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GEOLOGY OF BIG HORN COUNTY AND THE CROW INDIAN RESERVATION MONTANA

WITH SPECIAL REFERENCE TO THE WATER COAL, OIL, AND GAS RESOURCES

BY

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By W. T. Thom, Jr., G. M. Hall, C. H. Wegemann, and G. F. Moulton

ABSTRACT

Big Horn County lies in south-central Montana along the southern boundary of the State. Its area is 4,966 square miles, of which more than 3,000 square miles is in the Crow Indian Reservation and about 300 square miles in the Tongue River Indian Reservation. Its population in 1930 was 8,543. The Crow Indian Reservation lies chiefly in Big Horn County but partly in Yellowstone County.

The most famous event in the history of Big Horn County was the battle with the Indians on June 25, 1876, in which Gen. George A. Custer and his entire command were killed. The site of this battle, a few miles southeast of the Crow Agency, is now marked by the Custer Battlefield National Cemetery.

Big Horn County includes in its southwestern part the Big Horn and Pryor Mountains of the Rocky Mountain province. The remainder of the county is considered a part of the Great Plains province. The Big Horn and Pryor Mountains are parts of a single mountain mass, cut by Big Horn Canyon. They are bordered by "hogbacks" that rise abruptly from the plains. In the plains, where the relief rarely exceeds 600 feet except in the vicinity of the area known as the Rosebud Mountains, the topography is dependent upon the underlying rocks; the shales give rise to broad flats, which are separated by "rim rocks", and the more resistant sandstones form steep slopes.

The streams are all tributary either directly or indirectly to the Yellowstone River. The largest are the Big Horn, Little Horn, and Tongue Rivers and Pryor and Rosebud Creeks. Many of the smaller streams are intermittent.

The industries of the area are stock raising and farming. Areas amounting to many thousand acres are irrigated, and the most valuable crops are alfalfa, wheat, and sugar beets. On the uplands dry-farming methods are used, and wheat and other crops are raised.

The area is underlain by a series of sedimentary formations which probably rest everywhere upon pre-Cambrian granite, such as is exposed in the Big Horn Mountains in Wyoming. The exposed rocks range in age from early Paleozoic to very recent. The Paleozoic formations are exposed in the Big Horn and Pryor Mountains and in a few uplifts in their immediate vicinity; the Mesozoic and Tertiary rocks are at the surface over most of the other parts of the area. Deposits of gravel, sand, and silt lie in steplike terraces at five levels. The highest terrace is probably equivalent to the Oligocene of the Cypress Hills of Canada; the lowest may be of early or middle Pleistocene age (pre-Iowan).

The major structural features of the region are the Big Horn and Pryor Mountains, which are outliers of the Rocky Mountains. They are great uplifts from which the stratified formations dip in all directions. Surrounding the mountains is a narrow belt of foothills, or "hogbacks", in which the beds are generally tilted 45° to 90°. At relatively short distances from the hogbacks, both in the mountains and in the plains, the beds lie nearly horizontal. Some faults are visible in this area, but they are not so large or numerous as the faults in the southern part of the Big Horn Mountain uplift in Wyoming. The largest one is the Castle Butte fault, which has a linear extent of about 14 miles and a maximum throw of about 2,000 feet. The mountains are supposed to be the result of forces acting vertically, slightly modified by tangential compressive forces. The folds and faults suggest that the rocks have been bent and lifted by the rotation and elevation of the granitic basement. Numerous minor structural features are developed in the plains, apparently by the same forces that caused the main uplifts, but some of the relations are rather obscure.

Large deposits of coal of Cretaceous and Tertiary age exist in the eastern part of the area. The thickest coals are in the Fort Union formation, of Tertiary age. About 25 coal beds have been found, and their stratigraphic position has been approximately determined. These coals are subbituminous with a conchoidal fracture and slack rapidly on exposure to the atmosphere. There are no large-scale coal-mining operations in the area, but a few small mines are in operation and supply a part of the local requirements.

Some natural gas was yielded by wells drilled in 1915 north and west of Hardin, and oil was discovered in the Soap Creek field in February 1921. The gas near Hardin comes from thin sandstone and sandy shale that are probably in the Frontier formation. The oil of the Soap Creek field comes from the Amsden formation and the top of the Madison limestone. Neither the Hardin gas field nor the Soap Creek oil field has been commercially successful. Numerous holes drilled from 1920 to 1925 at other localities in the area were dry.

The ground-water supply available in Big Horn County is closely related in its quantity and quality to the geology. The shales usually yield meager supplies of poor water. The sandstones generally yield somewhat larger and better supplies. The limestones, which are found in the older formations, contain numerous water-bearing solution channels and yield large supplies of water. The alluvium in the stream valleys and the terrace deposits usually yield large supplies of rather highly mineralized water. In places these deposits are finer grained and yield less water. In the Wasatch, Fort Union, and Lance formations the sandstones and coal beds usually yield supplies of water adequate for domestic purposes, but the shales commonly yield much less. Most wells drilled in the Bearpaw shale and Claggett formation are failures. The Parkman sandstone is the best water-bearing formation in the Montana group, and wells in this formation are generally successful. The Eagle sandstone and the Telegraph Creek formation do not yield much water in this area, and much of the water from these formations is highly mineralized. Wells in the Colorado group are usually failures. The pre-Colorado formations are exposed in a thinly settled area where data on water wells are generally lacking; however, wells drilled for oil penetrated these older formations to and including the Madison limestone. The Cloverly formation contains a basal conglomeratic sandstone which yields large volumes of water, but in some places the water contains traces of natural gas. The Morrison formation is a poor waterbearer, except in the Soap Creek field, where it has yielded some water. The Sundance formation is an excellent water-bearing formation. The Chugwater formation yields meager supplies of very highly mineralized water. The Tensleep sandstone, the Amsden formation, and the Madison limestone have yielded some large flows of water to wells drilled in search of oil.

Artesian pressure is evident in nearly all wells drilled in this area except those ending in the alluvium and the terrace deposits. The wells drilled into the older formations have the higher pressures, and many of them overflow. The flowing wells are usually in the stream valleys and not on the uplands. The largest flowing wells in the area are in the valleys of Beauvais and Soap Creeks.

INTRODUCTION

SCOPE AND PURPOSE OF THE REPORT

This report contains information concerning the geology of Big Horn County and the Crow Indian Reservation and their resources in ground water, coal, oil, and gas. These facts were collected in the course of studies for about a dozen field projects, which ranged in character from reconnaissance studies of large areas to very detailed mapping of certain tracts to show the occurrence of oil and gas. Consequently, the information at hand, either as to the geology or the resources, is not equally complete and definite for all parts.

LOCATION AND GEOGRAPHIC RELATIONS OF THE AREA

The area described lies in southern Montana, on the western edge of the Great Plains. Big Horn County includes all but a small part of the Crow Indian Reservation and about two-fifths of the Tongue River Indian Reservation. The relative extent and geographic position are shown by figure 1 and plate 1. The names of the coal fields designated by numbers on figure 1 and references to the Geological Survey publications in which they have been described are as follows:

Coal fields whose locations are shown in figure 1

No.	Field	Bulletin	No.	Field	Bulletin
1	Marmarth	775.	15	Glendive	471-D.
2	Washburn	381-A.	16	Terry	471-D.
3	New Salem	726-A.	17	Baker	471-D.
4	Cannonball River	541-G.	18	Ekalaka	751-F.
5	Standing Rock and Cheyenne River.	575.	19	Little Sheep Mountain	531-F.
			20	Miles City	341-A.
6	Fort Berthold	381-A and 471-C.	21	Forsyth	812-A.
			22	Tullock Creek	749.
7	do	726-D.	23	Bull Mountain	647.
8	Williston	531-E.	24	Sheridan	341-B.
9	Sentinel Butte	341-A.	25	Powder River	381-B.
10	Northwestern South Dakota	627.	26	Little Powder River	471-A.
11	Culbertson	471-D.	27	Northward extension of Sheridan coal field.	806-B.
12	Scobey	751-E.			
13	Fort Peck	381-A.	28	Gillette	796-A.
14	Sidney	471-D.	29	Ashland	831-B.

The Crow Indian Reservation lies just north of the Montana-Wyoming State line and extends from the 107th meridian west nearly to the 109th, including 112 townships or parts of townships within Tps. 1 to 9 S., Rs. 25 to 38 E. Some of the northwestern townships of the Crow Indian Reservation lie beyond the limits of Big Horn County, in Yellowstone County; on the other hand, Big Horn County and the Tongue River Indian Reservation extend considerable distances north and east beyond the Crow Reservation. (See pl. 1.)

