lesq.
3. Ficus pseudo-populus Lesq.
4. Malapoenna (Tetranthera) sessiliflora (Lesq.) Kn.
5. Laurus socialis Lesq.
6. Laurus primigenia Ung.
7. Diospyros woodani Ung.

(Copies of Lesquereux's figures of specimens from Almy, Wyo.)

FOSSIL LEAVES FROM EVANSTON FORMATION.

and none such exist at present, favor taking one physical break or the other for the line between the Cretaceous and Tertiary, preferably the earlier and greater one. The Knight formation is not in dispute and has therefore been treated under the Eocene.

ALMY FORMATION.

DEFINITION AND DISTRIBUTION.

This formation is named from the town of Almy, situated a few miles north of Evanston. It is exposed at this point in the bluffs along the east side of Bear River immediately above the Evanston formation and extends eastward beneath the white beds of the Fowkes formation, from which it is readily distinguished lithologically. It consists of yellow and reddish-yellow sandy clays with irregularly bedded sandstones and near the base pronounced conglomerate beds. In the Almy section it has a thickness of 2,100 feet. The beds of the Almy formation are commonly exposed in this region only along lines of disturbance. The basal conglomerate beds were observed by Hayden at Almy and the Needles and correctly correlated with the lower Wasatch conglomerates exposed in Echo Canyon. These beds are well exposed in a narrow belt along the eastern side of the Rock Creek-Needles anticlinal from Chalk Creek to Medicine Butte. They have been brought up here, and in places highly inclined, by movement along the thrust fault associated with this anticline. It was their high inclination at the Needles and the dip of 15° to 20° near Almy (Pl. XIII, *B*) which led members of the King Survey to regard the first exposure as Dakota and the second as Laramie. These lower conglomerates are along this line unconformably overlain by the almost horizontal Knight beds. An unconformity of over 4,000 feet is thus indicated. Everywhere these Almy beds show pronounced disturbance, and at many places show very distinct angular unconformity with the Knight beds. (Pl. XIII, *A*.) The folding of the Almy beds is well shown at the head of Whitney Canyon (Pl. XVII, *A*), where the horizontal Knight strata rest directly on the folded Almy. Another point of great disturbance and folding in the Almy beds is at Round Mountain. The great force involved in the disturbance of the Almy strata is shown in the crushed character of the pebbles composing the conglomerate. The conglomerates are composed of light-colored, well-rounded quartzite and chert pebbles, but contain some sandstones of local origin. These pebbles, both quartzite and sandstone, are very often crushed and recemented in the manner shown in Pl. XVI, *B*. The matrix of the conglomerate is light colored, greatly resembling loose mortar.

FOSSILS.

Calcareous beds belonging to this formation yielded fossils just west of the fault line in sec. 15, T. 17 N., R. 120 W. These have been identified by Dr. W. H. Dall as *Physa*, small multaspiral *Planorbis*, *Aplexa*, *Valvata*, and *Planorbis*.

Similar beds in sec. 12, T. 17 N., R. 120 W., have yielded *Planorbis* (2 species), *Physa*, *Vivipera*, *Amnicola*, *Pisidium*, *Sphærium*, and ganoid fish scales. These are all fresh-water types. A small lot collected by Mr. Pishel on "crest of hill east of mine No. 6," Almy, either in the lower part of this formation or the top of the Evanston, showed *Physa* and *Cypris*.

Leaves were found in a sandstone in contact with the Nugget and Twin Creek beds in SW. ¼ sec. 16, T. 21 N., R. 118 W. This sandstone is in the lower part of the Wasatch exposed in this section and may belong either to the Almy or the Knight. Doctor Knowlton reports regarding this collection:

A considerable number of large leaves of *Platanus*, apparently *P. raynoldsii* Newb., but the margin is lacking in most cases. If correctly determined, the age should be Fort Union or near it.

FOWKES FORMATION.

DEFINITION AND DISTRIBUTION.

Overlying the Almy formation is a thick series of light-colored beds composed largely of rhyolitic ash and containing thin layers of white limestones. These beds are well exposed in the valley east of the Almy hills and thence northward to the Narrows. This formation is named from Fowkes ranch, about 9 miles from Evanston, around which these beds are well exposed. West of Bear River they occur along the base of the hills and show in the numerous cuts on the Chapman canal. South of Evanston along Yellow Creek there are limited exposures, here showing a conglomeratic or agglomeratic phase and underlain by white limestones. Farther north, along Dry Hollow, there are extensive exposures of almost pure ash. This formation conformably overlies the Almy, though the minor movements which occurred before the deposition of the Knight formation may have been initiated in this period and may slightly affect the upper beds.

The Fowkes formation is seen underlying the Knight on the west side of Bear River, opposite Almy. The contact relation here is not sharp, but viewed from the high hills south of Evanston appears distinctly unconformable. It is entirely absent between the Knight and the Almy east of the Rock Creek-Needles anticlinal. Specimens from this formation have been studied by Dr. Albert Johannsen, who reports as follows:

Near Utah-Wyoming line in Dry Hollow, 4 miles north of the Narrows.

No. 1 is a volcanic tuff, probably rhyolitic. It consists mainly of angular particles of glass, exhibiting flow structure. The glass has been partially devitrified. Mingled with the glass is a much smaller amount of crystalline material, consisting of quartz and biotite with a very little feldspar.

No. 2 is a tuff, probably rhyolitic; very much like No. 1, but somewhat more devitrified.

Sec. 9, T. 17 N., R. 120 W., just south of the Narrows.

No. 1 is a tuff, probably rhyolitic or latitic. The greater part of the material consists of rounded anisotropic particles, some of which are devitrified glass, while others are altered rock fragments. There are also a number of irregular grains of plagioclase, orthoclase, quartz, and biotite. The mineral grains and the devitrified particles are each surrounded by a thin film of chlorite. It is not certain that the mineral particles and the devitrified grains were derived from the same source, very probably they represent different sources.

Sec. 12, T. 14 N., R. 121 W., 5 miles southwest of Evanston.

No. 1 may be called a conglomerate, or possibly an agglomerate. The pebbles are seemingly latite porphyry like the material which makes the finer-grained matrix inclosing the pebbles. The larger particles of the matrix have phenocrysts of plagioclase and quartz and a few of biotite. The groundmass is microgranular and consists of orthoclase and plagioclase with considerable chalcedony and possibly some glass, the chalcedony being of secondary origin.

No. 2. Material, 90 per cent or more of which is now calcite, with crystalline particles of quartz and a little biotite and hornblende disseminated through it. A part of the calcite seems to represent the alteration of mineral or rock grains. Probably the occurrence will determine whether the rock should be considered an impure fresh-water limestone or a much-altered calcareous tuff.

The last is regarded as an impure fresh-water limestone, and here underlies the conglomerate. The exposure of the conglomerate or agglomerate material is very limited, covering only a few square feet, and its relations are not clearly shown. It suggests greater proximity to a volcanic vent than the material found at any other point. This suggestion is, however, in part negated by the fact that no similar deposits of volcanic origin are reported in the section on Echo Creek, a few miles to the west, and Chalk Creek, a few miles to the south. This appears to indicate that the source does not lie in that direction. There is no evident source for this material, and it is supposed to have been derived from local cones, perhaps comparable to, though older than, those penetrating the Cretaceous and Tertiary beds in the Leucite Hills in Sweetwater County,[a] situated in the region now buried by Knight deposits south of the Crawford Mountains and immediately west of this region.

Owing to the pronounced volcanic aspect of these beds and the fact that detailed examinations were not then made, they are represented as igneous rocks on the geologic map of the Fortieth Parallel Survey, which shows such rocks near the present site of Fowkes ranch, and on the geological map of Wyoming by Knight, which shows them in Dry Hollow. Emmons describes the occurrence near Fowkes ranch as follows:[b]

About midway between Evanston and the Narrows of Bear River occurs an outburst of rhyolitic tufa, rising above the foothills of Aspen Plateau, which is of interest, since it is far separated from any other known occurrence of this rock. In its physical habit it is a uniform fine-grained rock, of an arenaceous, pumice-like texture, crumbling readily, and having a prevailing lavender tint. The groundmass is an intimate admixture of fragments of feldspar and quartz grains, with thin laminæ of dark biotite plates and some bronze-colored mica.

King states regarding this locality:[c]

About 10 miles north of Evanston, in the neighborhood of some limited Cretaceous exposures, but otherwise altogether surrounded by the nearly horizontal beds of the Vermilion Creek Eocene group, is a small outcrop of rhyolite, far removed from all other volcanic rocks. It is a fine-grained, pumiceous, lavender-colored rock, the groundmass being the ordinary intimate mixture of sanidin and quartz, in which are interspersed laminæ of very dark and of brownish mica. The outcrop is only of importance from its wide separation from other volcanic fields, the nearest eruptions being some miles down Bear River in the neighborhood of its great bend [at Soda Springs, Idaho].

From the color reported it is believed that the specimens described by King and Emmons came from near the locality of the specimen collected just south of the Narrows and described above by Doctor Johannsen. This area was examined in great detail during the summer of 1905, and it can be stated positively that the King specimens came from the Fowkes beds near the type locality.

South of Sage there are three limited exposures of a light-colored pisolitic limestone, which is regarded as lower Wasatch and has been indicated on the geologic map as belonging to the Fowkes. These exposures are located in the northeast and southeast corners of sec. 24 and the southwest corner of sec. 36, T. 21 N., R. 121 W.

[a] Kemp, J. F., and Knight, W. C., Leucite Hills of Wyoming: Bull. Geol. Soc. America, vol. 14, 1903, pp. 305-336, and references there given.

[b] Rept. Explor. 40th Par., vol. 2, 1877, pp. 337-338.

[c] Rept. Explor. 40th Par., vol. 1, 1878, p. 608

FOSSILS.

Numerous specimens of fresh-water shells were obtained in the lower part of the Fowkes formation in the valley between Almy Hills and Medicine Butte. A fern was obtained in the southwest quarter of sec. 33, T. 16 N., R. 120 W., near the base of the formation, on which Doctor Knowlton makes the following report:

One specimen, representing a very large fern; probably new. I should presume that this was Tertiary in age, but as I have never before seen this plant I can not of course speak positively.

On the west side of Bear River, in the Fowkes exposures immediately below the Knight beds, a small collection was made. Dr. W. H. Dall identified the following invertebrates from this locality:

Invertebrates from SE. ¼ SW. ¼ sec. 1, T. 15 N., R. 121 W.

Planorbis, 2 sp.	Goniobasis.
Planorbula.	Ancylus.
Physa.	Pisidium.
Succinea?.	Ganoid scales.
Small Limnæa.	Fish bones.

Dr. F. H. Knowlton reports regarding the leaves from this locality:

Leaves from SE. ¼ SW. ¼ sec. 1, T. 15 N., R. 121 W.

Acrostichum hesperium Newb.	Equisetum. Very large stems; probably new species.

Belongs to the Green River group.

Cope reports, in a stratum of impure limestones, probably in the upper part of the Fowkes formation, at a point 2 miles east of the outcrop of the Evanston coal, the following species:[a]

Reptiles: Trionyx scutumantiquum.	Fishes: Rhineastes calvus.
Emys? euthnetus.	Clastes glaber.

EOCENE.

WASATCH GROUP (CONTINUED).

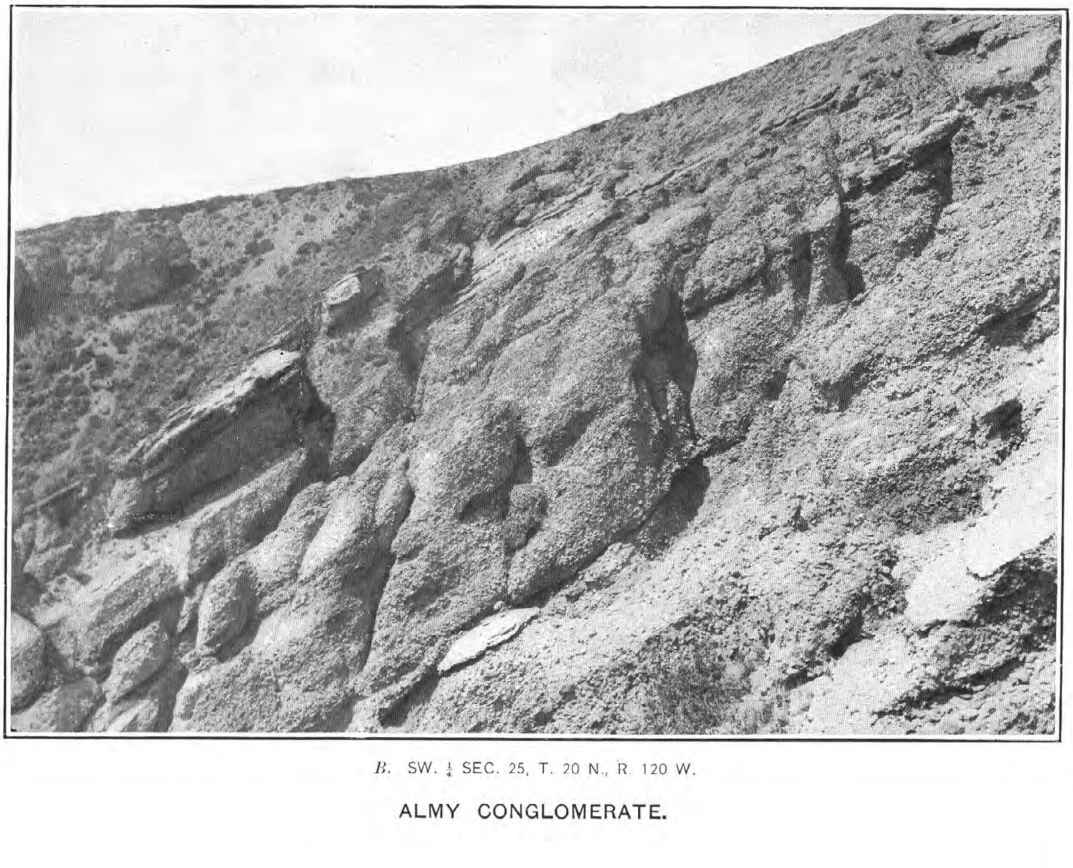
KNIGHT FORMATION.

DEFINITION AND DISTRIBUTION.

This formation, named from Knight station on the Union Pacific Railroad, near which Cope first obtained vertebrate remains from the Wasatch beds, consists of yellow and reddish-yellow sandy clays, with irregularly bedded yellow sandstones and occasional thin layers of fresh-water limestones in its upper portion. It is throughout the region but very gently inclined, the dips seldom exceeding 5°, and rests unconformably on the upturned edges of the Almy and older beds. It is overlain by the Green River and Bridger beds, which have the same low dips and are apparently conformable with it. There is no evidence in this region of angular unconformity or erosion between the Knight and the overlying beds, and while the Green River

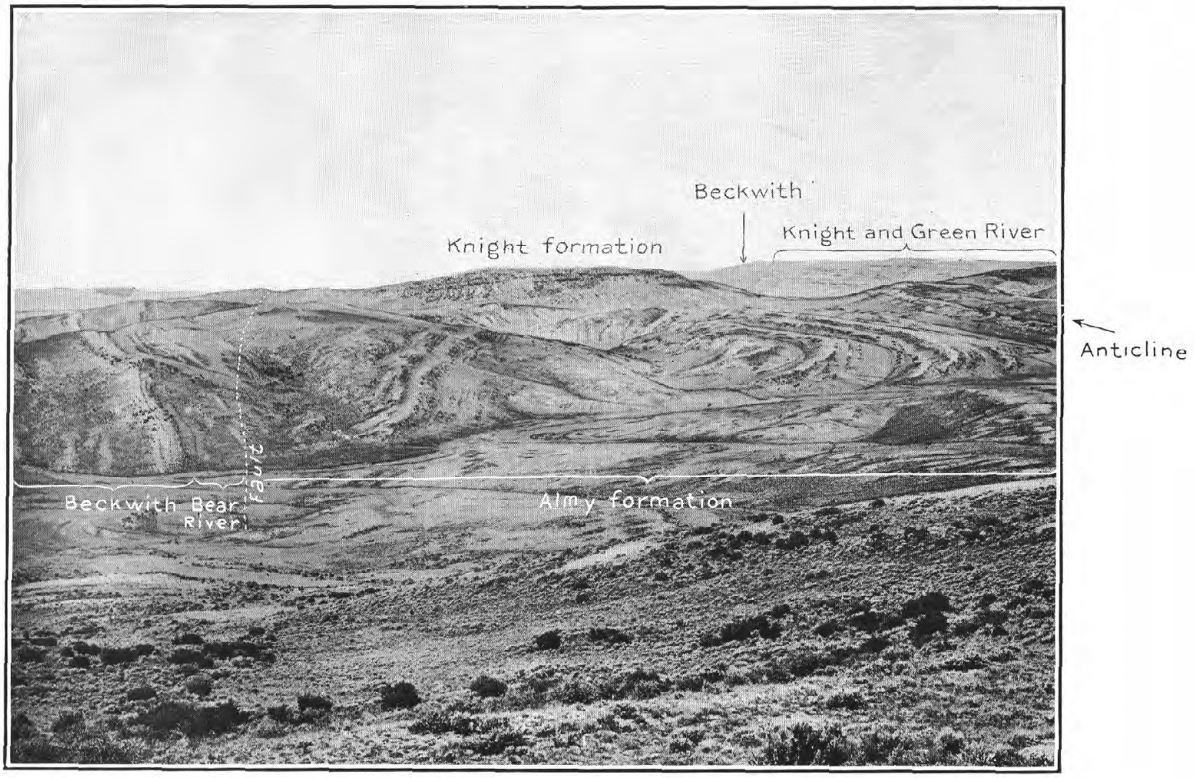
[a] Bull. U. S. Geol. and Geog. Survey Terr., vol. 1, No. 2, 1872, p. 13; Seventh Ann. Rept. U. S. Geol. Survey Terr. for 1873, 1874, p. 441; Rept. U. S. Geol. Survey Terr., vol. 2, 1875, p. 39.

A. CRUSHED AND RECEMENTED PEBBLE FROM LOCALITY BELOW; $\frac{5}{6}$ OF NATURAL SIZE.



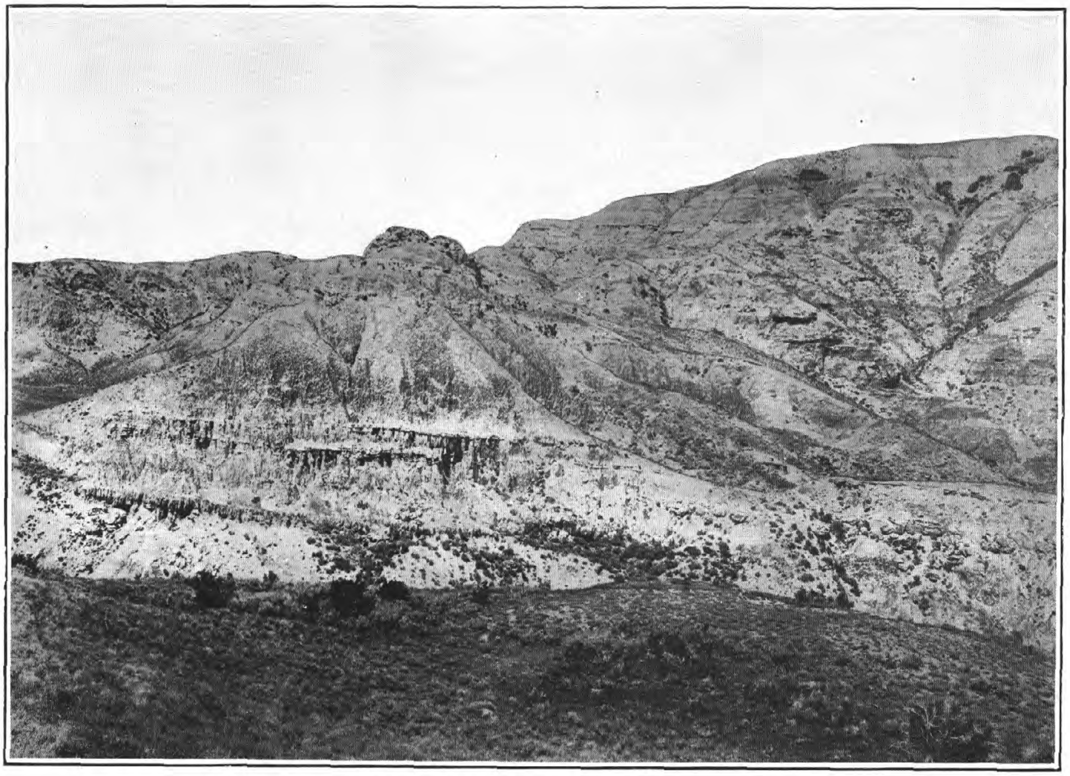
B. SW. $\frac{1}{4}$ SEC. 25, T. 20 N., R. 120 W.

ALMY CONGLOMERATE.



A. VIEW SHOWING RELATION OF BEDS NEAR AND EAST OF MEDICINE BUTTE FAULT, JUST NORTH OF WHITNEY CANYON.

Note Almy beds with Knight beds unconformable in the distance. This angular unconformity is also well marked just east of the anticline in the Almy beds.



B. TYPICAL LOWER KNIGHT BADLANDS, SW. ¼ SEC. 25, T. 20 N., R. 120 W.

OUTCROPS OF ALMY AND KNIGHT FORMATIONS.

beds show a distinct thinning to the south this is believed to be due to the conditions of sedimentation, including the broad and very gentle earth movements which produce overlap. Some difficulty was experienced in this reconnaissance in differentiating the Knight and Green River beds. In a broad way the Knight beds are sandy clays of a predominantly reddish cast, and the Green River beds are light colored and calcareous. There is certainly a great difference between the characteristic fish-bearing shales of the Green River and the characteristic Knight beds, but the exact line between the two can not always be fixed with certainty. Light-colored calcareous beds occur at several points overlain by the characteristic reddish clays of the Knight, and sufficiently near the top of the formation to raise the question whether they should be considered Green River or Knight.

Around the type locality these beds are extensively and characteristically exposed. In the bluff on Bear River, a few miles west of Knight, Cope collected vertebrate fossils in 1872, and a few miles to the northwest, north of the river, is the "Bathmodon bone bed" locality.

The total thickness of this formation is not known and is difficult to determine exactly, because of its unconformable relations to the underlying beds. Its estimated thickness in the type locality is over 1,500 feet.

Just east of Cumberland the basal beds of this formation are composed almost entirely of fragments of Aspen shale, indicating the presence of a local beach line and the irregularity of the surface on which these beds were deposited.

FOSSILS.

Vertebrate fossils.—The first vertebrate fossils found in the Wasatch beds were obtained in this region. The locality from which they were obtained is generally given simply as "near Evanston," and considerable difficulty has therefore been experienced in determining the precise geographic and stratigraphic positions of the fossils described. This difficulty is perhaps due to two causes. In the first place, the interest of the vertebrate paleontologist was primarily in the biologic aspect of the collections, the exact locality and stratigraphic position being of secondary importance, except in so far as they might be of use to him in obtaining further collections, and thereby hangs the second reason. Each collector was anxious to preserve for his own use so far as possible the important bone localities which he discovered.

From a careful consideration of the paleontological writings of Cope and Marsh, together with a thorough knowledge of the geography and stratigraphy of this region, the locality from which the fossils were obtained, as well as their stratigraphic position, has been determined within certain limits. Marsh[a] asserts that the first specimens of *Coryphodon* (Pl. XVIII) were found in 1871 near Evanston, Wyo., by William Cleburne, a surveyor in the employ of the Union Pacific Railroad. Some of the material collected was given to Prof. F. V. Hayden and by him transmitted to Professor Cope, and the remainder was presented to Professor Marsh. In 1872 Cope described the new genus *Bathmodon*—afterwards shown to be a synonym of *Coryphodon* Owen—and the new species *B. radians* and *B. semicinctus*, "from

[a] Marsh, O. C., Am. Jour. Sci., 3d ser., vol. 46, 1893, p. 321.

material discovered by Doctor Hayden in Tertiary beds of the Wasatch group near Evanston."[a] This is evidently the material referred to by Marsh. In 1872 Cope personally visited this region, and his account of this trip[b] forms the main basis for a determination of the localities near Evanston from which the Wasatch fossils were obtained. It appears from this account that Cope visited the bluffs about Almy coal mines and then proceeded up the river from Evanston. He describes outcrops at a point "7 miles above—that is, southeast of—Evanston" and at a point "11 miles above Evanston, or near the bend of Bear River." The point "11 miles above Evanston" is shown by the accompanying discussion to refer to the pronounced bluffs just west and south of the present railroad bridge, which is really only about 6 miles above Evanston. From this point he proceeded "5 miles to the northeast," to a point where "the strata are observed to dip in a direction opposite to those at Evanston." This they do immediately west of the Cretaceous and older beds exposed from old Bear River City northward. Continuing a little farther, he encountered the vertical sandstones and conglomerates of the Beckwith formation, which he regarded as the east flank of an anticline of the Wasatch beds. He cited, to prove this anticlinal theory, the pseudo-anticline shown in Fossil Cut near old Bear River City (Pl. VII, *A*). Regarding the localities from which fossils were collected, Cope says:

> My assistant, Professor Garman, and myself succeeded in discovering a number of species in the upper red and white strata on the bluffs 11 miles southeast of Evanston, or near the bend of Bear River. They occurred here on the upper and upper middle portions of the exposure. Extending our observations to the ridges of bluffs farther to the southward we found the same strata producing similar and in several cases the same fossils. They appeared lower down on the exposures, consistently with the dip of the strata, though a few were found near the top of these, also.

It is believed that the statement "extending our observations to the ridges of bluffs farther to the southward" should be changed to read northward. There are many fine exposures in the hills north of the bluffs on Bear River near the railroad bridge, and this is the natural direction for a fossil hunter to work from these bluffs. To work south would require crossing the broad Bear River bottoms to hills which, from the bluffs on the north of the river, do not show good clean exposures and do not look as promising as the territory to the north. *Notomorpha garmanii*, afterwards regarded as a synonym of *N. gravis*, is described as obtained "from a bluff 6 miles north of the Bear River," and was evidently obtained on this northeast trip from the bluff at a point near the Evanston-Fort Bridger road. In a later article, in describing these specimens, Cope gives the locality as "6 miles north of Evanston on Bear River;" but this is clearly an error when considered in connection with details given in the original report.[c]

In 1873 Cope again visited this region and succeeded in locating the "Bathmodon bone bed," from which the Cleburne or Hayden specimens were obtained. The only account of this trip which indicates anything regarding the locality is given below.[d]

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[a] Cope, E. D., Am. Jour. Sci., 3d ser., vol. 3, 1887, p. 224. Proc. Am. Philos Soc., vol. 12, 1872, pp. 417-422. [Fifth Ann.] Prelim. Rept. U. S. Geol. Survey Montana, 1872, pp. 350-352.

[b] Proc. Am. Philos. Soc., vol. 12, 1872, pp. 472-477.

[c] Rept. U. S. Geol. Survey Terr., vol. 3, 1884, p. 143.

[d] This data first appeared in Bull. U. S. Geol. and Geog Survey Terr., vol. 1, No. 2, 1874, p. 13. It was reprinted verbatim in Seventh Ann. Rept. U. S. Geol. and Geog. Survey Terr. for 1873, 1874, p. 441, and in Rept. U. S. Geol. Survey Terr. vol. 2, 1875, p. 39.

As already stated (Proc. Am. Philos. Soc., 1872, p. 473),[a] the upper or red-banded Tertiary beds of this locality[b] yielded the following species:

Perissodactyle bones, two species.	Emys testudineus.
Orotherium vasacciense [Eohippus vasacciensis].	Emys gravis.
Crocodilus, sp.	Clastes (?) glaber.
Alligator heterodon[c] [Crocodilus heterodon].	Unio, two species.
Trionyx scutumanitquum.[d]	

The lower sandstone beds yielded the following mammals:

Bathmodon radians. [Coryphodon radians.]
Bathmodon semicinctus. [Coryphodon semicinctus.]
Bathmodon latipes. [Coryphodon latipes.]
Orotherium index. [Eohippus index.]
Phenacodus primævus.

West of the contact of Bear River with the Tertiary bluffs the strata consist of sandstone and conglomerates and dip at about 30° to the northeast. Five hundred feet vertically below the *Bathmodon* bed a stratum of impure limestone crops out, forming the slope and apex of a portion of the bluff. In this I found the following vertebrates:

Reptiles: Trionyx scutumantiquum.	Fishes: Rhineastes calvus.
Emys? euthnetus.	Clastes glaber.

This is the nearest to a determination of the age of the Evanston coal bed, which Hayden regards as the most important west of the Missouri River, that I have been able to reach. From the limestone just described to the coal bed, 2 miles to the west, the strata are very similar in character and apparently conformable, so that they appear to belong to the same series.

The dip along Bear River from Evanston to the locality of the "upper or red-banded Tertiary beds" is for the most part easterly, and the "lower sandstone beds" are believed to be west of these bluffs at some point in the hills near and just north of Bear River. The impure limestone 500 feet vertically below the *Bathmodon* bed is evidently one of the limestones in the Fowkes formation, which outcrops in a belt about 2 miles east of the crop of the Almy coal. This agrees with Cope's statement that the coal bed is 2 miles west of the limestone. Further, the statement that the strata between this limestone and the coal are very similar in character to the upper Wasatch beds and apparently conformable likewise agrees with the conditions at this point. The statement that "west of the contact of Bear River with the Tertiary bluffs the strata consist of sandstones and conglomerates and dip at about 30° to the northeast" is evidently one of the interpolations common in Cope's writings. This sentence can only be taken to describe the conditions in the bluffs in the vicinity of Almy, which are distinctly east of Bear River. These Almy bluffs are, however, in a westerly direction from the "contact of Bear River with the Tertiary bluffs," near the railroad bridge and the hills to the north, where Cope first collected fossils.

It is believed that all the material described by Cope and Marsh was collected east of Evanston[e] in a limited area north and east of Bear River, south of a line

[a] Quoted on p. 94.

[b] "This locality" refers to the bluffs on Bear River near the Union Pacific Railroad bridge and the hills to the northeast.

[c] In Rept. U. S. Geol. Survey Terr., vol. 3, 1884, Cope states: "I only found it (*Crocodilus heterodon*) in the beds of the Wasatch, or perhaps Green River, epoch, at Black Butte, Wyoming." In his first account, Proc. Am. Philos. Soc., vol. 12, 1872, p. 473, its resemblance to *Limnosaurus* (*Crocodilus*) *heterodon* is suggested. The fragments are perhaps imperfect and not susceptible of close identification.

[d] Compared with *Trionyx guttatus* in first account, Proc. Am. Philos. Soc., vol. 12, 1872, p. 473. In Rept. U. S. Geol. Survey Terr., vol. 3, 1884, pp. 121-122, Cope states "Several fragmentary individuals from Wasatch beds near Black Butte, Wyoming, as also one from the corresponding formation on Bear River, resemble this species (*Trionyx scutumantiquum*) more nearly than any other."

[e] See in this connection statement of S. F. Emmons, in Rept. 40th Par. Survey, vol. 2, 1877, p. 329, regarding "the recent discovery by Professor Marsh's assistants of an interesting series of vertebrate remains in the hills to the east of Evanston."

connecting Medicine Butte and Lazeart coal mine, and west of the outcrops of the pre-Tertiary rocks exposed between Lazeart and old Bear River City. With the exception of the species listed from the limestone layer, which are believed to have come from some part of the Fowkes formation, all of the species collected come from the upper part of the Wasatch formation, stratigraphically 4,500 feet or more above the base of the Almy formation, which is here, according to the original definition of Hayden, basal Wasatch.

In addition to the species listed by Cope, Marsh has described from the "Bathmodon or Coryphodon beds" of this locality *Coryphodon hematus.*[a]

Invertebrate fossils.—Fresh-water shells are common in the white limestones that occur in the upper part of the Knight or the base of the Green River. They are abundant in the strata at the head of Bridger Creek, in the hill just south of Sage, and a few miles east of Cumberland. Shells were collected from the latter locality by Frémont in 1843[b] and described by James Hall under the names *Cerithium nodulosum* and *Turbo paludinæformis*. Hall gives the following description of this material:

> The rock is a perfect oolite, and, both in color and texture, can scarcely be distinguished from specimens of the Bath oolite. One of the specimens is quite crystalline, and the oolitic structure somewhat obscure. In this instance the few fossils observed seem hardly sufficient to draw a decisive conclusion regarding the age of the formation, but when taken in connection with the oolitic structure of the mass its correspondence with the English oolites, and the modern aspect of the whole, there remains less doubt of the propriety of referring it to the oolitic period. A further collection from this interesting locality would doubtless develop a series of fossils which would forever settle the question of the relative age of the formation. A few miles up this stream Captain Frémont has collected a beautiful series of specimens of fossil ferns. The rock is an indurated clay, wholly destitute of carbonate of lime, and would be termed a "fire clay." These are, probably, geologically, as well as geographically, higher than the oolite specimens, as the rocks at this place were observed to dip in the direction of N. 65° W. at an angle of 20°. This would show conclusively that the vegetable remains occupy a higher position than the oolite. Associated with these vegetable remains were found several beds of coal differing in thickness.

The fossiliferous limestones at this point dip gently eastward, and it was clearly Hall's unwarranted assumption that both the plant-bearing beds and the oolitic limestone had the same dip, that led to the conclusion that the shells came from a lower horizon than the leaves. Both Meek and White have recognized the identity of these forms with those found in beds of undoubted Eocene age and at about the same horizon, and have thus anticipated from paleontologic data the conclusion reached by visiting the type locality. Meek[c] pointed out that the *Cerithium* is clearly a *Goniobasis*, and suggested the name of *Goniobasis nodulifera*, while White[d] regards it as but a variety of *Goniobasis tenera* (*Cerithium tenerum* Hall). *Turbo paludinæformis* has likewise been referred to the fresh-water genus *Viviparus*.

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[a] Am. Jour. Sci., 3d ser., vol. 11, 1876, pp. 425-428; Am. Jour. Sci., 3d ser., vol. 46, 1893, pp. 321-326. Dr. W. D. Matthews states, in Bull. Am. Mus. Nat. Hist., vol. 12, 1899, pp. 33, 34, that *Eohippus pernix* Marsh (Am. Jour. Sci., 3d ser., vol. 12, pp. 321-326) came from this locality, but Mr. Walter Granger, of the American Museum, informs me that Marsh's locality catalogue shows that it came from Black Buttes.

[b] Rept. Explor. Exped. to the Rocky Mountains, House Ex. Doc. No. 166, 28th Cong., 2d sess., 1845, pp. 131, 297.

[c] Meek, D. B., [Fourth Ann.] Prelim. Rept. U. S. Geol. Survey Terr. for 1870, 1872, p. 299. Rept. U. S. Geol. Expl. 40th Parallel, vol. 3, 1877, pp. 179-180.

[d] White, C. A., Eleventh Ann. Rept. U. S. Geol. and Geog. Survey Terr. for 1877, 1879, pp. 226-227.

GREEN RIVER FORMATION.[a]

DEFINITION AND DISTRIBUTION.

The Green River formation was named and defined by Hayden in 1869 from the exposures along Green River in the vicinity of Green River city. The term is used here in the original sense, and, as adopted by the King Survey, applies to the light-colored calcareous beds occurring between the sandy reddish beds of the Wasatch and the greenish beds of the Bridger. Some confusion has arisen in the discussion of the geology of this general region by the use of Green River by Cope to include both the Wasatch and Green River deposits and by Lesquereux to include Wasatch, Green River, Bridger, Uinta, and White River beds. A certain amount of care must therefore be used in preparing faunal and floral lists of the Green River beds proper. This formation is noteworthy for the great number and wonderful state of preservation of the plants and fish remains it contains. (Pls. XIX, XX.) One of the most famous localities for the fish and plant remains is in the cliffs around Fossil, on the Oregon Short Line. Great quarries have been opened here, following the most fossiliferous strata for miles around the hillside, and the museums of the world supplied. At Fossil the line between the Green River and Wasatch beds is very sharp, but to the south some difficulty was experienced in locating this line of parting. Light-colored calcareous beds, lithologically suggestive of the Green River beds, occur overlain by pronounced red beds, suggesting the Wasatch. The areas in which these formations are most extensively developed were, however, not examined in great detail, and are indicated on the map as "undifferentiated Eocene." East of Oyster Ridge these beds are well developed in the northern part of this area. To the south they thin rapidly and lose their distinctive characteristics. Light-colored calcareous beds intercalated with reddish clays occur in the hills east and west of Muddy Creek near Piedmont. These have been mapped by the King Survey as Green River, and may represent the southern extension of this formation. Part of the white beds are distinctly overlain by red beds, suggesting the Knight, and the remainder are lithologically more like some of the white beds in the Bridger formation than the typical Green River.