The area of Big Horn County is 4,966 square miles, of which more than 3,000 square miles is in the Crow Indian Reservation and about

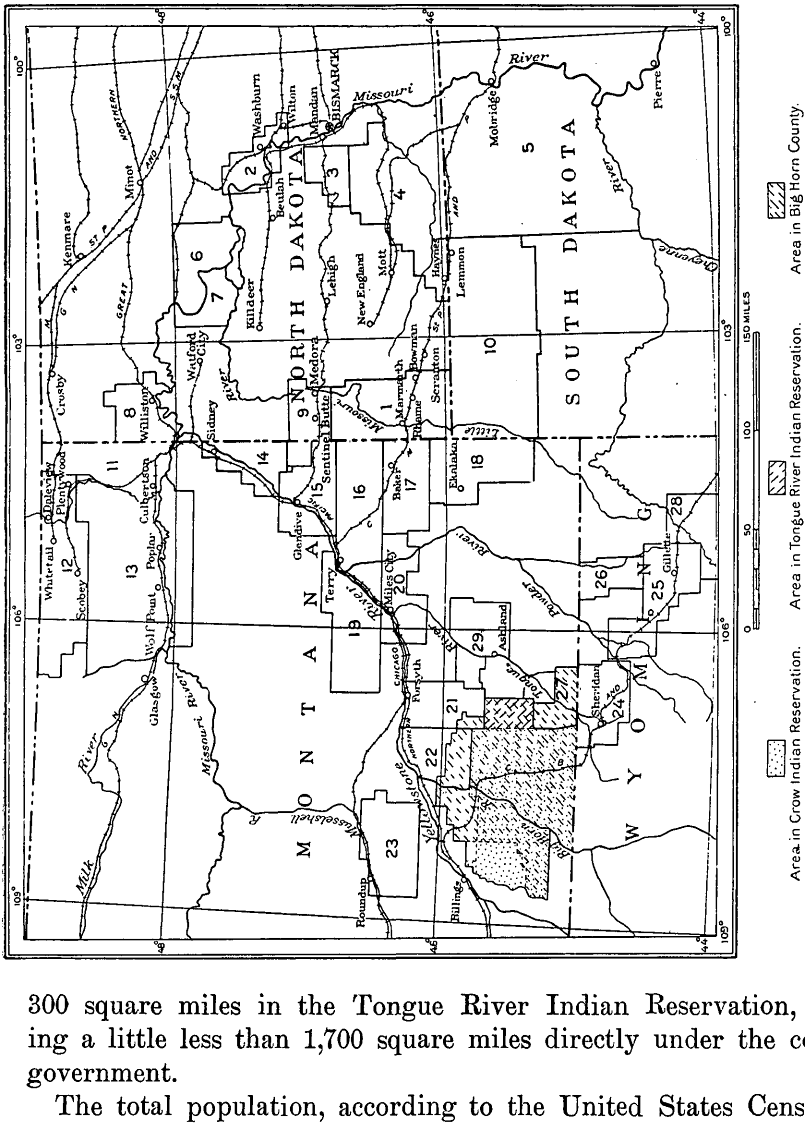

FIGURE 1.—Index map showing the location of Big Horn County and the Crow Indian Reservation, Mont., and their relation to other coal fields in eastern Montana and adjacent States. (See text.)

300 square miles in the Tongue River Indian Reservation, leaving a little less than 1,700 square miles directly under the county government.

The total population, according to the United States Census of 1930, is 8,543, of whom 1,169 live in Hardin, the county seat and the only incorporated town in Big Horn County. The area is thinly settled, having only 1.7 persons to the square mile, whereas the State of Montana as a whole has 3.7 to the square mile, and the entire United States has 41.3. The uplands are almost uninhabited, and the population is concentrated in the towns and along the major streams.

HISTORY OF THE REGION

The history of this region is part of the stirring story of the winning of the West. The first white men to visit southeastern Montana were the Vérendryes, Chevalier François and Louis Joseph, sons of Pierre Gaultier de la Varennes, Sieur de la Vérendrye, who were seeking a route to the Pacific. In April 1742 they left Fort La Reine, where Portage la Prairie, Manitoba, now is, and followed the Mouse River past the site of the present town of Verendrye, N.Dak., to the Missouri. The rest of their route is not definitely known. They may have followed the Missouri as far as Great Falls. Some authorities believe they kept on the bench between the Little Missouri and the Yellowstone, eventually reaching a point near the Little Horn River. They reached "the mountains" in January 1743 but were soon forced to turn back on account of tribal warfare among the Indians. The French made several other unsuccessful attempts to find a route to the Pacific through what is now the northern United States, but this passage left little impression on the country.

In 1763 France relinquished Canada to England but retained the part of Louisiana lying west of the Mississippi River between Mexico and Canada. This area passed from France to Spain and back again to France, but neither the French nor the Spanish made any determined efforts to penetrate far beyond the Mississippi in the northern part of the area. Between 1783 and 1803 both England and the United States made ineffectual attempts to explore this vast wilderness; several expeditions were organized, but none succeeded in penetrating as far as southeastern Montana.

In 1803, after Louisiana had been purchased from France by the United States, President Jefferson planned an expedition to explore the newly acquired territory. He placed in command Meriwether Lewis, who had been his private secretary, and William Clark, and they organized the expedition which is known by their names. The party left St. Louis in May 1804, ascended the Missouri River, and spent the winter of 1804–5 in the Mandan Indian village near the present Mandan, N.Dak. The following spring they continued up the Missouri, crossed the Continental Divide, and descended the Columbia River to the Pacific Ocean. After spending the winter of 1805–6 at the mouth of the Columbia, they returned by practically the same route as far as Three Forks, where the party divided. Captain Lewis continued down the Missouri. Captain Clark crossed overland to the Yellowstone; he named the Big Horn River and

Pryor Creek, the latter in honor of Sergeant Pryor, of the expedition. The parties of Lewis and Clark were reunited below the mouth of the Yellowstone, whence they proceeded down the Missouri and arrived at St. Louis in September 1806.

Although the Lewis and Clark expedition did almost no exploratory work except along the watercourses and did not explore what is now Big Horn County, they blazed a trail which was soon followed by numerous trading expeditions. The rivers continued to be the main arteries, but traders, trappers, and pioneers rapidly penetrated and explored the intervening areas.

From 1804 to 1806 Charles McKenzie and François Antoine Larocque, clerks in the employ of the Hudson Bay Co., made several trips into this part of Montana and explored the Big Horn and Yellowstone River Valleys and also the Big Horn Mountains to find out the trading possibilities of the region for their company.

In 1807 John Colter, who had been a member of the Lewis and Clark expedition, and Manuel Lisa, a famous trader, built Fort Lisa, at the mouth of the Big Horn River. Fort Lisa was abandoned after a few years of use. In 1832 Fort Cass was built on the Big Horn, but it also was soon abandoned. Other forts were built as trading posts along the Yellowstone from the Big Horn to the Rosebud, but none in what is now Big Horn County. In 1855 the last of these was abandoned, and trade with the Indians was centered around the forts at the junction of the Yellowstone and Missouri Rivers.

A reservation was set aside for the Crow Indians in 1851. The origin of these Indians, like that of some other tribes, is uncertain. They were in southeastern Montana as early as 1743, as the Vérendryes refer to them as the Beaux Hommes (handsome men). McKenzie and Larocque spent considerable time with them and give an excellent account of many of their customs. They ranged over much of Montana south of the Missouri and east of the mountains and over part of northern Wyoming.

The old Bozeman Emigrant Trail passed through the Crow Indian Reservation along a route roughly parallel to the Big Horn Mountains, crossed the Big Horn River at the site of Fort C. F. Smith, and thence went westward to the Clark Fork Valley, where it turned north. This famous trail was laid out by J. M. Bozeman and J. M. Jacobs as a short cut for emigrants from the Platte to the Missouri. In 1864 Bozeman led his first wagon over this route. Fort Reno, Fort Phil Kearny, and Fort C. F. Smith were built by the Government to protect this trail, but in 1866, after a massacre at Fort Phil Kearny and severe fighting at Fort C. F. Smith, the forts were abandoned and the road closed. During the few years this trail was in use many miners and settlers passed over it.

From 1850 to 1876 the Indians were in a belligerent mood, and many whites were killed in the Yellowstone Valley. This period, which was filled with raids, skirmishes, and battles, ended with the battle of June 25, 1876, on the Little Horn River, just south of the present site of Crow Agency, in which Gen. George A. Custer and five troops of the 7th Cavalry were killed after a gallant fight with Indians who outnumbered them. The Government took vigorous steps to prevent any repetition of this disaster, and after several brief but effective campaigns the region quieted down. Fort Custer was built on the high ground at the junction of the Big Horn and Little Horn rivers, and a strong garrison was maintained there for many years. The post was finally abandoned and the military reservation relinquished to the Interior Department April 23, 1902. Today there are few traces of this fort. The site of the Custer massacre is marked by the Custer Battlefield National Cemetery, in which memorials have been erected to those who fell.

During the last quarter of the nineteenth century the Crow Indian Reservation developed slowly. The stock industry flourished, and several ranches were established. In the early years of the present century agriculture became more important and greater efforts were made to irrigate the river bottoms. Later dry farming was undertaken, with great success at first, but many enterprises have failed.

In 1913 Big Horn County was organized from parts of Rosebud and Yellowstone counties, and Hardin was made the county seat.