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[a] Synonymy and usage of Green River formation:

=Second series [of the Tertiary of the Green River basin], Engelmann, House Ex. Doc. No. 40, 35th Cong., 2d sess., 1859, p. 47.

<Green River Tertiaries, King, 40th Par., vol. 3, 1870, p. 455, which includes all the Tertiary beds in the Green River basin.

=Green River shales, Green River beds, Green River group, Hayden, [Third Ann.] Prelim. Field Rept. U. S. Geol. Survey Colorado and New Mexico, 1869, pp. 90–91; [Fourth Ann.] Prelim. Rept. U. S. Geol. Survey Wyoming, 1872, pp. 40, 55, 58, 70, 142–143, 166.

=Green River group, King, Atlas, Explor. 40th Par., 1876; Emmons, Rept. Explor. 40th Par., vol. 2, 1877, pp. 240–244; King, Rept. Explor. 40th Par., vol. 1, 1878, pp. 377–394.

<Upper and Lower Green River group, Powell, Geol. Uinta Mountains, 1876, pp. 40, 45, 166–167.

<Green River beds, Comstock, 1875, Rept Reconnaissance Northwest Wyoming, by W. H. Jones, in 1873, table following p. 103, p. 123. Defines name to include beds between the "Green River coal group" and the Bridger; hence includes both the Wasatch and Green River.

<Green River group, Lesquereux, Rept. U. S. Geol. Survey Terr., vol. 8, 1883, p. 137, includes Wasatch, Green River, Bridger, Uinta, and White River. In Rept. U. S. Geol. Survey Terr., vol. 7, 1878, p. 19, he uses this term to include all Tertiary beds exposed between Rock Springs and Evanston.

<Green River group, Green River beds, Green River formation, Green River strata, Cope, Proc. Phila. Acad. Nat. Sci., vol. 24, 1873, p. 279; Sixth Ann. Rept. U. S. Geol. Survey Terr. for 1872, 1873, pp. 589, 625, 627, 628; Seventh Ann. Rept. U. S. Geol. and Geog. Survey Terr., 1874, p. 441. Here includes both Wasatch and Green River.

<Wasatch group, Cope, Rept. U. S. Geol. Survey Terr., vol. 3, 1884, p. 7, vol. 4, 1889, table following p. 43, which includes both Wasatch and Green River.

FOSSILS.

Plants and fish from the Green River shales in the vicinity of Fossil have been studied and described by Lesquereux and Cope. Lesquereux's account of the leaves is given in his Cretaceous and Tertiary Flora[a] under the locality names "Randolph County, Wyo.," and "Randolph County, Colo." Ward[b] and Knowlton[c] are both of the opinion that this material was undoubtedly obtained near Fossil. The error in name was probably due to a confusion with the town of Randolph, Utah, which is a few miles west of the State line. The species listed from this locality are given below and several are shown on Pl. XIX.

Plants listed and described from the Green River beds near Fossil by Lesquereux

[Where species are marked * figures of specimens from this locality have been published, species marved with † were first described from this locality.]

†*Cyperacites (Cyperites) haydenii (Lesq.) Knowlton.
*Typha latissima Al. Br.
†*Flabellaria florissanti Lesq.
*Quercus drymeja Ung.
†*Quercus castaneopsis Lesq.
*Quercus neriifolia Al. Br.
*Liquidambar europæum Al. Br.
†*Celtis mccoshii Lesq.
†*Andromeda delicatula Lesq.
†*Acer indivisum Lesq. (=Acer lesquereux Knowlton).
†*Euonymus flexifolius Lesq.
†*Ailanthus longepetiolata Lesq.
†*Amygdalus gracilis Lesq.
†*Antholithes improbus Lesq.

Cope has identified and described the following species from the neighborhood of Fossil (Pl. XX):

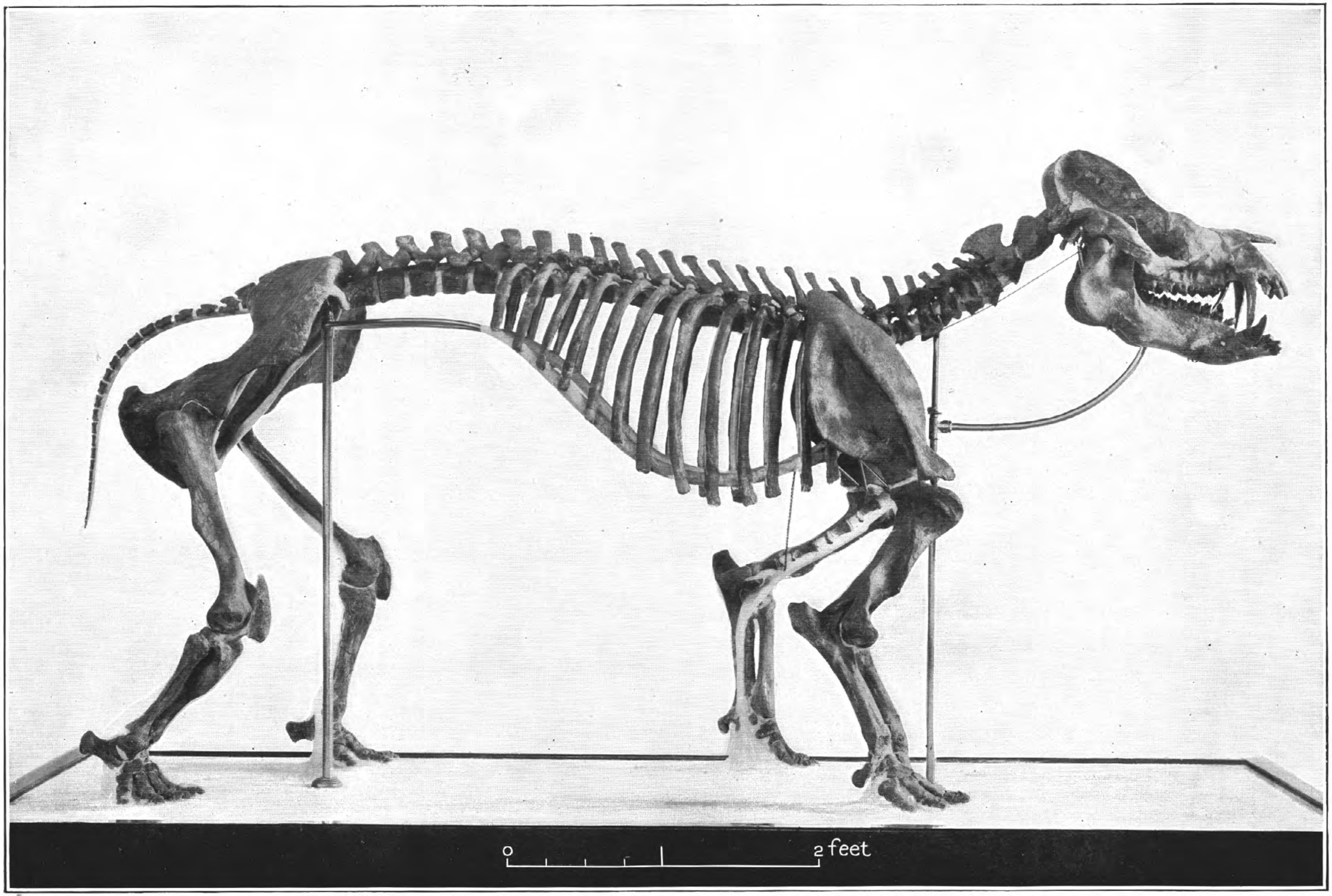
Fossil fish listed and described from the Green River beds near Fossil by Cope.[d]

[Where species are marked * figures of specimens from this locality have been published; species marked † were first described from this locality.]

†*Phareodus (Dapedoglossus) testis Cope.
†*Phareodus (Dapedoglossus) æquipennis Cope.
†*Diplomystus densatus Cope.
†*Diplomystus analis Cope.
*Diplomystus humilis (Leidy)=Chipea pusilla Cope.
*Diplomystus altus (Leidy) Cope.
†*Diplomystus pectorosus.
†*Amphiplaga brachyptera Cope.
†*Asineops pauciradiatus Cope.
†*Mioplosus abbreviatus Cope.
†*Mioplosus labracoides Cope.
†*Mioplosus beani Cope.
†*Mioplosus sauvageanus Cope.
†*Priscacara serrata Cope.
†*Priscacara cypha Cope.
†*Priscacara oxyprion Cope.
†*Priscacara clivosa Cope.
†*Priscacara pealei Cope.
†*Priscacara liops Cope.

Associated with these fish and plant remains are numerous fresh-water shells. A small collection from the white limestone beds which cap the hill just west of the Porter ranch on Rock Creek, and which are either basal Green River or upper Wasatch, contain a number of unidentified species of fresh-water shells.

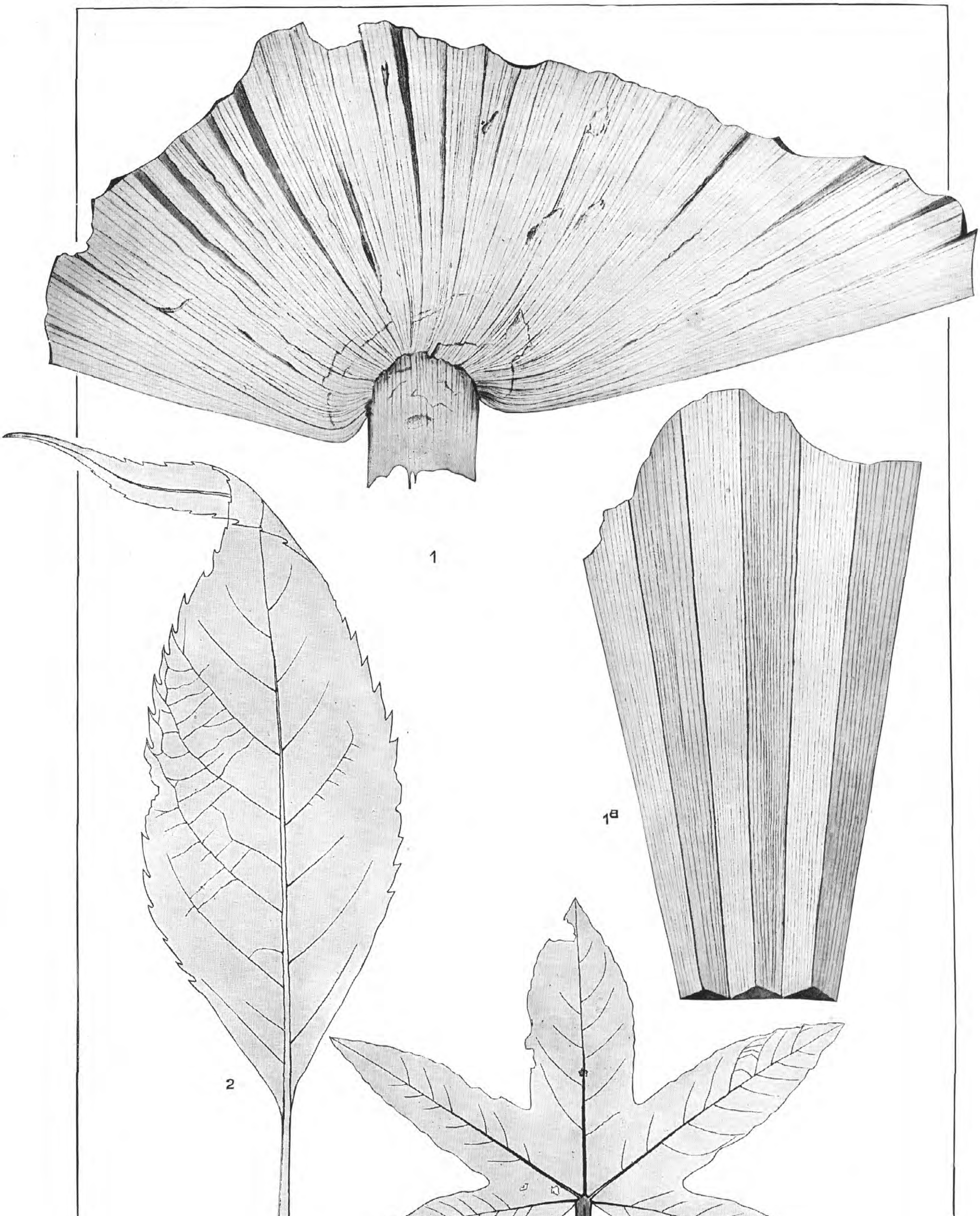
[a] Rept. U. S. Geol. Survey Terr., vol. 8, 1883.
[b] Eighth Ann. Rept. U. S. Geol. Survey, pt. 2, 1889. pp. 906-908.
[c] Bull. U. S. Geol. Survey No. 152, 1898, pp. 83, 107
[d] Bull. U. S. Geol. and Geog. Survey Terr., vol. 3, No 4, 1877. pp. 807-819; Bull. U. S. Geol. and Geog. Survey Terr., vol. 4, 1878, pp. 74-77; Rept. U. S. Geol. Survey Terr., vol. 3, 1884.



ONE OF THE CHARACTERISTIC MAMMALS OF THE KNIGHT FORMATION OR "CORYPHODON BEDS." FIRST FOUND NEAR EVANSTON, WYO.

Composite of nine individuals collected in Bighorn basin, Wyoming, by American Museum party under Dr J. L. Wortman, and mounted by Mr. Hermann under the direction of Dr. Henry F. Osborn. Original in American Museum of Natural History. Length from incisors to perpendicular of tail, 7 feet 9¼ inches; height at withers, 3 feet 4½ inches.

CORYPHODON RADIANS COPE.



1, 1a. Flabellaria florissanti Lesq. 2. Euonymus flexifolius Lesq. 3. Liquidambar europæum Al. Br.
(Copies of Lesquereux's figures of specimens from Fossil, Wyo.)

FOSSIL LEAVES FROM GREEN RIVER FORMATION.

BRIDGER FORMATION.

The Bridger formation—the upper member of the Eocene series of this region—was, like the Green River and Wasatch formations, named by Hayden in 1869. The name in this case was derived from Fort Bridger, near which point the beds are well developed and where numerous vertebrate remains had even then been found. These beds are noteworthy from a scientific standpoint, because of their large mammalian fauna, one of the most complete and varied fossil mammalian faunas found in the world. These beds, according to the observations of Mr. W. J. Sinclair, are composed largely of volcanic ash. In places they have a marked greenish cast and contain persistent white calcareous bands, filled with fresh-water shells that are identical in appearance with those found in the Green River and upper Wasatch beds. No attempt was made to map this formation areally, and it is included in the geological map in the area colored "undifferentiated Eocene." Its outcrops are for the most part limited to the area east and south of Muddy Creek. On Hams Fork Plateau, in the northern end of the area mapped, are two hills capped by Eocene beds that are very different from the underlying Green River, and it is possible that they represent outlying Bridger areas. These outcrops have a rather reddish cast, not like typical Bridger, and the suggested correlation is based more on their position above the typical Green River than on their lithologic resemblance to the Bridger of the type locality.

QUATERNARY.

In the region southeast of this area the topmost Bridger beds are succeeded by thick beds of conglomerate, which were named by the King survey "Wyoming conglomerate." These conglomerates are in places several hundred feet thick, are light in color, and are generally firmly cemented. Where typically developed, they cap the highest hills, forming flat-topped buttes or mesas. This deposit was referred to the Pliocene by the King survey and is to be regarded as either very late Tertiary or early Quaternary. These beds apparently represent the remnants of a very widely developed gravel sheet, probably spread over a relatively level surface, and the present topography is believed to have been developed entirely since that time. The gravel capping Aspen Mountain is thought to be an outlying remnant of this formation, which is shown on the maps of the fortieth parallel survey as extensively developed in the hills east and south of the part of the Uinta Forest Reservation shown on Pl. III. Sillem Hill, just south of Sage, is covered with well-rounded unconsolidated gravels, perhaps representing an outlier of the Wyoming conglomerates or an early stage in their redeposition.

As this region was eroded the gravels of the Wyoming conglomerate, with possibly others brought down from the mountains and derived from the conglomerates of the older formations, were redeposited successively at different levels. As a result of this action gravels occur irregularly over the surface of much of the area. They are particularly well developed on the Tertiary beds east of Muddy Creek. Occasionally they form pronounced gravel-capped terraces, which mark definite stages in the development of this region. Pronounced high level terraces of this type were observed just west of Hilliard Flat and between Millis and Knight. These two are clearly remnants of the same terrace and rise 400 feet above the present stream bottoms. Similar high terraces occur at an elevation of about 300 feet above Hams Fork, in the vicinity of Kemmerer. Numerous lower terraces are found in all the stream valleys.

The lower terraces and the present Bear River bottoms indicate certain rather recent changes in drainage which are of interest. Hilliard Flat, although it is the geological continuation of Mammoth Hollow and owes its major features to the fact that it is underlain by the soft Hilliard shale, shows evidence of once having been the main channel of Bear River. This is shown by the erosion of Oyster Ridge on the east side south of Hilliard and on the west side south of old Bear River City. Hilliard Flat is now covered by a mantle of gravel, which in places is 30 feet thick. Bear River passes west of Hilliard Flat through a narrow gorge cut along the natural line of weakness produced by the soft Bear River beds. Above these Narrows the present bottoms are 3 miles wide and the old Hilliard Flat valley appears as a terrace 50 feet above the present bottom. The normal course of Bear River in the present bottom appears to be along Mill Creek, and this was evidently the course immediately before the present time. Now the river leaves the bottom occupied by Mill Creek and passes into a relatively distinct valley in the Wasatch beds. One of the most interesting examples of this recent stream diversion is that found at the Narrows, 20 miles north of Evanston. Here the river leaves a broad valley and after making a detour of about 3 miles through the hills returns to its old valley. This diversion is apparently associated with the accumulation of sands and gravels, forming the lowest terraces. Before their accumulation Bear River flowed west of the Narrows Hill and Salt Creek flowed southwest through the upper Narrows and Alkali west through the lower Narrows. When Bear River, overloaded with sediments, derived, perhaps, from the glaciers at its headwaters, commenced to fill up its channel, the main river filled up more rapidly than the tributary streams, and thus a differential elevation was produced which permitted the deflection of Bear River around the Narrows Hill.

Although the Uinta Mountains to the south were covered with glaciers during a part of the Quaternary, there are no deposits of undoubted glacial origin in this area. Deposits suggesting glacial action were found near Sage. Here there is a north-south ridge covered with an unassorted mass of débris containing large, angular masses of Carboniferous limestone. The whole suggests a moraine formed by an ice sheet coming from the west, but this supposition could be proved only by detailed work in areas beyond that examined.

Travertine deposits were found at several points. The hillside south of the Lazeart coal mine is covered with these deposits, and in Pioneer Hollow the Soda Springs have built up low cones several feet high.

At many points coal beds, in both the Frontier and Adaville formations, have burned out, baking the surrounding beds. Notable examples of such baked areas occur northeast and southeast of Round Mountain, immediately south of Adaville and southwest of the old Twin Creek mines.

COMPARISONS WITH PUBLISHED SECTIONS IN THIS AND ADJOINING REGIONS.

MEEK'S SULPHUR CREEK SECTION.

A further word is perhaps necessary regarding Meek's Sulphur Creek section because of its great historical importance. This locality was visited by nearly all of the early geologists, who, without exception, misinterpreted the stratigraphic relations of the beds exposed. In Meek's figure as here given (fig. 5) the fossiliferous horizons found by Doctor Stanton in 1891 have been indicated by crosses and the formations described in the present report are given beneath.

Section of rocks exposed on Sulphur Creek near Bear River, Wyoming.[a]

	Feet
1. Black shale, only seen in bottom of Sulphur Creek, thickness unknown.	
2. Slope apparently occupied by clays, thickness perhaps 100 feet or more	100
3. Soft light-grayish sandstone, nearly vertical	90
4. Covered space, probably occupied by clays, but showing some sandstone that may or may not be in place; perhaps room enough for 250 to 300 feet	300
5. Two or three rather heavy beds of light yellowish-gray sandstone, separated by clays, probably occupying some of the space included in division 4. Near the lower part two layers, 15 to 18 inches each, of sandstone, containing *Ostrea soleniscus, Trapezium micronema*, etc. Altogether 90 to 100 or more.	100
6. Greenish and bluish-gray sandy clays, with some dark shale at places	100
7. Bed of good coal, said to be 7½ feet in thickness	7.5
8. Heavy massive bed of light-colored sandstone, about 90 feet in thickness, standing nearly vertical, with some 3 to 5 feet of sandy clay between it and the coal of division 7	95
9. Gray sandy shales with alternations of sandstone and clays	255
10. Light gray sandstone	20
11. Slope and unexposed space, perhaps 200 yards or more across.	
12. Light-gray sandstones and clays, including a bed of good coal, said to be 7½ feet in thickness, all dipping south-southeast 55° below horizon, and the sandstone above the coal containing many casts, *Inoceramus problematicus*, with a few casts of *Cardium* and undetermined univalves; altogether showing about	150
13. A valley or depression showing no rocks, perhaps 150 yards across.	
14. Ferruginous sandstone in thin layers, dipping northwest about 80° below horizon	40
15. Bluish laminated clays with, at top (left or west side), a 2-foot layer of sandstone, containing fragments of shells not seen in a condition to be determined	125
16. Clays and sandstone below (20 feet), gray and brown pebbly sandstone above (25 feet)	45

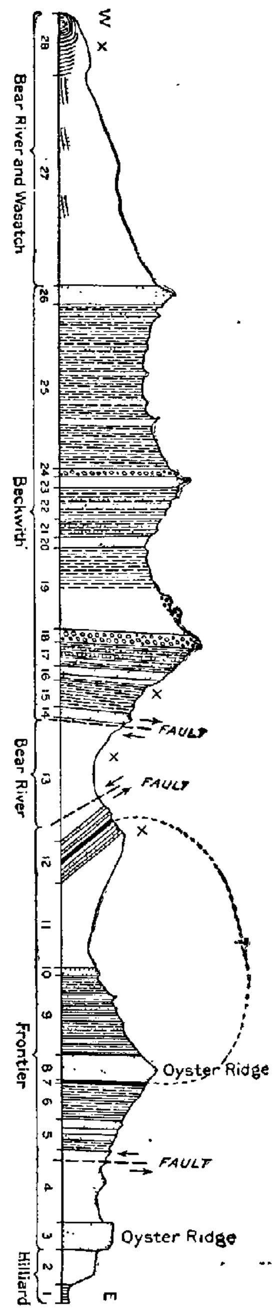


FIG. 5.—Meek's section at Sulphur Creek, with the addition of fault lines and names of formations described in the present report.

[a] Meek, F. B., Sixth Ann. Rept. U. S. Geol. and Geog. Survey Terr., for 1872, 1873, pp. 451-452.

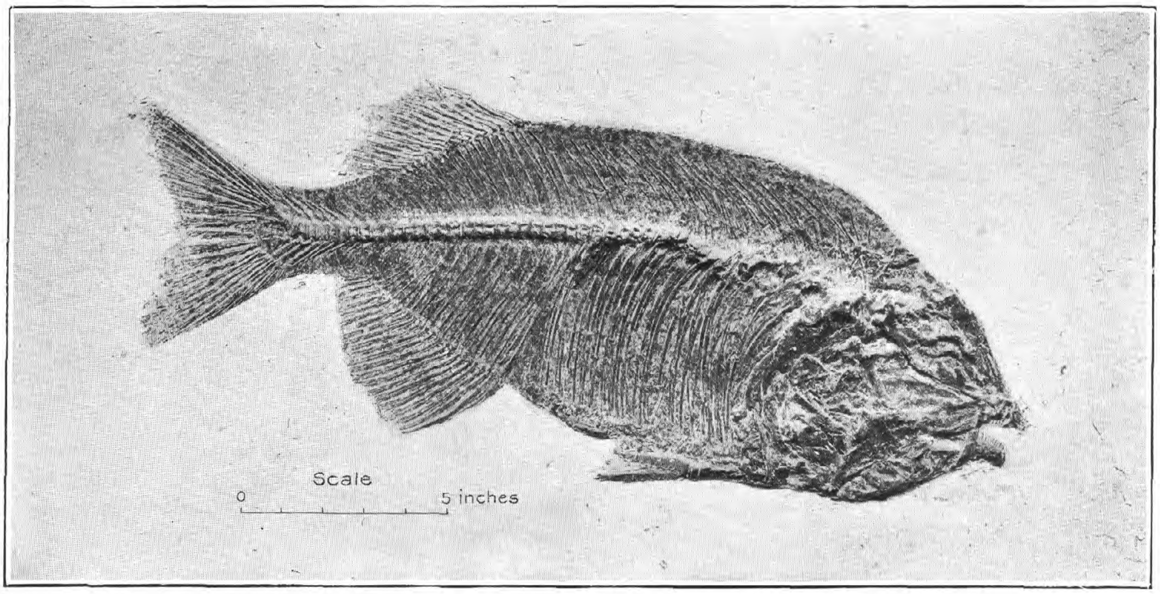
		Feet.
17.	Brownish and bluish clays with some beds of white, greenish, and brownish sandstones	115
18.	Hard gray conglomerate, standing nearly vertical and forming crest of hill about 350 feet high.	40
19.	Slope showing above some masses of conglomerate like that of division 18, perhaps not in place, with, at places below this, some reddish clays; altogether space enough for 500 to 600 feet in thickness	600
20.	Greenish-white sandstone	40
21.	Brownish clays and sandy layers	60
22.	Brownish clays and beds of sandstone, the latter light gray below	110
23.	Whitish sandstone; forms crest of hill about 220 to 240 feet in height	40
24.	Conglomerate and some red clays	20
25.	Brownish and reddish clays with a few distinctly separated thin beds and layers of gray sandstone; altogether 750 feet to 800 feet in thickness	800
26.	Gray sandstone in place, apparently connected with some masses (that *may* not be in place), so as to include space enough for 60 to 80 feet; forms crest of a hill	80
27.	A long space of perhaps 260 yards or more, with only a few low exposures of light-gray sandstone, showing a slight westward dip.	
28.	Numerous thin seams and layers of dark carbonaceous shales, with harder thin bands of various-colored argillaceous, arenaceous, and calcareous matter, including a few very thin streaks of coal, the whole being highly charged with vast numbers of fresh- and brackish-water shells, such as species of *Unio, Corbicula, Corbula, Pyrgulifera, Viviparus, Melampus,* etc. Dip nearly east, about 75° below the horizon; thickness, 175 to 200 feet exposed	200

This section was examined by Prof. J. W. Powell about 1875 and republished in his report on the geology of the Uinta Mountains, with an indication of the classification of the strata according to his divisions.[a] Strata Nos. 1 and 2 he regarded as belonging to the Sulphur Creek (Hilliard) group, 3 to 17 to the Salt Well group, 18 to 28 to the Point of Rocks group. According to this classification the strata represent a continuous series, with the oldest beds at the eastern end. The Salt Well group includes in this section a portion of the Frontier, the Bear River, and the lower part of the Beckwith. The Point of Rocks group includes the upper part of the Beckwith, the Bear River, and some unconformable Wasatch beds, No. 27. Powell's interpretation of this section was evidently greatly influenced by the view prevailing at that time that the Bear River beds were the highest of the Cretaceous series. The section was reexamined by Stanton in 1891 and the true complexity of the structure recognized. In No. 13 characteristic Bear River fossils were found, and in No. 15 the following distinctive Jurassic species:[b]

Belemnites densus M. and H.
Trigonia quadrangularis Hall and Whitf.
Myacites (Pleuromya) weberensis Meek?

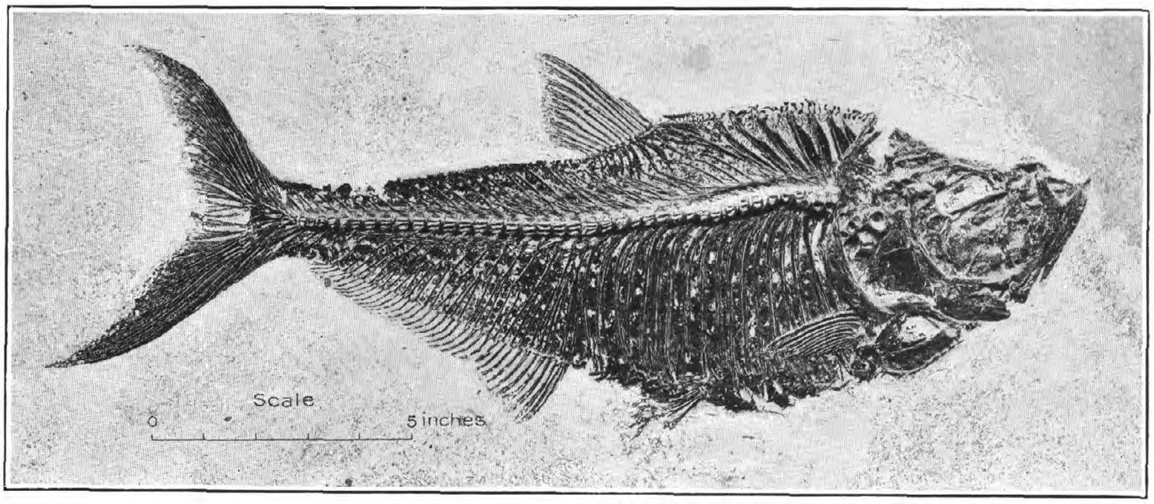
The folding suggested by No. 28 of Meek's section is due entirely to hill creep, as shown in Pl. XXI. The overturned portion entirely lacks the regularity of bedding found in portions dipping eastward. The general relations of Meek's section are shown in Pl. IV. section K.

[a] Geology of the Uinta Mountains, 1876, pp. 158–160.
[b] Stanton, T W., Am. Jour. Sci., vol. 43, 1892, pp. 98–104.



A. PHAREODUS ENCAUSTIS (COPE).

Photograph of specimen in U. S. National Museum from Fossil, Wyo.



B. DIPLOMYSTUS DENSATUS COPE.

Photograph of specimen in U. S. National Museum from Fossil, Wyo.

FOSSIL FISH FROM GREEN RIVER FORMATION.

STANTON'S SECTIONS AT COALVILLE AND ROCKPORT, UTAH.[a]

The Beckwith beds may be traced, with minor interruptions, southward in a narrow belt along the Rock Creek-Needles anticline from the large exposures in the vicinity of Medicine Butte through the Needles to Chalk Peak and the upper part of Chalk Creek in Utah. These exposures lie for the most part on the western flank of the anticline. Although no Cretaceous beds higher than the Bear River formation are exposed in the region north of the Needles, the Cretaceous beds are exposed west of Chalk Peak almost to the very center of the great syncline which crosses the Union Pacific Railroad in the vicinity of Echo City. There is thus a relatively continuous stratigraphic connection between this region and the exposures at Coalville, Utah. On Chalk Creek, west of and above the upper Beckwith beds, there is a series of black shales with fish scales, clearly representing the Aspen formation. Farther west, above these black shales, lie the sandstones and coal-bearing beds of the Frontier formation, in which the principal mines at Coalville are located. The Coalville section was studied in detail by Doctor Stanton in 1891 and 1892. Doctor Stanton extended his work south, up the Weber River to the Triassic beds exposed at Peoa, south of Rockport. The Weber Valley section, which he published in two parts, the Rockport section and the Coalville section,[b] is very closely related in many ways to the general section in southwestern Wyoming. This Weber Valley section is given below:

Weber Valley section, Utah.

[By T. W. Stanton, 1891.]

	Feet.
Tertiary Echo Canyon conglomerates	
Shale and soft, coarse sandstones, not well exposed	1,500
Coalville section:	
10. Gray and brownish sandstone, with bands of shale. The upper 30 feet is a massive, irregularly bedded brownish sandstone, with many specimens of *Inoceramus erectus*, *Cardium*, *Ostrea*, and a few other species, mostly in the form of casts	150
9. Mostly covered, but evidently underlain by shales and soft sandstone. A band of sandstone about the middle of this member yielded specimens of *Mactra*, *Cardium*, and *Pecten*	1,500
8. Massive gray and yellow sandstone forming the Third Ridge, with *Ostrea soleniscus*, *Pholadomya subventricosa* (?), *Cardium*, and a few other marine Cretaceous species	200
7. Clay shales interstratified with thin bands of sandstone and two or three thin seams of coal (including the Carleton bed) of no economic importance, near the base. Fossils abundant, including marine and brackish- and fresh-water invertebrates and plants	110
6. Mostly covered, but showing soft clay shales and thin beds of coarse sandstone where exposed	845
5. Massive conglomerate	60
4. Clays, with thin beds of sandstone	165
3. Gray and yellowish hard sandstone, forming the First and Second ridges, with numerous fossils, many of which are identical with species of the Pugnellus sandstone in Huerfano Park, Colorado	100
2. Gray sandstones 30 feet thick, forming roof of coal bed, overlain by dark clay shales with numerous specimens of *Inoceramus labiatus*	795

[a] Bull. U. S. Geol. Survey No. 106, 1893, pp. 38-44.

[b] For geographic position of these points with relation to this area, see index map forming part of Pl. III

Coalville section—Continued.

		Feet.
1.	Interstratified sandstones and shales, with heavy bed of coal at the top. The underlying beds are cut off by a fault. Several of the sandstone layers in upper part are very fossiliferous. Estimated thickness	500–600
	Sequence broken by faulting. Section is taken up again at a point 12 miles south.	
	Lowest fossiliferous zone of Coalville section with characteristic species such as *Barbatia micronema*, *Mactra utahensis*, *Modiola multilinigera*.	
	No good exposures for 2,200 feet.	

Rockport section:

1.	Alternating beds of coarse sandstone and shale. The beds of sandstone vary in thickness from 10 feet to over 100 feet, and their aggregate thickness is somewhat less than that of the shales. A few specimens of *Ostrea* and casts of *Cardium* and other bivalves were found in the lower portions. Total apparent thickness	2,500
2.	Drab shales with indurated bands in which numerous scales of fishes and an obscure impression of an ammonite were collected	215
3.	Covered for a distance of 700 feet.	
4.	Reddish and brownish shales alternating with thinner beds of coarse gray sandstone, changing to brown pebbly conglomerate in the lower 650 feet. (These lower conglomerates were mapped as "Dakota" by Mr. Emmons)	2,400
5.	Reddish shales with thin beds of brown sandstone	433
6.	Dark greenish-gray sandstone, somewhat calcareous, especially toward the top. A specimen of *Trigonia quadrangularis*? and a few other obscure fossils indicate that this bed is Jurassic	55
7.	Gray and reddish sandy shales, with bands of sandstone	1,295
8.	Yellowish-gray shales, becoming calcareous toward the base	935
9.	Blue thin-bedded limestone and calcareous shales containing *Pentacrinus asteriscus*, *Pleuromya subcompressa*, and other Jurassic fossils	422
10.	Reddish-brown thin-bedded Triassic? sandstone, exposed	750

In the Rockport section stratum No. 10 is clearly the Nugget formation. No. 9 and possibly some of No. 8 is Twin Creek. Nos. 4 to 8 are Beckwith. No. 2 is Aspen. No. 1 of the Rockport and the lower members of the Coalville section are clearly Frontier. The line between the Frontier and Hilliard is, however, not evident. Lithologically it should be drawn above No. 8 or the Third Ridge, and this agrees with the report of Doctor Stanton that a small lot of fossils collected from the top of the Frontier formation just south of Frontier, in southwestern Wyoming, are from the horizon of the Third Ridge of Coalville, Utah. Regarding the position of the line between the Colorado and Montana in the Coalville section, Doctor Stanton says:[a]

Provisionally I have taken the base of conglomerate No. 5 as the top of the Colorado formation at this locality. The soft strata of No. 6 are seldom exposed in the Coalville area and no fossils have been found in them, but they appear to belong to No. 7.

From the general lithological and paleontological resemblance of the southwestern Wyoming and Utah sections and from the abundance of *Inoceramus exogyroides* in the Hilliard formation west of Frontier, 3,000 feet above the characteristic forms of the Third Ridge, it is believed that the Colorado-Montana line was perhaps drawn too low in the Coalville section by Doctor Stanton. From the data collected in southwestern Wyoming, No. 8 should clearly be referred to the Colorado and the line between the Colorado and Montana occurs somewhere in the overlying shales. A comparison of thickness of the formation in these two regions is of interest:

[a] Bull. U. S. Geol. Survey No. 106, 1893, p 41.

Table showing comparative thicknesses of formations in southwestern Wyoming and Weber Valley, Utah.

Formation.	Southwest Wyoming.	Weber Valley, Utah.
	Feet.	*Feet.*
Nugget	1,900	750+
Twin Creek	3,500–3,800	422+
Beckwith	3,800–5,500	5,118–5,800
Bear River	500–5,000	0
Aspen	1,500–2,000	215+
Frontier	2,200–2,600	4,575±
Hilliard	5,500–6,800	3,000+?

With the exception of the Frontier and Beckwith the formations in the Weber section are much thinner than in southwest Wyoming. The greatest difference is noticed in the Aspen, Twin Creek, and Bear River. Supposing that strata which are the time equivalents of the Twin Creek and Bear River have in the Weber River been included in the Beckwith on purely lithologic grounds, all the formations except the Frontier show a noticeable thinning in that direction. The greater apparent thickness of the Frontier may be due (1) to duplication of the strata by faulting; (2) to the more sandy development of the upper Aspen, which may be here on lithologic grounds classed with the Frontier, or (3) to the possible inclusion of beds which are regarded as basal Hilliard in the region of Oyster Ridge.

GREEN RIVER SECTIONS NEAR FLAMING GORGE, UTAH.

The sections[a] of this locality published by Powell and Emmons, while too meager to warrant exact correlations, suggest that there are more important differences between the Green River and Oyster Ridge sections than between the Oyster Ridge and Weber Valley sections.

Section in vicinity of Flaming Gorge, Utah.

[After Powell.[b]]

	Feet.
Point of Rocks group:	
1. Alternating gray and yellow sandstones and clays with pronounced hogback topography; coal bearing	1,350
Salt Well group:	
2. Friable sandstones and arenaceous shales	1,860
Sulphur Creek group:	
3. Dark argillaceous and arenaceous shales	2,000
Henrys Fork group:	
4. Conglomerate; pebbles very small	25
5. Light-gray and yellow sandstone	80
6. Teleost shales	70
7. Varicolored sandstones with conglomerates at base	500
Flaming Gorge group:	
8. Gray, greenish-gray, pink, purple, and chocolate beds, very friable	110
9. Bluish-gray limestone	200
10. Coarse red sandstone, Unio beds	500
11. Limestone; bluish buff; compact; sometimes shaly and interstratified with orange shales and thin beds of gypsum	250

[a] For geographic position of this point with relation to this area, see index map forming part of Pl. III.
[b] Prepared from Geology of the Uinta Mountains, 1876, pp. 41, 152, 156, 157.

	Feet.
White Cliff group:	
12. Massive sandstone, light gray and light orange, everywhere exhibiting false stratification in many directions and at many angles	1,025
Vermilion Cliff group:	
13. Sandstone; massive bedded; gray, drab, and brown within, but weathering with bright vermilion surfaces; well exposed on the summit of Flaming Gorge	300
14. Shales, somewhat argillaceous	6
15. Sandstones; rather friable, with intercalated shales, the latter containing much gypsum; weathering in variegated bright colors	359
Shinarump group:	
16. Shales and sandstones containing much gypsum; weathering in many colors, but brown and chocolate tints prevailing; in many places constituting badland beds	1,095
Upper Aubrey:	
17. Sandstones and limestones, the latter cherty. To the north there are two members of this group, the upper is cherty limestone from 100 feet to 200 feet in thickness, which we have called the Bellerophon limestone. The lower, the Yampa sandstone, is very massive, rarely showing evidences of stratification; in some places obliquely laminated. Farther southward cherty limestones prevail, and the whole group is more minutely stratified	1,000
Lower Aubrey:	
18. Sandstones and limestones massive bedded or shaly. In some localities sandstones prevail and are exceedingly friable	1,000
Red Wall:	
19. Chiefly limestones. In the Uinta Mountains massive limestones are separated by thin strata of sandstones	2,000

Section at Flaming Gorge, Green River, Utah.

[After Emmons.[a]]

	Feet.
Vermilion Creek:	
1. Red argillaceous sandstone and conglomerate beds dipping 25° north	
Unconformity.	
Laramie:	
2. Gray and white sandstone, often iron stained, containing clay beds and very rich in coal seams. Thickness not known.	
Fox Hills:	
3. Heavy-bedded white sandstone, producing Bighorn Ridge, with a few coal seams and comparatively little clay	3,000
Colorado:	
4. Soft clays, not well exposed	2,600
5. Gray, flaggy sandstones	50–100
6. Blue-gray clays and shales carrying small fish scales, inclosing a prominent bed of coal	100–150
7. Yellowish-gray sandstones with carbonaceous seams	150
Dakota:	
8. Sandstones, brownish in color in upper portions, white in the middle, and toward base assuming reddish hue	150–200
9. Striped clay beds, pinkish and pale green	75–100
10. Impure sandstone	50
11. Variegated clays	100
12. Gravel conglomerate, characterized by small, rather angular pebbles of black chert	50–125
Jurassic:	
13. Sandstones with varying admixture of colored clays	150–200
14. Highly fossiliferous, bluish-drab limestones and calcareous shales with *Rhynconella myrina*, *R. gnathopora*, *Lima occidentalis*, *Camptonectes bellistriatus*	200

[a] Rept. Explor. 40th Par., vol. 2, 1877, pp. 199, 201, 264-266.

		Feet.
	15. Indurated red sandstones	100
	16. Sandstones and shaly limestones with thin beds of gypsum	100–150
Triassic:		
	17. Massive buff or white sandstone with, near center, a bed of yellow argillaceous sandstone 50 feet thick	1,000
	18. Pinkish red sandstone, relatively rather thin bedded, the lighter color being due to an alternation of thin beds of nearly white color, and a lower portion of darker colored, more heavily bedded red sandstone, at base running into clay beds with gypsum	1,500
Permo-Carboniferous:		
	19. Light-colored beds, largely clays of a prevailing greenish hue.	
Upper Coal Measures:		
	20. Limestone and fine-grained sandstone of prevailing light-gray and drab colors, with some darker, very fossiliferous limestones at the base.	

On comparing these two sections it appears that the teleost fish-scale shales, No. 6 of both sections, are the same and are the southern extension of the Aspen shales. From these data, going upward, Emmons's No. 5 equals Powell's No. 5; Emmons's No. 4 equals Powell's Nos. 4 and 3, with perhaps the lower part of 2; Emmons's No. 3 is Powell's Nos. 1 and 2. Below No. 6 Powell's No. 7 equals Emmons's Nos. 7 to 12, inclusive. Powell's No. 9 equals Emmons's No. 14, and Powell's No. 12 equals Emmons's No. 17. The two sections thus agree very well in their general features. Compared with the southwestern Wyoming section, the lower dark-colored fossiliferous Upper Coal Measures limestones—No. 20 of Emmons and No. 19 of Powell—suggest the limestone found in the Crawford Mountains; the overlying sandy beds, the unnamed sandstones of the Tunp Mountains. The "Permo-Carboniferous" Thaynes formation of Rock Creek is certainly different lithologically from the greenish clays referred to that horizon by Emmons in the Flaming Gorge region. The lower red-bed member and upper yellow sandstone member of the Triassic strongly suggest the dual division of the Nugget formation observed on Rock Creek and Twin Creek. The upper red beds—Powell's No. 10 and Emmons's No. 15—are not represented in the southwest Wyoming section. No. 14 of Emmons's section and No. 9 of Powell's section clearly represent the Twin Creek formation both lithologically and paleontologically, but while the thickness in the Uintas is about 200 feet along Rock Creek these beds are from 3,600 to 3,800 feet thick. The conglomerates and varicolored clays between the limestones and the dark-colored teleost fish-scale shales are the Beckwith formation.

The correlation of the Cretaceous portion of the section without any fossil evidence is extremely hazardous. Assuming that the upper part of Emmons's section is really Laramie, the two sections are quite dissimilar. The fish-scale shales above the Beckwith are clearly Aspen, and the associated coal-bearing sandstones—Emmons's No. 7—suggest the Bear River. The overlying shales lithologically resemble the Hilliard formation and the Frontier is thus without a distinct representative in this section. The overlying coal-bearing sandstones apparently are the equivalent of the upper Hilliard and the Adaville formations. On the whole, on this interpretation the Cretaceous section here is much nearer that worked out in the Yampa River, Colorado, district by Messrs. Fenneman and Gale during the season of 1905 than the southwest Wyoming and Weber Valley sections.

STRUCTURE.

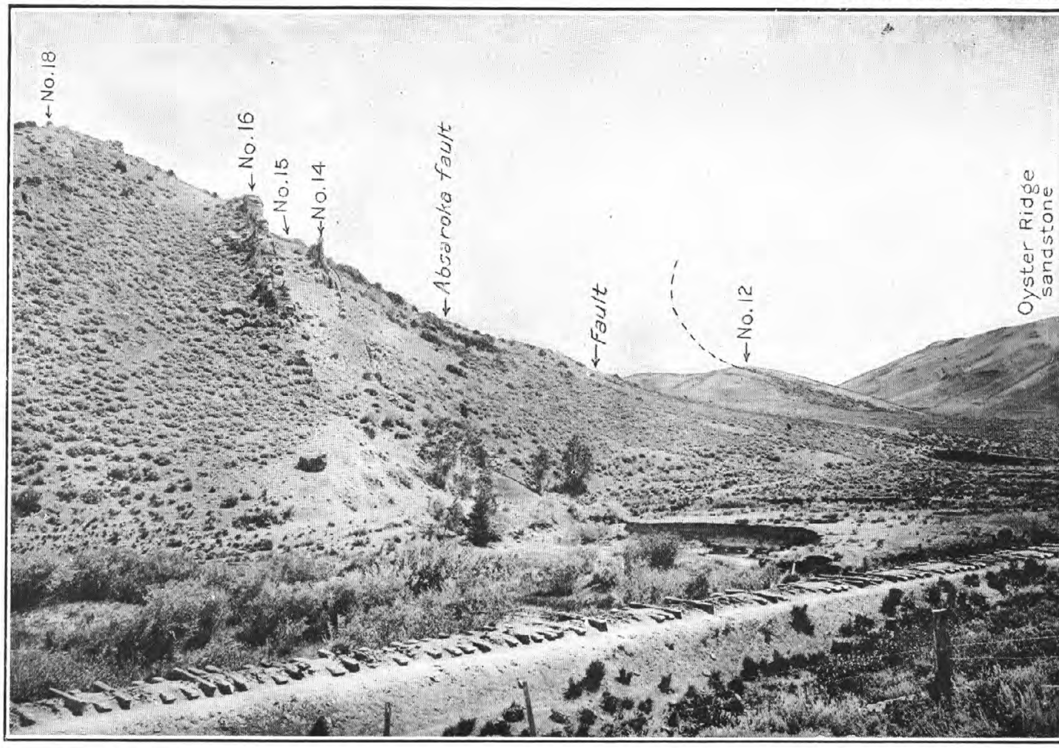
The principal structural features of this region have a north-south trend and are parallel to the Wasatch-Bear River Mountain disturbance rather than to the nearer Uinta Mountain uplift. They are the direct southern continuation of the structural features found in the Salt River and Wyoming ranges to the north, but because of the covering of Tertiary deposits are much less readily studied. The broader features, enumerated from east to west, are (Pl. IV): (1) A rather regular anticline, the Meridian anticline showing near the northern part of this area one or more secondary folds to the east; (2) A somewhat irregular and in places overturned syncline, the Lazeart syncline; (3) A much broken region lying along the western part of this syncline and east of the Absaroka fault, representing the minor adjustments resulting from this great faulting; (4) a very large and persistent thrust fault representing a profoundly broken anticline, the Absaroka fault; (5) a broad syncline, the Fossil syncline, deeply buried beneath Tertiary deposits; (6) a greatly disturbed region which, in its major features, is a somewhat broken anticline of Carboniferous and Jurassic beds—the Rock Creek-Needles anticlinal, whose western flank is broken by a number of minor faults and folds; (7) a much folded and faulted area of upper Carboniferous rocks, the Crawford Mountains, near the northwest corner of this area.

MERIDIAN ANTICLINE.

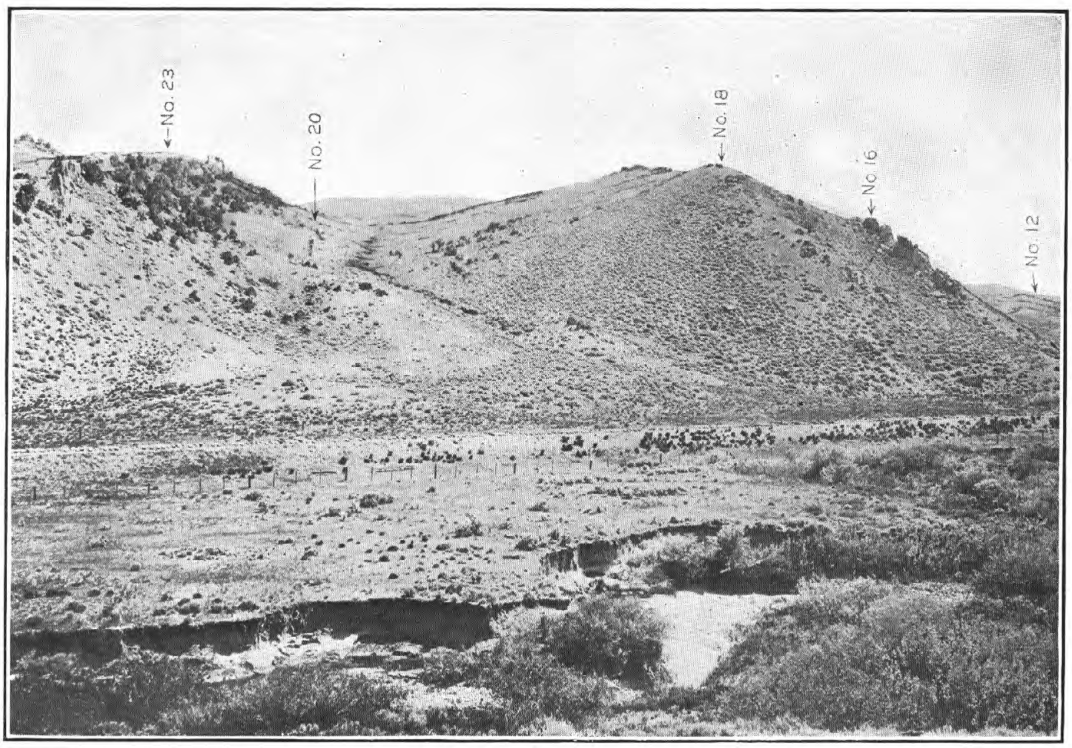
The crest of the Meridian anticline is exposed only in the northeastern part of this area and in a limited outcrop on Little Muddy Creek east of Cumberland. Throughout the remainder of the region it is covered by the Tertiary beds, which commonly dip regularly eastward across it and give no hint of its position. From the dips and general structural relations observed in the Cretaceous beds which outcrop along its western flank and the relation of the same beds to the anticline where it is fully exposed to the north, the position of the anticline may be inferred with considerable exactness. The well boring of the Union Pacific Railroad at Bridger station (pp. 155–156) shows that the anticline lies west of it, at about the position inferred from the attitude of the Cretaceous exposures to the west. The crest of this anticline, as shown by the exposures and inferred from its approximate position beneath the Tertiary beds, is composed almost wholly of strata of the Beckwith formation. To the north of Slate Creek it rises slightly and exposes the Twin Creek beds. East of Cumberland it sinks slightly and shows a very thin capping of Bear River strata. This anticline is for the most part very regular. Minor faults are developed in the region of Hams Hill and Quealy Peak, but on the whole it is a simple feature. It was traced many miles to the north by Peale in 1877,[a] and was named by him the Meridian fold, whence the name adopted in this paper.

North of Hams Fork unusually extensive erosion of the Eocene beds has exposed a minor anticline about 3 miles east of the main Meridian anticline, and at Labarge Mountain, 24 miles farther north, and 7 miles east of the Meridian fold, a pronounced anticline is shown by Peale entirely surrounded by Tertiary deposits. For the most part the Tertiary beds entirely conceal the structural development of the older beds

[a] Peale, A. C., Eleventh Ann. Rept Geol and Geog. Survey Terr for 1877, 1879, p. 536, Pl. LIII



A



B

VIEWS SHOWING RELATION OF BEDS IN EASTERN PORTION OF MEEK'S SECTION AT OLD BEAR RIVER CITY, WYO.

Compare with fig. 5 (p. 101). The numbers are those used in Meek's original description.

SULPHUR CREEK SECTION.

east of the Meridian anticline. Farther east along the Oregon Short Line and Union Pacific railroads the Tertiary beds for a long distance dip very gently eastward. Then they dip gently westward, and still farther east, in the region of Rock Springs, the Cretaceous beds appear. There is thus indicated a broad syncline, with an axis in the vicinity of Granger. Whether the underlying Cretaceous beds show a similar broad syncline is not known, but is quite probable. The meager exposures of the older rocks east of the Meridian anticline, however, suggest that minor folds are to be expected in the older beds along the western edge of this broad syncline. The possibility of such folds greatly increases the probability of obtaining coals at workable depths over a considerable area east of the Meridian anticline (Pl. IV). On the south this broad syncline is terminated by the Uinta Mountains, and the Meridian anticline likewise dies out against the same structural feature.

LAZEART SYNCLINE.

The Lazeart syncline lies from 4 to 12 miles west of the Meridian anticline and has the same general direction. It is well exposed throughout this area and is susceptible of more direct study than the Meridian anticline. The western limb of this syncline is much steeper than the eastern and is in many places overturned and at some places considerably faulted. The syncline is exposed at the surface of the whole area north of Hams Fork. At the north end it is slightly overturned. It plunges rapidly to the south and passes under the Tertiary beds just south of Hams Fork, reaching its greatest depth west of Oakley, then rises and is again exposed just west of Cumberland. South of this point the axis lies on the west side of Mammoth Hollow, about 1 mile from the West Oyster Ridge and 2½ miles from East Oyster Ridge. At Clear Creek it turns westward, plunges sharply, and is involved in the Round Mountain fault. The exact location of the syncline between this point and the Lazeart coal mine, where it is again exposed, can only be inferred, as it is deeply buried by Tertiary beds. South of the Lazeart coal mine (Pl. XXII, *A*), from which point this feature was named, the syncline rises as far as Aspen Mountain, then turns westward and, plunging abruptly southward, is overturned and its western edge greatly faulted in the region of Hilliard.

ABSAROKA FAULT AND ASSOCIATED MINOR FAULTS.

A large fault, developed on the east side of Absaroka Ridge, and hence named the Absaroka fault, was observed by Peale in 1877, and indicated in his sections as extending many miles north of this area.[a] It is an enormous thrust fault, in which the thrust has come from the west. Besides its exposure in the east side of Absaroka Ridge, it is shown near the Cumberland Reservoir, on Little Muddy Creek, and from near Lazeart mine southwestward 15 miles to Bear River. Between these three exposures it is buried by Tertiary deposits, but its position is fixed within very narrow limits by other structural features. North of Cumberland Reservoir it lies west of the Lazeart syncline and east of the Short well (p. 145), in sec. 6, T. 20 N., R. 117 W., which encountered Nugget red beds immediately beneath the Wasatch. Between Reservoir Gap and Lazeart mine the position of the fault is not fixed with

[a] Eleventh Ann. Rept. U. S. Geol. and Geog. Survey Terr. for 1877, 1879, Pls. XLIX, LIII, and LIV.

as much certainty. The location indicated on the map (Pl. XXIII) represents the most eastern position it can possibly occupy; it may be located farther west. Indeed, a minor abrupt western deflection in the vicinity of Clear Creek is regarded as probable. At the southern end of Absaroka Ridge the faulting is confined to a very narrow band. The beds on the west side of Lazeart syncline are not greatly disturbed, and the lower Frontier rests directly against the base of the Thaynes formation. The throw thus indicated exceeds 15,000 feet. North of Cumberland reservoir the beds for some distance east of the principal fault are much broken. These minor faults are regarded as mere accessories of the major disturbances, and the blocks probably do not have the extremely regular arrangement shown in Pl. IV, section E. The aggregate throw indicated at this point, where the Thaynes formation is brought in contact with the Oyster Ridge sandstone and the whole of the Hilliard formation is faulted out, exceeds 20,000 feet. South of Lazeart mine the lower Beckwith strata are in contact with Frontier beds of about the Oyster Ridge horizon, and, including the distributive faulting to the east, the total stratigraphic throw here is from 10,000 to 15,000 feet.

Throughout this area from the region of Cumberland reservoir southward there is a zone of pronounced faulting and folding just east of the main fault and apparently associated with it. In this zone of faulting is the Oil Spring fault, extending from Hilliard Flat to a point west of the Lazeart syncline, where it passes beneath the Tertiary covering. It has produced between Hilliard and Altamont a duplication of Oyster Ridge, which is somewhat confusing to one who is first studying the geology. West of this fault line, near Carter Oil Spring, is a pronounced syncline involving the Oyster Ridge sandstone (Pl. XXII).

FOSSIL SYNCLINE.

West of Absaroka fault the exposures of the older beds are very limited. In the region of Hilliard these dip eastward and are on the upper flank of an overturned syncline. On the southern end of Absaroka Ridge the Carboniferous and Jurassic beds dip regularly westward and the overlying Tertiary beds show a gentle syncline with an axis in the neighborhood of Fossil. This axis appears to be very nearly coincident with the syncline in the underlying strata, which has therefore been named the Fossil syncline. Throughout this area it is deeply buried by the Tertiary deposits, but its position may be roughly inferred from the adjoining structural features.

ROCK CREEK-NEEDLES ANTICLINAL AXIS.

Bordering the deeply Tertiary-filled trough of the Fossil syncline on the west is a greatly disturbed region which in its broader features is a somewhat faulted anticlinal axis whose western flank is broken by a number of minor faults and folds. It has been found convenient to refer to these structural features as the Rock Creek-Needles anticlinal axis, named from the two prominent points which are its northern and southern limits in this area. Along Rock Creek there is a very pronounced anticline, in places slightly overturned, with a long gradual western slope and a very short, abrupt, and in places overturned eastern slope. The eastern slope shows a secondary fold which in the field was interpreted as a fault and was so shown on the preliminary cross section published in a brief article on the oil and coal fields of southern Uinta County.[a] A more critical consideration of the fault data has led to the conclusion that the relation observed is more probably due to folding than to faulting, as shown in sections C and D, on Pl. IV. South of Twin Creek the anticline passes beneath the Tertiary beds. North of Twin Creek the beds on the western flank are exposed for several miles and by the exposures just north of the limit of the map may be connected with the westward-dipping Bear River coal beds at Sage and Beckwith. Judging from the relations north of this area, there is a syncline just west of Boulder Ridge and east of the Carboniferous rocks exposed in the Beckwith Hills. This syncline is indicated on Pl. XXIII as the Beckwith syncline.

The Beckwith beds, exposed on the west flank of the Rock Creek anticline, may be traced southward by almost continuous surface exposures to Bridger Creek, where a secondary anticline is developed, apparently on the west flank of the main anticline. This has been indicated as extending through Bridger Hill, but the evidence of this extension is not conclusive. On the southern part of the Bridger Hill exposures the Beckwith beds show a pronounced and regular westward dip, which suggests an anticlinal axis about in the position of the southern extension of the Rock Creek anticline. South of this there is an overturned fold in the Beckwith beds at the Cockscomb, which, like all other important features in this region, was produced by a west-to-east thrust. This Cockscomb anticline terminates very abruptly on the north end, and, like the Bridger Hill anticline, is believed to be slightly west of the principal axis. West of the Cockscomb anticline is the Alkali syncline, the Narrows anticline, and the Dry Hollow syncline. The last is terminated to the west by the Crawford fault, on the east side of the area of Pennsylvanian rocks. The Dry Hollow syncline and Beckwith syncline are possibly the same feature. The overturned Cockscomb anticline has been traced southward on the east side of Alkali and Salt Creek flats almost to the triangular exposure of Beckwith beds extending from east of the Narrows to a point south of Medicine Butte and bounded on the east side by faults. This triangular area is an anticline of Beckwith beds with a pronounced thrust fault on the east, the Medicine Butte fault, and a normal fault on the west, the Acocks fault. This combination of faults with associated anticlinal feature extends to and beyond the Needles. Movement along this double line of faulting has resulted at the Needles in giving to the Almy conglomerates a high dip to the east immediately along and east of this fault line and in depressing the beds to the west several thousand feet without pronounced tilting. Between Medicine Butte and the railroad cut east of Evanston the Medicine Butte and Acocks faults are almost coincident at the surface, and the relative displacement of the Evanston beds at the southern end of Medicine Butte, about 4,000 feet, is due to movements along these two faults rather than to a single fault (Pl. IV, section J). The Evanston beds exposed along Bear River are brought up by the normal Almy fault. Between this fault and the Acocks fault is a great block which has been tilted eastward. The throw of this Almy fault is about 4,000 or 5,000 feet, with the downthrow to the

[a] Bull. U. S Geol. Survey No. 285, 1906, p. 350, Pl. XII, *B*.

west. This Almy faulting appears to be connected with the Narrows anticline, but the connection could not be conclusively proved.

South of the Needles, on Chalk Creek, the oldest strata on the west side of the Rock Creek-Needles anticlinal are extensively exposed and may be followed westward to the axis of the Echo City syncline. The Aspen, Frontier, and Hilliard formations are here exposed in regular succession. It has been presumed that west of the Almy fault this same regular sequence occurs, and it has been so represented on the cross sections.

CRAWFORD MOUNTAINS FOLDS AND FAULTS.

The contact between the Carboniferous limestones of the Crawford Mountains and the Bear River beds to the east is for the most part concealed by Quaternary and Tertiary beds, but the relation is believed to be one of faulting, probably a large thrust fault similar to the Absaroka and Medicine Butte faults. The thrust is here clearly from the west. At the southern end of the exposure the principal end of the anticline plunges very abruptly beneath the Bear River bottoms. South of Bear River the whole country is covered with gently dipping Wasatch beds. The western flank of the Crawford Mountains is greatly disturbed, but the details of the structure were not worked out.

CHAPTER IV.

ECONOMIC GEOLOGY.

COAL.

As shown in the economic column of the geologic table facing page 50, coal has been found in four formations in southwestern Wyoming, the Bear River, Frontier, Adaville, and Evanston. All of these formations are of Cretaceous age, with the possible exception of the last, which is probably Eocene. Coal has not been found in this area in the two other Cretaceous formations, the Aspen and Hilliard, but in adjoining regions beds of the same age yield coal, and these beds may be coal bearing here. Judging from the conditions throughout this portion of the Rocky Mountains and the known character of the pre-Cretaceous rocks in this local area, it is highly improbable that commercial coal will be found in rocks older than the Cretaceous.

COAL IN THE BEAR RIVER FORMATION.

The Bear River formation consists of a group of very dark-colored shales, with considerable carbonaceous material. These shales naturally attract the attention of those hunting for coal and have been prospected from the time of the settlement of this region. On the map of the United States, published by the Land Office in 1866,[a] coal is indicated on Bear River near the present town of Cokeville, immediately north of this area. These coal-bearing beds at Cokeville are in the Bear River formation, and persistent attempts have been made to develop them since that time. The coal is reported as high-grade bituminous, with decided coking properties, but the beds thus far discovered are not of a character to justify extensive development. The seams are thin and the coal is dirty. The town was named Coketown, or Cokeville, more for what it was hoped it would produce than for what it did. No commercial shipments of importance have been made from this point.

The existence of coal in the Bear River formation at the Narrows was reported on hearsay by Hayden in 1872.[b] Two coal seams are indicated at this locality on the "Map of Contested Union Pacific Lands, Uinta County, Wyoming," furnished by Mr. B. A. McAllaster, land commissioner, but these coal seams appear on field examination to be bands of carbonaceous shale containing thin coal streaks of no commercial value as coal beds. This locality has been repeatedly prospected by the coal companies working at Almy, but no workable coal has been found.

[a] 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.

[b] [Fifth Ann.] Prelim. Rept. U. S. Geol. Survey, Montana, for 1871, 1872, p. 158.

Peale reports[a] that coal was discovered near Sage in 1875, and that before his visit in 1877 a mine had been opened by the Wyoming Coal and Coking Company and coke ovens erected. The slope was 470 feet in length, with a single entry 120 feet long. He reports the following section:

Section of coal-bearing strata at Sage, Uinta County, Wyo.

	Feet.
1. Light-colored sandstone, forming roof.	
2. Coal, mined by Wyoming Coal and Coking Company	6
3. Clay	3-6
4. Coal	.3
5. Shales and slate.	
6. Coal	3.5
7. Sandstone, with thin bed of coal.	

It is reported that picked samples of this coal will make coke, and that washing was tried to remove the impurities. With the building of the Oregon Short Line in 1881 a second attempt was made to develop this locality, and a third trial was made about 1900, when it is reported that the slope was extended 200 feet and several new entries opened. A new coke oven was constructed under the direction of a Pennsylvania expert, who after careful tests pronounced the coal of no value as a coking coal. Altogether about $130,000 has been spent in a fruitless attempt to develop this coal. The beds dip from 35° to 45° westward, and the natural system of working, as at other places in this region, is a slope at right angles to the strike, with entries departing from the direction of the strike only enough to insure free drainage, and rooms worked up the dip from the entries. The lower part of this mine is now filled with water. An examination of the coal bed in the slope above the water level showed 5.5 feet of very dirty coal, about one-third worthless. Coal prospects have within the last year or two been opened just east of Beckwith, and a considerable tract of land has been covered with coal declaratory statements. These Beckwith coals are clearly of the same age as those outcropping at Sage and are in about the same stratigraphic position. Their value can be fully determined by relatively shallow openings.

The general shallow-water character of the Bear River beds and the persistent occurrence of coal beds approximating workable thickness and quality make it seem probable that local developments of coal of commercial value will be found in them. Irregular developments similar to that found in the Evanston beds at Almy, where the workable bed entirely loses its workable character in a distance of 2 miles, are certainly to be expected. In prospecting it is well to remember that the general character of the coal can be determined within a short distance from the surface. The only reason for continuing a slope to a depth of several hundred feet is the possibility that the coal may become cleaner in that direction. The general character of the coal, except for this question of ash, will not ordinarily change with depth, and there is no reason for believing that the coal would be cleaner at greater depths than along the strike in either direction.

[a] Peale, A. C., Eleventh Ann. Rept. U. S. Geol. and Geog. Survey Terr. for 1877, 1879, p. 575.

COAL IN THE FRONTIER FORMATION.

COAL HORIZONS.

The Frontier formation consists of a series of clays and light-colored sandstones, limited above and below by dark-colored shales not known to be coal bearing in this area. Detailed cross sections have been prepared by the Union Pacific Coal Company at Spring Valley, Spring Gap, and Cumberland, and these, through the courtesy of Mr. George L. Black, superintendent, are presented on Pl. XXIV. Coal-bearing beds occur throughout the formation, but they vary considerably from point to point, and the exact equivalence of the coal beds in different parts of the region was not fully determined. In general there is a group of coals near the base which has been referred to as the Spring Valley group. At Spring Valley this contains the Carter coal, the Spring Valley coal, or the main bed worked at the Union Pacific mine at Spring Valley with two associated minor seams, and the lower Spring Valley seam, reported to have a thickness of 3½ feet. Above this group and below the Oyster Ridge sandstone there are several seams, but only one is now known to be of importance, and that only in the northern part of the area. This is the Willow Creek seam. At Willow Creek Gap this bed is about 200 feet below the Oyster Ridge sandstone. A coal in the Cumberland section (Pl. XXIV, *A*), about 500 feet below the Oyster Ridge sandstone, is marked Willow Creek in the Union Pacific Coal Company's cross sections, but it is by no means certain that this is the southern representative of the Willow Creek seam. Above the Oyster Ridge sandstone are the upper coals or Kemmerer group. These contain the lower Kemmerer, mined at Frontier; the main Kemmerer, mined at Frontier, Diamondville, Oakley, Glencoe, and the Cumberlands, and the upper Kemmerer, mined at Diamondville. The exact equivalence of the main seams worked at Cumberland, Diamondville, and Frontier can not be asserted. They are certainly at approximately the same horizon, but may not be identically the same bed. The general relations and variation of the upper seams are well shown in the diamond-drill borings presented on Pl. XXV. The local variations of the main coal in the Cumberland mines are shown in fig. 6.

The position of the surface exposures of the Frontier formation is shown on the areal geology map, Pl. III, and the position of some of the coal outcrop and the depth to the Kemmerer coal are indicated on the economic geology map, Pl. XXIII. This formation is found at or near the surface just west of the Meridian anticline. It underlies the great shale valley, Mammoth Hollow, and is again exposed in part of the region between Lazeart syncline and the Absaroka fault. In this portion of the area the beds are greatly disturbed and the conditions for economic mining not so favorable as on the east side of Mammoth Hollow. This formation underlies the whole region east of the Meridian anticline, as indicated on Pl. XXIII, but the exact position of the western edge can be determined only by drilling

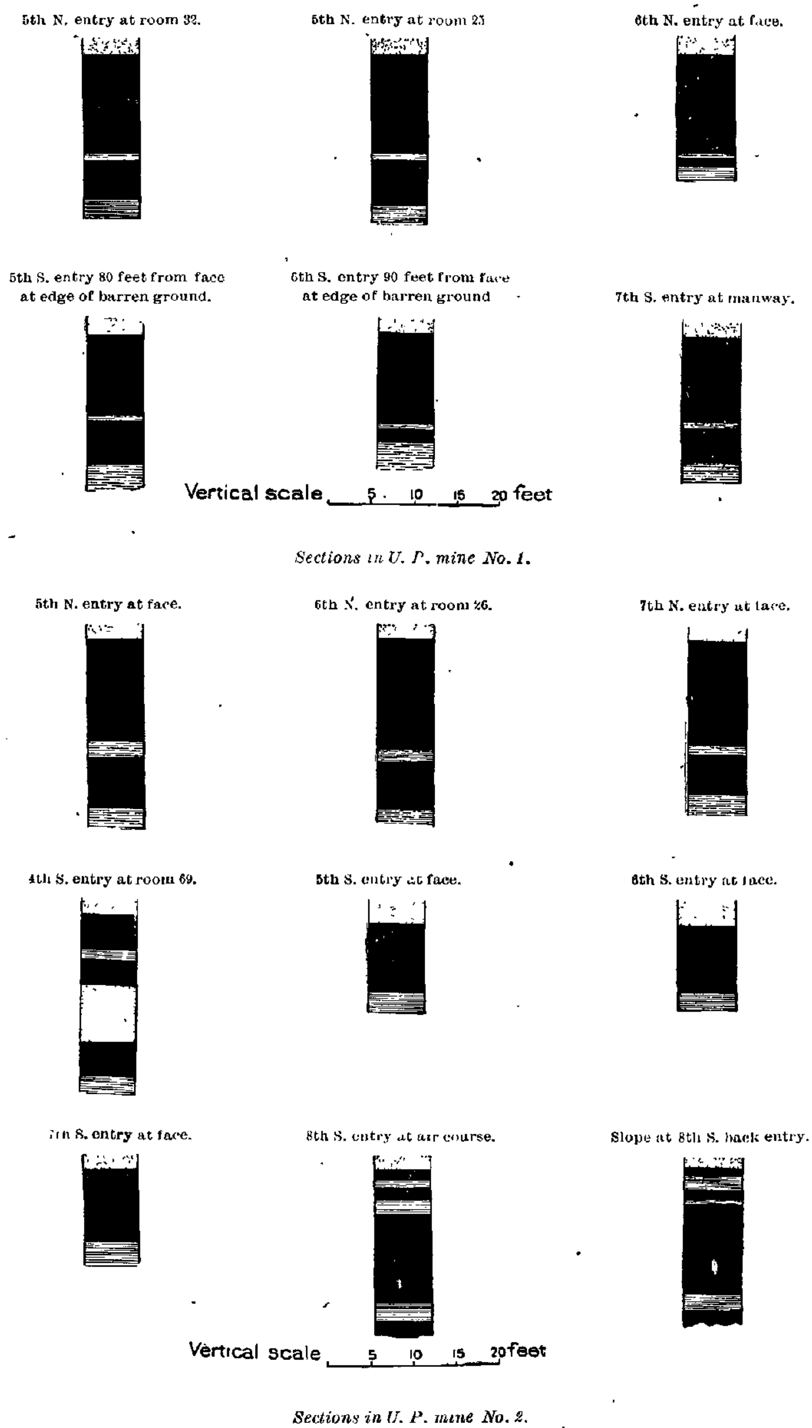


FIG. 6.—Coal sections in Union Pacific Coal Company's mines at Cumberland, showing variation in main Kemmerer seam.

OUTLINE OF DISCOVERY AND DEVELOPMENT.

The coals of this group were discovered by Frémont on August 19, 1843.[a] He found "alternating beds of coal and clay" on Muddy Creek just east of the present town of Cumberland and reported the following section:

Section of coal-bearing beds east of Cumberland.[b]

	Ft.	In.
Sandstone	1	0
Coal	1	3
Coal	1	3
Indurated clay, with vegetable remains	20	0
Clay	5	0
Coal		
Clay	5	0
Coal		
Clay	5	0
Coal		

The rocks at this place were observed to dip in the direction N. 65° W. at an angle of 20°.* * * The stratum containing the fossil ferns is about 20 feet thick, and above it are two beds of coal about 15 inches.