LEGAL STATUS OF THE LAND

The Crow Indian Reservation, as originally defined by treaty with the Crow Indians, concluded and ratified by Congress in 1868,[1] consisted of the roughly triangular area lying between the 107th meridian, the south boundary of Montana, and the Yellowstone River. By a subsequent treaty this area was considerably enlarged, but by still later treaties it has been successively reduced, principally on the south and west. In 1899 an agreement with the Indians was reached for the cession of the northern part of the reservation to the Government in consideration of an expenditure of $1,150,000 on irrigation projects, stock, fences, and schools for the Indians. This agreement was ratified by act of Congress April 27, 1904, and in October 1910, in accordance with this act, a part of the ceded land was thrown open for sale. The remainder, which comprised parts of Tps. 1 S. and 1 to 5 N., R. 36 E., and Tps. 1 S. and 1 to 4 N., Rs. 37 and 38 E., had previously been withdrawn from entry as possible coal land and reserved for special examination.

[1] U.S.Stat.L., vol. 15, p. 649.

On July 13, 1912, on the recommendation of the United States Geological Survey, parts of Tps. 1 to 4 N., Rs. 34 and 35 E., not yet sold, were ordered withheld from sale until they could be examined for coal. During the summer of 1912 a party in charge of G. S. Rogers examined this land and classified it as to its mineral character. In October of the same year a sale of the noncoal land classified during the summer, together with the lands not formally withdrawn or previously sold, was ordered. During 1913 the lands affected by the formal withdrawal were examined, so that all the ceded portion of the Crow Reservation has been definitely classified either as coal land or noncoal land, surface rights being separated from coal rights in the tracts officially classified as coal land.

By virtue of allotments in severalty, part of the lands included within the present Crow Indian Reservation are held in fee simple by members of the Crow tribe and therefore are subject to Federal and local laws relating to real estate. The title to other allotted tracts is held in trust by the United States Government for a period of years following the allotment, the trust period being subject to extension by order of the President. Patents in fee simple covering these trust lands may be issued to the allottee upon application and showing that he is capable of managing his own affairs, or to a white purchaser of the land through sale under supervision of the Secretary of the Interior, or through allowing the trust period to expire. However, a large part of the area of the Crow Reservation yet consists of unallotted tribal lands which have been reserved for the benefit of the tribe as a whole. Leases or permits for the utilization or exploitation of these tribal lands or of their mineral resources are usually submitted to the Crow tribal council for approval before being formally approved by the Interior Department. Another area of 300 square miles in eastern Big Horn County lies within the Tongue River Indian Reservation and accordingly is also subject to special restrictions. In the southeastern and extreme northeastern parts of the county the lands are or have been parts of the public domain, and titles thereto are consequently governed by the United States public land laws.

FIELD WORK

COAL, OIL, AND GAS

During the years 1901 to 1905 Darton's studies of the Big Horn Mountains [2] covered a considerable portion of the county and reservation, and in 1912 and 1913 Rogers and Lee [3] examined areas within

[2] Darton, N. H., Geology of the Big Horn Mountains: U.S. Geol. Survey Prof. Paper 51, 1906.

[3] Rogers, G. S., Geology and coal resources of the area southwest of Custer, Yellowstone, and Big Horn Counties, Mont.: U.S. Geol. Survey Bull. 541, pp. 316–328, 1914. Rogers, G. S., and Lee, Wallace, The Tullock Creek coal field, Mont.: U.S. Geol. Survey Bull. 749, 1923.

and adjacent to the northeastern part of the county. In 1916 Wegemann, assisted by C. K. Wentworth and for a time by Thom, made a reconnaissance examination of the oil and gas possibilities of the reservation, while R. W. Howell, working under Wegemann's general supervision, made a general determination of the extent of the coal lands in the reservation. In 1917 further work was done on determining the coal resources of the reservation by A. J. Collier and Wentworth, and a small area in the northwestern part of Big Horn County was mapped by Hancock [4] and Dobbin during their examination of the Huntley field. In 1920 Thom and Dobbin [5] made a reconnaissance examination extending into the eastern part of Big Horn County.

In 1921 the discovery of oil within the reservation led to further detailed structural study of promising areas by Thom,[6] assisted by Moulton and N. W. Bass; and in 1922 Thom, assisted by W. W. Rubey, made further reconnaissance examinations and local detailed studies in the western part of the reservation, with the cooperation of R. S. Knappen and Moulton, who were working just west of the reservation.

In 1923 Dobbin's mapping in the Forsyth coal field [7] included a few square miles in the northeastern part of Big Horn County; Bass [8] mapped a strip of land along the valley of the Tongue River; and Thom made a reconnaissance of the area lying in the Rosebud Creek Valley, east of the Crow Indian Reservation.

In 1924 and 1925 Baker [9] made a detailed study of the coal resources of the southeastern part of Big Horn County, and in 1929 Thom did further reconnaissance mapping of parts of the county and of the Crow Indian Reservation as a preliminary to the preparation of this report.

GROUND WATER

In 1915 and 1916 a reconnaissance of the ground-water conditions in the part of Montana lying south of the Yellowstone River was made by the late Arthur J. Ellis, of the United States Geologi-

[4] Hancock, E. T., Geology and oil and gas prospects of the Huntley field, Mont.: U.S. Geol. Survey Bull. 711, pp. 105–148, 1920.

[5] Thom, W. T., Jr., and Dobbin, C. E., Oil possibilities in southeastern Montana: U.S. Geol. Survey Press Notice, 1920.

[6] Thom, W. T., Jr., and Moulton, G. F., The Soap Creek oil field, Crow Indian Reservation, Mont.: U.S. Geol. Survey Press Mem., Dec. 5, 1921. Thom, W. T., Jr., Oil and gas prospects in and near the Crow Indian Reservation, Mont.: U.S. Geol. Survey Bull. 736, pp. 35–53, 1923.

[7] Dobbin, C. E., The Rosebud coal bed south of Forsyth, Mont.: U.S. Geol. Survey Press Mem. 16925, Mar. 21, 1924; The Forsyth coal field, Rosebud, Treasure, and Big Horn Counties, Mont.: U.S. Geol. Survey Bull. 812, pp. 1–55, 1930.

[8] Bass, N. W., Coal in Tongue River Valley, Mont.: U.S. Geol. Survey Press Mem. 16748, Feb. 12, 1924; The Ashland coal field, Rosebud, Powder River, and Custer Counties, Mont.: U.S. Geol. Survey Bull. 831, pp. 19–105, 1932.

[9] Baker, A. A., The northward extension of the Sheridan coal field, Big Horn and Rosebud Counties, Mont.: U.S. Geol. Survey Bull. 806, pp. 15–67, 1929.

cal Survey, working in cooperation with the State. The chemical analyses were made in the laboratory of the Montana State College and the State Board of Health, at Bozeman, under the supervision of W. M. Cobleigh, director of the laboratory, and the records of some of the wells were collected through correspondence by A. W. Mahon, State engineer. As a result of this reconnaissance it became possible for the Geological Survey to give advice to many of the residents of this section of the State in regard to obtaining water supplies by drilling wells.

In subsequent years somewhat more detailed work was done in several counties in this region by Ellis,[10] Renick,[11] and others, and the results have in part been published as water-supply papers covering specific counties. In 1921 Yellowstone, Treasure, and Big Horn Counties were covered by George M. Hall; the report on the ground waters of Yellowstone and Treasure Counties has been published,[12] and the report on Big Horn County is presented in this bulletin. (See fig. 2.) A report on Fergus County is in preparation.

Samples of water from wells and springs were collected by Ellis and by Hall. Those collected by Ellis were analyzed under the direction of Dr. Cobleigh, as already noted; those collected by Hall were analyzed in the water-resources laboratory of the Geological Survey, in Washington, by C. S. Howard.

ACKNOWLEDGMENTS

The writers wish to express their appreciation of the courtesies received during the progress of their work from representatives of the Indian Service and from officials of Big Horn County. For maps, well records, and items of information which have been of great assistance in the work done they are greatly indebted also to representatives of the Northern Pacific Railway, the Western States Oil & Land Co., Dox Oil Co., Rice & Hoffman, Eder & LaDow, Producers & Refiners Corporation, Mid-Northern Oil Co., California Co., Maxwell Syndicate, Big Horn Oil & Gas Development Co., Inc., and others operating within the Crow Indian Reservation. Many residents of the county and reservation likewise were most courteous and helpful and have contributed in many material ways to the success of the field work. The writers also wish to record their indebtedness to N. H. Darton, E. T. Hancock, G. S. Rogers, Wallace Lee, C. E. Dobbin, and A. A. Baker for information taken from their

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[10] Ellis, A. J., and Meinzer, O. E., Ground water in Musselshell and Golden Valley Counties, Mont.: U.S. Geol. Survey Water-Supply Paper 518, 1924.

[11] Renick, B. C., Geology and ground-water resources of central and southern Rosebud County, Mont., with chemical analyses of the waters by H. B. Riffenburg: U.S. Geol. Survey Water-Supply Paper 600, 1929.