The coals referred to by Frémont are shown on the Cumberland section near the point marked "leaves," Pl. XXIV. Passing westward from this point Frémont reports that "coal made its appearance occasionally in the hills during the afternoon, and was displayed in rabbit burrows in a kind of gap, through which we passed over some hills and descended to make our encampment on the same stream [Little Muddy Creek]." This clearly refers to the coal outcrops on the hills just north of Reservoir Gap, and is of particular interest in connection with the fact that when this area was surveyed by the Land Office in 1881 no coal was reported, and the land is therefore classed by the Land Office as agricultural land. In 1848 Clayton[c] reported coal in these beds on Sulphur Creek near the site of the old Bear River City. In 1852 Stansbury[d] examined this locality and placed on the map accompanying his report the words "Great Coal Basin," extending from the west bank of Bear River, near the present town of Evanston, to Point of Rocks in Sweetwater County. The beds at old Bear River City were opened about the time of the building of the Union Pacific Railroad in 1869, but were never worked to any great extent. In 1859 a United States military coal reservation was established at a point about 3 miles farther east, in beds of the same age, but the coal was never worked to any great extent, although it is probable that small amounts were hauled to Fort Bridger for blacksmithing purposes. With the abandonment of Fort Bridger this reservation was returned to the public domain.

In 1874 the deputy land office surveyors separated as coal land the greater part of the outcrops of this formation in the western part of R. 116 W., Tps. 18, 19, and 20 N., and in the same year Cope reported coal in these beds in the valley

[a] Frémont, James C., Rept. Explor. Exped. to Rocky Mountains and to Oregon and Northern California, House Ex. Doc. No. 106, 28th Cong., 2d sess., 1845, p. 131.

[b] By Frémont, 1843, ibid., pp. 297, 298.

[c] Clayton, W., Latter Day Saints' Emigrants' Guide, 1848, p. 24.

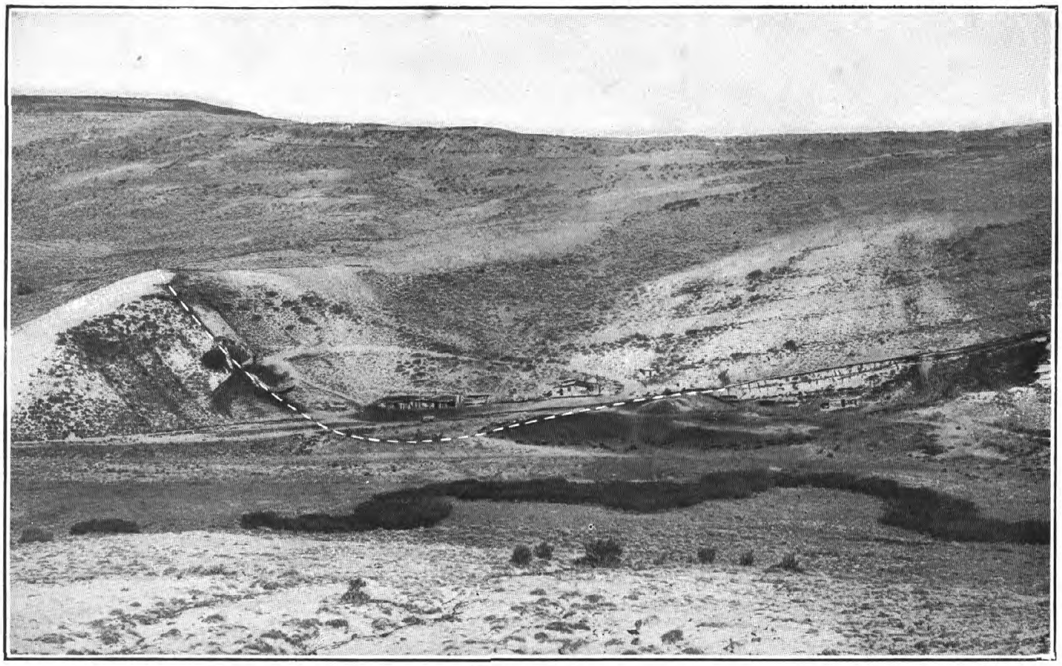
[d] Stansbury, Capt. Howard, Exploration and Survey of the Great Salt Lake of Utah, 1852, pp. 226, 280.

of Hams Fork.[a] The Spring Valley coal was reported by Emmons in 1877, who states that in Pioneer Hollow in a sandstone dipping 20° westward there is a bed of coal 20 feet thick.[b] Coal prospects were opened throughout this region as the country was settled, and in 1893 Knight reports: "Coal mines have been opened on Hams Fork, on the Oregon Short Line, but their workings have been very light and irregular."[c] The first important mine in these beds was that of the Diamond Coal and Coke Company at Diamondville, which began mining coal in July, 1894. Mines were opened by the same company at Glencoe in the fall of 1898, and at Oakley in the summer of 1899. The Frontier mine was opened in the summer of 1897 by the Kemmerer Coal Company, and the Cumberland mines of the Union Pacific Coal Company in the fall and spring of 1900 and 1901. All these mines develop the upper or main Kemmerer group of coals. The Union Pacific Coal Company opened mines on the Spring Valley seam at Spring Valley in November, 1899, and shipped coal in September, 1900. The mine was finally abandoned and closed in February, 1905. A small mine northeast of Hilliard develops one of this Spring Valley group of beds and supplies a limited amount of coal for local use. Two openings have been made in sec. 12, T. 15 N., R. 118 W., to supply fuel for drilling neighboring oil wells. The Kemmerer Coal Company proposes to open a mine on the Willow Creek seam in sec. 6, T. 22 N., R. 115 W. Tests of this coal have yielded coke of fair quality, and it is for its coking value that this coal is to be developed.

The mines at Frontier, Diamondville, and the two Cumberlands each have an average output of from 1,500 to 2,000 tons a day. Through the courtesy of the superintendents, all these mines were visited. Mr. Carl D. Smith examined the mines of the Diamond Coal and Coke Company and the Cumberland mines, and his reports on Diamondville No. 1 and Cumberland No. 1 follow.

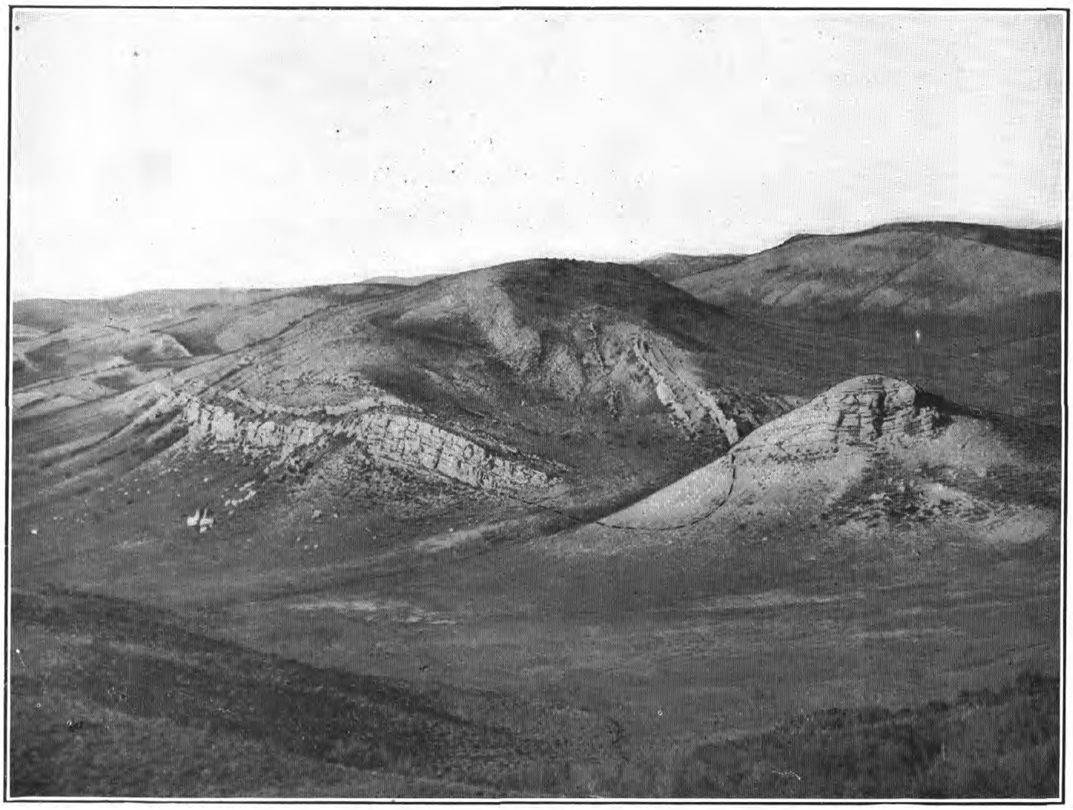
Mine No. 1, Diamond Coal and Coke Company, Diamondville, Wyo.—The entrance to the coal is by slope, which begins on the crop of the coal. The slope is 6,080 feet in length and has an average pitch of 16°, 3° N. of W. Coal is hoisted out by cable in cars of 2,000 pounds capacity. The output averages about 1,500 tons a day of twenty-four hours. Coal is shipped principally to smelters at Anaconda, Mont., and to Salt Lake City, Utah, and is said not to be a good smithing coal, because the "heat is in the blacksmith's face and not in the fire." Coal is said not to coke well, though for what reason is not known. Coal gives a light brown ash and is reported to give very little clinker where pure lump is used. Slack gives a good deal of clinker. Electric signals are used in mine. Telephones connect all important places. Large horses are used for hauling in entries. McGintys are used for pulling empty cars from entries into rooms. Room-and-pillar system is used. Rooms are about 20 by 300 feet, with break-throughs and barriers left at times, especially where top is bad. Barriers were left for awhile, then discontinued, but were found necessary and used again. Rooms are turned up the rise on bottom bench of coal, the upper being used as roof. The upper bench is then worked down the dip. Coal is shot off the solid except in upper bed of coal, where it is undercut. Pumping is done in the upper levels by steam; in the lower levels by compressed air. Mine is ventilated by exhaust fan. The main slope is the intake. Air goes to bottom parts, and returns to fan through air courses parallel to entries and main slope. Air is run into rooms by means of canvas curtains. Open lamps are used for lighting. Gas is drawn out by exhaust fan. A peculiar gas, or "depleted air," is found in the mine. It is said to have been analyzed at Stanford University and to contain, instead of 21 per cent of oxygen, only 16 per cent. Nitrogen takes the place of oxygen. It does not burn nor support combustion, but is as

[a] Seventh Ann. Rept. U. S. Geol. and Geog. Survey Terr. for 1873, 1874, p. 440.
[b] Rept. Explor. 40th Par., vol. 2, 1878, p. 252.
[c] Bull. Wyo. Experiment Station No. 14, 1893, p. 148.



A. LAZEART SYNCLINE AT LAZEART COAL MINE, SE. ¼ SW. ¼ SEC. 8, T. 15 N., R. 118 W.

The white sandstone underlies the Adaville coal seam, here 35 feet thick. The beds forming the upper part of the hill are horizontal Knight.



B. SYNCLINE 1 MILE SOUTHWEST OF CARTER OIL SPRING.

Prominent white sandstone is Oyster Ridge sandstone. Vegetation largely sage, with occasional haw bushes, and with exceptional clump of quaking aspen in the head of the hollow in the right foreground.

STRUCTURE.

fatal as CO_2 for breathing. Timbering is used in parts of mine where top is bad. The roof is extremely variable. In the entries near the crop the top is of shaly sandstone of gray color, which makes a pretty good roof. This is fairly regular over all the north entries, there being little variation in either coal or top. In the south entries, beginning with the thirteenth, the top consists of shale, with tongues of sandstone and fire clay, varying in thickness from 1 foot to 20 feet. This produces much water, and on exposure slacks and squeezes. Much timbering has been done, but it seems to be impossible to hold up the roof. When allowed to fall, about 20 feet comes down and the top is then fairly stable. No rooms can be turned under this top. About halfway down the main slope an area of low coal was struck. In order to avoid this, the course of the main slope was changed so as to run more nearly west. At one place in the mine an oyster bed was noticed in the sandstone about 6 inches above the coal. This had a thickness of only a few inches, and its lateral extent does not seem to be great. No other fossils were noticed in the top except a few impressions of leaves. The joints in the top are very far apart and do not seem to extend into the coal. The difference in the thickness of the coal is due principally to irregularities in the top of the lower bench, the bottom remaining practically smooth. The floor is of a dark-colored fire clay, which squeezes considerably on getting wet. This gives much trouble by throwing the track off grade.

The thickness of the coal is rather variable, but averages 12 feet. The coal is in two benches, the bottom one being 7 feet and varying more in thickness than the upper. Between the benches is a parting of variable thickness. The parting consists of a light-colored sandstone, which in places pinches down to a mere division of cleavage plane, also in places giving way to shale and muck or soapstone. The upper 5 feet of coal, forming the upper bench, is freer from impurities than the lower bench. Sulphur balls are common in the lower, and at times are of considerable size. These interfere with drilling. About 18 inches below the top of the upper bench is a band of yellowish coal, which is said to be very persistent throughout this seam. The upper bench of coal has a shiny luster, and cleaves more into cubical blocks than the lower. The lower bench looks dirtier, and has no decided cleavage, except vertically. Face slips are rather pronounced. Rolls occur in the coal, running across the pitch. These are not sharp, however, only two or three coming in the mine. In the lower north entries the coal is low, not over 7 feet thick. It is also somewhat faulted and disturbed.

About 50 feet stratigraphically above the Kemmerer coal is another bed, which is reached by an intercoal tunnel. This bed is about 5 feet thick, is a very good quality of coal, and has a parting about 1 foot from bottom. This coal is dug by undermining. The sandstone top is good. Between the two beds of coal are alternating beds of sandstone and shale.

Mine No. 1, Union Pacific Coal Company, Cumberland, Wyo.—Entrance to coal by slope 4,000 feet in length; average dip, 23° W.; capacity of cars, about 5,000 pounds. Coal shipped west and sold mine run. Coal is said to be good for blacksmithing; not tested for coke. Electric signals and telephones in mine. Steel used on main slope is heavy, propably 56 pounds; in entries is lighter. Coal is run down from rooms on flat sheet or chutes. A short switch is put in from entry and coal is slid into cars. Horses used to pull coal to gangway. The roof consists of sandstone, with a few inches of clod or soft clay immediately above the coal. It does not vary much in different parts of the mine. At places a band of shale occurs at variable distances from the coal. The roof in places adheres to the coal and in places is free. The clod usually holds up when the coal is shot down. The thickness of the coal averages about 7 feet, though it shows considerable variation, due to irregularity of roof. Roof fills valleys in coal. Quality of coal is very good. Has very few partings except a rather persistent yellow band near the top. Some sulphur balls occur. Coal has a black, shiny luster and cleaves best on bedding planes. First 6 inches of floor is of soft fire clay, which slacks and falls down when exposed to the air. Beneath this there is a kind of shaly sandstone, which is very hard. Floor is more regular than roof, though hummocks appear in it. In the north entries of the mine the coal pinches out. This pinching begins farther north, in the upper levels, and swings southwestward toward the main slope; then seems to turn again to the north. A diamond-drill hole between this mine and No. 2 struck only a trace of coal where it should have been. In one of the south entries a peculiar granulated coal comes beneath the regular bed. The contact between it and the other is very marked, so that it can hardly be due to crushing. It is probably wash coal filling an irregularity in the floor.

A similar abrupt thinning of the coal was observed in the southern entries of mine No. 2, and is believed by Mr. F. H. Manley, of the Union Pacific Coal Company, to indicate an island in the original coal-forming marsh, rather than a fault, as has been suggested. There is certainly no evidence of faulting at this point, and the surface conditions are such that a fault would be readily detected.

SECTIONS OF THE COALS OF THE FRONTIER FORMATION.

Many test pits and test slopes have been opened into the coal beds of the Frontier formation and a few tests made with diamond drills. The results of a large number of these tests are presented in the following table, under numbers corresponding to those used on the economic map, Pl. XXIII.

Sections of coal beds in the Frontier formation.

No.	Location.			Sections.			Remarks.
	T.	R.	Sec.		Ft.	In.	
1	23	116	2, NE. ¼ NW. ¼	White sandstone			
				Shaly clay	2	0	
				Coal	4	0	In the Kemmerer group.
2	23	116	36, SW. ¼ SW. ¼	Coal	8	0	In the Kemmerer group.
3	22	115	6, SW. ¼ SW. ¼	Coal	5	8	Willow Creek seam.
4	22	115	19, SW. ¼ NW. ¼	Coal	3	0	Willow Creek seam.
5	22	116	1, NE. ¼ SW. ¼	Coal	4	0	In the Kemmerer group.
6	22	116	1, NW. ¼ SW. ¼	Coal	6	0	In the Kemmerer group.
7	22	116	1, SE. ¼ SW. ¼	Coal	8	0	In the Kemmerer group
8	22	116	12, NE. ¼ NW. ¼	Coal	4	0	In the Kemmerer group.
9	22	116	13, NW. ¼ NE. ¼	Coal	8	0	In the Kemmerer group.
10	22	116	13, SW. ¼ NE. ¼	Coal	8	0	In the Kemmerer group
11	22	116	13, SW. ¼ SE. ¼	Coal	3	0	In the Kemmerer group.
12	22	116	24, NW. ¼ NE. ¼	Coal	4	0	In the Kemmerer group.
13	22	116	24, SW. ¼ NE. ¼	Coal			3 seams of the Kemmerer group have been prospected at this point.
14	21	115	5, SE. ¼ SE. ¼	Clay			In the Spring Valley group.
				Coal, rather dirty	5	0	
				White clay	0	10	
				Coal	0	2	
				Clay	0	4	
				Coal, very dirty	1	8	
15	21	116	12, SE. ¼ NW. ¼	Coal	4	0	Upper Kemmerer seam, Kemmerer Coal Co.'s mine No. 1.
				Sandstone and shale	40	0	
				Coal 6 to	14	0	Main Kemmerer seam, Kemmerer Coal Co.'s mine No. 1.
				Sandstone and shale	15	0	
				Coal	6	6	Lower Kemmerer seam, Kemmerer Coal Co.'s mine No. 1.
16	21	116	24, NW. ¼ NW. ¼	Below surface	98	0	Diamond-drill hole; see section on Pl. XXV.
				Sandstone	1	0	
				Coal	1	0	
				Shale	14	0	
				Coal	0	3	
				Sandstone	65	9	
				Shale	2	0	
				Coal	1	0	
				Sandstone	7	0	
				Black shale	16	0	
				Sandstone	13	0	

Sections of coal beds in the Frontier formation—Continued.

No.	Location. T.	Location. R.	Location. Sec.	Sections.	Ft.	In.	Remarks.
16	21	116	24, NW. ¼ NW. ¼	Coal	0	4	
				Shale	10	8	
				Sandstone	4	0	
				Shale	1	0	
				Coal	1	0	
				Clay	0	6	
				Shale	22	6	
				Black shale	3	0	
				Coal	3	6	
				Shale	1	6	Main Kemmerer seam
				Sandstone	1	0	
				Coal	1	0	
				Sandstone			
17	21	116	25, NE. ¼ NW. ¼	Shaly sandstone			Diamondville Coal and Coke Company's mine No. 1.
				Coal	5	0	Upper Kemmerer seam.
				Shale and sandstone	50	0	
				Coal	5	0	
				Sandstone parting			Main Kemmerer seam.
				Coal	7	0	
				Dark-colored fire clay			
18	21	116	35, NE. ¼ SE. ¼	Below surface	459	0	Diamond-drill hole.
				Brown shale	2	0	See section on Pl XXV.
				Black shale	1	0	
				Coal	0	6	
				Shale	0	6	
				Coal	0	6	
				Shale	0	6	
				Sandstone	50	0	
				Sandstone and shale	19	0	
				Sandstone	11	0	
				Coal	2	0	
				Sandstone	0	1	
				Coal	0	11	
				Sandstone	0	2	Upper Kemmerer.
				Coal	0	10	
				Sandstone	0	3	
				Coal	0	9	
				Clay	0	5	
				Sandstone	5	8	
				Shale and sandstone	35	0	
				Sandstone	2	6	
				Shale	0	6	
				Coal	4	0	
				Bony coal	0	1	
				Coal	4	11	
				Bony coal	0	1	Main Kemmerer.
				Coal	1	11	
				Brown rock	0	2	
				Coal	1	10	
				Brown sandstone	0	6	
				Sandstone	10	6	
				Black shale	8	0	
				Coal and clay	0	6	Lower Kemmerer.
				Coal	1	0	
				Sandstone			
19	20	116	4, SE. ¼ NW. ¼	Shale	0	6	Tunnel 175 feet long.
				Coal	1	0	
				Sandstone	0	½	
				Coal	7	1	Main Kemmerer.
				Bone	0	4	
				Coal	4	0	
20	20	116	4, SW. ¼	Clay			
				Coal	0	6	
				Clay and shale	1	5	In the Kemmerer group.
				Coal	1	2	
				Sandstone	0	3	
				Coal	1	0	
				Bone	0	3	
				Coal	4	0	
21	20	116	4, SW. ¼	Coal	0	8	Tunnel 125 feet long.
				Shale	0	8	
				Coal	1	0	
				Bone	2	5	

Sections of coal beds in the Frontier formation—Continued.

No.	Location: T.	R.	Sec.	Sections.	Ft.	In.	Remarks.
21	20	116	4, SW. ¼	Coal Bone Coal Bone Coal Coal and bone Bone Coal	0 0 0 0 0 4 0 1	8 1 4 1 4 0 9 8	In the Kemmerer group.
22	20	116	4, SW. ¼	Below surface Sandstone Coal Sandstone Coal Sandstone Shale Coal Shale Coal Shale Sandstone Coal Sandstone	231 13 1 51 0 3 5 0 19 2 26 1 0	0 0 0 0 2 10 0 1 0 0 0 0 6	Diamond-drill hole. See section on Pl. XXV. In the Kemmerer group.
23	20	116	8, SE. ¼ SE. ¼	Sandstone Coal Clay Coal	 3 0 0	 8 10 10	Upper Kemmerer seam.
24	20	116	9, SW. ¼ NW. ¼	Coal Slate and clay Coal	 0 4	 8 5	In the Kemmerer group.
25	20	116	16, NW. ¼ NW. ¼	Coal Shale Coal Bone Coal Clay Coal	 0 3 0 3 0 6	 4 0 2 6 5 0	In the Kemmerer group. 6-foot coal seam has two streaks of dirt near top.
26	20	116	17, NE. ¼ SE. ¼	Sand rock Coal Dark drab fire clay Sandstone Coal Sandstone	 12 0 0 to 3	 0 6 0	Diamondville Coal and Coke Company's mine No 4. Main Kemmerer seam (Coal; Dark drab fire clay). Lower Kemmerer seam (Coal 0 to 3 0).
27	20	116	17, NE. ¼ SE. ¼	Coal (washed) Brown sandstone Coal Bone Coal Clay Coal	 0 3 0 5 0 4	 1 0 2 1 5 0	Main Kemmerer seam.
28	20	116	20, NE ¼ NE ¼	Coal Sandstone Coal Bone Coal Clay and sandstone Coal	6 0 2 0 4 0 4	8 2 9 3 7 9 0	In the Kemmerer group.
29	20	116	20, SW. ¼ NE ¼	Coal (burned) Sandstone Coal Sandstone Bone Sandstone and clay Coal	 0 2 0 4 0	 1 8 2 10 7	In the Kemmerer group.
30	20	116	20, SW. ¼ SE. ¼	Coal Dirt Coal Dirt	 0 5 0	 1 8 2	In the Kemmerer group.

Sections of coal beds in the Frontier formation—Continued.

No.	Location. T.	Location. R.	Location. Sec.	Sections	Ft.	In.	Remarks.
30	20	116	20, SW. ¼ SE. ¼	Coal Dirt Coal	5	9	
31	20	116	29, NE. ¼ NW. ¼	Coal Sandstone Bony coal Coal	5 0 0 1	0 4 6 0	In the Kemmerer group.
32	20	116	29, SW. ¼ NE. ¼	Coal (washed) Sandstone Coal	 0 3	 9½ 10	In the Kemmerer group.
33	20	116	32, NE. ¼ NW. ¼	Below surface Sandstone Coal Black shale Shale and sandstone Coal Shale Sandstone Coal Shale Sandstone	87 6 10 31 0 3 32 1 12	0 0 0 0 6 6 0 0 0	Diamond-drill hole. See section on Pl. XXV.
34	20	116	32, NE. ¼ NW. ¼	Shale Coal Rock Coal Clay	 1 0 2	 8 10 11	In the Kemmerer group.
35	20	116	32, NE. ¼ NW. ¼	No coal			
36	20	116	32, SE. ¼ NW. ¼	Coal, partly burned	3	4	In the Kemmerer group.
37	20	116	32, SE. ¼ NW. ¼	No coal			
38	20	116	32, SE. ¼ SW ¼	Shale Coal Rock Coal	 1 0 2	 4 10 9	In the Kemmerer group
39	20	116	32, SE. ¼ SW. ¼	Coal, in part burned Rock Coal	3 0 2	1 1 7	In the Kemmerer group
40	19	116	5, NE. ¼ NW. ¼	No coal			
41	19	116	5, SE. ¼ NW. ¼	Sandstone Coal Coal and dirt Coal	 4 1 2	 10 2 2	In the Kemmerer group.
42	19	116	5, SE. ¼ NW. ¼	Shale Coal Rock Coal	 1 0 3	 4 8 3	In the Kemmerer group.
43	19	116	5, NE. ¼ SW. ¼	Below surface Sandstone Coal Shale Coal Sandstone Sandstone and shale Sandstone Coal Sandstone	96 0 1 5 7 27 27 4 16	0 3 9 0 0 0 0 10 2	Diamond-drill hole. See section on Pl. XXV. In the Kemmerer group.
44	19	116	5, NE. ¼ SW. ¼	Coal, burned Dirt Coal	 1 4	 2 1	In the Kemmerer group.

Sections of coal beds in the Frontier formation—Continued.

No.	Location.			Sections.		Remarks.
	T.	R.	Sec.		Ft. In	
45	19	116	8, NE. ¼ NW. ¼	No coal		In the Kemmerer group.
46	19	116	8, SE. ¼ NW. ¼	Coal Dirt Coal Dirt Coal	0 9 0 3 1 7 0 3 5 6	Tunnel, 35 feet long. In the Kemmerer group.
47	19	116	8, SE. ¼ NW. ¼	Sandstone Dirt Coal Dirt Coal Rock Coal	 0 3 0 7 0 9 1 9 0 5 2 11	In the Kemmerer group.
48	19	116	8, SE. ¼ SW. ¼	Coal	4 0	
49	19	116	17, SW. ¼ NW. ¼	Coal Dirt Coal Bone Coal	3 0 0 1 3 1 2 3 8 6	In the Kemmerer group.
50	19	116	17, SW. ¼ NW. ¼	Coal Bone Coal Bone and rock Coal	6 6 0 4 5 10 1 0 7 10	In the Kemmerer group.
51	19	116	17, SW. ¼ SW. ¼	Coal Bone and rock Coal Bone Coal	6 10 0 3 6 3 0 5 5 4	In the Kemmerer group.
52	19	116	19, SE. ¼ NE. ¼			Cumberland mine No. 2; see fig. 6, p. 116.
53	19	116	19, NW. ¼ SE. ¼	No coal		Diamond-drill hole; see section on Pl. XXV.
54	19	116	19, NW. ¼ SE. ¼	No coal		Diamond-drill hole; see section on Pl. XXV.
55	19	116	19, SW. ¼ SE. ¼	Below surface Sandstone Coal Sandstone	547 0 3 9 1 3 	Diamond drill hole; see section on Pl. XXV. In the Kemmerer group.
56	19	116	20, NE. ¼ NE. ¼	Coal	6 0	In the Spring Valley group.
57	19	116	20, NE. ¼	Coal	6 0	In the Spring Valley group.
58	19	116	20, NE. ¼	Sandstone Coal Clay	 5 6 	In the Spring Valley group.
59	19	116	20, SE. ¼ NE. ¼	Sandstone Coal Clay	 5 8 	In the lower group.
60	19	116	30, SW. ¼ NE. ¼	Coal Fire clay Coal	12 0 0 4 1 6	In the Kemmerer group.
61	19	116	30, SW. ¼ SE. ¼	Coal Fire clay Coal	14 0 1 0 7 0	In the Kemmerer group.
62	19	116	31, NE. ¼ SW. ¼			Cumberland mine No. 1; see fig. 6, p. 116.
63	19	116	31, NW. ¼ NE. ¼	Coal Fire clay Coal Fire clay	10 3 0 6 5 0 	In the Kemmerer group. See section on Pl. XXIV, A.

Sections of coal beds in the Frontier formation—Continued.

No.	Location: T.	Location: R.	Location: Sec.	Sections.	Ft.	In.	Remarks.
64	19	116	32, NW. ¼ NW. ¼	Sandstone			
				Coal	0	9	
				Clay	3	3	In the lower group. See section on Pl. XXIV, A.
				Coal	0	9	
				Dark clay	1	9	
				Coal	0	3	
				Sandstone			
65	19	116	32, NE. ¼ NW. ¼	Sandstone			
				Coal	1	9	
				Clay	2	6	In the Spring Valley group. See section on Pl. XXIV, A.
				Bone	0	10	
				Coal	1	3	
				Sandy shale			
66	19	116	32, NE. ¼ NW. ¼	Clay shale			
				Coal	3	10	In the Spring Valley group. See section on Pl. XXIV, A.
				Black shale			
67	19	116	32, NE. ¼ NW. ¼	Sandstone			
				Coal	1	7	
				Shale	0	1	
				Coal and bone	1	0	
				Clay	0	4	In the Spring Valley group. See section on Pl. XXIV, A.
				Coal	1	10	
				Dark clay shale			
68	18	117	1, NE. ¼ NE. ¼	Below surface	277	0	Diamond-drill hole; see section on Pl. XXV.
				Sandstone			
				Coal	6	8	
				Clay shale	1	4	In the Kemmerer group.
				Coal	2	6	
				Clay shale	5	6	
				Coal	4	6	
				Clay shale			
69	18	117	1, SE. ¼ NE. ¼	Below surface	400	6	Diamond-drill hole. See section on Pl. XXV.
				Sandstone			
				Coal	7	0	
				Sandy clay	17	6	
				Shale and sandstone	24	0	In the Kemmerer group.
				Coal	1	0	
				Brown shale	4	0	
70	18	117	1, NE. ¼ SE. ¼	Below surface	394	0	Diamond-drill hole.
				Sandstone			
				Shale	6	0	See section on Pl. XXV.
				Coal	1	6	
				Bone	0	4	
				Coal	3	2	In the Kemmerer group.
				Clay shale	21	0	
				Coal	4	0	
				Clay shale			
71	18	117	4, SW. ¼ SW. ¼	Sandstone			
				Coal	5	0	
				Clay	0	4	In the Kemmerer group.
				Coal	1	0	
				Clay			
72	18	117	5, SW. ¼ SE. ¼	Sandstone			
				Coal	1	0	
				Bone	0	1	
				Coal	4	0	In the lower group.
				Clay	0	1	
				Coal	0	10	
73	18	117	12, NW. ¼ SE. ¼	Coal and clay	4	0	
				Coal	0	8	In the Kemmerer group.
74	18	117	13, NE. ¼ SW. ¼	Clay			Slope 150 feet long.
				Coal	2	0	
				Clay shale	0	11	
				Coal	2	6	In the Kemmerer group.
				Clay shale			

Sections of coal beds in the Frontier formation—Continued.

No.	Location.			Sections.	Ft.	In.	Remarks
	T.	R.	Sec.				
75	18	117	13, NE. ¼ SW. ¼	Coal, clean Coal, dirty	5 4	0 9	In the Kemmerer group.
76	18	17	13, SE. ¼ SW. ¼	Coal Clay Coal	4 2 1	4 2 3	
77	18	17	13, NW. ¼ SW. ¼	Below surface Sandstone Coal Shale Coal Sandstone	330 0 0 0 1	0 6 4 4 10	Diamond-drill hole. See section on Pl. XXV. In the Kemmerer group.
78	18	17	13, SW. ¼ SW. ¼	Below surface Shale Coal Shale	477 14 3	7 5 7	Diamond-drill hole. See section on Pl. XXV In the Kemmerer group.
79	18	117	18, SE. ¼ NE. ¼	Sandstone Clay Coal Bone Coal Clay	 0 4 0 3	 4 0 3 6	In the lower group.
80	18	117	24, NE. ¼ NW. ¼	Coal	3	0	In the Kemmerer group
81	18	117	24, NE. ¼ NW. ¼	Coal	3	0	In the Kemmerer group.
82	18	117	24, NE. ¼ NW. ¼	Coal	3	0	In the Kemmerer group.
83	18	117	24, SE. ¼ NW. ¼	Shale Coal Clay	 6	 0	In the Kemmerer group.
84	18	117	24, SW. ¼ SW. ¼	Shale Coal Shale Coal Clay	 2 1 0	 4 2 8	In the Kemmerer group.
85	18	117	26, NE. ¼ NE. ¼	Coal Clay	1	8	In the Kemmerer group
86	18	117	26, NE. ¼	Shale Coal Shale Coal Clay	 2 0 0	 9 7 6	In the Kemmerer group.
87	18	117	26, SE. ¼ NE. ¼	Sandstone Coal Shale Coal Clay	 0 0 2	 6 8 0	In the Kemmerer group.
88	18	117	26, SE. ¼	Shale Coal Coal and shale Coal Clay	 2 1 0	 6 2 7	In the Kemmerer group.
89	18	117	26, NW. ¼ SE. ¼	Coal Fire clay Coal Clay	5 1 2	0 0 9	In the Kemmerer group.
90	18	117	26, SW. ¼ SE. ¼	Coal Shale Coal Clay	5 0 2	8 8 5	In the Kemmerer group.

Sections of coal beds in the Frontier formation—Continued.

No.	Location: T.	Location: R.	Location: Sec.	Sections.	Ft.	In.	Remarks.
91	18	117	26, SW. ¼ SE. ¼	Sandstone			
				Coal	5	3	In the Kemmerer group.
				Shale	1	3	
				Coal	2	0	
				Clay			
92	18	117	35, NE. ¼ NW. ¼	Coal	5	0	In the Kemmerer group.
				Shale	1	0	
				Coal	2	3	
93	18	117	35, NW. ¼	Dirt roof			Slope 150 feet long.
				Coal	5	6	
				Shale	0	3	In the Kemmerer group.
				Coal	1	9	
94	18	117	35, SE. ¼ NW. ¼	Coal	5	2	In the Kemmerer group.
				Shale	0	2	
95	18	117	35, SE. ¼ NW. ¼	Coal	2	0	
				Below surface	335	0	Diamond-drill hole.
				Shale			See section on Pl. XXIV.
				Shale and sandstone	1	0	
				Coal	0	2	
				Shale	7	10	
				Shale and sandstone	1	0	
				Brown shale	1	0	
				Coal	6	4	In the Kemmerer group.
				Shale	0	5	
				Coal	1	7	
				Shale	11	8	
				Shale and coal	2	0	
				Shale			
96	18	117	35, NE. ¼ SW. ¼	Bone	0	7	
				Coal	3	9	In the Kemmerer group.
97	18	117	35, SE. ¼ SW. ¼	Clay roof			
				Coal	8	2	
				Clay	0	4	In the Kemmerer group.
				Coal	1	5	
				Clay			
98	17	117	2, NW. ¼	Sandstone			In the Kemmerer group.
				Coal	7	2	
				Clay			
99	17	117	2, SE. ¼ NW. ¼	Coal	2	7	
				Clay	1	2	In the Kemmerer group.
				Coal	1	10	
100	17	117	2, SW. ¼	Shale			
				Coal	2	0	
				Fire clay	1	3	In the Kemmerer group.
				Coal	1	10	
101	17	117	2, SW. ¼ SW. ¼	Coal	3	6	In the Kemmerer group.
				Clay	1	6	
				Coal	3	6	
102	17	117	7, SE. ¼ SE. ¼	Coal	6	0	In the Kemmerer group.
103	17	117	10, SE. ¼	Coal	2	6	
				Fire clay	0	10	In the Kemmerer group.
				Coal	1	4	
				Clay			
104	17	117	11, SW. ¼ NW. ¼	Sandstone			
				Coal	4	0	In the Kemmerer group.
				Clay			
105	17	117	11, NW. ¼ SW. ¼	Coal	5	0	In the Kemmerer group.
				Clay			
106	17	117	22, SE. ¼ NE. ¼	Coal	2	7	In the Kemmerer group.
				Clay	2	4	
				Coal	2	5	

Sections of coal beds in the Frontier formation—Continued.