[12] Hall, G. M., and Howard, C. S., Ground water in Yellowstone and Treasure Counties, Mont.: U.S. Geol. Survey Water-Supply Paper 599, 1929.

published reports and to R. W. Howell, A. J. Collier, C. K. Wentworth, N. W. Bass, W. W. Rubey, Frank G. Evans, Jr., Howard

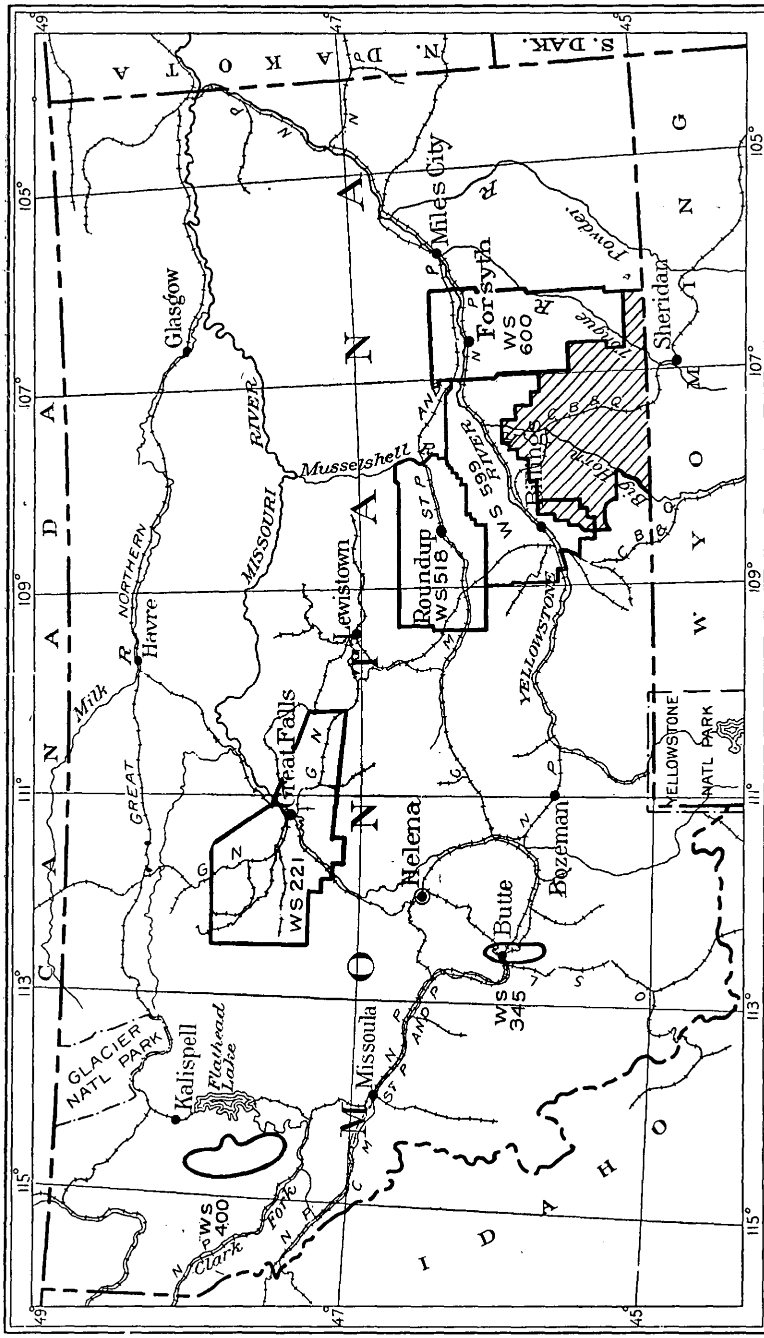

FIGURE 2.—Index map of Montana showing areas considered in this report (shaded) and other reports of the United States Geological Survey relating to ground water. WS, Water-supply paper.

Clark, Allan Brooke, and Homer Renner, all of whom participated in the mapping of one or more parts of the reservation.

GEOGRAPHY

SURFACE FEATURES AND RELIEF

Big Horn County lies partly in the Middle Rocky Mountains but mostly in the Great Plains province, as these provinces are defined by Fenneman.[13] It includes high mountains, rugged though less lofty divides, and extensive areas of relatively level bench and bottom lands. The general nature and distribution of these surface types within a large part of the area described are indicated by the topographic maps of the Huntley, Fort Custer, St. Xavier, and Rosebud quadrangles, published by the United States Geological Survey. The major differences of relief are due largely to the superior hardness of the granite, dolomite, and limestone that compose the mountain masses as compared with the more easily eroded sandstones and shales of the lowland areas, but to some extent these differences are due also to the relative amount of deformation undergone by the strata. The Big Horn and Pryor Mountains, in the southwestern part of the area, are great northwestward-trending anticlinal folds, which terminate somewhat abruptly at their north ends. The gravel-capped plateau known as Pine Ridge, in the northern part of Big Horn County west of the Big Horn River, and the Rosebud Mountains, which form the high divide east of the Big Horn River drainage basin, are erosional remnants that owe their preservation mainly to protective cappings of sandstone, gravel, or "clinker" (a natural brick that occurs extensively in the eastern part of the area as a result of the spontaneous burning of coal beds beneath areas of thin cover).

Surface altitudes within the area here described range from about 2,750 feet above sea level in the Big Horn Valley near Hardin to 4,100 feet on Pine Ridge, 5,600 feet in the Rosebud Mountains, more than 8,000 feet in the Pryor Mountains, and about 9,250 feet in the Big Horn Mountains. The total relief is therefore about 6,500 feet. The relief of the mountains is accentuated by their abrupt rise to a height of more than 5,000 feet above the general level of the plains. The plains themselves, though mostly less than 4,000 feet above sea level, are by no means all flat; smooth, nearly flat tracts are not uncommon in the interstream areas, but the relief in some parts is 500 to 600 feet.

Terrace surfaces are conspicuous features; they are due in part to erosional planation but have been produced chiefly by the deposition of sand, gravel, and boulders on such planed surfaces along the courses of former streams issuing from the mountains. Extensive

[13] Fenneman, N. M., Physiographic divisions of the United States: Assoc. Am. Geographers Annals, vol. 18, p. 276, 1928.

remnants of these old alluvial fans and former flood plains now descend in steplike fashion to the alluvium of the present Big Horn and Yellowstone Valley bottoms.

BIG HORN AND PRYOR MOUNTAINS

The Big Horn Mountains and the Pryor Mountains are structurally a unit but are separated by Big Horn Canyon. Both derive their names from the streams named by members of the Lewis and Clark expedition. Their area in Big Horn County, Mont., is about 500 square miles, or about one-tenth of the total area of the county.

By far the greater part of the Big Horn Mountains, including their loftiest peaks, is in Wyoming; the highest point is Cloud Peak, 13,165 feet above sea level, and the general level of the higher part of the range is about 10,000 feet. In Montana the altitude does not exceed 9,250 feet, and much of the rugged grandeur of the southern part of the range is lacking; the mountains in this area are more gentle and rounded but are furrowed with steep-walled canyons.

The Pryor Mountains are entirely within Montana, about three-fifths in Big Horn County and two-fifths in Carbon County. They are somewhat lower and less rugged than the Big Horn Mountains. Their tops range in altitude from 7,000 to more than 8,000 feet above sea level, with one summit that reaches 8,800 feet. They lack the sharp peaks of the Big Horn Mountains and present a much more rounded appearance.

Of the large number of very beautiful canyons in or near the Big Horn Mountains, three deserve special mention—Big Horn, Black, and Little Horn Canyons.

Big Horn Canyon is the largest. This canyon is more than 1,000 feet deep. The shales and limestones form steep slopes at the bottom and are surmounted by almost vertical walls of massive limestone, which in many places is capped with massive sandstone. The river fills the bottom completely and does not leave sufficient space on either side at water level for even a footpath. However, in recent years a pack trail has been cut in the side walls. The depth of the canyon is but a fraction of the total depth to which the river has cut below the general level of the upland surface. The amount of material removed must have been enormous. This deep, narrow notch with the river flowing through it is an impressive sight and is visited by an increasing number of tourists each year.

Black Canyon is tributary to Big Horn Canyon. It is 1,200 to 1,500 feet deep, although popularly described as 2,000 feet deep, The view into this canyon gives an impression of darkness and mystery that may account for its name. Black Canyon is deeper and narrower than Big Horn Canyon, and Canyon Creek, which flows in the bottom, is a small, inconspicuous stream compared with the Big Horn River. This canyon is so disproportionately deep in relation to the size of the present stream that it seems probable that at least part of the cutting was done during an earlier period when the supply of water was greater and the volume of the stream larger.

Little Horn Canyon is a deep canyon with brilliantly colored walls that rise 1,200 to 2,000 feet above the canyon floor; its more picturesque parts are in Wyoming. During recent years this canyon has become very popular, especially with fishing parties.

The Pryor Mountains also are cut by numerous steep-walled canyons. Of these Pryor Gap is of particular interest, inasmuch as it is the only low-grade pass through these mountains and was formerly used by a railroad. Pryor Gap is a "wind gap" without a permanent stream. Sage Creek, which rises in the mountains, flows past its southwest end and Pryor Creek past its north end, but the stream that cut the deep and relatively wide gap has vanished. Alden[14] suggests that the canyon may have been cut by the Clark Fork of the Yellowstone River when that river flowed at a higher level and on a course farther east than its present one. (See also p. 67.) This canyon, or gap, has lofty castellated walls that rise 1,000 feet or more above its bottom. The road through it is at present rough but affords easy access to tourists, particularly those on the way from Billings to Cody.

Parts of the upland on both ranges are smoothly rolling with sparse forests and open parks that are used for summer pasture for thousands of head of stock. These are evidently old erosion surfaces produced during an earlier cycle of erosion. A few peaks rise above these uplands from a few hundred feet to as much as 3,000 feet.

The Big Horn and Pryor Mountains are parts of one large anticlinal arch. The structure is relatively simple, and faulting has produced greater complications than folding. The steeper dip of the folds alternates from one side to the other, and in many places the surface slope of the mountains is formed by the dip slope of the rocks. Crustal deformation is greater in the Big Horn Mountains, and erosion there has cut through the sedimentary formations into the granite; in the Pryor Mountains the igneous complex has not yet been uncovered.

Hogbacks—long, narrow ridges that parallel the mountains—mark the transition from the plains. They are named from their fancied resemblance to the razorback hog and are formed by tilted hard

[14]Alden, W. C., Physiographic development of the northern Great Plains: Geol. Soc. America Bull., vol. 35, p. 399, 1924.

layers that resist erosion while softer layers above and below are removed. Though in many places the hogbacks are only a few hundred feet high and are dwarfed by comparison with the mountains, they are a striking feature of the landscape. A typical hogback is shown in plate 2, *A*. Situated as they are at the foot of the mountains, it may be questioned whether they belong to the mountains or to the plains, but structurally they are part of the mountains. The traveler approaching the mountains is impressed by the abrupt change in the attitude of the beds from nearly flat to almost vertical, and especially by the short distance within which the change takes place—not uncommonly within a few yards.

The period of uplift of the Big Horn and Pryor Mountains is not definitely fixed. The folding is post-Cretaceous and may have reached its climax in middle or late Eocene time. There have been several subsequent uplifts, which apparently were not accompanied by folding, although there may have been some faulting. The high-level gravel in the mountains was deposited subsequent to the initial uplift, probably in Oligocene or Miocene time, and a long period must have been necessary in which to erode so much rock. Later uplift renewed the streams that began cutting the present canyons. In some parts the upland surfaces of the mountains have not been deeply eroded since the original beveling, but elsewhere, especially near the flanks, the mountains have been deeply trenched and scored.

As in other high ranges of the Rocky Mountains, the upper slopes of the Big Horn Mountains were occupied by glaciers, which moved down the valleys and left moraines.[15] The Montana part of the range, however, was too low for the accumulation of sufficient ice to form glaciers, and the striking glacial phenomena so prominent farther south are lacking in Big Horn County.

ROSEBUD MOUNTAINS[16]

The Rosebud Mountains comprise a series of exceedingly rugged pine-covered hills east of the Little Horn River. They form the divide between the Big Horn River drainage basin and that of Rosebud Creek and the Tongue River. These mountains start practically at the Montana-Wyoming boundary and extend northward across

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[15] Darton, N. H., Geology of the Big Horn Mountains: U.S. Geol. Survey Prof. Paper 51, pp. 71–90, 1906.

[16] According to the official map of Big Horn County, compiled in the office of the county surveyor in 1920, the name "Rosebud Mountains" is applied to all of the range that begins near the Montana-Wyoming boundary and runs north for about 35 miles. Earlier usage varied. On the Geological Survey map of the Rosebud quadrangle, the survey for which was made in 1892, the south end of the present Rosebud Mountains was called "Wolf Mountains", but another range that begins in the northeastern part of Big Horn County and continues into Rosebud and Treasure Counties is called "Wolf Mountains" on some maps. The name as given on the Big Horn County map and as used in this report is believed to reflect the best current local usage.

Big Horn County into Treasure County. Compared with their lofty neighbors, the Big Horn Mountains, they are insignificant and hardly deserve the name of mountains; but compared with other hills in the plains area they are considerable elevations, rising more than 2,000 feet above the valley of the Little Horn River and attaining a maximum altitude of 5,500 feet above sea level. They form a somewhat formidable barrier to east-west communication, and only a few wagon trails have been constructed across them. The steeper slopes face the west; those on the east are much gentler.

The Rosebud Mountains are composed of the same rocks that underlie so many square miles in the Great Plains and might be included in that province but for their ruggedness. Moreover, they are tree-covered, a condition that is not common in the plains.

These mountains are really the western scarp of the hard sandy beds in the Lance and Fort Union formations, which are the youngest formations exposed in the large syncline that forms so much of eastern Montana and lies between the Big Horn and Black Hills anticlines.

From the west the beds appear to be a series of regular horizontal layers, but they have a gentle dip to the east. These resistant beds have been removed over the axis of the Big Horn anticline, and the underlying softer beds have been so deeply eroded that the west limb of the syncline now stands in considerable relief.

The rocks of the mountains consist of alternating layers of sandstone and shale with a few beds of coal. The hard sandstones withstand erosion and form steep walls; the softer shales form slopes. Where steep cliffs of sandstone border open valleys or gentle slopes they are known locally as rim rocks. The hard sandstones have been reinforced by clinker beds which are also resistant. Many of the coal beds, particularly those in the Fort Union formation, have burned along the outcrop and partly fused the overlying beds of shale and sandstone. These fused beds, which are usually red, owing to ferric oxide, are known locally as clinker, slag, and lava. Not only are the clinker beds resistant to weathering, but they form conspicuous features of the mountain landscape. The bright bands, which are visible for miles, contrast with the yellow sandstones and drab shales and with the green of the pines that cover the slopes.

High-level terrace gravel is present in the northern part of the area (see p. 68), but in the Rosebud Mountains erosion has apparently cut below the old level at which this gravel was deposited and removed all traces of it. The nearly level tracts now found at several places in these mountains are apparently the result of the stripping of soft beds from the very gently dipping underlying harder beds.

The Lebo shale member of the Fort Union formation forms strike valleys parallel to the front of the Rosebud Mountains.

Considerable quantities of good coal are present in these mountains, but as most of it is in the Indian reservations and as there are well-developed mines only a few miles south, at Sheridan, little effort has been made to develop it. The mountains support a growth of pine trees, but they are usually small and not closely spaced and most of the lumber is of poor quality. The logs are most useful for the construction of buildings on the treeless plains. At present there are some dry farms in these mountains, but as in some other areas in Montana dry farming has not been entirely successful and many farms have been abandoned. The greater part of the arable land open to settlement has been taken up. In the past these mountains have been used by the cattle ranches for stock grazing. The grass is excellent and the rim rocks and timber furnish excellent shelter in times of severe weather.

PLAINS

The plains comprise the largest part of the county. The relief is generally moderate, particularly in the northern part, but increases toward the mountains. In the northern part the relief rarely exceeds 500 feet, though Pine Ridge, northwest of Hardin, which rises 1,000 feet above the Big Horn River, is a striking exception; in the southern part the relief may be 1,000 feet or more. The rocks that crop out in the plains are almost exclusively sandstones and shales. The beds appear horizontal in many places but have gentle northerly dips, interrupted here and there by minor folds and faults. The topography depends largely upon the underlying rock. The shale weathers readily and is removed rapidly compared with the more resistant sandstone. The shale, where thick, gives rise to broad, gently rolling flats, which are separated from one another by rim rocks of sandstone. Where the sandstones are less resistant they weather to steep slopes instead of cliffs. In some areas where the alternating beds of sandstone and shale are relatively thin, the country is rugged, with numerous steep slopes covered with scrub pine.

The youngest beds cropping out in the plains over large areas are those of the Fort Union and Wasatch formations, and the sedimentary record of the plains ceases with these beds. Younger Tertiary (?) deposits of gravel are to be found on parts of the upland, and Quaternary alluvium occurs in the valleys of all the larger streams. The gravel deposits are described on pages 66–69. Throughout most of the region the gravel terraces have been cut away, and many of the broad, nearly flat surfaces are simply the result of the erosion of overlying soft beds from a flat-lying harder bed rather than to widespread baseleveling.

The plains are dissected by the branches of the master streams. The streams, in general, have narrower and deeper valleys in the hard rock than in the shale; however, under the semiarid conditions of this part of the area, the streams cut sharp valleys or boxlike canyons even in the shales.

RIVER VALLEYS

Although only the main streams of Big Horn County are perennial, the volume of water carried at certain times in the year is large, and its erosive power is considerable.

Most of the stream valleys are cut deep below the general level of the country. In the mountains the Big Horn and Little Horn Rivers have cut narrow canyons more than 1,000 feet deep. In the plains the width and depth of the valleys differ with the kind of rock. Valleys in shale are wider than those in sandstone, but nearly all have flat bottoms with strips of alluvium and sides that rise steeply to the level of the surrounding upland.