No.	Location. T.	Location. R.	Location. Sec.	Sections.	Ft.	In.	Remarks.
107	17	117	23, SW. ¼	Coal Shale Coal Clay	1 0 6	8 4 0	In the Kemmerer group.
108	17	117	24, SW. ¼ NW. ¼	Coal	3	8	In the lower group.
109	17	117	26, SW. ¼ SW. ¼	Coal Clay Coal	4 1 1	0 9 6	In the lower group.
110	17	117	34, NE. ¼ SW. ¼	Coal Clay Coal	3 0 7	8 3 8	In the Kemmerer group.
111	17	117	34, SW. ¼ SW. ¼	Coal Shale Coal	0 0 4	10 3 10	In the Kemmerer group.
112	17	117	34, NE. ¼	Coal Clay Coal	4 1 1	6 2 0	In the lower group.
113	17	117	35, NW. ¼	Coal	3	8	In the lower group.
114	16	117	5, NW. ¼	Coal Shale Coal	0 0 4	10 3 5	In the Kemmerer group.
115	16	117	6, NE. ¼ SE. ¼	Coal Shale Coal	1 0 5	0 4 0	In the Kemmerer group.
116	16	117	7, NE. ¼	Coal Shale Coal	2 0 3	0 3 6	In the Kemmerer group.
117	16	117	8, NE. ¼ SW. ¼	Coal Clay Coal	4 1 3	6 3 0	In the lower group.
118	16	117	8, NE ¼ SW. ¼	Clay Coal Clay	 4	 8	In the lower group.
119	16	117	18, SE. ¼	Coal	5	2	In the lower group.
120	16	117	18, NW. ¼	Coal Shale Coal	2 0 2	0 3 3	In the Kemmerer group.
121	16	117	18, NW. ¼ SW. ¼	Coal Shale Coal Shale Coal	1 0 3 2 2	0 3 0 2 2	In the Kemmerer group.
122	16	117	30, NW. ¼ NW. ¼	Coal Clay Coal	4 2 2	2 0 8	In the lower group.
123	16	117	30, NW. ¼ NW. ¼	Coal	1	0	In the lower group.
124	16	117	30, NW. ¼ NW. ¼	Coal	4	0	In the lower group.
125	16	117	30, NW. ¼ SW. ¼	Coal Clay Coal	1 1 4	6 9 9	See section on Pl. XXIV, *B*. In the lower group.
126	16	117	30, NW. ¼ SW. ¼	Coal	1	0	In the lower group.
127	16	117	30, SW. ¼ SW. ¼	Coal	5	0	In the lower group; see section on Pl. XXIV, *B*.

Sections of coal beds in the Frontier formation—Continued.

No	Location.			Sections.			Remarks.
	T.	R.	Sec.		Ft.	In.	
128	16	118	24, NE. ¼ NE. ¼	Coal Shale Coal	2 0 	0 3 	In the Kemmerer group.
129	16	118	24, NW. ¼ SE. ¼	Coal Shale Coal	1 0 6	5 3 6	In the Kemmerer group.
130	16	118	25, NE. ¼ NW. ¼	Coal Shale Coal	1 0 4	6 2 8	In the Kemmerer group.
131	16	118	25, SW. ¼	Sandstone Coal Shale Coal Clay shale	 1 0 4 	 6 2 8 	See section on Pl. XXIV, *B*. In the Kemmerer group.
132	15	118	1, SW. ¼ NE. ¼	Coal Fire clay Coal Shale	0 0 0 0	6 6 6 6	In the lower group.
133	15	118	12, NE. ¼ NW. ¼	Gray clay Coal Shale Coal	 2 0 2	 3 2 7	Richardson coal mine. In the lower group.
134	15	118	12, SW. ¼ SW. ¼	Coal Shale Coal	2 0 3	0 3 3	In the lower group; Jager Oil Co. prospect.
135	15	118	22, NW. ¼ NW. ¼	Below surface Coal and shale	1,180 100	0 0	3 coal beds were encountered between 1,180 and 1,280 feet. Thickest coal bed was 8 feet. In the Kemmerer group.
136	15	118	32, NE. ¼ SE. ¼	Below surface Sandstone Coal Coal and dirt White limestone	1,183 4 4 	0 0 0 	Churn-drill hole, Baker oil well. See section on p. 84. In the Kemmerer group.
137	15	118	33, NE. ¼ NE. ¼	Below surface Shale Coal Shale and sandstone Coal Shale Soft shale Coal Coal and dirt Coal Shale and sandstone Coal Shale	521 0 43 0 14 1 0 0 4 49 0 	6 6 7 5 0 2 9 2 7 2 1 	U. P. diamond-drill hole No. 5. See section on Pl. XXIV, *C*. In the Kemmerer group.
138	15	118	33, NE. ¼ NE. ¼	Below surface Sandstone Black shale and 2 inches coal. Shale and sandstone Coal Fire clay	389 9 17 4 	0 0 0 0 	U. P. diamond-drill hole No. 4 See section on Pl. XXIV, *C*. In the Kemmerer group.
139	15	118	34, NW. ¼ NW. ¼	Below surface Clay shale Coal (dirty) Clay shale	209 1 	0 0 	U. P. diamond-drill hole No. 9. See section on Pl. XXIV, *C*. In the lower group.
140	15	118	34, NW. ¼	Coal Rock Coal Clay Coal	1 0 4 1 2	9 5 0 2 6	Carter coal mine. Carter seam. See section on Pl. XXIV, *C*.

Sections of coal beds in the Frontier formation—Continued.

No.	Location. T.	Location. R.	Location. Sec.	Sections.	Ft.	In.	Remarks.
141	15	118	34, NW. ¼ NE. ¼	Clay roof Coal Bone Coal Clay	 1 0 4	 6 3 3	U. P. Coal Co., Spring Valley mine. Spring Valley seam. See section on Pl. XXIV, *C*.
142	15	118	34, SW. ¼ NE. ¼	Coal	6	6	In the lower group.
143	15	118	34, SW. ¼ NE. ¼	Coal	6	4	In the lower group.
144	15	119	12, SW. ¼ NE. ¼	Coal	2	6	In the lower group.
145	14	119	12, SE. ¼ NW. ¼	Coal, burned			
146	14	119	12, NE ¼ SW. ¼	Coal	19	0	Dip E. 42°.
147	14	119	12, NE. ¼ SW. ¼	Coal	8	6	Dip E. 42°.
148	14	119	12, SE. ¼ SW. ¼	Coal	8	5	Dip E. 45°.
149	14	119	12, SE. ¼ SW. ¼	Coal	6	7	Dip N. 30° E. 52°.
150	14	119	12, SE. ¼ SW. ¼	Coal	10	0	Dip S. 24° E. 43°.
151	14	119	13, NE. ¼ NE. ¼	Shale Coal	 5	 6	Dip S. 25° E.
152	14	119	13, SE. ¼ NE. ¼	Shale Coal	 11	 0	Dip S. 35° E.
153	14	119	13, SW. ¼ NE. ¼	Coal	9	0	Dip N. 25° W.
154	14	119	13, NW. ¼ SE. ¼	Sandstone Coal	 9	 0	Dip N. 20° W.
155	14	119	13, SW. ¼ SE. ¼	Sandstone Coal	 8	 6	Dip 90°.
156	14	119	13, NE. ¼ SW. ¼	Coal	10	6	
157	14	119	13, SE. ¼ SW. ¼	Sandstone Coal	 9	 0	Dip S. 20° W.
158	14	119	13, SE. ¼ SW. ¼	Coal	7	0	Dip W. 30°.
159	14	119	13, SW. ¼ SW. ¼	Coal	6	4	
160	14	119	13, SW. ¼ SW. ¼	Coal	8	0	Dip E. 20°.
161	14	119	16, SW. ¼	Sandstone Coal, bony Coal	 1 2	 0 0	Dip S. 35°, E. 55°.
162	14	119	20, NE. ¼ SW. ¼	Coal	16	0	Miller coal mine.[a]
163	14	119	22, SW. ¼ SE. ¼	Sandstone Coal Clay	 7 	 0 	Dip NE.
164	14	119	24, NW. ¼ SW. ¼	Coal	1	10	
165	14	119	24, NW. ¼ NW. ¼	Coal	7	0	
166	14	119	24, NW. ¼ NE. ¼	Coal	18	0	Dip S. 90°.
167	14	119	26, NW. ¼ NE. ¼	Coal	7	0	
168	14	119	27, NW. ¼	Sandstone Coal	 15	 0	Dip N. 60°.

[a] W. C. Knight, The oil fields of Crook and Uinta counties, Wyo.: The School of Mines, University of Wyoming, Petroleum Series, Bull. No. 3, Nov., 1899, p. 14.

Sections of coal-beds in the Frontier formation—Continued.

No.	Location. T.	R.	Sec.	Sections.	Ft.	In.	Remarks.
169	14	119	28, NE. ¼ SE. ¼	Sandstone Coal Clay	 10 	 0 	Dip W. 60°.
170	14	119	28, SW. ¼ SE. ¼	Sandstone Coal Clay	 7 	 6 	Dip W. 80°.
171	14	119	28, SE. ¼ SW. ¼	Sandstone Coal Coal, dirty	 5 5	 0 0	Dip W. 65°.
172	14	119	33, SW. ¼ NE. ¼	Clay Coal, dirty			Dip W. 80°.
173	14	119	33, SW. ¼ NW. ¼	Gravel Clay	10 8	0 0	Drill hole.
174	14	119	33, SW. ¼ NW. ¼	Gravel Blue shale	10 14	0 0	Drill hole.
175	14	119	33, SE. ¼ NW. ¼	Gravel Clay Blue shale	8 7 25	0 0 0	Drill hole.
176	14	119	33, SE. ¼ NW. ¼	Gravel Clay Blue shale	8 7 25	0 0 0	Drill hole.
177	14	119	36, NE. ¼ NE. ¼	Sandstone Coal	 4	 0	Byrnes coal mine. Dip W. 20° N. 45°.
178	13	119	10, SE. ¼	Shale Coal	 3	 0	Dip W. 20° N 30°. In the Kemmerer group.

COALS IN THE ADAVILLE FORMATION.

This coal-bearing group has been noted from an early day for the great number and thickness of its coal seams. Peale reports that in 1876 the Smith and Bell brothers discovered and opened, in the region of Hodges Pass, on the divide between the head of Twin Creek and Hams Fork, 29 beds of coal, ranging in thickness from 1½ to 48 feet and having an aggregate thickness of 315 feet.[a] On the completion of the Oregon Short Line the Union Pacific Coal Company opened mines a mile west of Hodges Pass tunnel. Mine No. 1 was opened in 1881 and No. 2 in 1882. In mine No. 1 a horizontal prospect tunnel 1,400 feet long cut beds 5, 2, 8, 10, 5, and 15 feet in thickness in 650 feet of strata, while in mine No. 2 two beds, stratigraphically 750 feet above the uppermost bed in No. 1, were opened 120 feet apart, one 20 and the other 14 feet thick. These mines were abandoned in 1885 because the coal slacked badly. The Hodges Pass tunnel, 1,400 feet long, cut coal beds of the following thicknesses: 9, 5, 38, 6, 14, 6, 5, and 6 feet. About 3 miles south of the Hodges Pass tunnel the prospect tunnel at the Adaville opening cut a bed 84 feet thick, with a single parting of clay 2 inches thick. This mine was abandoned after one shipment of coal because the coal slacked badly, but the fact that the roof of the opening, composed entirely of coal and not timbered,

[a] Peale, A. C., Eleventh Ann. Rept. U. S. Geol. Survey Terr. for 1877-1879, p. 535. Peale states that the 29 beds occurred in a thickness of 315 feet, which is incorrect, but a statement that the aggregate thickness is 315 feet is quite within the facts now known and was probably the actual statement made by his informant.

is solid and of good luster after fifteen year's' exposure to the air suggests that the coal may perhaps have shipping qualities. The coal exposed in this mine is, on the whole, much cleaner than that found in the Frontier formation. Three-quarters of a mile west of the Adaville mine the St. Albans opening penetrates a coal bed 25 feet thick. The Adaville seam has been opened farther south, at the Lazeart mine, west of Spring Valley, where it was found to be 32 feet thick, and at the Carlton mine, near Hilliard, where it is 22 feet thick. The Lazeart mine was in operation the summer of 1905, and its small product was hauled by wagons to Evanston or sold to local oil operators. At both these mines it was stated that the product crumbled badly.

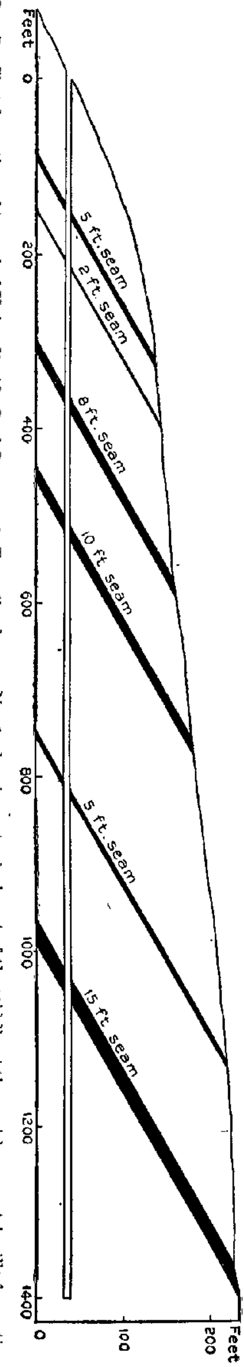


FIG. 7.—Sketch section of tunnel of Union Pacific Coal Company's Twin Creek mine No. 1, showing a typical part of the middle of the coal-bearing Adaville formation.

Because of the rising and pitching character of the Lazeart syncline the beds of this group occupy three basins, the first extending from 2 miles north of Hams Fork to 2 miles north of Little Muddy Creek, the second from Clear Creek to Lazeart coal mine, and the third from near Sulphur Creek southward for an undetermined distance, probably but a few miles. (Pl. XXIII.)

This coal-bearing group represents an immense storage of fuel of fair quality, and will undoubtedly be largely developed in the future.

COALS IN THE EVANSTON FORMATION.

The Evanston coal-bearing beds outcrop at three points in the vicinity of Evanston: (1) Along the bluff on the east side of Bear River at Almy; (2) near the well of the Michigan-Wyoming Oil Company; (3) extending from the Union Pacific Railroad cut east of Evanston to the southern end of Medicine Butte. The Almy exposures are on the west side of an eastward-tilted fault block (Pl. XIII), which is limited on the west by the Almy fault and on the east by the Acocks fault (Pl. XXIII). West of the Almy fault the coal is very deep. The beds exposed on the west side of Bear River at the level of the bottoms are upper Fowkes, and it is inferred from the thickness of the Fowkes (2,000 to 2,500 feet) and of the Almy (2,100 feet) that the principal coal of the Evanston formation is about 4,000 feet below the surface at this point.

With the completion of the Union Pacific Railroad in 1869 mines were at once opened in the Almy exposures, and Hayden in 1871 stated that he regarded these mines as "more valuable and the coal of better quality than any found west of the Mississippi."[a]

[a] [Fourth Ann.] Prelim. Rept. U. S. Geol. Survey Wyoming for 1870, 1871, p. 154.

The dates of opening and abandonment of the principal mines at this point are given in the following table, which shows clearly the rise and decline of this coal field:

Coal mines at Almy, Wyo.

Mine No.	Owner.	Opened.	Abandoned.
1	Wyoming Coal Co., succeeded by Union Pacific Coal Co.	1869	Before 1888.
2	Rocky Mountain Coal and Iron Co	June, 1869	Do.
3	Union Pacific Coal Co	1880	May, 1887.
4	....do	1875	November, 1888.
5	Rocky Mountain Coal and Iron Co	August, 1869	Still operating.
6	....do	First, April, 1871; second, 1888	About 1901.
7	Union Pacific Coal Co	1888	April, 1900.

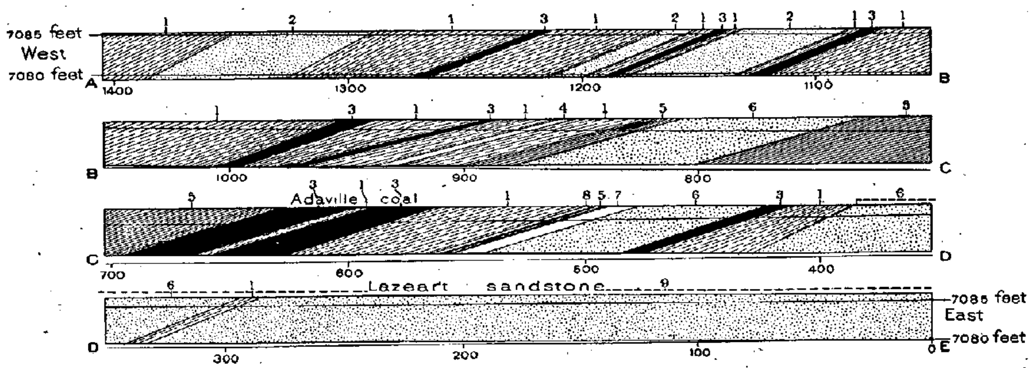


FIG. 8.—Section of Oregon Short Line Railroad tunnel at Hodges Pass. A typical section in the lower part of coal-bearing Adaville formation. (Vertical scale 5 times horizontal.) 1, Clay; 2, rock; 3, coal; 4, black slate; 5, "soapstone;" 6, sand rock; 7, hard sandstone; 8, soft clay; 9, solid sand rock.

Detailed examination of these mines was made by Territorial Geologist Ricketts in 1888,[a] and the following account is abstracted from his report:

There are in all at least five seams of coal, of which but one is clean enough to work. Two of them are said to be about 50 feet apart and the lower to be about 100 [feet] above the seam on which the mines are located. The upper is said to be 9 feet thick, the lower about 6 feet, the measurements including the numerous bands of slate the seams contain. From 8 to 20 feet below the seam worked there is a small seam from 4 to 6 feet in thickness, and from 70 to 100 feet below it there is another seam from 8 to 12 feet thick. While the latter usually contains so many bands of slate that it is of no practical value, yet I am informed that toward the south it is prospectively capable of furnishing good coal.

The great seam from which the Almy coal is mined has been opened up and developed along the entire line of crop. The first mine was opened near the southern end of the field, the last near the northern. * * * An opening upon the northeast quarter of section 18, township 16, range 120, shows the seam to be about 12 feet in thickness and to consist of little more than a stratum of carbonaceous shale. To the south the thickness rapidly increases by the widening out of the bands of coal between the slates. * * * Almy mine No. 7, belonging to the Union Pacific Railway, lies south of section 18. * * * The slope runs a little north of east and has an average inclination of about 5.5°. Near the surface the dip is from 7° to 8°, but it flattens toward the face, evidently, however, only a local flattening, as evinced by the apparent great increase in dip shown up Red Canyon.

[a] Ricketts, L. D., Ann. Rept. Territorial Geologist Wyoming for 1888 and 1889, 1890, pp. 7-12.

An upraise was made at the pump station, 150 feet south of the main slope, at a point 1,500 feet from the surface, to determine the structure of the seam. The floor is an impure fire clay, merging into an argillaceous sandstone. The roof is a clay shale that changes into an impure sandstone. * * * [Fig. 9 shows a section of coal taken at the time the upraise was made.]

The section is taken on a north and south line near the center of the mine and a little more than 1 mile from the opening upon section 18 just described. As shown in section, only the lower beds are mined. At this point they are 15 feet thick. North of the slope this thickness rapidly decreases and is probably not over 11 or 12 feet 1,000 feet north. South of the slope it increases and is fully 20 feet 2,000 feet. The slate is, of course, separated in mining, but it has to be hoisted to the surface, together with all slack, as the gob soon suffers spontaneous combustion.

No. 5 mine belongs to the Rocky Mountain Coal and Iron Company. It lies south of No. 7 mine. The two slopes are about $1\frac{1}{4}$ miles apart. The main slope of the latter mine runs directly east with the dip. It has an average inclination of 13° and is about 1,500 feet in length. Unlike the method adopted at No. 7 mine, the slopes and entries are made in the center of the coal worked, and in starting a room they run level until the floor of the coal is reached, and then rise with the pitch. Also, on account of the great height of the coal, the rooms are run their length at a height of only 15 or 16 feet and then are mined back on the coal remaining in the roof. * * * No. 6 mine, belonging to the owners of No. 5, is opened by a slope starting about half a mile northwest of the head house of No. 5 mine. This necessarily indicated a westward swing of the outcrop of the seam from its normal course of north and south, and might be explained either by a fault or local swing of the strike to the northwest. Development showed that the phenomenon was caused by a fault of about 105 feet displacement, which was struck about 600 feet down the slope. As the fault was an upthrow to the east, the slope struck through it into the very impure and bony seam 12 feet in thickness which here lies 104 feet beneath the main seam. It is unnecessary to say that the management were at first considerably puzzled over the apparent decided change in the character of their coal, but they soon discovered the cause and developed the ground above the fault by an entry from No. 5 mine. It was found that the fault had a course nearly due north and south, and that it rapidly decreased in displacement toward the south, so that although the main slope of No. 5 crossed the line of the fault there was no fault observed. A crosscut from an entry from No. 5 mine to a point about midway between Nos. 5 and 6 shows the fault to have there a displacement of less than 50 feet. Of course the seam east of the fault does not outcrop for a considerable distance from the point where displacement first begins, but comes directly against rock in places on the downthrown side. Ultimately, however, it does appear at the surface in the No. 7 outcrop.

A similar fault, beginning as a mere fissure in No. 5 mine near the outcrop and just south of the slope, assumes toward the southeast a displacement with a downthrow to the west. It is a fault of 45 feet a quarter of a mile south of the slope. Farther south it is said to decrease, and to have a throw of but 20 feet where cut by No. 4 slope, and to disappear a short distance beyond. A third fault, with a throw down to the west, appears to lie just west of No. 6. It has never been developed.

The mines south of No. 5 have all been abandoned, and it is impossible to enter them. No. 4, belonging to the Union Pacific, was abandoned in the fall of 1888 on account of a creep and the presence of fires, which, on account of the explosive gases the seam generates, rendered working dangerous. * * *

It is the opinion of the largest consumers of the coal, and no better evidence could be adduced, that there is a regular variation in the quality. It is said that the coal formerly produced by the Union Pacific's No. 4 and the Rocky Mountain Coal and Iron Company's No. 2 mines was the best for all purposes and that the quality gradually deteriorates, both to the north and south. The analysis of samples taken by the writer from Nos. 5 and 7 indicates this change as far as they apply.

From the description of the Almy seam given above it appears that it begins on the northern exposure of the outcrop as a small stratum of shale, but the bands of coal rapidly widening, it soon becomes workable; that the seam continues to increase in thickness until it reaches a maximum in the ground just south of No. 4 mine, and that there is a noticeable improvement in the quality of the coal also; that from the latter point the seam begins to split up into a group of smaller seams, and that with this latter change the quality of the coal slowly deteriorates; that the splitting up of the seam is caused by the thickening of two well-defined bands and by a third band of clay that only makes its appearance near the southern limits of the field, and that all of these marked changes have taken place in the comparatively short distance of about 5 miles.

The sections shown on fig. 9 comprise those reported by Ricketts and a section of mine No. 1, obtained by Peale in 1870. After Ricketts's visit mine No. 6 was opened on the main bed. An east-and-west fault, with downthrow to the south, was found in this opening, beginning about 1,000 feet from the mouth of the mine and increasing rapidly toward the east. About 2,000 feet from the mouth of the mine the throw is 40 feet. The Almy mines have all been abandoned, with the exception of No. 5, which is still operating on a small scale. The output is hauled from the mine by wagons, and the consumption is entirely local. The main building burned during the summer of 1905, but was immediately rebuilt.

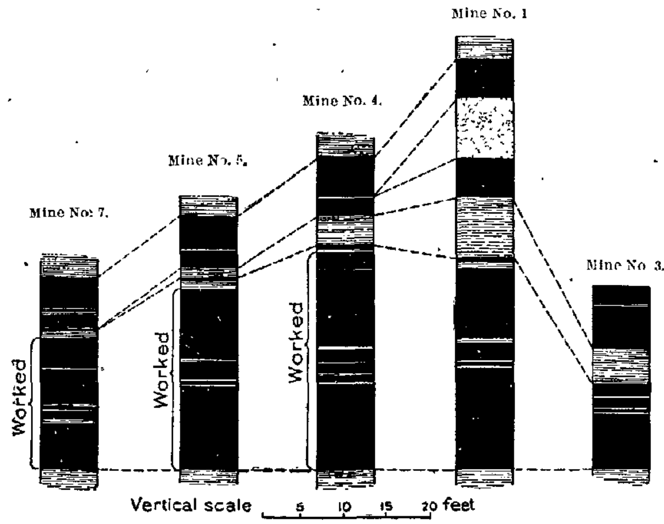


FIG. 9.—Sections of Big or Almy seam at Almy, Wyo.

Near the Michigan-Wyoming Oil Company's well several thin coal seams outcrop. One, a short distance west of the well, has been opened and furnishes the fuel used at this point. The coal is rather dirty and is inclined to clinker. The section at the opening is as follows:

Section at coal opening of Michigan-Wyoming Oil Company, in sec. 35, T. 17 N., R. 120 W.

	Ft.	in.
Shale.		
Coal	1	8
Bone		2
Coal	2	6
Shale.		

Mr. J. A. Morehouse, who drilled the well, reports that coal beds were found in it from 74 to 79 feet, 120 to 128 feet, and 200 to 202 feet, and that below the lowest coal beds the red shales and sandstones of the Beckwith formation were encountered.

Coal seams have been found in the Evanston beds at the Union Pacific Railroad cut, and at the southern end of Medicine Butte exposures of the Beckwith beds, at about the horizon of the Almy coals. These have been prospected, but have not yet been shown to be of commercial importance. The beds here outcrop on the east side of the Medicine Butte-Needles fault and dip almost due east at angles of from 10° to 15° (Pl. IV, section J).

The coal found in the Baker well, west of Spring Valley, between 230 and 236 feet, associated with conglomerate beds, suggests the conditions found in the cut at Evanston, and this coal may belong to the Evanston formation (see p. 84).

QUALITY AND CLASSIFICATION OF COALS.

Ten samples of coal were collected from mines in this region. The samples were taken with great care, were pulverized and quartered in the mines, and were sent in sealed cans to the chemical laboratory of the United States Geological Survey's coal-testing plant at St. Louis, Mo., where the following analyses were made:

Analyses of coals from southern Uinta County, Wyo., made at United States Geological Survey's coal-testing plant, St. Louis, Mo., 1905.[a]

[F. M. Stanton, analyst.]

	I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.	X.
Loss of moisture on air drying	6.90	6.70	[b]6.70	[b]14.80	2.60	1.30	2.40	2.00	1.40	2.60
Analyses of samples as received:										
Proximate. Moisture	14.11	14.43	19.15	22.37	6.78	5.13	5.89	5.86	3.96	6.85
Proximate. Volatile matter	35.34	36.81	36.79	34.50	39.79	40.51	37.59	39.49	36.16	35.62
Proximate. Fixed carbon	34.40	41.54	38.80	40.21	47.43	49.75	49.01	51.00	55.11	43.86
Proximate. / Ultimate. Ash	16.15	7.22	5.26	2.92	6.00	4.61	7.51	3.65	4.77	13.67
Ultimate. Sulphur	4.45	.21	1.18	.50	.43	.49	1.39	1.07	.77	.94
Ultimate. Hydrogen	5.30	5.37	6.13	6.10	5.56	5.63	5.28	5.57	5.17	4.99
Ultimate. Carbon	48.91	59.97	57.03	56.02	69.01	72.95	68.48	72.96	76.03	63.91
Ultimate. Nitrogen	.82	1.15	1.01	.88	1.12	1.18	1.07	1.08	1.31	1.12
Ultimate. Oxygen	24.37	26.08	29.39	33.58	17.88	15.14	16.27	15.67	11.95	15.37
Calorific value determined:										
Calories	4,898	5,804	5,631	5,440	6,815	7,202	6,870	7,102	7,501	6,205
British thermal units	8,816	10,447	10,136	9,792	12,267	12,964	12,366	12,784	13,502	11,349
Analyses of air-dried samples:										
Proximate. Moisture	7.74	8.29	13.34	8.88	4.29	3.38	3.57	3.94	2.59	4.36
Proximate. Volatile matter	37.96	39.45	39.43	40.49	40.85	41.04	38.52	40.30	36.68	36.57
Proximate. Fixed carbon	36.95	44.52	41.58	47.20	48.69	50.41	50.21	52.04	55.90	45.03
Proximate. / Ultimate. Ash	17.35	7.74	5.65	3.43	6.17	4.67	7.70	3.72	4.83	14.04
Ultimate. Sulphur	4.78	.22	1.26	.58	.44	.50	1.42	1.09	.78	.96
Ultimate. Hydrogen	4.86	4.97	5.77	5.24	5.41	5.56	5.15	5.46	5.09	4.83
Ultimate. Carbon	52.53	64.28	61.12	65.76	70.85	73.91	70.18	74.45	77.11	65.61
Ultimate. Nitrogen	.88	1.23	1.08	1.03	1.15	1.20	1.09	1.10	1.33	1.15
Ultimate. Oxygen	19.60	21.56	25.12	23.96	15.98	14.16	14.46	14.18	11.86	13.61
Calorific value determined:										
Calories	5,261	6,220	6,035	6,385	6,997	7,297	7,039	7,247	7,607	6,473
British thermal units	9,469	11,197	10,864	11,493	12,587	13,130	12,664	13,044	13,694	11,652
Thickness of coal bed sampled, in feet	4	24	15	84	8	7	9	6½	3	4
Name of coal bed	Almy.		Adaville.		Main Kemmerer.			Lower Kemmerer.	Willow Creek.	Spring Valley.
Geologic age	Evanston.		Upper Montana.[c]		Frontier (Benton).					

[a] Chemical laboratory in charge of Prof. N. W. Lord, of the Ohio State University.
[b] The air-drying losses in the Adaville and Lazeart coals do not appear to be entirely comparable.
[c] This is just below the Laramie coals and may be said to represent them.

I. Michigan-Wyoming Oil Company mine, NW. ¼ sec. 33, T. 17 N., R. 120 W. Sample taken 40 feet from mouth of mine. Bone, 1 inch thick 6 inches from the roof and 4 inches thick 18 inches from the roof, omitted in sampling. Sample represents total thickness of bed.

II. Rocky Mountain Coal and Iron Company mine No. 5, Almy, Wyo. Sample taken 3,000 feet from mouth of slope in room 5, entry 12, and represents lower 8 feet of 24-foot vein. Upper part of bed contains numerous partings.

III. Lazeart mine, SE. ¼ SW. ¼ sec. 8, T. 15 N., R. 118 W. Sample taken 15 feet from mouth of slope. Bed is 30 feet thick and sample represents upper 13 feet.

IV. Adaville mine, NE. ¼ SW. ¼ sec. 20, T. 21 N., R. 116 W. This sample is from a tunnel driven horizontally across the coal bed, which is here 84 feet thick, and dips 18° westward. Tunnel is 5 feet high and sample was collected by means of vertical cuts every 50 feet. This combined sample represents slightly less than half the thickness of the bed. There are no partings, and the coal is remarkably uniform throughout.

V. Union Pacific Coal Company, Cumberland No. 1, Cumberland, Wyo. Sample from the face of seventh entry south, 2,100 feet west, and 2,000 feet south of mouth of mine. Sample represents entire bed.

VI. Diamondville Coal and Coke Company, Diamondville No. 1. Sample from room No. 45, entry No. 1 north, 160 feet west, and 3,300 feet north of mouth of mine. The clay seam 4 inches thick 1 foot from roof was omitted in sampling. Coal at the point sampled is regarded as best in the mine.

VII. Kemmerer Coal Company, Kemmerer No. 1, Frontier, Wyo. Sample taken from room 46, entry 3 south, 600 feet west, and 2,250 feet south of mouth of mine. Sample represents a complete section of coal. No definite partings.

VIII. Kemmerer Coal Company, Kemmerer No. 1, Frontier, Wyo. Sample from working face in new opening in lower bed. From mouth of mine 600 feet south, 250 feet east (this portion is a crosscut from the vein to the lower bed), and 250 feet south of the working face. Bed is 6½ feet thick and 40 feet below main bed. Band of dirt 6 inches thick 4 feet from floor omitted in sampling.

IX. Kemmerer Coal Company, Willow Creek opening, SW. ¼ NW. ¼ sec. 19, T. 22 N., R. 115 W. Sample from face of entry 150 feet from mouth of mine. Bed 3 feet thick, with no partings. Regarded by owners as a coking coal.

X. Richardson mine, NW. ¼ sec. 12, T. 15 N., R. 118 W. Sample taken 150 feet west and 50 feet north from mouth of mine. Clay seam 3 inches thick and 1 foot from floor omitted in sampling.

In order that these analyses may be compared with other analyses of coals from this region, the following table is presented, in which the coals are separated into groups according to their geological horizons. The ash and sulphur have been recalculated on the basis of air-dried samples. The moisture, volatile combustible matter, and fixed carbon have been recalculated on the basis of the air-dried ash-free samples.

Proximate analyses of coals from southern Uinta County, Wyo.

COALS OF THE FRONTIER FORMATION, INCLUDING THE KEMMERER, WILLOW CREEK, CARTER, AND SPRING VALLEY BEDS.

Owner, bed, and location.	Calculated for air-dried ash-free samples.				As determined in air-dried samples.			Analyst.
	Moisture.	Volatile combustibles.	Fixed carbon.	Calorific value in calories.	Calorific value in calories.	Ash.	Sulphur.	
J. D. Curtis, Hams Fork, prospect sample.	1.54	39.01	59.45	7,782	7,560	2.85	1.00	Slosson and Knight.[a]
William Goodell, Hams Fork, 6-foot face sample.	3.07	39.65	56.28	7,782	7,467	4.05	....	Do.
A. Kendall, Hams Fork, prospect sample.	3.89	38.65	57.46	7,647	7,372	3.60	.60	Do.
Cumberland No. 1, Kemmerer bed	4.69	43.91	51.40	....	....	5.25	....	W. S. Robinson.[b]
Cumberland No. 2, Kemmerer bed	3.69	43.22	53.09	....	....	5.13	....	Do.
Spring Valley No. 1, Spring Valley bed.	3.88	42.80	53.32	....	....	7.16	....	Do.
Kemmerer, main Kemmerer bed	3.87	41.73	54.40	7,628	7,039	7.70	1.42	F. M. Stanton.
Kemmerer, lower bed	4.09	41.86	54.05	7,527	7,247	3.72	1.09	Do.
Cumberland No. 1, main Kemmerer bed.	4.51	43.53	51.90	7,452	6,997	6.17	.44	Do.
Diamondville, main Kemmerer bed	4.07	43.06	52.87	7,654	7,297	4.67	.50	Do.
Richardson, Spring Valley bed	5.09	42.53	52.38	7,530	6,473	14.04	.96	Do.
Kemmerer, Willow Creek bed	2.73	38.54	58.73	7,994	7,607	4.83	.78	Do.
Average[c] of Benton coals	3.76	41.54	54.61	7,666	7,226	5.76	.84	

[a] University of Wyo. special bulletin: The heating power of Wyoming coal and oil, January, 1895.
[b] These analyses, made in laboratory of Union Pacific Company, were selected from many hundred by Mr. Frank Manley, chief engineer, as typical.
[c] See note *h*, p. 138.

Proximate analyses of coals from southern Uinta County, Wyo.—Continued.

COALS OF THE ADAVILLE FORMATION.