TERRACES

In Big Horn County large, nearly flat areas are covered with gravel that ranges in size from cobbles 6 inches or more in greatest dimension to small pebbles and in some places to fine sand. The distribution of these terraces is shown on plate 3. Such gravel is found at various altitudes from the present stream bottoms to the tops of high hills. The tops of the Rosebud Mountains and the peaks of the Big Horn Mountains are not gravel-covered, but the top of Pine Ridge is. Terraces are conspicuously developed along the Big Horn River, where they are locally called benches. The term "bench" is also used locally to describe a nearly flat area resulting from the erosion of soft shale from a nearly horizontal harder and more resistant underlying bed. The gravelly terraces, or benches, bevel the tilted shale and sandstone beds without respect to difference in hardness. The depth of the gravel cover ranges from a few inches to 35 or 40 feet; in places it is more than 50 feet, but usually it is less than 25 feet.

The terraces owe their preservation at the present levels to the fact that a surface covered by gravel resists erosion, because water falling on it quickly percolates through the gravel and slowly drains out, either as springs or as seepage along the sides. Erosion is most active where a small stream is working headward in a terrace or a larger stream is undercutting the terrace by lateral planation. (Further description of the terraces is given on pp. 66–69.)

DRAINAGE

GENERAL FEATURES

The streams of Big Horn County are all tributary either directly or indirectly to the Yellowstone River. The central part of the county is drained by the Big Horn River and its tributaries, of which the Little Horn River is the largest; the western part is drained by Pryor Creek; the eastern part by Sarpy and Rosebud Creeks and the Tongue River; and several townships in the northern part by Fly Creek. All these streams have branches, some of which rise in the mountains and are perennial, but the great majority, irrespective of where they rise, are intermittent. The smaller branches are ephemeral and flow only while snow is melting or during and immediately after storms.

The Big Horn River is by far the largest of all these streams. It rises in the mountains of western Wyoming, far south of the Montana boundary, and flows in a general northerly direction across the county. Through the mountains it flows in a magnificent canyon, but after it leaves the older rocks and enters the plains, it has a much broader valley and a meandering path. (See pl. 2, *B*.) North of Hardin, where it leaves the rocks of the Colorado group and crosses those of the Montana group, its valley narrows again and becomes almost gorgelike where it crosses the Lance formation. Beyond this its bottom merges with the flood plain of the Yellowstone River, into which it flows in Yellowstone County. The width of the valley varies, ranging from a few hundred yards to more than 2 miles. It is widest where the river flows over Colorado shale, but even here it is distinctly cut below the general level, and there is everywhere an abrupt rise from the valley to the interstream uplands. This abruptness depends not only on the kind of rock over which the river is flowing but also on the nearness of the river to the scarp: in places, where the river is actively cutting, cliffs of soft shale rise almost vertically to heights of 100 feet or more. The bluffs at old Fort Custer are a good example. The river flows in general against the west side of its valley, with a broad strip of alluvium on the east side, as far as Two Legging Creek; from this point it flows on the east side and the wider strip of alluvium is on the west. This relation continues, with few exceptions, to the mouth of the river; one notable exception is the Old Horn Bottom, on the east side of the river east of Foster. Where the river flows over the Lance formation the strip of alluvium is much narrower.

The Big Horn River carries a large volume of water at all times, but in the spring and early summer, when it is generally in flood from the melting snow and ice, its flow is very large. At periods of flood the water is heavily laden with silt. The flow of this stream is maintained largely by the tributaries farther south, as the Little Horn River is the only perennial tributary in this county. Beauvais, Woody, and Two Legging Creeks are the largest intermittent tributaries from the west; Soap, Rotten Grass, and Tullock Creeks are the largest from the east. Three of these creeks, Beauvais, Soap, and Rotten Grass, rise in the mountains and in unusually wet summers flow throughout the year. There are numerous smaller intermittent streams. The Big Horn River furnishes large supplies of water for irrigation of the lowlands on its banks.

The Little Horn River rises in the Big Horn Mountains not far south of the State line and after flowing through a picturesque canyon, the walls of which rise in places nearly 2,000 feet, flows out on the plains. It joins the Big Horn River near the site of old Fort Custer, a little southeast of the town of Hardin. Its valley resembles that of the Big Horn in that it flows from a mountain canyon onto the plains in a relatively wide valley partly covered with alluvium, over the floor of which it meanders. The valley is somewhat narrower and consequently appears deeper than that of the Big Horn. Most of the course across the plains is over rocks of the Montana group. Pass and Lodgegrass Creeks are the only perennial branches, and neither of these carries a large volume of water as far as the Little Horn River except when in flood. Numerous intermittent streams that enter from the east and west carry large volumes of water during and immediately after storms.

Pryor Creek rises in the mountains of the same name and flows in a general northerly direction into the Yellowstone River. It has a large valley which may have been formed when the stream that cut Pryor Gap flowed through it on its way to the Yellowstone. This valley has considerable deposits of Quaternary alluvium in places as well as higher terrace gravel along its sides. The valley floor is several hundred feet below the general level of the interstream areas, and the rise is very abrupt. Pryor Creek always has a fairly strong flow, and in spring it carries large volumes of water derived from the melting of the snow in the mountains. It has several tributaries, some of which rise in the Pryor Mountains, but none are perennial. This creek is used to irrigate considerable areas, particularly in the vicinity of the village of Pryor, and some of its intermittent tributaries, which rise in the Pryor Mountains, are also used to irrigate small areas where they issue from the mountains.

Fly Creek, an intermittent stream that drains several townships in the northern part of the county, is directly tributary to the Yellowstone River. All the tributaries of Fly Creek rise in poorly watered regions, and none are perennial for any considerable distance.

Rosebud Creek drains part of the area east of the Rosebud Mountains through Big Horn and Rosebud Counties to the Yellowstone River. It flows in a relatively small valley with a narrow bottom, some of which is capable of cultivation, but the sides rise steeply to the general level of the bordering rugged upland. The Rosebud Mountains, in which this creek and its larger tributaries rise, are not lofty, and there is not sufficient precipitation and ground-water discharge to maintain a perennial stream across a plains region such as that intervening between the headwaters of the creek and the Yellowstone River. During the spring and early summer this creek carries a considerable volume of water, part of which is used for irrigation, but the flow decreases rapidly during the summer. There is generally a small flow in the part of the stream in Big Horn County, but the lower stretches are usually dry.

The Tongue River, which rises in the Big Horn Mountains in Wyoming, drains the extreme southeastern part of Big Horn County. This perennial stream, the branches of which are all intermittent, flows in a meandering course in a relatively broad valley over rocks of the Fort Union formation. The stream is shallow, with numerous sand bars. The valley, which contains considerable alluvium, is bounded by steep slopes above which are the more rugged uplands. During most of the year the river is shallow and carries a relatively small volume of water, but at the time of the spring floods it frequently overflows its banks, shifting its channel and doing considerable damage.

The smaller tributaries in Big Horn County are distinctly younger than the master streams, have steeper gradients, and are actively eroding. Those in the shales are cutting back into the soft beds with considerable rapidity, but even in the areas underlain by the softer beds the valleys are almost as narrow and steep-walled as those in the harder beds; a thin protecting sandstone near the surface is apparently the cause of such narrow valleys in the western part of the reservation.

Even the smallest streams, in which the water flows but for a short time, are actively cutting back headward and slowly destroying the flat interstream areas. During the violent storms that occur at times during the late spring and summer one of these streams may work back a number of yards, and a large volume of material is removed to be deposited in the valley lower down.

RECORDS OF STREAM FLOW

Big Horn County is thoroughly drained, with almost no marsh land in the flood plains that the river inundates at irregular intervals. Except for the streams rising in the mountains, perennial streams are few. Even those that rise in the mountains and issue from miniature canyons with a considerable flow rapidly disappear in their course across the dry plains, owing to the high evaporation and the character of the creek beds, as well as diversion for irrigation. The rain that falls upon the plains flows off rapidly because of the sparseness of the vegetation, the well-developed drainage system, and the violent nature of many of the rainstorms. For this reason the streams are very "flashy" and rise with great rapidity.

The United States Geological Survey has in the past maintained gaging stations on certain streams in this area, and detailed records have been published.[17]

A gaging station was operated on the Big Horn River at the highway bridge 2 miles northeast of Hardin from June 16, 1904, to May 31, 1925. The maximum discharge recorded at this station was 42,300 second-feet October 1, 1923, and the minimum was 516 second-feet July 15–18, 1919. The drainage area above the station is 20,700 square miles, and considerable water is diverted for irrigation above the station.

Two stations have been operated on the Little Horn River, one near Wyola and the other at the Crow Agency. Both of these stations were in operation from September 7, 1911, to September 30, 1924. At the Wyola station the maximum recorded discharge was 1,610 second-feet June 16, 1924, and the minimum was 32 second-feet April 10–12, 1915. At the Crow Agency station the maximum recorded discharge was 8,200 second-feet July 23, 1923; the stream was dry from July 28 to August 6, 1921. The stream flow is affected by diversion for irrigation above these gaging stations.