Owner, bed, and location.	Calculated for air-dried ash-free samples.				As determined in air-dried samples.			Analyst.
	Moisture.	Volatile combustibles.	Fixed carbon.	Calorific value in calories.	Calorific value in calories.	Ash.	Sulphur.	
U. P. Coal Co., Twin Creek mines	9.16	37.59	53.25	....	....	6.30	....	Mineral Resources.[a]
Adaville mine	9.20	41.93	48.87	6,613	6,385	3.43	0.58	F. M. Stanton.
Lazeart mine	14.14	41.79	44.07	6,396	6,035	5.65	1.26	Do.
Carlton mine	10.40	43.38	46.21	....	....	5.55	....	Louis D. Ricketts.[b]
Average of upper Montana-Laramie coals.	10.72	41.17	45.60	6,502	6,210	4.84	0.92	
COALS OF EVANSTON FORMATION—ALMY COALS.								
Almy No. 5, lower 8 feet	10.02	42.27	47.70	6,665	6,220	7.74	0.22	F. M. Stanton.
Michigan-Wyoming mine	9.36	45.92	44.72	6,365	5,261	17.35	[4.78]	Do.
Almy No. 6	8.29	37.56	54.15	7,012	6,553	6.55	.29	Slosson and Knight.[c]
Almy No. 5, lower 9 feet	8.07	39.20	52.73	6,891	6,340	8.00	.44	Do.
Almy No. 7, upper seam	8.10	38.33	53.57	6,753	6,145	9.00	....	Do.
Almy No. 7, lower seam	9.37	35.65	54.98	6,393	6,017	5.90	.65	Do.
Almy No. 5, middle 2½ feet	7.54	40.20	52.26	6,538	5,933	9.25	....	Do.
Almy (average of three analyses)	6.29	40.33	53.38	....	....	7.46	....	Persifor Frazier, jr.[d]
Almy	8.85	43.42	47.73	....	....	8.83	....	O. D. Allen.[e]
Do	8.88	43.04	47.08	....	....	8.88	....	Do.
Do	9.15	37.59	53.26	....	....	6.30	....	J. V. Hodge.[f]
Almy No. 5	9.64	44.73	45.63	....	....	9.70	.10	J. S. Cory.[g]
Almy No. 6	9.97	44.10	45.93	....	....	2.80	.14	Do.
Average[h] of Evanston coals	8.73	40.95	50.24	6,660	6,067	8.29	[i] .30	

[a] Mineral Resources U. S. for 1882, 1883, p. 88.
[b] Ann. Rept. Terr. Geol. Wyo. for 1887, 1888, p. 12.
[c] University of Wyo. special bulletin: The heating power of Wyoming coal and oil, January, 1895.
[d] [Fourth Annual] Prelim. Rept. U. S. Geol. Survey Wyoming and contiguous Territories, 1871, p. 184.
[e] Rept. Expl. 40th Par., vol. 3, 1870, p. 473.
[f] [Fourth Annual] Prelim. Rept. U. S. Geol. Survey Wyoming and contiguous Territories, 1871, p. 321.
[g] Chemist in charge, Dept. Mines, World's Columbian Exposition.
[h] These averages are not entirely satisfactory in the volatile combustible and fixed carbon columns, as it is evident from comparison of analyses that two different methods have been used in the determination of these values. The Slosson and Knight analyses show higher values in fixed carbon than the Stanton analyses, without any corresponding increase in the calorific value. Thus, in the Almy coals, where the moisture is the same, Stanton finds a value 6,365 calories from sample showing fixed carbon, 44.72, while Slosson and Knight obtained a value of 6,393 calories from a sample showing fixed carbon 54.98.
[i] Omitting Michigan-Wyoming mine.

According to these analyses and the general physical character of the coals, the Benton coals are to be regarded as high-grade bituminous, the Evanston coals as low-grade bituminous, and the upper Montana-Laramie (Adaville and Twin Creek coals) as subbituminous coals.[a]

According to the carbon-hydrogen ratio classification of coals, recently proposed by Mr. M. R. Campbell,[b] these coals fall in the following groups:

The Willow Creek coal, of Benton age, falls in group G, which includes upper Freeport and Pittsburg coals of northern West Virginia, Kanawha Valley coals, high-grade Kentucky coals, and Alabama coals.

The Kemmerer (Benton coal) belongs to group H, which includes Indian Territory coals, Kansas coals, high-grade Illinois, Iowa, and Missouri coals, and second-grade Kentucky coals.

[a] This term is here used as a substitute for the misnomer "black lignite." These coals can not be called lignites except on the definition that all coals of Cretaceous age, or younger, are lignites, which is an arbitrary definition without good foundation. They are really semibituminous coals and have been so called in the reports of this Survey, but this term is commonly applied to certain coals in the eastern field that lie between the bituminous and anthracite grades, and to avoid confusion the name subbituminous has been adopted for these western so-called black lignites.

[b] The classification of coals: Trans. Am. Inst. Min. Eng., Washington meeting, May, 1905.

The Evanston coals belong to group I, which includes the great majority of Iowa, Illinois, Missouri, and Indiana coals and some bituminous coals from Wyoming and Montana.

The Adaville[a]-Twin Creek coals fall in group J, with the Gallup (New Mexico) and Boulder (Colorado) subbituminous coals.

Slosson has already shown that the Benton coals of this region, considered from the standpoint of carbon content and calorific value, are the best coals in Wyoming. According to the analyses made at the United States Geological Survey's coal-testing plant of samples collected by Fenneman and Gale in the Routt County (Colorado) field and by J. A. Taff in the Coalville and Castlegate fields in Utah, given elsewhere in this volume, the coals found in this region in the Benton are better than the best bituminous coals in these Colorado and Utah fields, but higher carbon and fuel values are shown in the latter fields in portions of the beds which have been altered to "anthracite" or "natural coke" by dikes or flows. Similarly, the analyses made of the samples collected by Schrader and Shaler in the Gallup, N. Mex., field show that on the whole the Benton coals of Wyoming are of the same grade as the best coals of that region. They are much better than the Red Lodge (Montana) coals tested at St. Louis.[b] On the whole, the Benton coals of the Uinta County region may be said to belong to the group containing the best bituminous coals of the Rocky Mountain region.

OIL.

Oil has been found in southern Uinta County in springs on Hilliard Flat (sec. 4, T. 13 N., R. 119 W., and sec. 33, T. 14 N., R. 119 W.); at Aspen tunnel (sec. 12, T. 14 N., R. 119 W., and sec. 7, T. 14 N., R. 118 W.); 3 miles north of Aspen tunnel, at Carter Oil Spring (sec. 31, T. 15 N., R. 118 W.); in springs and wells on the south branch of Twin Creek (T. 21 N., R. 117 W.), and in wells near Spring Valley (Tps. 14 and 15 N., R. 118 W.).

HISTORY OF DEVELOPMENT.

The oil spring near Hilliard, in NW$\frac{1}{4}$ sec. 4, T. 13 N., R. 119 W., was doubtless well known to the trappers who first built the trading post of Fort Bridger, but the first published account was the result of the examination made by the Mormons in their pioneer journey to Great Salt Lake in 1847. W. Clayton,[c] who accompanied this expedition, published in 1848 a little book which was known for years as the Mormons' Guide Book, containing the following account:

> About a mile from this place [the crossing of the road over Sulphur Creek], in a southwest course, is a "tar," or "oil spring," covering a surface of several rods of ground. There is a wagon trail running within a short distance of it. It is situated in a small hollow, on the left of the wagon trail, at a point where

[a] Calculated on the excessive air-drying loss reported in the Adaville analyses, the Adaville coal belongs high in group I, while the Lazeart coal belongs in group J. According to physical characters and general fuel value, these two coals clearly belong together and are to be regarded as subbituminous coals. An examination of the two original analyses will suffice to show that the air-drying losses reported for these two coals are not entirely comparable, and new analyses are now being made.

[b] Bull. U. S. Geol. Survey No. 261, 1905, p. 49.

[c] Clayton, W., The Latter-Day Saints Emigrants' Guide: Being a table of distances, showing all the springs, creeks, rivers, hills, mountains, camping places, and all other notable places, from Council Bluffs to the valley of the Great Salt Lake, etc., St. Louis, 1848, pp. 18, 24.

the trail rises to a higher bench of land. When the oil can be obtained free from sand, it is useful to oil wagons. It gives a nice polish to gunstocks, and has been proved to be highly beneficial when applied to sores on horses, cattle, etc.

This spring is mentioned in the accounts of Stansbury[a] and Engelmann,[b] but their statements do not differ materially from the earlier account of Clayton. It is reported that Brigham Young caused a shallow well to be dug at this point, and the locality is now known as the Brigham Young oil well or spring. The oil was skimmed off the surface of the water in this well, sold to emigrants, and in small quantities carried to Salt Lake City.

In 1867 Judge C. M. White began operations at a spring in NW. ¼ sec. 33, T. 14 N., R. 119 W., now known as the White oil spring. He dug a large hole and skimmed off the oil, which he sent to Salt Lake and sold to tanners. He began drilling in 1867, but abandoned the hole in 1868 at a depth of 480 feet. Later the Evanston Oil Company sunk a well at this place, but it was likewise abandoned at a depth of a few hundred feet.

The Carter oil spring locality became important in 1868, when, in driving a tunnel for coal, a slight flow of petroleum (8 to 10 gallons a day) was obtained and the discharge of the spring ceased. This oil was collected and sold to the Union Pacific Railroad and to neighboring coal mines for lubricating purposes. In 1886 a local company was formed and drilled three wells 225 to 300 feet deep. Two of them are reported to have yielded 6 barrels a day. This spring was incidentally mentioned by Meek[c] in 1871, and a short statement regarding it was published by Emmons[d] in 1877, but the first account of importance is that published by Ricketts[e] in 1888.

The oil springs along the South Fork of Twin Creek, in T. 21 N., R. 117 W., are perhaps referred to in Lander's general statement that in the mountains along the divide in latitude 42° N. there are "beds of coal, iron, and salt, and a spring of peculiar mineral oil which by chemical process may be made suitable for lubricating machinery." At any rate, the map of his explorations in 1857 shows that he passed up Twin Creek and over Hodges Pass.[f] Operations were begun here by the Twin Creek Land and Oil Company in 1885. They drilled two wells between this time and 1887, one 110 feet deep and the other 185. Both yielded a large flow of brackish sulphur water, with a little oil and gas. The deeper of the two is now open and is commonly known as the "Clark well," from Senator C. D. Clark, who was interested in this company. The oil is dark and heavy. The gravity is given by the Union Pacific Railroad Company[g] as 26.75° Baumé, by Slosson[h] as 19.7° Baumé.

[a] Stansbury, Capt. Howard, Exploration and Survey of the Valley of the Great Salt Lake of Utah, 1852, p. 280.

[b] Engelmann, H., Preliminary report on the geology of the country between Fort Bridger and Camp Floyd, Utah Territory; accompanying Simpson's Report on Wagon Routes in Utah Territory, Senate, Ex. Doc. No. 40 (vol. 10), 35th Cong., 2d sess., 1859, p. 52.

[c] Meek, F. B. [4th Annual], Preliminary Rept. U. S. Geol. Survey Wyoming, 1871, p. 306.

[d] Emmons, S. F., Rept. Geol. Explor. 40th Par., vol. 2, 1877, p. 252.

[e] Ricketts, Louis D., Ann. Rept. Territorial Geologist of Wyoming for 1887, 1888, pp. 23, 42.

[f] Lander, F. W. Preliminary report upon explorations west of South Pass for a suitable location for the Fort Kearney, South Pass, and Honey Lake wagon route, Senate Ex. Doc. No. 36 (vol. 10), 35th Cong., 2d sess., 1859, p. 33.

[g] Mineral Resources U. S. for 1885, 1886, p. 154.

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

In August, 1900, the Union Pacific Railroad Company began a water well at Spring Valley, Wyo., and on October 14, 1900, at a depth between 491 and 493 feet, struck a sand containing oil of very high grade. Oil of a similar high grade was struck again in December between 573 and 581 feet, and the following May between 1,148 and 1,170 feet.

Intense excitement followed this find, which appears to have lost nothing in magnitude as the news spread. The whole country was soon staked out with petroleum claims under the placer-mining laws. The greater part of these claims were purely speculative, the claimants generally having neither the intention nor ability to develop them. The lands staked were of two types—unoccupied Government land and unpatented odd sections within the limit of the grant made to aid in the construction of the Union Pacific Railroad. This grant, embodied in the acts of July 1, 1862 (12 Stat. L., 489), and July 2, 1864 (13 Stat. L., 356), gave the Union Pacific all the odd-numbered sections of the public lands within certain prescribed limits; but mineral lands other than coal and iron were expressly excepted from its operations.

The section on which the Spring Valley well was drilled happened to be an unpatented odd section, and it was therefore located by several claimants, who assumed that the oil discovered in the Union Pacific well satisfied the law in respect to the discovery required for each locator. The Union Pacific Coal Company had opened a large coal mine on this section and opposed this view of the matter, placing guards about the section to prevent others from prospecting on the land. In April, 1902, the General Land Office sent a special agent, Charles T. Forbes, to make an examination of these unpatented odd sections, including section 27, with a view of determining their character, whether valuable for minerals other than coal or iron. In this inquiry Special Agent Forbes conducted oil operators to section 27 against the protest of the Union Pacific Company, and installed machinery there for the purpose of drilling. In this he was held to have exceeded his instructions, and was supplanted by Special Inspector J. W. Zevely, who, during the summer of 1902, conducted an exhaustive inquiry. This inquiry clearly showed that section 27 was more valuable for coal than oil, and was so declared by the Department in December, 1902. With respect to the other contested sections and the region in general, the Land Office took the very important step of removing from entry or patent, except under the mining laws, all Government land in Tps. 13–14 N., Rs. 117–121 W., Tps. 15–21 N., Rs. 115–120 W., and refused to issue to the Union Pacific Railroad patents for the unpatented odd sections within the railroad grant within the limits of this reservation until after December 1, 1903, when the issuance of patents was to be determined by the "then known character of the land." In the words of the Department:[a]

The purpose of this order is to permit, encourage, and protect, so far as the Department can do so, but within the time herein named, the exploration and exploitation of the unpatented alternate odd-numbered sections within said railroad land grant which are within the limits hereinbefore specifically described, and of the public lands within said limits, for the purpose of ascertaining and demonstrating whether, as claimed, such lands, or any of them, are mineral in character, in that they are chiefly valu-

[a] Decisions of the Department of the Interior and General Land Office in cases relating to Public Lands, vol. 33, 1903, p. 50.

able for their oil or other mineral deposits; but in justice to the railroad company, whose line of railroad has long since been completed in conformity with the land-grant act, and in justice to others who may desire to take any of the public lands within said limits under any of the public-land laws other than the mining laws, it is necessary that this order of suspension shall not be operative longer than until December 1, 1903, that being deemed ample time within which, in addition to the exploration and exploitation heretofore had, to fairly develop the character of these lands.

The effect of this order was, on the one hand, to stimulate prospectors to attempt to develop this field, and on the other, it is claimed, to make the Union Pacific Railroad Company hinder the development in such ways as it might, being the only line of transportation in this region. Certain cases affecting sec. 23, T. 15 N., R. 118 W., and sec. 33, T. 14 N., R. 119 W., were heard before a special examiner in the district land office August 23 and 25, 1904, and decision was rendered that these tracts were not "known mineral lands" and that patent should be issued to the Union Pacific Railway in accordance with the terms of its land grant. All the Union Pacific lands are now patented, and with the termination of this land contest it is stated that the railroad has offered freight facilities which will materially aid in the development of the field.

TEST WELLS.

The following table gives the wells drilled in this field up to the present time:

List of test wells drilled for oil in southern Uinta County, Wyo.

No.	Location.	T.	R.	Section.	Name of well or owner.	Year drilled.	Approximate depth.	Product.	Remarks.
		N.	W.						
[a]1	Hilliard, 2 miles west	13	119	4, NE. ¼ NE. ¼	Brigham Young Oil Spring or Well.	1848?	57	Water, oil	Well reported to have been sunk by order of Brigham Young on site of oil spring. Yields a few gallons a day.
[a]2	....do	13	119	4, NW. ¼ NW. ¼	El Rio Verde Oil Co	1902	1,600	Water	This well is located on upper flank of an overturned syncline and the strata at bottom of well are higher geologically than those just below the surface gravels.
3	....do	13	119	4, NW. ¼ NW. ¼	J. R. White	1902	100	Oil	North of El Rio Verde well and near the Brigham Young Oil Spring; small amount of oil.
					Judge C. M. White Oil Spring	1867	10±	Water; oil	Shallow pits in which oil collected and was skimmed from time to time from surface of water.
[a]4	Hilliard, 2 miles northwest.	14	19	33, SE. ¼ NW. ¼	Judge C. M. White well.	1867–68	480	Water	Seepage of oil. Ricketts gives depth of this well as 250 feet and date as 1869.
					Evanston Oil Co	1884	484	....do	
					Consolidated Oil Co	1902 1903	80 300	....do ....do	
[a]5	Knight, 3 miles west	14	120	12, NW. ¼ SW. ¼	Bettys Oil and Development Co.	1902–1904	1,197	....do	Flowing fresh water of good quality at 700, 1,020, 1,197 feet. Flows 30 gallons a minute. Well in synclinal basin and entirely in the Eocene. Pl. IV, section X.
[a]6	Altamont	14	118	7, SW. ¼	Aspen Tunnel, Union Pacific R. R. Co.	1900–1902	....	Water, oil	Seepage of oil 1,600 feet from west end of tunnel.
[a]7	Altamont, 1 mile east	14	118	18, NE. ¼ NW. ¼	Consolidated Oil Co	1902	500	Water	Well too shallow to reach oil-bearing shales in the Aspen formation. Large amounts of water encountered near surface.
[a]8	Spring Valley 2 miles south.	14	118	10, NW. ¼ NE. ¼	Pittsburg-Salt Lake Oil Co.	1902–3	1,283	Oil	Large quantity of water reported at 805 feet. Oil was found at 862 and 1,005 feet in sand beds in a gray shale. The oil is heavy and black and altogether different from that in the Benton shales.
9	Spring Valley, 1½ miles southwest.	14	118	4, NE. ¼ NE. ¼	Piedmont Oil Co	1901	400	Water	Small quantities of water. Well not deep enough to reach oil-bearing shales.
[a]10	Spring Valley, 3 miles west.	15	118	31, SW. ¼ NE. ¼	Carter Oil Spring	1868	....	Oil	Shaft and shallow pits reported to have been dug here yielded 8 to 10 gallons of heavy black oil per day. Gravity, 21.5° Baumé.[b]
					Carter Oil Well	1886	225 228 300	....do ....do	Estimated that 6 barrels a day of heavy lubricating oil was obtained from first two wells.
[a]11	Spring Valley, 2 miles west.	15	118	32, NE. ¼ SE. ¼	"Baker Well," Western Wyoming Oil Co.	1901–2	1,600	....	Not deep enough to reach oil-bearing Aspen formations. Strong flow of water from Oyster Ridge sandstone caused abandonment of well.
[a]12	Spring Valley	15	118	34, SE. ¼	Consolidated Oil Co	1902–3	350 500 1,000	....	Small amount of oil above 500 feet. Abandoned.
13	....do	15	118	34, E. ½ NW. ¼	"Craig Well"	1902	2,000	....	Small amount of oil at 1,000–1,100 feet.
[a]14	....do	15	118	27, SE. ¼ SE. ¼	Union Pacific R. R. Co.	1900–1901	1,183.5	Oil, water.	Oil at 491–493, 573–581, 1,148–1,170 feet. Gravity, 43° Baumé.
15	Spring Valley, ½ mile northeast.	15	118	26, SE. ¼ NW. ¼	J. A. Beverly	1902	800	....	No oil. This well begins near base of the Aspen oil-bearing shale.
[a]16	Spring Valley, 1 mile north.	15	118	26, NW. corner	Pittsburg-Salt Lake Oil Co.	1903	1,530	Oil	Small amount of oil 835–845 feet, at 1,225–1,250 feet main oil sand; some oil between 1,400–1,500 feet. Oil in Aspen formation.

[a] For additional data see "Descriptive notes" following this table.

[b] Reported by E. E. Slosson, School of Mines, University of Wyoming; Petroleum series, Bull. No. 3, 1899, page 31.

List of test wells drilled for oil in southern Uinta County, Wyo.—Continued.

No.	Location.	T.	R.	Section.	Name of well or owner.	Year drilled.	Approximate depth.	Product.	Remarks.
						1902	1,388	Oil	Surface water. Oil sands at 1,025, 1,160, 1,363 feet in Aspen formation.
a17	Spring Valley, 1 mile north.	N. 15	W. 118	22, SE. corner	Pittsburg-Salt Lake Oil Co.	1903	1,726	do	Surface water. Oil sands at 780 feet (trace); 1,375, 1,650 feet in Aspen formation.
						1903	2,065	do	Surface water. Slight showing of oil at 1,035, 1,270, 1,675 feet in Aspen formation.
						1903–1905	1,400	do	Oil struck in Aspen formation.
18	do	15	118	23, SW. corner	Consolidated Oil Co.	1903	1,115	do	Oil at 800–820 (trace), 1,100–1,115 feet in the Aspen formation. No water.
						1903	1,600	Dry	Dry hole; no oil; no water. Well 300 feet north of above.
19	Spring Valley, 2 miles northeast.	15	118	24, NW. ¼	Pittsburg-Salt Lake Oil Co.	1902	1,100	Oil; water.	Well abandoned because of large amount of water encountered in bottom.
20	Spring Valley, 2 miles north.	15	118	23, SE. ¼ NW. ¼	Consolidated Oil Co.	1903–4	1,100	Oil	Oil at 600 (trace), 800, 1,000–1,100 feet; surface water only.
a21	Spring Valley, 2 miles northwest.	15	118	22, NW. ¼ NW. ¼	"Nebergall Well," Wyoming Illuminating Oil Co.	1901	1,600		No oil. This well was not deep enough to reach the oil-bearing Aspen formation.
22	Spring Valley, 2 miles north.	15	118	15, NE. ¼ SW. ¼	Consolidated Oil Co.		500		Entirely in Wasatch beds.
23	Spring Valley, 2½ miles north.	15	118	14, SW. ¼	do	1902	1,100–1,400	Water	This well was used to supply water for drilling adjoining wells. This is the only well which yielded enough water for this purpose. The water is reported to be from a depth of about 300 feet.
24	Spring Valley, 2½ miles northeast.	15	118	14, SE. ¼	do	1902–3	1,000?	do	Considerable water in upper part of well.
25	do	15	118	14, SE. ¼	do	1902–3	950?	Oil	No water. Oil in Aspen formation.
a26	do	15	118	14, SE. ¼	do	1902–3	1,150?	do	Reported to be the best oil well in the field. Oil in Aspen formation.
27	Spring Valley, 3 miles northeast.	15	118	14, NE. ¼	do	1902	1,190	do	Water at surface only. Oil in Aspen formation.
28	Spring Valley, 3½ miles northeast.	15	118	12, SW. corner	Jager Oil Co.	1902	1,100	do	Oil reported at 950 feet. Large quantity of water at 1,100 feet caused stoppage of work.
a29	Spring Valley, 5 miles northeast.	15	118	12, SE. ¼ NW. ¼	Standard Reserve Oil Co.	1904	1,235	do	Oil reported at 90–120, 195–220, 485–545, 560–655, 880–915, 1,075–1,093, 1,232–1,235 feet. The last is in the Bear River formation, the others in the Aspen formation.
a30	Bridger	16	117	2, NE. ¼ SW. ¼	Union Pacific R. R.	1890–91	1,390	Water	Artesian alkali water. Flow 30 gallons a minute.
a31	Evanston, 11 miles north.	17	120	26, SE. ¼ SW. ¼	Michigan-Wyoming Oil Co.	1903	1,238		No oil. Well starts near base of Bear River formation on north slope of a faulted steeply pitching anticline.
a32	Round Mountain	17	118	14, SE. corner	Intermountain Oil Co.	1901–2	600		No oil. Well drilled on upper flank of overturned syncline. Strata at bottom of well are higher geologically than those of the top.
33	Fossil, 1 mile west	21	117	7, NW. ¼ NW. ¼	Idaho-Wyoming Oil Co.	1901–2	1,710	Water	Impotable water between 800 and 1,000 feet. Flows 5 gallons per minute.
34	Fossil, 3 miles east	21	117	11, SE. ¼ SW. ¼	Robinson Well	1895?	100±		Well located near small anticline in Wasatch beds produced by slight movement of underlying buried Absaroka fault.
35	Fossil, 3½ miles southeast.	21	117	14, SE. ¼	Seitz	1902	15	Oil	Small quantity of oil. Open well dug near oil spring.
36	Fossil, 4 miles southeast.	21	117	23, NE. ¼ NE. ¼	Fossil Consolidated Oil Co.	1902	750	Water; oil.	Oil reported at depth of 520 feet.

a For additional data see "Descriptive notes" following this table.

List of test wells drilled for oil in southern Uinta County, Wyo.—Continued.

No.	Location.	T.	R.	Section.	Name of well or owner.	Year drilled.	Approximate depth.	Product.	Remarks.
		N.	*W.*						
[a]37	Fossil, 4 miles southeast.	21	117	23, SW. ¼ NE. ¼	Twin Creek Land and Oil Co.	1885	100	Water; oil; gas.	Flowing brackish sulphur water with a little oil and gas. Well caved.
					Twin Creek Land and Oil Co., "Clark Well."	1887	185	....do......	Flowing brackish sulphur water with a little oil and gas. Well still open.
38	Fossil, 4½ miles southeast.	21	117	27, NE ¼ SE. ¼	Utah-Wyoming Oil Co.	1902-3	1,110	Water, gas.	Flowing brackish sulphur water with some gas.
39	Fossil, 5 miles southeast	21	117	26, SW. ¼ SE. ¼	Globe Oil Co	1903-4	600	Water; gas; oil	Flowing brackish sulphur water with some gas and a trace of oil. Well located in small syncline in Wasatch beds produced by movement along Absaroka fault.
40	....do	21	117	26, SW. ¼ SE ¼	Paraffine Oil Co	1902-3	147	Water; oil..	Two wells. Flowing brackish sulphur water with a little oil.
[a]41	Fossil, 6 miles southeast.	21	117	25, SE. corner	Orlando Curtis	1903	457	....	Drilled entirely in Adaville beds.
42	Fossil, 7 miles southeast.	20	117	6, SW. ¼ SW. ¼	G Short	1903-4	2,200	....	Red beds from 1,650-2,200 feet. These are clearly Nugget beds on the west side of Absaroka fault.

[a] For additional date see "Descriptive notes" following this table.

DESCRIPTIVE NOTES ON TABLE OF TEST WELLS.

1. *Brigham Young Oil Spring, sec. 4, T. 13 N., R. 119 W.*—This is the oil spring described by Clayton and mentioned by Stansbury and Engelmann. It is situated in a little gulch on the side of one of the lower gravel-covered terraces, and is on the same line of disturbance as the White Spring, the seepage in the Aspen tunnel, and the Carter Oil Spring. The surface covering of gravel is a few feet thick, and the underlying beds belong to the Frontier formation. It is reported that in 1848 a well was dug here by the order of Brigham Young, and the place is now known as the Brigham Young Oil Spring. Mr. J. R. White, manager of the El Rio Verde Oil Company, reports regarding this spring or well:

"We found the spring filled with water, and, not being able to get any information otherwise, we pumped it out. We were surprised to find it to be 57 feet deep. There were cross tunnels 40 feet below the surface, one running east and one south. The next morning after pumping the water out we took out some 40 gallons of oil, and we can any day—that is, day by day—take 20 to 30 gallons. The moment you reduce the water below the point at which the oil seeps in, the oil seeps in with wonderful rapidity, but the moment the water comes above the point of seepage the yield will not be as large."

2. *El Rio Verde Well, sec. 4, T. 13 N., R. 119 W.*—This well is drilled about 400 feet southeast of the Brigham Young Oil Spring, and its location was evidently determined by the occurrence of oil in this spring and by Prof. W. C. Knight's singular deduction: "The oil rises through a fault. There is a vast difference in oil oozing from a ledge of outcropping oil sandstone to form a spring, and oil forcing its way up through a fault which is filled with mud and water. Oil coming through a fault indicates there must be quite a pressure in order to force it to the surface. * * * Drill very near the oil spring, and it may be possible the drill will have to follow the fault. In case the oil sand is one of the lower groups, a well would have to be very deep."[a] It is believed that the oil in the Carter Oil Spring undoubtedly comes up from the Aspen shale along a fault, but the desirability of drilling along a fault in this field is regarded as very doubtful, even if it was in any way practicable "for the drill to follow the fault." No well would be harder to drill or be more likely to go crooked than such a hole on a fault plane. In this case the Oil Spring fault dips westward, and as the well is east of the fault there is no possibility of its striking this fault. The strata here are on the upper edge of an overturned and faulted syncline, and the bottom of the well is in younger strata than the top. If this well were drilled to a depth of 7,000 feet it would then be in the same layer that lies immediately below the surface gravel. The oil sands are here from 9,000 to 10,000 feet from the surface, and hence out of reach of the drill (Pl. IV, section X). The escape of oil along the fault plane is not regarded as necessitating great pressure. The fault plane may, and probably does, here yield ready access to the oil horizon, and oil works its way up through the water because of its lighter gravity. In other words, it is floated up by the water.

The approximate section of this well, reported from memory by Mr. J. R. White, the manager, is given below. The total depth of the well at the time this log was taken is reported by Mr. White as 1,081 feet, and the thicknesses given for some of the strata are therefore too great.

Approximate section of well of El Rio Verde Oil Company, near Hilliard, Wyo.

	Feet.
1. Cobble stones	0– 30
2. Blue clay	30– 47
3. Water sand	47– 60
4. Shale	60– 120
5. Water sand	120– 128
6. Shale and blue clay	128– 335
7. Sandstone	335– 347
8. Shale with a little coal	347– 487
9. Sandstone	487– 495
10. Shale	495– 565
11. Water sand	565– 590
12. Hard rock	590– 595
13. Brown shale	595– 652

[a] Knight, W. C., The oil faults of Crook and Uinta counties, Wyoming: Bulletin School of Mines, Univ. of Wyoming, Petroleum series, No. 3, November, 1899, page 16.

	Feet.
14. Sand	652– 677
15. Shale and coal	677– 880
16. Sand	880– 893
17. Shale	893–1,023
18. Blue shale	1,023–1,058
19. Sand	1,058–1,118
20. Coal	1,118–1,130

4. *White Oil Spring, sec. 33, T. 14 N., R. 119 W.*—Mr. John G. Fiero reports:

"In 1867 Judge C. M. White sunk a large hole in the gravel at this point and skimmed off the oil which accumulated on top of the water. In the fall of 1867 and the winter of 1867–68 he shipped a quantity of this oil to Salt Lake by wagon road, where it was sold to tanners. In 1867 I began to bore a well for Judge White at this point with a spring pole. In the spring of 1868, with an engine, the hole was deepened to 480 feet. The tools stuck in the hole and the drilling was abandoned. Later the Evanston Oil Company was organized and drilled about 400 feet, when they exhausted their means and quit."

This locality was examined by Territorial Geologist Ricketts in 1887, who reports that two wells have been sunk here—one in 1867, 250 feet deep (evidently the White-Fiero well), and the other in 1884, 484 feet deep (evidently the Evanston Oil Company well). After the discovery of oil at Spring Valley attention was again turned to the White Oil Spring, and the American Consolidated Oil Company drilled two shallow wells, reported to be 300 feet and 80 feet, respectively.

5. *Bettys Oil and Development Company, sec. 12, T. 14 N., R. 120 W.*—As shown by the prospectus of this company, the well was supposed to be located on an anticline. This was due to a misinterpretation of the eastward-dipping beds near Millis, which were supposed to indicate a simple anticline to the west. As has already been shown on page 61, the beds near and just east of Millis are on the upper flank of an overturned syncline (Pl. IV, section K). The well is in reality located very near the axis of the Fossil syncline. This is deeply filled with Tertiary beds, and the Bettys well did not succeed in penetrating these surficial deposits. While not finding oil, it has furnished important information to this region on the artesian water in the Wasatch beds. The following record has been transmitted by Mr. L. L. Bettys, general manager:

Section of well of Bettys Oil and Development Company in sec. 12, T. 14 N., R. 120 W.

	Feet.
1. Sandstone and reddish clay, surface water at 40 feet	0– 663
2. Sandstone	663– 685
3. Clay	685– 700
4. Sand with artesian water	700– 780
5. Clay	780– 795
6. Sand	795– 810
7. Clay	810– 835
8. Sand	835– 840
9. Clay	840– 850
10. Sand	850– 895
11. Clay	895– 905
12. Sand	905– 930
13. Clay	930– 955
14. Sand	955– 960
15. Clay	960–1,000
16. Thin layer of limestone	1,000–1,004
17. Clay	1,004–1,020
18. Sand with artesian water	1,020–1,040
19. Clay	1,040–1,050
20. Sand	1,050–1,074
21. Shale	1,074–1,090

	Feet.
22. Fire clay. Heaving clay rose 150 feet in casing. Drilled two weeks, cleaning out the clay that kept rising	1,090–1,150
23. Clay	1,150–1,167
24. Limestone	1,167–1,170
25. Red rock	1,170–1,172
26. Fire clay	1,172–1,173
27. Red rock	1,173–1,177
28. Fire clay	1,177–1,187
29. Sandy shale	1,187–1,197
30. Water sand, with artesian water	1,197

Clay mostly reddish, but some porcelain clay, was found at about 1,000 feet. Main water horizon at 700 feet; flow, 30 gallons a minute.

6. *Aspen tunnel, sec. 7, T. 14 N., R. 118 W.*—The oil seepage encountered in this tunnel has been the source of considerable discussion. It was encountered about the time of the oil discovery at Spring Valley and added greatly to the intense excitement. According to the statement of Mr. M. M. Ketchum, oil flowed from the tunnel for thirty or forty days at the rate of 200 or 300 gallons a day, when the seep was closed up by an elaborate concrete and timber dam. The statement of Mr. K. C. Weedin, resident engineer in charge of the construction of the tunnel, is as follows:

"There was an oil seepage on the west side of the tunnel, about 1,600 feet from the west end and 17 feet from the bottom. The seepage was never closed up with concrete or anything of that sort, and there is nothing there now to prevent seepage of oil. The tunnel is here lined with 3-inch planks behind uprights, but these were not placed there to prevent the flow, as the joints are not sealed. There is a 6-inch tile pipe for drainage, the tube beginning 200 or 300 feet west of where the oil seepage was. It passed the seepage and comes out at the east end of the tunnel. I have seen the water which comes through this drain pipe, and I have never seen any evidence of oil of importance. The oil seepage in the tunnel lasted from the time we struck it until the tunnel was lined, in November, 1901. If there is any seepage there now, it is absorbed by the ground or flows into the drain pipe. The concrete work in the tunnel comes within 200 feet of where we found the seepage. I think some 3 or 4 barrels of oil were collected from this seepage during the time of construction by Mr. M. M. Ketchum."

The Oil Spring fault passes through the western end of this tunnel, and a seepage comparable to that found at the Brigham Young, White, and Carter oil springs was to be expected when this fault was cut. That the initial flow might have amounted to a number of barrels a day is regarded as quite probable, but the geologic conditions preclude the possibility of a persistent supply from this source. The very limited amount which has through a long period worked its way up along the fault plane and accumulated in the strata above the tunnel would drain out quickly and temporarily give the appearance of a large supply. Considerable amounts of water were encountered in sandstone, both in the tunnel and in the sandstone in the shaft. This is of importance as indicating the water-storage capacity of the sandstones of the Frontier formation. The section of the shaft, according to the report of Mr. K. C. Weedin, resident engineer, is as follows:

Section of shaft at Aspen tunnel.

Wasatch formation, dip 10°–15°:	Feet.
1. Yellow clay, with streaks of red clay	0 – 16.5
2. Soft sandstone	16.5– 24.5
3. Hard sandstone	24.5– 28.5
4. Fine-grained blue clay	28.5– 29.5
5. Indurated red clay, with water dripping from joint between it and blue clay above.	29.5– 49.5
6. Streaks of indurated red clay, 1 to 3 inches in thickness, alternating with streaks of soft white sandstone, 1 to 3 inches in thickness	49.5– 62
7. Indurated red clay	62 – 68.5
8. Hard sandstone containing iron pyrites	68.5– 71
9. Indurated red clay containing hard sandstone bowlders in detached masses of one one-hundredth to one-third cubic yard each	71 – 81.5

Frontier formation, dip 22°-30°:

	Feet.
10. Blue clay containing streaks of yellow clay (hard)	81.5-132
11. Dark-blue shale shading into black shale	132 -165
12. Clay	165 -165.2
13. Hard black shale	165.2-176
14. Clay	176 -181
15. Hard black shale	181 -196.5
16. Clay	196.5-197
17. Black shale bearing mollusk fossils	197 -199.7
18. Soft coal	199.7-200
19. Hard black shale	200 -204
20. Clay	204 -204.4
21. Hard black shale	204.4-212.5
22. Clay	212.5-215
23. Soft black shale, with small stream of water	215 -222.4
24. Clay	222.4-223.1
25. Hard black shale	223.1-242
26. Very hard gritty gray shale	242 -243.2
27. Very hard bluish-gray shale	243.2-262
28. Hard fine-grained sandstone	262 -302.5
29. Soft black shale	302.5-306
30. Hard fine-grained sandstone	306 -313.7

"February 3, 1900, water was struck at a depth of 257 feet, driving out men and causing suspension of work. February 16, at 5 p. m., a Cameron double-plunger vertical mining pump No. 5 was set to work, water being then 126.5 feet deep in shaft. With this the shaft was pumped clear at 7 a. m. February 26, pump having run night and day without interruption. The work of excavation was then resumed.