Three gaging stations have been in operation on Pryor Creek. The station in the SW¼ sec. 31, T. 5 S., R. 26 E., was above the intake of the Pryor Ditch. Records for this station extend from April 15, 1921, to October 7, 1924. The maximum discharge recorded was 112 second-feet May 23, 1924; the minimum 3.9 second-feet April 3, 1922. The station at Pryor was in operation from June 19, 1921, to October 7, 1924. The maximum recorded discharge was 163 second-feet May 17, 1924; the minimum 3.4 second-feet June 24–25, 1921. The station at Coburn is in the SE¼ sec. 35, T. 1 S., R. 27 E., within the Crow Indian Reservation but in Yellowstone County. The station was in operation from September 13, 1911, to September 30, 1924. The maximum recorded discharge was 746 second-feet May 20, 1912; there was no flow June 30 and July 6–21, 25–31, 1919.

A gaging station was in operation on Lost Creek in the SE¼ sec. 34, T. 5 S., R. 26 E., from June 27, 1921, to October 7, 1924. The maximum recorded discharge was 78 second-feet May 23, 1924;

[17] Records for 1921–25 appear in U.S. Geol. Survey Water-Supply Papers 526, 546, 566, 586, and 606. Earlier records may be found in the similar water-supply papers for earlier years covering the surface water supply of the Missouri River Basin.

the minimum 0.74 second-foot September 16, 1922. The station on Soap Creek was in operation from September 11, 1911, to September 30, 1924, but the location was shifted several times during the period. The maximum recorded discharge was 438 second-feet May 11, 1914; there was no flow August 29–30 and September 18–25, 1920, and September 8, 1923. Two stations have been operated on Lodgegrass Creek. One in the SE¼ sec. 6, T. 8 S., R. 34 E., was operated from May 12, 1921, to September 30, 1924. The maximum recorded discharge was 540 second-feet May 22, 1923; the minimum 3.6 second-feet December 2, 9–12, 1922. The other station, in sec. 30, T. 6 S., R. 35 E., was in operation from September 9, 1911, to December 20, 1915, and from April 13, 1921, to September 30, 1924. The maximum discharge, April 7, 1924, with a stage of 7.25 feet, was not calculated; the minimum discharge was 2.7 second-feet September 2, 1921.

IRRIGATION BY SURFACE WATER

All the larger streams and many of the smaller ones, especially those that issue from the mountains, are used to irrigate some of the adjacent bottom lands. Irrigation has been practiced for many years by utilizing the spring floods as well as by systematic ditching. Since 1900 many new ditches have been installed and the area of irrigated land has greatly increased.

The valleys of the Big Horn and Little Horn Rivers contain by far the greater part of the total irrigated area in the county, but there are also considerable tracts along Pryor Creek, particularly in the vicinity of the village of Pryor. By aid of diversion dams a part of the stream flow is turned into the main ditches and is distributed through them to the secondary ditches, from which it is applied to the land. There has always been an ample supply of water in the past, and most irrigators have used large quantities. In some places the application of water has been excessive, and drainage problems have arisen. The soil is fertile and with irrigation yields large crops.

At several ranches along the Big Horn and Pryor Mountains fields of varying size are irrigated by utilizing one or more of the small intermittent streams that issue from the mountains. Alfalfa for cattle feed is the chief crop, as these ranches are primarily cattle ranches, but other crops are not entirely neglected. Bulky crops cannot be raised profitably for shipment on account of the cost of transportation, as most of these ranches are remote from shipping points.

The total area irrigated in Big Horn County in 1929 [18] was 43,492 acres, which was 28.2 percent of all improved farms. The 37 exist-

[18] Fifteenth Census of the United States, Irrigation, p. 147, 1930.

ing enterprises are reported to be capable of irrigating 76,773 acres. The total length of main canals is 194 miles, and the total capacity 1,080 second-feet. The total length of lateral ditches is 204 miles. The dams, with two exceptions, are all diversion dams which do not store water but merely divert part of the flow. The two storage dams are small and have a total capacity of only 128 acre-feet.

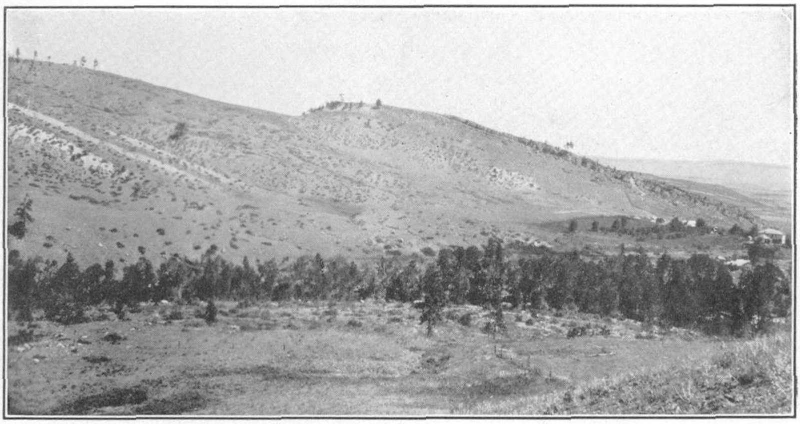
Although the total capacity of the existing ditches has not been reached, plans have been made to build a dam on the Big Horn River at the mouth of the canyon to store the flood waters that now go to waste and make them available when needed. This proposed dam will be one of the highest in the world and will furnish water for power development as well as for the irrigation of many thousands of acres that lie high above the present ditches.

CLIMATE

The climate of Big Horn County resembles that of other parts of southeastern Montana, except in the Big Horn and Pryor Mountains, where the increased altitude causes a much lower mean annual temperature and considerably greater precipitation than is normal for the open plains.

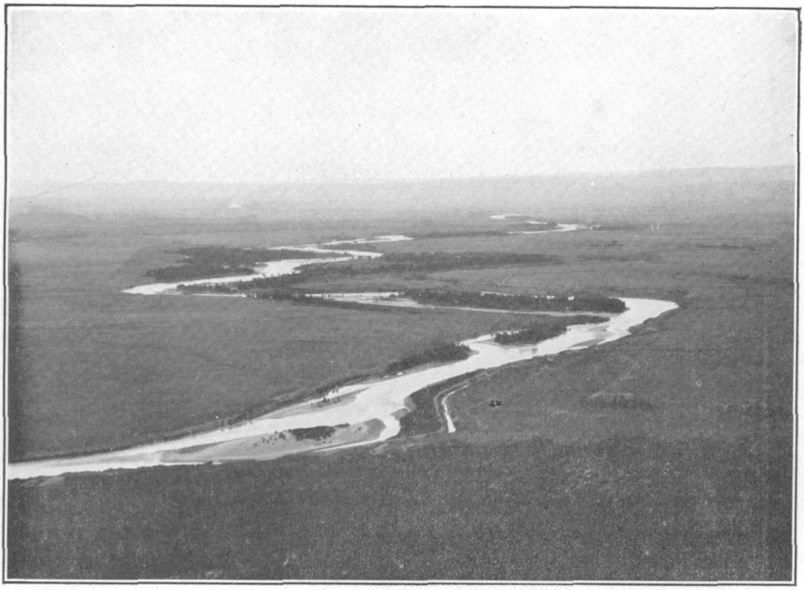
There are three cooperative stations of the Weather Bureau in this county, at Crow Agency, on the Little Horn River in the Crow Indian Reservation; at Busby, on Rosebud Creek in the Tongue River Indian Reservation; and at Foster, on the Big Horn River. Observations have been made at these stations since 1879, 1908, and 1913, respectively, but none of these records are continuous. A cooperative station was maintained at Decker, on the Tongue River, from 1904 to 1910, with incomplete records for 1904, 1906, and 1910. There are no stations in either the Big Horn or Pryor Mountains, and consequently remarks concerning the climate in those areas cannot be substantiated by records. Although these mountains are almost uninhabited, the climate is of importance because the amount and distribution of precipitation upon them exert a great influence upon the flow of the streams rising there, which are so essential for irrigation of the plains. On the whole, the precipitation is higher than on the plains, as is shown by the forests that cover the sides of the mountains.