"March 10, 1900, total depth 262 feet, flow of water had increased to 48,000 gallons in 24 hours. No. 5 pump was then replaced by a No. 7. March 19, 1900, total depth 279.5 feet. Flow of water 65,000 to 70,000 gallons in 24 hours. April 1, 1900, total depth 290 feet. Flow of water had increased to 10,430 gallons in 24 hours, when both No. 7 and No. 5 pumps were set to work, No. 7 not having been able to handle flow."

7. *Consolidated Oil Company, sec. 18, T. 14 N., R. 118 W.*—This well is situated immediately south of the Aspen tunnel, and its location was evidently determined by the oil seep encountered in the tunnel. Large amounts of water were struck in the sandstones of the Frontier formation in this well, as in the Aspen tunnel. The well is situated a little west of the trough of the Lazeart syncline, at a horizon several hundred feet below the Oyster Ridge sandstone. The depth of the Aspen shale is here about 1,500 feet, and to be thoroughly prospected a well 3,500 feet would be required. If drilled it should be located on the axis of the Lazeart syncline. Such a location would have a number of advantages, though the possibility of excessive leakage through the Oil Spring fault tends to decrease the value of the point as a site for a test well.

8. *Pittsburg-Salt Lake Oil Company, sec. 10, T. 14 N., R. 118 W.*—The following original driller's record has been furnished by Mr. A. V. Taylor of the Pittsburg-Salt Lake Oil Company:

"Red and gray shale alternating to 340 feet, where a little sand with a little water was encountered, not enough to drill with. Put 11⅝ casing in at 500 feet and shut off water by landing casing in red rock. A continuation of red and yellow rock, with an occasional streak of light blue, to 775 feet, where a light showing of oil was found; bluish black then to 805 feet, where a sand was found with lots of water; shut water off in a hard blue shale at 823 feet, 8-inch drive pipe; blue shale on to 862 feet, where a sand was found with a heavy oil. Through this sand at 897 feet light shale and shells to 935 feet, where a heavy shell, very hard, of about 3 feet in thickness. Under this, directly, a little soft sand; light-blue shale then to 1,005 feet, where a little more sand was found, with a nice showing of oil of a much lighter gravity than that above. Well continued on to 1,283 feet, but nothing more found. Six and a quarter drive pipe all pulled and 5 joints of the 8-inch pulled, the remaining amount left in."

The upper 500 to 750 feet of strata are regarded as belonging to the Wasatch. The dark-colored oil-bearing shale belongs to the Bear River formation. The oil is heavy, its gravity being reported as 23°, and quite different from the light oil found in the Aspen shales at Spring Valley. In a previous report[a] it was suggested that these dark-colored beds might be Jurassic (Twin Creek), but the data now at hand show that they are clearly higher. The location of the Meridian anticline and the thickness of the Beckwith beds entirely preclude a reference of these beds to a formation older than the Bear River.

10. *Carter Oil Spring, sec. 31, T. 15 N., R. 118 W.*—Ricketts[b] gives the following account of the early exploration at this point:

"In 1868 a tunnel was run into the hill about 200 yards from the oil spring to strike a vein of coal. At a distance of 240 feet it struck the coal and oil at about the same time, and Mr. J. G. Fiero, who ran the tunnel and owned the ground, tells me that he obtained from 8 to 10 gallons of oil a day from it through a period of several months. East of the oil spring and from 150 to 200 yards up the gulch the strata are almost vertical. * * * This oil was sold for lubricating purposes to the Union Pacific Railway, then in course of construction, and to the contractors at work on the grade, and to various coal mines, including the Carbon mines. In all, over $5,000 worth was sold at prices ranging from 40 cents to $1 a gallon."

This ground was, at an early date, sold to Judge C. M. Carter and became known as the Carter Oil Spring. Mr. Morris Groshon, who had charge of the drilling operations here in 1886, reports regarding this exploration:

"In the summer of 1886 we put down a well in front of the house, and at a depth of 225 feet struck oil. The well was pumped for nine days, and we estimated that it yielded about 6 barrels a day. We then moved about 50 feet to the spring back of the house and struck oil again at 228 feet. We estimated that the second well produced 6 barrels a day, but we worked it only for a couple of days. The third well was abandoned at a depth of 300 feet without striking oil. Immediately before reaching the oil strata in wells Nos. 1 and 2 we struck a vein of coal about 4 feet thick. Nothing has been done here since that time."

11. *Baker well, sec. 32, T. 15 N., R. 118 W.*—This well was started in the Wasatch beds. It reached the Kemmerer coals between 1,383 and 1,257 feet, and at 1,600 feet struck the upper member of the Oyster Ridge sandstone, which outcrops about three-quarters of a mile east. These sandstones are good water carriers, and the well quickly filled with water and was abandoned. The oil-bearing shale is here about 2,000 feet lower down, and the well shows nothing regarding its oil-bearing character at this point (Pl. IV, section Y). It would require a well about 4,000 feet deep to reach the top of the shale at this point and one in the neighborhood of 6,000 feet to thoroughly prospect them. Such a well would be more likely to yield a large amount of oil than one near the crop, but the depth is practically prohibitive.

Partial section of well of Wyoming Western Oil Company (Baker well), in sec. 32, T. 15 N., R. 118 W.

	Feet.
1. Red dirt	0– 27
2. Yellow clay	27– 79
3. Red conglomerate	79– 147
4. Light-colored clay	147– 172
5. Gray conglomerate	172– 230
6. Coal	230– 236
7. Coal and conglomerate	236– 257
8. Shale	257– 356
9. White, sticky clay shale	356– 374
10. White shale	374– 396
11. Blue mud	396– 406
12. Dark shale	406– 443
13. Blue conglomerate	443– 468
14. White clay	468– 478
15. Oil sand	478– 488
16. White, sticky clay	488– 498
17. Limestone shell	498– 525

[a] Bull. U. S. Geol. Survey No. 285, 1906, pp. 334, 353.
[b] Ricketts, Louis D., Ann. Rept. Territorial Geologist of Wyoming for 1887, 1888, pp. 23–42.

	Feet.
18. Blue mud	525– 530
19. Black shale	530– 647
20. No record	647–1,076
21. White shale	1,076–1,169
22. Blue limestone	1,169–1,171
23. White sandstone	1,171–1,183
24. Coal	1,183–1,187
25. Coal and dirt	1,187–1,191
26. White limestone	1,191–1,222
27. White shale	1,222–1,230
28. Dark fossils	1,230–1,242
29. Sand shell, hard stone	1,242–1,250
30. Coal	1,250–1,257
31. White sandstone	1,257–1,282
32. White shale	1,282–1,307
33. White lime	1,307–1,342
34. Shale	1,342–1,358
35. Varying formation, white lime and shale	1,358–1,400

The beds, Nos. 1 to 7, and possibly part of 8, belong to the Wasatch and Evanston, Nos. 9 to 22 are Hilliard, and those from No. 23 to the bottom belong to the Frontier. For a graphic representation of the upper part of the section see Pl. XIV, p. 84.

12. *Consolidated Oil Company, sec. 34, T. 15 N., R. 118 W.*—David McCauley, driller, gives the following partial record of well No. 1:

Section of well No. 1 of Consolidated Oil Company at Spring Valley.

	Feet.
1. Surface dirt and shale	0– 58
2. Sand	58– 98
3. Black shale	98–335
4. Sand, not passed through	335–350

This was abandoned because of crooked hole, and two other wells were drilled a few feet away. Oil is reported in the first two sands; no oil below 500 feet.

14. *Union Pacific well, Spring Valley.*—This well was drilled by L. E. Nebergall for the Union Pacific Railroad between September 3, 1900, and May 11, 1901. It was intended to supply water for a water tank at this station and for the mine of the Union Pacific Coal Company. The log of this well as entered in the driller's log book is given below:

Section of Union Pacific well at Spring Valley.

	Feet.
1. Clay	0– 58
2. White sand with some water	58– 92
3. Black shale	92–230
4. Light shale	230–338
5. Dark shale	338–424
6. White sand with oil	424–463
7. Dark shale	463–535
8. Black sand	535–567
9. White sand with oil	567–575
10. Gray shale	575–685
11. Black shale	685–875
12. Black shale and streaks of harder material	875–920
13. Gray shale	920–924
14. Black shale and streaks of harder material	924–980
15. Gray shale	980–983

	Feet.
16. Black shale and streaks of harder material	983 -1,008
17. Black shale	1,008 -1,035
18. Gray sand rock	1,035 -1,037
19. Black shale and streaks of harder material	1,037 -1,050
20. Black shale	1,050 -1,095
21. Hard black limestones	1,095 -1,100
22. Black shale and streaks of harder material	1,100 -1,115
23. Black shale	1,115 -1,147
24. Sand rock, oil bearing	1,147 -1,159
25. Hard blue sand rock	1,159 -1,173
26. Gray shale	1,173 -1,177
27. Black shale	1,177 -1,181.5
28. Shale with gas	1,181.5-1,183.5

In the hearing of the protest against patenting this section to the Union Pacific Railroad, Mr. Nebergall testified that by his orders the depths to the oil sands were not correctly entered in this record, which in all other respects was correct. According to his statement the first oil sand extended from 491 to 493 feet, the second from 573 to 581, and the third from 1,148 to 1,170. A little gas is reported at 1,183 feet. The second sand yielded 7½ barrels the first twenty-four hours, but in a second test, five or six weeks later, it was found that the yield had fallen to 1 barrel in twenty-four hours. No tests were made of the first and third sands.

The oil appears to have initially risen to within 200 or 300 feet of the surface, and in March, 1902, to have flowed over the surface. This overflow was stated to have been due to the fact that the well was located in a sag, and that the well filled with surface water derived from melting snows. The well was then capped by the railroad company. It was opened in August, 1902, for the purpose of making official tests, and found filled with oil and water. It was cleaned out and measured with a steel tape and found to be 1,197.3 feet deep. It was "cleaned out dry" and then pumped. On August 14 the yield was two-thirds barrel, on August 15 between one-half and one-third barrel, and on August 16 one-third barrel. As shown by recent experiments in the wells of the Pittsburg-Salt Lake Oil Company on sec. 22, T. 15 N., R. 118 W., this yield was probably much too low. The oil is very volatile, with a paraffin base, and when the well is pumped dry and the oil commences to seep in again, the evaporation of the volatile constituents causes a deposition of the paraffin in the pores of the oil sand. This has been remedied in the case of the Pittsburg-Salt Lake Oil Company's wells by using a steam jet to melt out the deposited paraffin, and then taking the precaution to never pump the wells dry. In this way a steady yield of from 5 to 6 barrels a day has been obtained from wells which had yielded but a small fraction of a barrel.

16. *Pittsburg-Salt Lake Oil Company, sec. 26, T. 15 N., R. 118 W.*:

Section of well of Pittsburg-Salt Lake Oil Company, in sec. 26, T. 15 N., R. 118 W.

	Feet.
Knight formation:	
1. Red sandy clay	0- 130
2. Sand with water	130- 145
3. Red sandy clay	145- 550
4. Red sandy clay, gradually growing lighter	550- 620
5. Light-colored shale	620- 730
Frontier? and Aspen formations:	
6. Shales with thin beds of sandstone	730- 835
7. Sand, oil bearing	835- 845
8. Shale	845-1,225
9. Sand, would probably produce 4 or 5 barrels of oil	1,225-1,250
10. Black shale, more or less sandy, showing some oil	1,250-1,530

17. *Pittsburg-Salt Lake Oil Company, sec. 22, T. 15 N., R. 118 W.*—The three wells at this point are all situated in the very southeast corner of the section. They were drilled by the Atlantic and Pacific.

Oil Company and then sold to the present company, which has completed well No. 4 and cleaned out wells Nos. 1 and 2, and made them producing. In these two wells the oil sands had become so clogged with paraffin that they were no longer producers. Mr. D. H. McMillan succeeded in melting the paraffin out by steam jet, and they are now yielding 4 to 5 barrels a day. During 1905, 1,450 barrels of this oil were shipped to the Florence, Colo., refinery. The company now intends to build its own refinery. The sections of the wells are given below:

Section of well No. 1, Pittsburg-Salt Lake Oil Company, 20 feet west of SE. corner sec. 22, T. 15 N., R. 118 W.

	Feet.
Knight formation:	
1. Red sandy clay with brackish water at 145, 200, and 345 feet. Put in $11\frac{5}{8}$-inch casing at 580, shutting off water	0– 600
Frontier and Aspen formations:	
2. Light and dark shale, alternating with some thin layers of hard rock	600–1, 025
3. Sand; very little oil	1, 025–
4. Shale, with occasional thin hard bands	–1, 160
5. Oil sand	1, 160–
6. Similar to No. 4	–1, 370
7. Sand	1, 370–1, 388

It is reported that Mr. Gray, the driller, has stated that considerable water was encountered in the bottom of this well, and that it was cut out by placing a long wooden block in the lower part of the well. The original record contains nothing to this effect, but the water horizon suggests that reported in wells Nos. 26 and 28.

Section of well No. 2.

	Feet.
Knight formation:	
1. Red sandy clay	0– 225
2. Black sand with sulphur gas	225– 250
3. Red sandy clay with water at 310 and 515. First water shut off with 374 feet of $11\frac{5}{8}$-inch casing and second with 515 feet of $7\frac{5}{8}$-inch casing	250– 700
Frontier and Aspen formations:	
4. Black and light shale	700– 780
5. Sand, small amount of oil	780– 805
6. Light and black shales	805–1, 375
7. Sand with good showing of oil	1, 375–1, 425
8. Black shale	1, 425–1, 625
9. Oil sand; hole filled up to 1,000 feet	1, 625–1, 655
10. Shale	1, 655–1, 690

Section of well No. 3.

	Feet.
Knight formation:	
1. Usual red formation with water strata at 210 and 575 feet	0– 600
Frontier formation:	
2. Black and light shale	600– 810
3. Coal	810– 813
Aspen formation:	
4. Shale, with streaks of sand and occasional hard layers and showing of oil at 1,055 feet	813–1, 270
5. Black shale	1, 270–1, 300
6. Hard formation resembling limestone, containing some sand	1, 300–1, 360
7. Shale	1, 360–1, 479
8. Hard sand	1, 479–1, 579
9. White shale	1, 579–1, 625
10. Hard limestone	1, 625–1, 650
11. Dark shale	1, 650–1, 675
12. Hard sand with oil	1, 675–1, 700
13. Limestone and shale	1, 700–2, 065

Section of well No. 4.

	Feet.
Knight formation:	
1. Red formation with considerable water at 326 feet	0–600
Frontier formation:	
2. Coal	605–
3. Shale	–630
4. Hard rock	630–645
5. Black shale	645–675

This well was completed in the fall of 1905 to 1,650 feet and oil obtained. Near well No. 2 there is a shallow well from which the company pumps a little brackish water. One of the great hindrances to development at this point has been the difficulty in obtaining a sufficient water supply for drilling.

21. *Nebergall well, sec. 22, T. 15 N., R. 118 W.*—Water-bearing sand is reported in this well between 1,170 and 1,180 feet and three beds of coal between 1,180 and 1,280 feet, the thickest of which was 8 feet. These coals are clearly in the Kemmerer group, and are 1,500 to 2,000 feet above the Spring Valley coal. The water-bearing sand, like that found in the Baker well, is in one of the sandstones of the Frontier formation. It would require a very deep well here to thoroughly test the Aspen shales.

26. *Consolidated Oil Company, sec. 14, T. 15 N., R. 118 W.*—It is reported that this well when about at a depth of 1,150 feet encountered a strong flow of water, which was cut off.

29. *Standard Reserve Oil Company, sec. 12, T. 15 N., R. 118 W.*—Mr. Charles O. Richardson, president and manager of the Standard Reserve Oil Company, has furnished one of the most complete and carefully kept records obtained in this field. This record was accompanied by a complete set of samples, indicating the careful and scientific manner in which this drilling was done. The following is the original record furnished by Mr. Richardson, with slight additions and corrections from the samples and the addition of names of the formations:

Section of well No. 1, Standard Reserve Oil Company, in sec. 12, T. 15 N., R. 118 W.

	Feet.
Knight formation:	
1. Yellow sandy clay	0– 40
2. Reddish yellow clay and sandstone	40– 80
Aspen formation:	
3. Very fine-grained sandstone	80– 90
4. First oil sand, yellow oil	90–120
5. Very fine-grained gray sandstone	120–160
6. Gray sandstone	160–180
7. Medium blue-gray shales	180–195
8. Second oil, black amber, from light oil sand	195–220
9. Oil sand turned darker	220–235
10. Shale and sandstone	235–250
11. Dark shale	250–270
12. Light shale	270–300
13. Sandstone and shale	300–325
14. Gray shale	325–350
15. Light-gray shale	350–355
16. Dark calcareous shale	355–385
17. Gray, very fine-grained sandstone	385–410
18. Dark sandy shale	410–420
19. Rotten shale	420–445
20. Black shale	445–485
21. Oil No. 3, black amber oil sand	485–545
22. Shale	545–550
23. Very fine-grained sandstone with gas	550–560
24. Oil No. 4, first green oil, fine oil sand	560–655
25. Black shale, sometimes sandy	655–875
26. Fine-grained calcareous sandstone	875–885
27. Oil No. 5, second green oil, oil-bearing shale	885–915

	Feet.
Aspen formation—Continued.	
28. Dark shale	915– 920
29. Light hard fine shale	920– 925
30. Darker shale	925– 930
31. Lime with a little iron	930– 935
32. Dark rotten shale	935– 945
33. Dark shale grit	945– 960
34. Shale very oily	960– 975
35. Very soft black shale	975– 990
36. Light-drab shale	990–1, 000
37. Black shale	1, 000–1, 015
38. Soft black shale	1, 015–1, 025
39. Lighter shale	1, 025–1, 035
40. Dark-gray calcareous shale	1, 035–1, 050
41. Black shale	1, 050–1, 065
42. Fine light-gray calcareous shale	1, 065–1, 070
43. Shale	1, 070–1, 075
44. Oil No. 6	1, 075–1, 093
45. Dark rotten shale	1, 093–1, 115
46. Very oily dark rotten shale	1, 115–1, 120
47. Dark rotten shale; a little asphalt here	1, 120–1, 125
48. Drab shale	1, 125–1, 140
Bear River:	
49. Shaly limestone, with Bear River fossils	1, 140–1, 145
50. Gray limestone	1, 145–1, 160
51. Limestone and shale	1, 160–1, 195
52. Shale	1, 195–1, 232
53. No. 7 oil sand	1, 232–1, 235

"We have penetrated the last formation only 3 feet, and oil stands within 170 feet of top of well."

30. *Union Pacific Bridger well, sec. 2, T. 16 N., R 117 W.*—This well was drilled by the Union Pacific Railroad to supply the water tank at Bridger, but the water was so alkaline that it could not be used. Mr. D. V. Bell, assistant superintendent of water service in Wyoming, gives the following data: "This well was drilled during the fall of 1890 and spring of 1891 and is 1,390 feet in depth. The following is a copy of the record made by myself while working on the well as driller:"

Section of water well of Union Pacific Railroad at Bridger, Wyo.

	Feet.
Quaternary:	
1. Red clay	0– 30
2. Sand and gravel, water bearing	30– 38
Wasatch formation:	
3. Red shale	38–125
4. Sandstone	125–133
5. Red shale	133–148
6. Gray shale	148–228
7. Hard sandstone; small flow of water	228–236
8. Gray, green, and red shales	236–345
9. Sandstone	345–360
10. Gray shale	360–405
11. Sandstone	405–410
12. Gray shale	410–460
13. Sandstone; small flow of water	460–465
14. Gray shale	465–505
15. Sandstone	505–520
16. Gray shale	520–530
17. Sandstone	530–540

	Feet.
Wasatch formation—Continued.	
18. Red shale	540– 565
19. Gray shale	565– 620
20. Shale with thin layers of sand rock	620– 640
21. Gray shale	640– 665
22. Red shale	665– 675
23. Sandstone; small flow of water	675– 695
24. Gray shale	695– 730
25. Black shale	730– 740
26. Shale with thin layers of sandstone	740– 750
27. Gray shale	750– 800
28. Red shale	800– 880
Bear River formation:	
29. Sandstone	880– 895
30. Black shale	895– 920
31. Gray shale	920– 960
32. Hard gray and black shale	960–1,300
33. Shale, with thin layers of sandstone	1,300–1,318
34. Gray shale	1,318–1,378
Beckwith formation:	
35. Red shale	1,378–1,386
36. Sandstone not passed through, yielding flow of water 20 gallons per minute	1,386–

"Well commenced flowing in a few minutes after sand rock was drilled into, and sample of water was taken for analysis, which showed 1,525 grains solids per gallon, and further drilling was discontinued. At the time last flow was struck well was cased with 39 feet of 9⅝-inch casing and 740 feet of 5⅝-inch casing, which was left in well at the time drilling ceased, with the expectation that it would be removed in the near future. About two years afterwards, when it was desired to pull it for use in another well, it had been entirely consumed by corrosion, and nothing remained to show that well had ever been cased."

31. *Michigan-Wyoming Oil Company, sec. 26, T. 17 N., R. 120 W.*—This well is situated on the crest of the Rock Creek-Needles anticlinal (Pls. XXII, IV, section H) at a point where the crest of the anticline assumes a nearly horizontal position after a very abrupt northward plunge. It was evidently this structural relation which determined the location of the well. The well starts in the Evanston formation and enters the Beckwith beds at a comparatively shallow depth. This well is therefore drilled in beds below those which yield the oil at Spring Valley. Mr. J. A. Morehouse, the driller, states, from memory, regarding this well: "Coal beds at 74–79, 120–128, 200–202 feet. Below the last coal bed there are alternations of red shale with thin beds of sandstone."

33. *Idaho-Wyoming Oil Company, sec. 7, T. 21 N., R. 117 W.*—This well is situated in a synclinal trough between the Absaroka fault uplift and the Rock Creek-Needles anticlinal. This syncline is deeply filled with Eocene beds containing water, and the geologic conditions are not favorable for an oil well. Mr. J. J. Deming, of the Idaho-Wyoming Oil Company, gives the following log of this well:

Section of well of Idaho-Wyoming Oil Company at Fossil, Wyo.

	Feet.
1. Gravel, with water, yielding 100 gallons a minute	0– 100
2. Clay and shale	100– 300
3. Brown shale	300– 500
4. Sandy shale, with water, amount not determined	500– 800
5. Shale and sandstone, with artesian water; flow about 5 gallons a minute	800–1,000
6. Dark shale, small streaks of sand	1,000–
7. White clay, probably fire clay	–1,400
8. Clay with thin streaks of shale, little oil and gas	1,400–1,500

In the Fossil district little change has been noted from the surface to about 1,400 feet. The formation is mostly a brown shale, which, on exposure to water or air, decomposes and caves, and in every instance requires casing.

37. *Twin Creek Land and Oil Company, sec. 23, T. 21 N., R. 117 W.*—Territorial Geologist Ricketts furnishes the following account of early work at this point, based on the report of Mr. D. V. Bell: [a]

"The Twin Creek Land and Oil Company let a contract for a well in 1886.[b] This well caved in, the ground being soft, and a new one was started the present season (1887) and has been drilled to a depth of 185 feet. The rock for the first 129 feet was very soft, and resembled a light-colored, hardened mud. At 129 feet very hard rock was penetrated, and pierced at 131 feet. From the latter point to 165 feet the former soft rock was passed through. From 165 to 175 feet a hard sandstone was encountered, which gave off so much gas that when ignited it burnt in a flame from 8 to 10 feet high. The last 10 feet was in soft rock again, and yielded much water and oil mixed with it. The water caused the clay to run, and work was stopped temporarily. It was estimated that fully 1 barrel of oil per 24 hours came up with this water. Another well, situated about 100 feet from the last, is said to have produced 20 barrels per day, but it has since clogged up with the soft clay. An oil spring is very near these two wells, and flows fully 1 gallon per day."

41. *Curtis well, sec. 25, T. 21 N., R. 117 W.*—This well is drilled very near the line between the Adaville and Eocene beds and on the east side of the Lazeart syncline. The section, according to Mr. Curtis, is as follows:

Section of Curtis well, sec. 25, T. 21 N., R. 117 W.

	Feet.
1. Surface sand and clay	0–70
2. Sandstone	70–450
3. Black bituminous clay	450–455
4. Coal	455–457
5. Clay	457–

GEOLOGIC RELATIONS.

The natural oil springs in this area occur in the region of profound disturbance along the Absaroka fault. The Brigham Young, White, and Carter springs occur along a secondary fault just east of the main fault line. This Oil Spring fault cuts the western end of the Aspen tunnel, and the oil seepage in this tunnel is to be regarded as essentially of the same character as that in the neighboring oil springs. In this case the oil issues directly from faulted Cretaceous rocks of Benton age at a horizon stratigraphically 1,600 feet above the top of the black shales which yield oil in the wells at Spring Valley. As these lower shales are about 2,000 feet thick it would require a hole 3,600 feet deep at the fault line to prospect them fully if the strata were horizontal, but as they are highly inclined wells drilled at the fault line must go to much greater depths. Where, as at Hilliard, the strata are overturned, a well at the fault line like the El Rio Verde well must drill through some of the strata twice (Pl. IV, section Y), and such a location is to be avoided, both because of the unnecessary duplication required and the fact that the oil yield will be smaller than at greater distances from the fault, owing to loss by leakage along the fault line.

In the Fossil region the oil comes from a group of springs which, with the exception of occasional globules of oil, are of the type commonly found in the Eocene beds. The strata around these springs and for many feet below belong to the Wasatch. These beds show a gentle anticline with dips of about 5°, and the springs occur very near the axis of this anticline. Farther east, between this anticline and the outcrop of the coal-bearing Adaville beds, there is a similar syncline. The geologic relations of the adjoining areas indicate rather conclusively that this anticline corresponds

[a] Ricketts, L. D., Ann. Rept. Territorial Geologist of Wyoming for 1887, 1888, pp. 42–43.

[b] According to the report of S. H. Stowell, the first well at this point was 100 feet deep when visited by him in the summer of 1885 (Min. Res. for 1885, 1886, pp. 1–54).

very nearly in position and direction with that of the underlying Absaroka fault, and it has doubtless been produced by a slight movement along this older axis (Pl. XXII). The oil floating up through the water which has penetrated to the oil-bearing beds along the fault has naturally collected in the fairly water-logged beds of the Wasatch and has found outlet in the springs along this low anticline, which is at the same time the highest point stratigraphically and the lowest point topographically, and is very nearly directly over the fault line. The Short well penetrated red beds from 1,650 feet to the bottom of the well, 2,200 feet, conclusively showing that it is situated west of the Absaroka fault. The other wells in this field obtained water, with a little gas and oil, in the Wasatch beds. The conditions here are manifestly unfavorable for the accumulation of oil in commercial quantities.

The oil found in the Spring Valley wells commonly comes from sandy layers in the Aspen shale. It has been found in the upper Bear River beds in the Standard Reserve Oil Company well (No. 29 in list of wells on pp. 144, 154–155) and in the Pittsburg-Salt Lake Oil Company well on sec. 10, T. 14 N., R. 118 W. (No. 8). Failure to obtain oil has been recorded in three types of wells: (1) Those not deep enough to reach the oil-bearing strata, such as the Nebergall (No. 21) and Baker (No. 11) wells; (2) those which, because of irregularities of the sandy layers in the shales, fail to develop oil, although it is found in adjacent wells, like the Consolidated Oil Company's wells in the southwest corner of sec. 23, T. 15 N., R. 118 W.; (3) wells located on the outcrop of the shales, particularly those near the eastern edge, where the beds are less than 500 feet thick, like the well of the Wyoming Illuminating Oil Company in sec. 26 and the well on the west side of sec. 24, T. 15. N., R. 118 W.

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 (No. 28) and the Consolidated Oil Company well (No. 26). The occurrence of large quantities of water in the Bettys well (No. 5) and the Baker well (No. 11) 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. This is the case also in the Boulder and Florence fields, although at those localities the shales are geologically younger. 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. At Hilliard the lowest point in the shale bed is over 11,000 feet from the surface, and the dip of the beds is such that a deep well would be extremely difficult to sink.

Between Hilliard and Aspen tunnel the syncline rises, and these beds may be thoroughly prospected with a hole 2,500 to 3,000 feet deep. This is a good location, although the Oil Spring fault to the west introduces a point of leakage and the deepening of the syncline to the south affords a lower point of accumulation. Because of the normal character of the syncline at this point a well properly placed may be drilled entirely in nearly horizontal strata.

Farther north the synclinal trough deepens rapidly, and at the Lazeart mine the oil shale is perhaps 10,000 feet from the surface. At Round Mountain the strata are overturned and faulted and the site is not favorable for an oil well. Between Round Mountain and the top of the Adaville beds north of Little Muddy Creek the synclinal trough rises. The rise is gradual, the syncline is normal, and the locality in these respects the best in the region. The great depth of the oil-bearing shales, 5,000 to 7,000 feet, however, is practically prohibitive. Farther north the syncline sinks, and at the Oregon Short Line Railroad the lowest point of the oil-bearing beds is in the neighborhood of 15,000 feet from the surface. Still farther north the syncline rises, and in the long trough north of a point 10 to 15 miles north from Kemmerer the conditions for oil are favorable. The depth of the oil-bearing shale in the center of the syncline is such that wells could be readily sunk, and test holes in this region are likely to yield returns. This region is beyond that examined this year, but enough was learned regarding it to warrant the above suggestion. Oil springs are, moreover, reported in this region, and it is hoped they may be critically examined next year.

In general, in the region of this report, the depth of the oil-bearing shale at the axis of the syncline is practically prohibitive, but the soft character of the strata suggests that the diminution of pore space, due to the pressure of the superincumbent beds, may be so great that the maximum accumulation of oil will be at some point on the limb of the syncline between the axis and the outcrop. Indeed, though the oil-bearing shale underlies a much larger area, prospecting should be restricted to the region between the axis of the Lazeart syncline and the eroded edge of these beds on the west flank of the Meridian anticline (Pl. XXII).

The well of the Pittsburg-Salt Lake Oil Company in sec. 10, T. 14 N., R. 118 W. (No. 8), develops an oil-bearing horizon in the lower part of the Bear River formation. The oil is black and more of the nature of a lubricating oil than that from the upper horizons. In a preliminary report[a] it was suggested that the beds here might be of Jurassic age and belong to the same horizon as the shale exposed on Twin Creek west of Nugget, but a more complete correlation of the data collected has shown this inference to be unwarranted.

QUALITY OF OIL.

The oil obtained from the Brigham Young, White, Carter, and Fossil oil springs, and wells in their neighborhood, is a dark, heavy oil which has perhaps been derived from the Aspen oils by the evaporation of its more volatile portions. The gravity of the Carter oil is given by Slosson [b] as 21.5° Baumé. The gravity of the Fossil or Twin Creek oil is given by the Union Pacific Railroad Company [c] as 26.75° Baumé

[a] Bull. U. S. Geol. Survey No. 285, pp. 334, 353.
[b] Slosson, E. E., Bull. School of Mines, Univ. of Wyoming, Petroleum Series, No. 3, 1899, p. 31.
[c] Mineral Resources U. S. for 1885, 1886, p. 15.

and by Slosson[a] as 19.7° Baumé. The results of several analyses of the Spring Valley petroleum are given below:

Analysis of oil from Union Pacific well at Spring Valley, Wyo.

[By Thomas Price & Son, San Francisco, 1901.]

	Per cent.
Naphtha (gasoline and benzine)	28
Kerosene	24
Signal and headlight oil	8
Lubricating, reduced stock	23
Paraffin	17

Tests of oil from 650-foot sand of Union Pacific well at Spring Valley, Wyo.

[By Louis Falkenau, San Francisco, 1901.]

Temperature, in degrees Fahrenheit, at which gas was given off on distillation	Per cent by volume.	Per cent by weight.	Specific gravity of product.	Gravity, Baumé.	Nature of product.
66–302	15	17.1	0.740	60	Gasoline and benzine.
302–491	33.1	33.4	.802	46	Illuminating oil.
491–602	26.5	27.1	.830	35	Heavy illuminating or signal oil.
602, boiled dry	19.5	20.4	.840	31	Lubricating oil and paraffin.
Residue:					
Bituminous (soluble)		1			
Carbon and ash (insoluble)		1			

Specific gravity of crude oil at 66° F., 0.825.
Crude flashes at 66° F.

Analysis of oil from Union Pacific well, Spring Valley, Wyo.

[By G. W. Gray, Chemist, Standard Oil Company, 1902.]

	Per cent.
Gasoline	19
Refined illuminating oil	35
Heavy lubricating oil	21
Intermediate lubricating oil	21
Coke	1.8
Loss	2

Sample bailed from well upon first day of opening, Thursday, January 26, 1902, run into tank car and taken from tank car Sunday, June 29, 1902.

Gravity 0.8211, or 41.5° Baumé.

Tests of oil from Union Pacific well, Spring Valley, Wyo.

[By Wilbur C. Knight, professor of geology, University of Wyoming, 1902.]

No.	Temperature, in degrees Centigrade, at which gas was given off on distillation.	Specific gravity of product.	Temperature, in degrees Centigrade, at which specific gravity was taken.
1	77–130	0.7230	15
2	130–170	0.7540	15
3	170–200	0.7800	15
4	200–259	0.8040	15
5	259–292	0.8190	15
6	292–320	0.8340	15
7	320–350	0.8470	18
8	350–370	0.8580	22
9	370–380	0.8640	22
10	380–400	0.8880	22

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

These numbers represent tenths of the product, with the exception of the last, which was only half filled. This means that with the ordinary method of distilling oils one would save 95 per cent of the crude.

Specific gravity of crude oil, 0.8100.

Oil flashes at a point below 70°.

This oil will yield approximately the following products:

	Per cent.
Gasoline and lighter oils	20 to 30
Kerosene	30 to 40
Paraffin	10 to 20

The remainder of the oil could be utilized to some extent for lubricating purposes.

This is a superior quality of crude for the production of gasoline and kerosene; but is of little importance for lubricants. For the lighter oils it is worth a little more than the ordinary crude from Colorado or Pennsylvania.

Tests of oil from well of Pittsburg-Salt Lake Oil Company in sec. 22, T. 15 N., R. 118 W., 1 mile north of Spring Valley, 1906.

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

Temperature, in degrees Centigrade, 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.
350–330	15.4	37	Oil partially cracked.

Residue, 7.2.

Specific gravity, 0.81 or 44° B.

The oil begins to crack at 350°; of course this product is really gas oil. The distillates at 305°–350°, 350°–330°, 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 nor 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 Territory.

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.

YIELD OF OIL.

The yield of a single well in this field has been estimated as high as 50 to 100 barrels a day, but these estimates are clearly excessive. The best wells of the Pittsburg-Salt Lake Oil Company, which are the only wells carefully tested, yield about 5 barrels a day. The oil is very volatile, with a paraffin base, and soon clogs the oil sand at the point cut by the well unless carefully pumped. The very low yield of the Union Pacific well on the official test is believed to be due to such a clogging (see p. 152). From the geologic conditions, wells with very large production are not to be expected, but a very large territory of wells with a low yield is indicated.

PRACTICAL SUGGESTIONS.

The best oil territory in this region is between the axis of the Lazeart syncline and the outcrop of the oil-bearing Aspen formation west of the Meridian anticline (Pl. XXII).

The whole territory underlain by the Aspen shale may be expected to yield oil of the same character as that found at Spring Valley, and a considerable oil field is thus outlined. Present developments indicate that the quantity obtained will increase toward the axis of the syncline. The yield per well will be small, but the high character of the oil warrants the development of small wells.

In developing this section wells should preferably be placed in valleys. First, because such locations will save much needless drilling; second, because a water supply can often be obtained in shallow bored wells in such locations, and, third, supplies can be transported more cheaply.

Between the Absaroka fault and the Rock Creek-Needles anticlinal this principal oil-bearing horizon is in general either deeply buried or absent and is not of probable economic importance.

West of the Rock Creek-Needles anticlinal the rocks are all older than the Aspen oil-bearing shale, with the exception of the Evanston and Eocene beds, which are not oil bearing. Prospecting here should be confined to points where the Bear River formation is of considerable thickness. The possibility that it may prove an oil horizon has been demonstrated by the Pittsburg-Salt Lake Oil Company well in sec. 10, T. 14 N., R. 118 W. (No. 8), and the Standard Reserve Oil Company well in sec. 12, T. 15 N., R. 118 W. (No. 29).

UNDERGROUND WATERS.

Strata of probable importance as sources of underground water are found in the Wasatch (Knight and Almy), Adaville, Frontier, Beckwith, and Nugget formations. The sandstones and conglomerates of the Almy and Knight formations are generally sufficiently porous to make them readily absorb and transmit water. Between the Rock Creek-Needles anticlinal and the Absaroka fault these beds form a gentle syncline, along which in many of the deeper valleys flowing wells may perhaps be had. Flowing brackish sulphur water has been obtained in these beds at the head of Twin Creek (see wells Nos. 37 to 42, p. 145). The Bettys well (No. 5) developed several artesian horizons, and a flow of 30 gallons a minute of water of fair quality is reported at a depth of 700 feet. Similar developments are possible on Duncomb Creek, on Needle Creek, on Goodman Creek, and on the head of Yellow Creek. In the area east of the Meridian anticline these beds dip gently eastward and artesian conditions are again present. Small flows from these beds were obtained at Bridger Station, but the water was very alkaline. On the whole the conditions are more favorable in the Fossil syncline than in the area east of the Meridian anticline in the great Green River syncline.

The Adaville formation contains several beds of sandstone which will probably yield water. The relative height of the outcrop and the general attitude of these beds indicate that flowing wells are not to be expected from them.

The sandstones of the upper part of the Frontier formation, particularly the Oyster Ridge sandstone, are good water carriers. When encountered in oil wells they have yielded large quantities of water, generally alkaline. The depth of this horizon throughout Mammoth Hollow is indicated approximately by the depth shown for the Kemmerer coal on Pl. XXIII. The area of outcrop of this bed is, however, quite limited, the rainfall small, and persistent yields of large amount are not to be expected.

The Beckwith formation contains beds of sandstone and conglomerate that may be important water bearers. These have been penetrated only in the Bridger well. Here one of the upper sandstones yielded a flow of 30 gallons a minute of very alkaline water. The Nugget formation is listed as a possible water horizon because of its physical character and not because it has been proved by wells to be water bearing.

Throughout this region the underground water is derived almost wholly from the rain that falls on the surface of the local area. The geologic conditions, except in the Wasatch beds in the Fossil syncline, are not favorable to an underground circulation with the Uinta Mountains or the mountains to the north as a source. In the Fossil syncline it is probable that water is transmitted in the basal Wasatch gravels from the Uinta region, and this condition is distinctly favorable for deep wells at the head of Chalk Creek and on Yellow, Goodman, Sage, and Needle creeks.

COPPER.

The Beckwith red beds, wherever exposed along the Rock Creek-Needles anticlinal (Pl. XXIII) 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.

SANDSTONE.

The irregular sandstone beds in the Evanston and Adaville formations have been quarried for stone for foundations at Evanston and the old town of Twin Creek. Sandstone of considerable value as building stone is found in the Frontier formation, and a large quarry, with switch from the railroad, has been opened just east of Oakley. This quarry has not been in operation for several years and no data were obtained regarding the extent of shipments. Several stone buildings in Kemmerer, it is reported, were built of this stone. Local quarries have been opened at Frontier and Cumberland in the same sandstone.

CLAY.

None of the clays of this region are at present used industrially. Brick has been burned at Almy and Glencoe, in both places from residual or alluvial soils, but the kilns have been abandoned. The absence of timber tends to greatly retard the burning of ordinary brick. Clays of importance are reported associated with many of the coal seams, but little is known definitely regarding their value. Clay from the coal mine of the Standard Reserve Oil Company at Spring Valley has been tested at Salt Lake and is reported to make a very excellent fire brick suitable for any purpose in the furnace line.

STATUS OF LANDS.

As shown on Pl. XXVI, the Government is to-day the largest owner of lands in this region. The lands which have been disposed of and the laws under which they were patented are also indicated on this plate. The coal and oil values of these vacant Government lands may be seen by comparing this plate with the economic map, Pl. XXIII.

The following figures give the approximate area of coal lands in the two most important coal-bearing groups, the Adaville and Frontier. In this statement lands have been classed as coal lands in which the coal is less than 3,000 feet from the surface. This depth was chosen because it is the limit indicated by the land purchases of three of the largest coal companies in this field and is the depth shown upon the map filed by one of these companies with the State mine inspector as the limit to which they expect to work the coals. The tables may therefore be taken to show coal lands of the same character as those which have been purchased as investments by coal companies in this region:

Total coal lands in the Kemmerer-Hilliard coal field in ranges 13–23 N., inclusive (Frontier formation).

		Acres.
Total coal lands		158,459
Coal lands sold or otherwise disposed of:		
1. Union Pacific land grant	59,967	
2. As agricultural land (homestead, desert entry, preemption, timber culture, etc.)	14,220	
3. As coal land	7,452	
4. As State land [a]	6,360	
		87,999
Coal land remaining in which title is with the Government		70,460

[a] Because of its mineral value, the title of some of this land may be found to be with the General Government and not with the State.

Of the latter amount, on June 1, 1906, 3,240 acres were covered with coal declaratory statements, 3,260 acres with unpatented agricultural entries, and 2,360 acres with unapproved State selections.

Total coal lands in the Adaville-Lazeart coal field in Tps. 13-23 N., inclusive, Uinta County, Wyo., Adaville formation.

		Acres.
Total coal lands		63,338
Coal land sold or otherwise disposed of:		
(1) Union Pacific land grant	16,116	
(2) As agricultural land (homestead, desert entry, preemption, timber culture, etc.)	916	
(3) As coal lands	5,384	
(4) As State land [a]	4,760	
		27,176
Coal land remaining in which title is with the Government		36,162

Of the land remaining in which title is with the United States Government on January 1, 1906, 360 acres were covered with coal declaratory statements and 1,310 acres with unapproved State selections.

Summary of coal lands acquired as agricultural lands in Tps. 13-23 N., Rs. 115-119 W., Uinta County, Wyo.

		Acres.
Frontier coals.		
Total coal land acquired as agricultural land		14,220
Coal land with some agricultural value and in which there is some excuse for the acquisition as agricultural land, but where the coal value is without exception greater than the agricultural value	6,352	
Land acquired solely for coal values held almost without exception by coal companies	7,868	
Adaville coals.		
Total coal land acquired as agricultural land		916
Coal land with some agricultural value and in which there is some excuse for the acquisition as agricultural land	836	
Land acquired for coal values alone	80	
Summary.		
Total coal lands acquired as agricultural land		15,136
Coal land with some agricultural value and in which there is some excuse for its acquisition as agricultural land	7,188	
Land acquired solely for coal values	7,948	

It is important to note in these tables that the coal lands of the Adaville formation which have already been disposed of were acquired almost wholly under the coal-land laws—5,316 acres acquired under the coal-land laws and only 916 under the agricultural laws. These lands were for the most part acquired in the early eighties, apparently by individuals and not by organized coal companies. In the Frontier formation, where the lands were acquired by large coal companies, one-third was bought as coal land, one-third was acquired as agricultural land

[a] Because of its mineral value, the title of some of this land may be found to be with the General Government and not with the State.

where there is some excuse for an agricultural entry, and one-third was acquired as agricultural land for its coal value alone. In the case of the Adaville coals, which are not being actively mined, there were on January 1, 1906, 360 acres of agricultural entries pending and 1,310 of State selections pending. In the area of the Frontier coals, which are being actively worked and which are the best coals in the region, there are 3,260 acres of agricultural entries and 2.360 acres of State selections pending.

INDEX.

CLASSIFICATION OF THE PUBLICATIONS OF THE UNITED STATES GEOLOGICAL SURVEY.

[Professional Paper No. 56.]

The publications of the United States Geological Survey consist of (1) Annual Reports, (2) Monographs, (3) Professional Papers, (4) Bulletins, (5) Mineral Resources, (6) Water-Supply and Irrigation Papers, (7) Topographic Atlas of United States—folios and separate sheets thereof, (8) Geologic Atlas of United States—folios thereof. The classes numbered 2, 7, and 8 are sold at cost of publication; the others are distributed free. A circular giving complete lists can be had on application.

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1. A limited number are delivered to the Director of the Survey, from whom they can be obtained, free of charge (except classes 2, 7, and 8), on application.
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B 232. Gazetteer of Virginia, by Henry Gannett. 1904. 159 pp.
B 233. Gazetteer of West Virginia, by Henry Gannett. 1904. 164 pp.
B 234. Geographic tables and formulas (second edition), compiled by S. S. Gannett. 1904. 310 pp. (Out of stock.)
B 245. Results of primary triangulation and primary traverse, fiscal year 1902-3, by S. S. Gannett. 1904. 328 pp., 1 pl.
B 248. Gazetteer of Indian Territory, by Henry Gannett. 1904. 70 pp.
B 258. The origin of certain place names in the United States (second edition), by Henry Gannett. 1905. 334 pp.
PP 45. The geography and geology of Alaska, a summary of existing knowledge, by A. H. Brooks, with a section on climate, by Cleveland Abbe, jr., and a topographic map and description thereof, by R. U. Goode. 1906. 327 pp., 34 pls.
B 274. A dictionary of altitudes in the United States (fourth edition), compiled by Henry Gannett. 1906. 1072 pp.
B 276. Results of primary triangulation and primary traverse, fiscal year 1904-5, by S. S. Gannett. 1905. 263 pp., 1 pl.
B 281. Results of spirit leveling in the State of New York for the years 1896 to 1905, inclusive, by S. S. Gannett and D. H. Baldwin. 1906. 112 pp.
B 288. Results of spirit leveling in Pennsylvania for the years 1899 to 1905, inclusive, by S. S. Gannett and D. H. Baldwin. 1906. 62 pp.
B 291. Gazetteer of Colorado, by Henry Gannett. 1906. 185 pp.
B 299. Geographic dictionary of Alaska, by Marcus Baker; second edition, prepared by James McCormick. 1906. 690 pp.
B 302. Areas of the United States, the States, and the Territories, by Henry Gannett. 1906. 9 pp., 1 pl.
B 306. Rate of recession of Niagara Falls, by G. H. Gilbert, accompanied by a report on the survey of the crest, by W. C. Hall. 1906. 31 pp., 11 pls.
PP 56. Geography and geology of a portion of southwestern Wyoming, with special reference to coal and oil, by A. C. Veatch. 1907. 178 pp., 26 pls.

Correspondence should be addressed to

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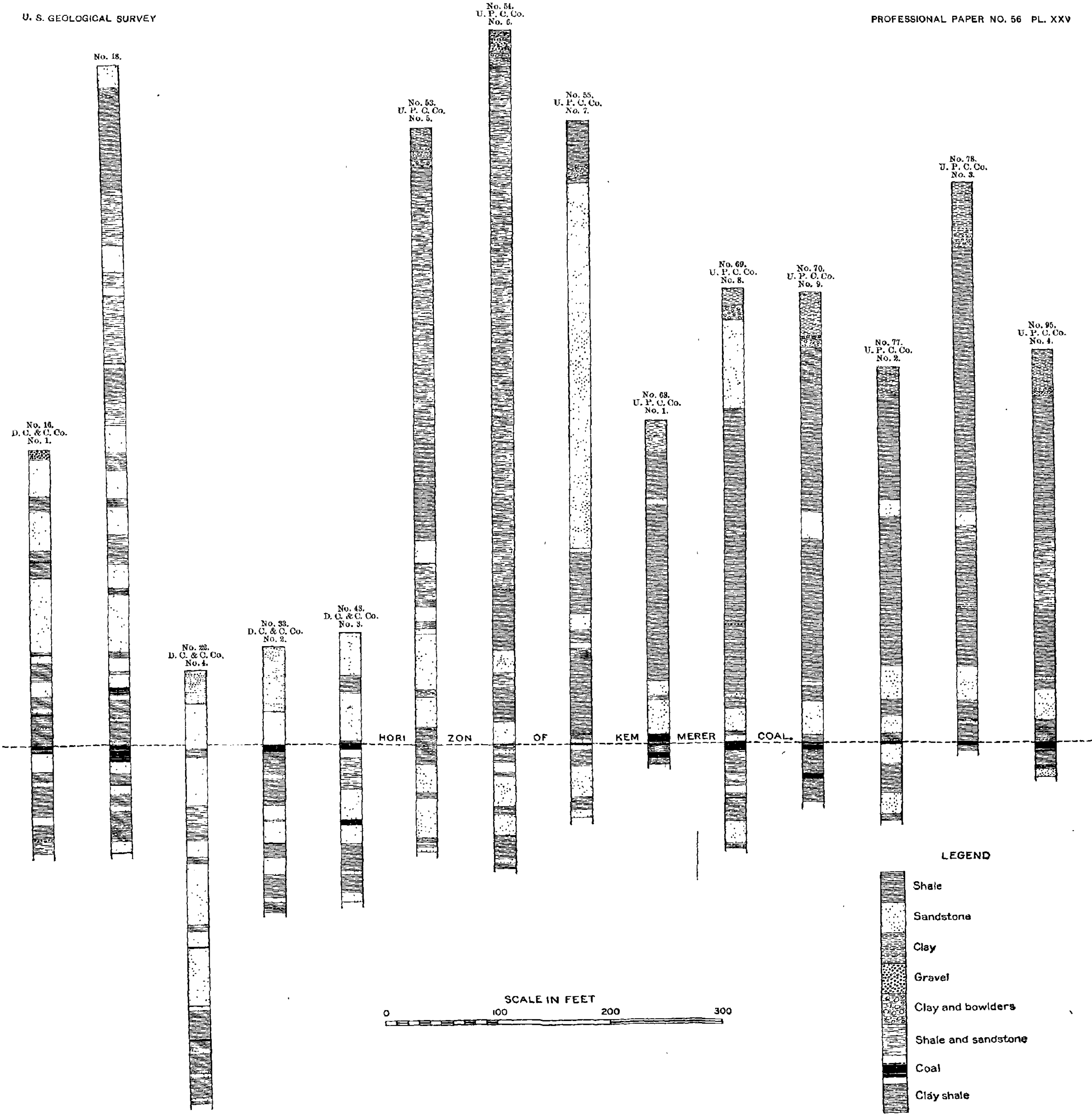
Geologic column in that part of southwestern Wyoming shown on Pl. III.

(For graphic representation of thickness of formations and lithological character see Pl. IV.)

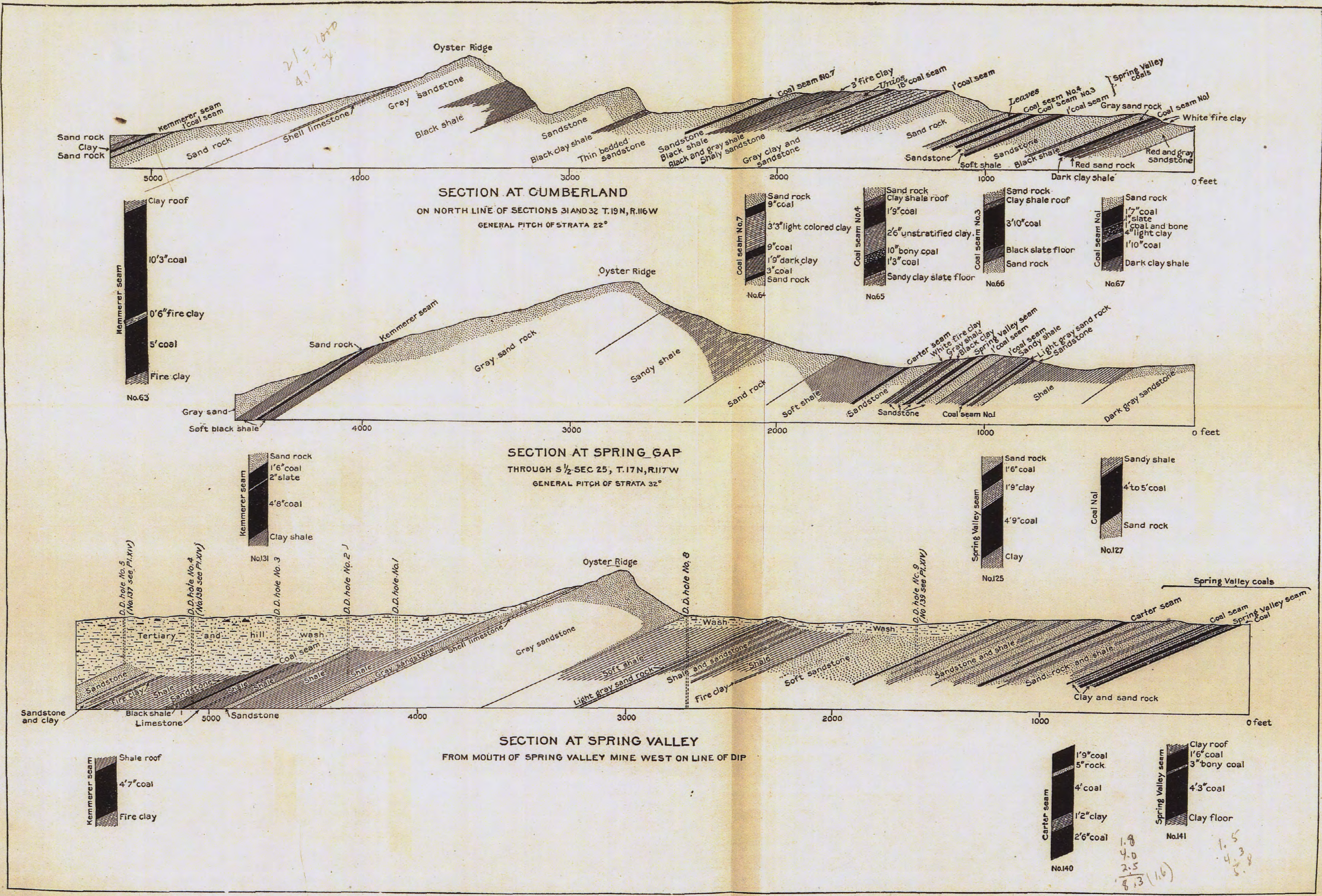
Systems and groups.		Formations.	Symbol used on geologic map.	Character of rocks.	Thickness.	Economic value.
Quaternary.		Flood-plain deposits	Qfp	Clay and fine silts	0- 25	Contains with terraces most important agricultural areas of this section.
Quaternary.		Small stream bottoms, with accompanying river terraces.	Qb	Silt, sand, and gravel	0- 75	
Quaternary.		Hill wash, talus slopes, etc., masking underlying formations.	Qhw	Silt, sand, gravel, and rock débris	0-200	
Quaternary.		Low terraces	Qlt	Silt, sand, and gravel	0- 40	
Quaternary.		High terraces	Qht	Silt, sand, and gravel	0- 40	Important agricultural land. Gravel for road metal and concrete work.
Quaternary.		Undifferentiated Pleistocene (?)	Qx	Gravel remnants on Aspen Mountain, Sillem Ridge, and Bowlder Ridge, some of which suggest the Wyoming conglomerate.	0- 50	
		Unconformity				
Eocene.	Bridger.	Bridger formation	(Not separated)	Greenish sand and clays, composed largely of volcanic ash,[a] with occasional calcareous white bands filled with fresh-water shells. Contains a large mammalian fauna.	[b]1,200-1,800	
Eocene.	Green River.	Green River formation	Tg	Predominently light-colored calcareous beds, characterized by light-colored, thin-bedded shales with abundant fish and plant remains. Layers of dark bituminous shales show near Fossil at base of formation.	[c]2,000±	
Eocene.	Wasatch.	Knight formation	Tk	Variegated yellow and red sandy clays, with irregularly bedded white and yellow sandstones. Contain *Coryphodon* and other animal remains.	500-1,500±	Yields oil and flowing water at Fossil, but oil has clearly leaked thru fault from underlying Cretaceous beds. Yields flowing water of good quality on Bear River above Evanston.
		Unconformity				
Eocene.	Wasatch.	Fowkes formation	Tf	"White beds;" light-colored rhyolitic ash beds with interbedded limestones containing fresh-water shells, fish, and plants.	0-2,500+	
Eocene.	Wasatch.	Almy formation	Ta	Yellow and reddish-yellow sandy clays, with irregularly bedded sandstone and near the base conglomerate beds.	2,100-2,200	Of probable importance as an artesian-water horizon.
	"Upper Laramie."	Evanston formation	KTe	Yellow, gray, and black carbonaceous clays, with irregular yellow sandstone, in places conglomeratic. Several coal beds. Characterized by plants which are distinctive of the upper Laramie or Denver beds, and by invertebrates, some of which are common to the Laramie and Fort Union. Rests on Bear River and Beckwith beds.	0-1,600+	Contains coal mined at the Evanston (Almy and Red Canyon) mines. The main coal seam has been reported as much as 33 feet thick, but it contains much bone, and for fuel purposes may be regarded as having a thickness of 18 feet, workable in two benches.
		Unconformity				
Cretaceous.	"Lower Laramie."	Adaville formation, with basal Lazeart sandstone.	Kav Kl	Yellow, gray, and black carbonaceous clays, with irregularly bedded brown and yellow sandstones and numerous coal beds. South of Hodges Pass tunnel there is at the base of this formation a prominent white sandstone, 100 to 200 feet thick. Immediately above this is the Adaville-Lazeart coal, 20-84 feet thick, and associated with it are beds containing plants and invertebrate remains, which are older than Laramie. The overlying strata contain lower Laramie leaves.	4,000+	Contains many beds of coal of workable thickness. The Adaville coal has been opened at Adaville (84 feet thick), Lazeart (35 feet thick), and Carlton (22 feet thick). The Hodges Pass tunnel, 1,400 feet long, cut seven coal beds, varying in thickness from 2.5 to 30 feet. Farther west the Twin Creek mine tunnel, 1,400 feet long, cut six beds 5, 2, 8, 10, 5, and 15 feet thick.
Cretaceous.	Montana.					
Cretaceous.	Colorado. Niobrara.	Hilliard formation	Kh	Gray to black sandy shales and shaly sandstones, which weather readily and produce a region of low relief, Mammoth Hollow, affording few exposures. West of Frontier and 3,000 to 3,800 feet above the base of the formation there are several thick lenses of white sandstone. These contain numerous specimens of large *Inoceramus exogyroides*, a species characteristic of the basal Niobrara or upper Benton in the Cretaceous east of the Rocky Mountains.	5,500?-6,800	Is not known to contain coal of economic importance. Carbonaceous matter has been observed at several points and coal is reported in the Baker well near Spring Valley, 940 feet above the Kemmerer coals, but this coal occurs in the conglomerate beds between the Hilliard and the Knight, and is probably Evanston.
Cretaceous.	Colorado. Benton.	Frontier formation, with Oyster Ridge sandstone member.	Kf Kor	Alternating beds of yellow and gray sandstone and yellow, gray, and black carbonaceous clays with numerous coal beds. Forms pronounced parallel ridges or hogbacks. Contains distinctive Benton fossils. In upper part of formation is a pronounced bed of coarse sandstone, occasionally conglomeratic, containing numerous large oysters. This is the "Oyster Ridge sandstone."	2,200-2,600	Contains Kemmerer, Willow Creek, Carter, and Spring Valley coals. The Kemmerer coals are extensively mined at Frontier, Diamondville, Oakley, Glencoe, and Cumberland. Contains beds of sandstone of good quality, used for building purposes at Kemmerer. Quarry between Waterfall and Oakley.
Cretaceous.	Colorado. Benton.	Aspen formation	Ka	Black and gray shales containing abundant fish scales; often weathering *silvery gray*	1,500-2,000	Contains oil developed in wells northeast of Spring Valley. Probable source of oil in Hilliard, Carter, and Fossil oil springs.
Cretaceous.	Bear River, Dakota?, and Lower Cretaceous?	Bear River formation	Kbr	Dark-colored shales with thin-bedded, shaly sandstones and limestones, containing abundant invertebrate fossils and several thin beds of impure coal.	500-5,000±	Attempts have been made to develop coal beds in this formation at Sage and Cokeville. Beds too thin and impure to be of value at present. Yields oil in two wells near Spring Valley.
	Bear River, Dakota?, and Lower Cretaceous?	Beckwith formation	Jkb	Red, yellow, and reddish-yellow shales and sandstones, at many places containing thick, reddish conglomerate beds.	3,800-5,500	Has been extensively prospected for copper, and near center of overturned anticline at the Cockscomb, T. 19 N., R. 120 W., a small showing of carbonates has been found in a yellow sandstone containing some carbonaceous matter.
Jurassic.		Twin Creek formation	Jtc	Black and gray shales and shaly limestones with occasional beds of yellow sandstone, the whole containing numerous characteristic marine upper Jurassic fossils.	3,500-3,800	
Triassic?		Nugget formation, with basal red-bed member.	Ѣn {Ѣn, Ѣr}	Yellow, thin-bedded sandstones and shales, merging into bright-red sandstones and shales	1,900 {1,300, 600}	
Carboniferous.		Thaynes formation	Ct	Thin-bedded gray limestones and yellow sandstones, containing an abundant and characteristic "Permo-Carboniferous" fauna.	2,400-2,600+	
Carboniferous.		Woodside formation	Cw	Red shales and sandstones	500	
Carboniferous.		Park City formation	Cp	Gray sandy limestone	700+	
Carboniferous.		Weber quartzite	Cwq	Gray to white quartzitic sandstones, often brecciated. Base not seen	1,000+	Has been prospected for copper, and just north of Watercress Canyon, T. 22 N., R. 118 W., a showing of carbonates has been found.

[a] Observation of W. J. Sinclair, of American Museum of Natural History party of 1905.
[b] Measured by W. D. Matthews and Walter Granger in Bridger basin, east of this area.
[c] Estimate of Clarence King of maximum thickness east of this region.



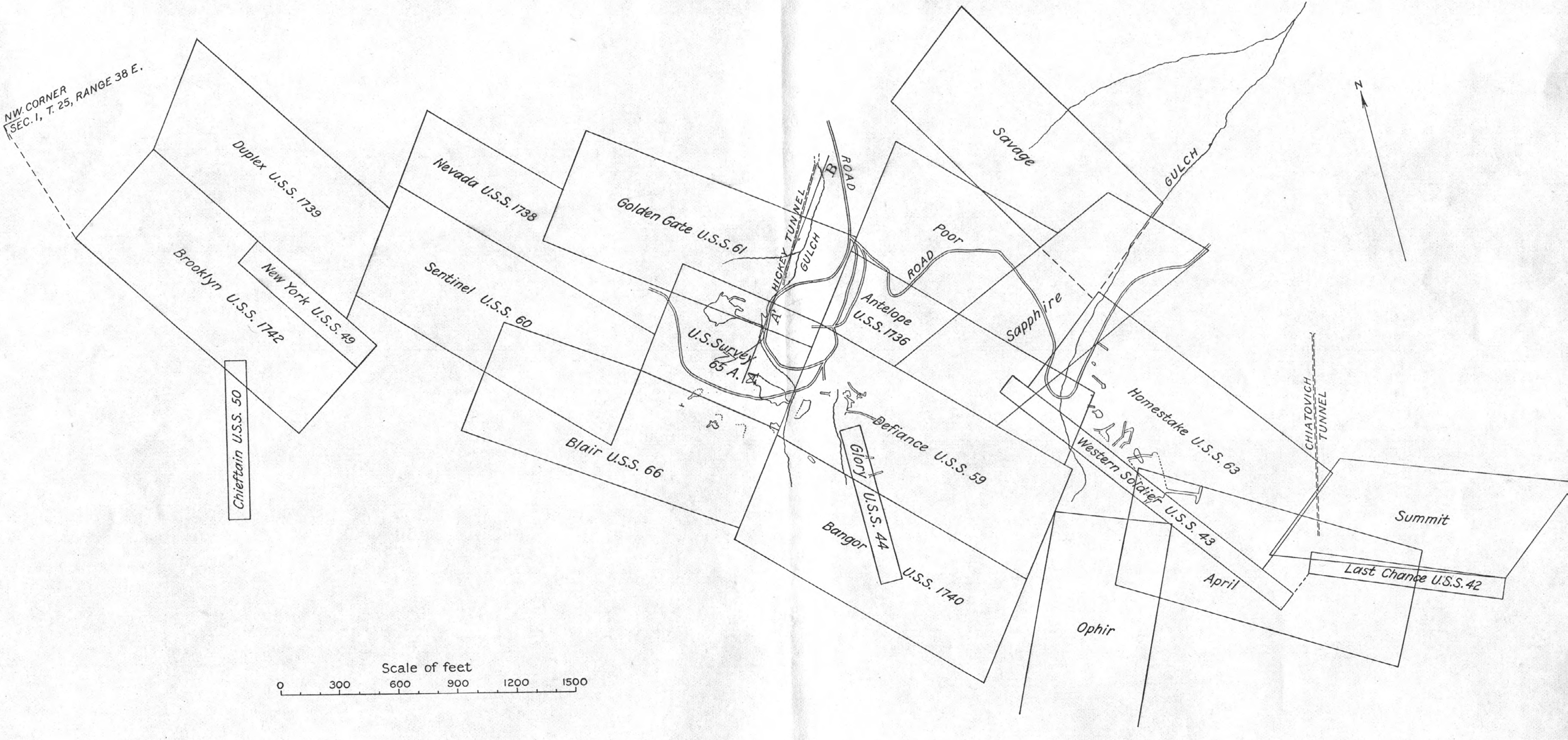
DIAMOND-DRILL BORINGS BETWEEN KEMMERER AND DEVILS GLEN, UINTA COUNTY, WYO.

For locations see Plate XXIII. D. C. & C. Co. = Diamond Coal and Coke Company; U. P. C. Co. = Union Pacific Coal Company.

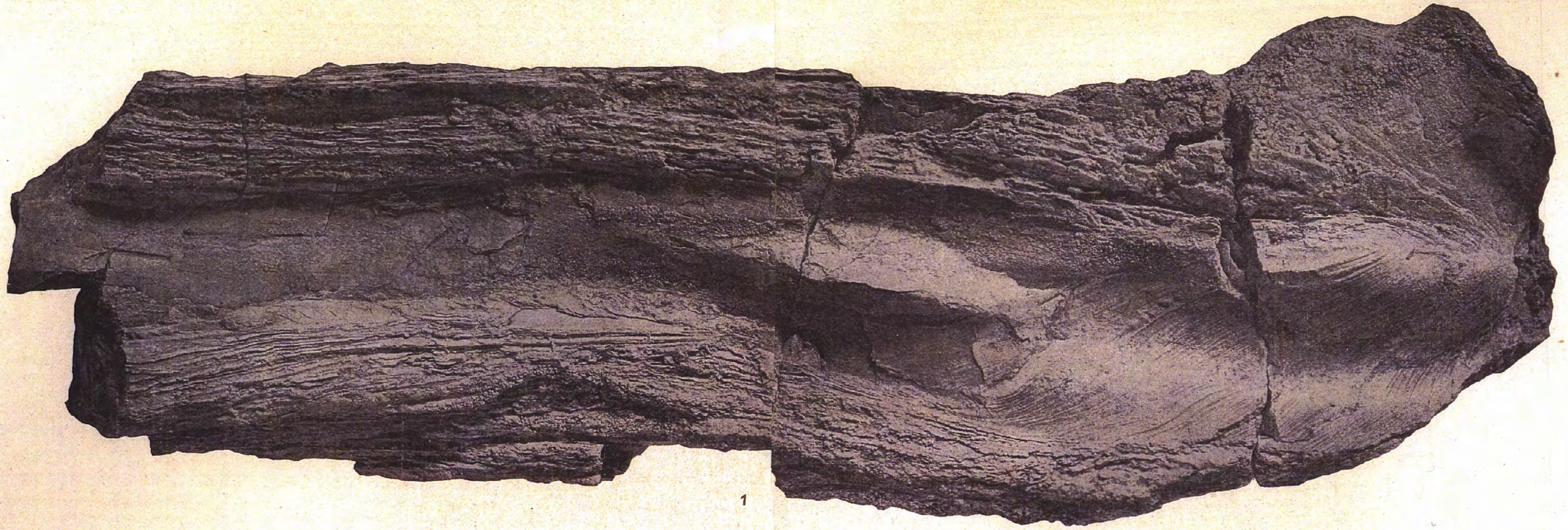


SECTIONS OF COAL-BEARING FRONTIER FORMATION IN UINTA COUNTY, WYO.

By Union Pacific Coal Company, 1904.

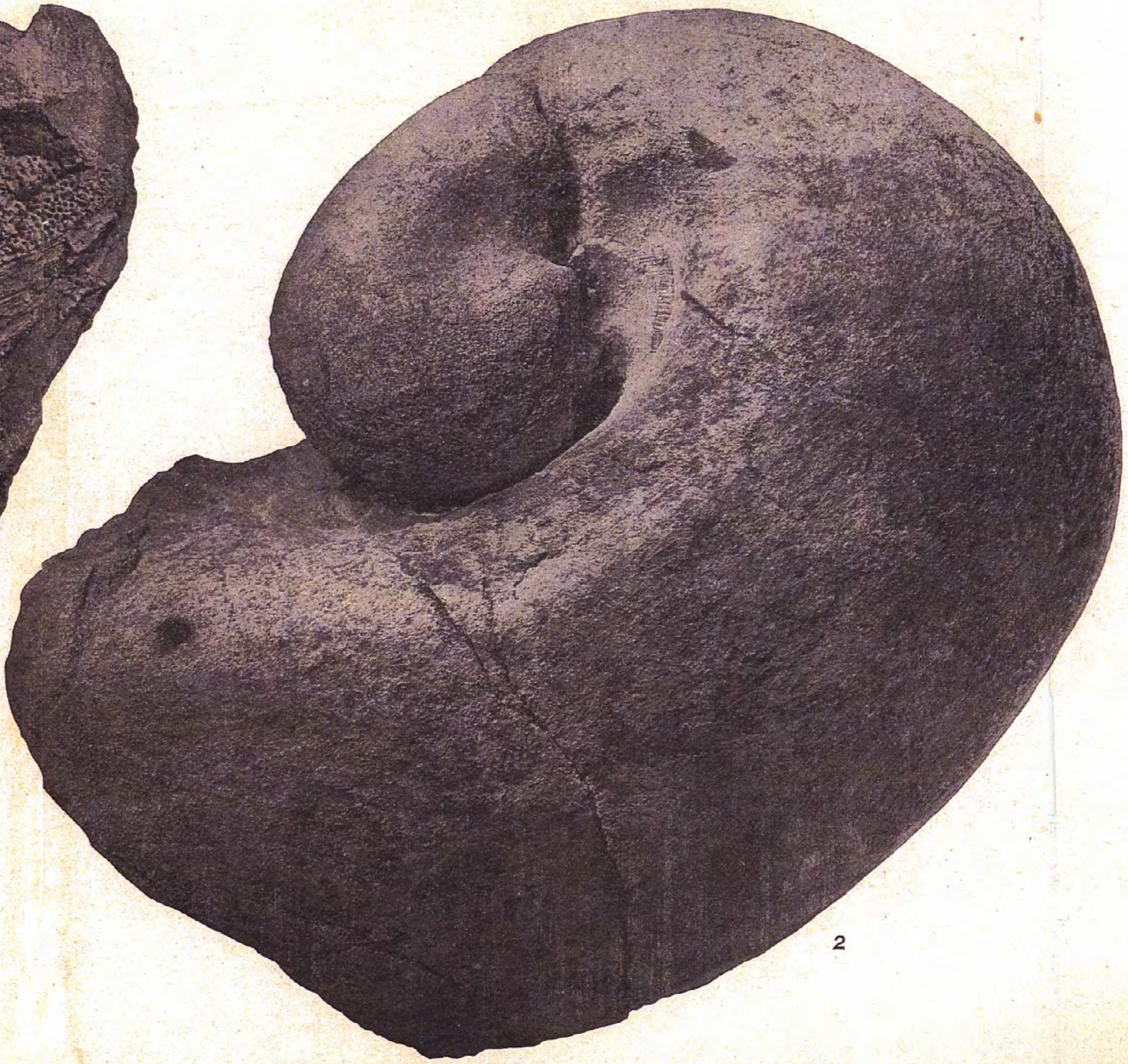


NW. CORNER
SEC. 1, T. 25, RANGE 38 E.
Duplex U.S.S. 1739
Brooklyn U.S.S. 1742
New York U.S.S. 49
Chieftain U.S.S. 50
Nevada U.S.S. 1738
Sentinel U.S.S. 60
Golden Gate U.S.S. 61
Blair U.S.S. 66
U.S. Survey 65 A.
A'
HICKEY TUNNEL
GULCH
B
ROAD
Poor
ROAD
Antelope U.S.S. 1736
Savage
GULCH
Sapphire
Defiance U.S.S. 59
Glory U.S.S. 44
Bangor U.S.S. 1740
Homestake U.S.S. 63
Western Soldier U.S.S. 43
CHIATOVICH TUNNEL
Summit
Last Chance U.S.S. 42
April
Ophir
N
Scale of feet
0 300 600 900 1200 1500



1

1a



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1, 1a. *Ostrea soleniscus* Meek, from horizon of sandstone lentil in Hilliard formation north of Hams Fork, southwest corner sec. 33, T. 23 N., R. 116 W.

2. *Inoceramus umbonatus* Meek and Hayden, from 2 miles southwest of Altamont.

FOSSILS FROM HILLIARD FORMATION.