The mean annual precipitation as recorded at the cooperative Weather Bureau stations was as follows: Crow Agency, mean for 36 years, 15.12 inches; Busby, mean for 14 years, 14 inches; Foster, mean for 9 years, 11.74 inches; Decker, mean for 4 years, 13.38 inches. The total precipitation may vary greatly from year to year at any station. At Crow Agency the smallest precipitation was 8.03 inches in 1889, and the greatest 25.25 inches in 1912; in only three years



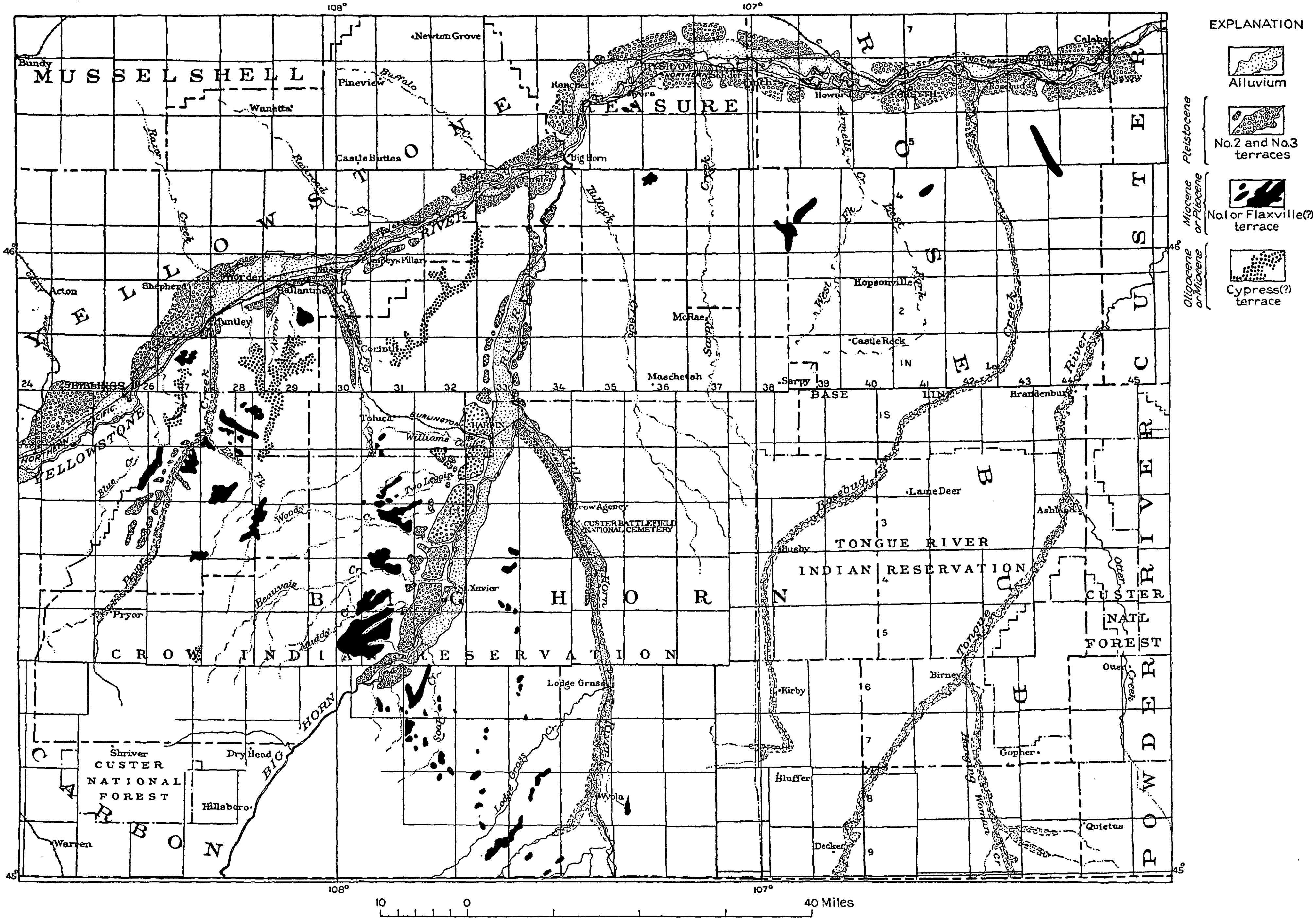
A. TYPICAL HOGBACK OF CLOVERLY SANDSTONE ON EAST SIDE OF BIG HORN MOUNTAINS, NORTHWEST OF SHERIDAN, WYO.

Ledges with trees are sandstones in the Cloverly formation; slopes to left are shales in the Morrison and Sundance formations. Photograph by N. H. Darton (U.S. Geol. Survey Prof. Paper 51, pl. 18, *A*).

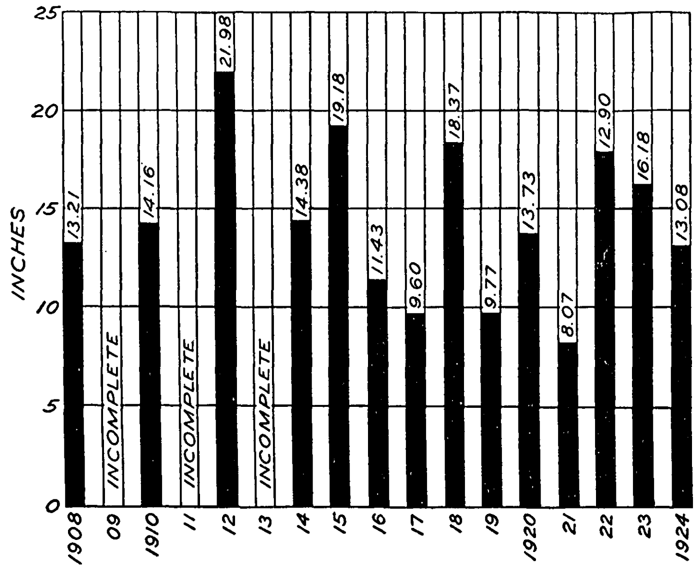


B. BIG HORN RIVER CROSSING PLAIN JUST AFTER LEAVING CANYON

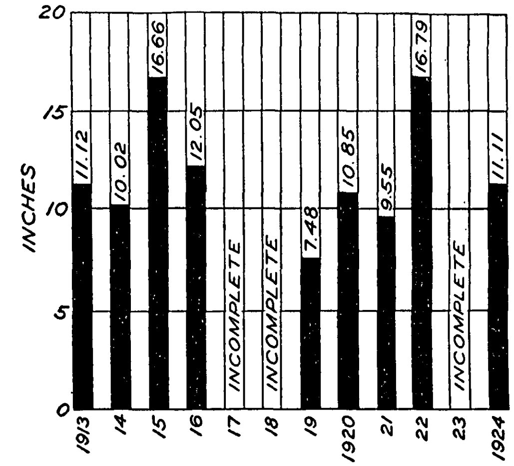
Photograph by J. Stimson.



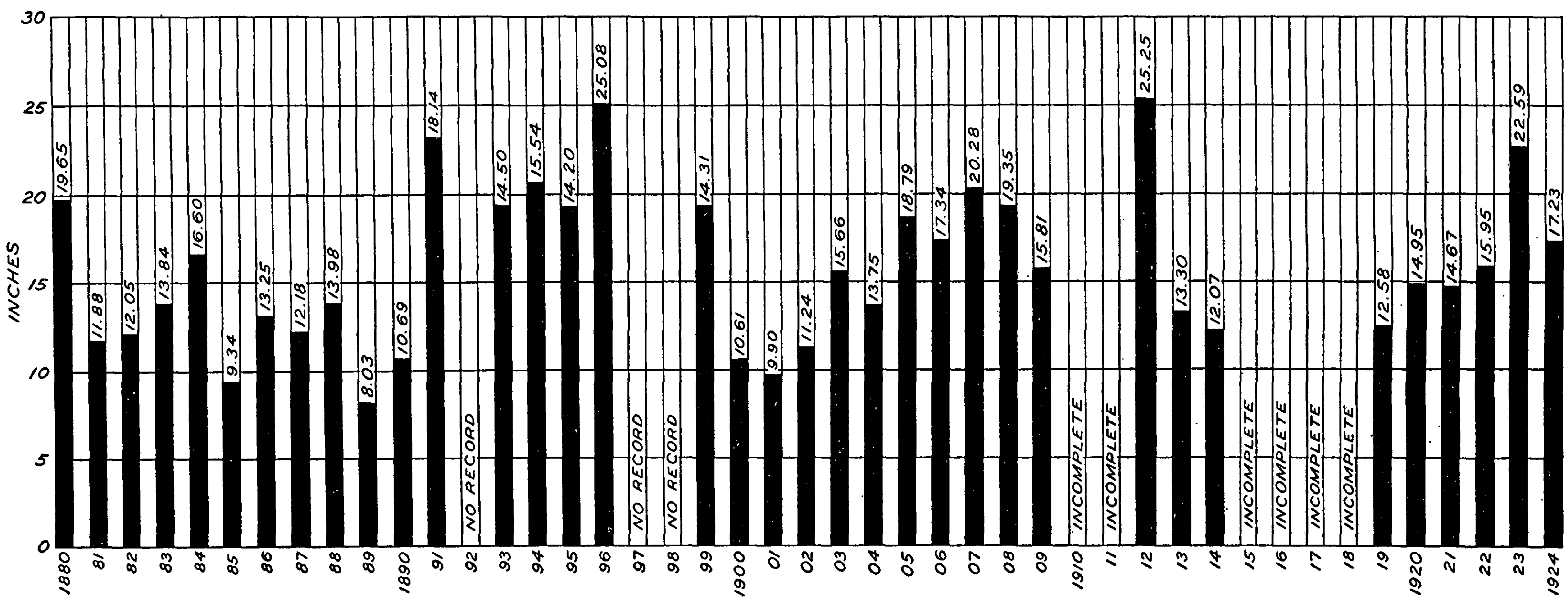
MAP SHOWING EXTENT OF TERRACES AND ALLUVIUM IN THE CROW INDIAN RESERVATION AND ADJACENT AREAS.



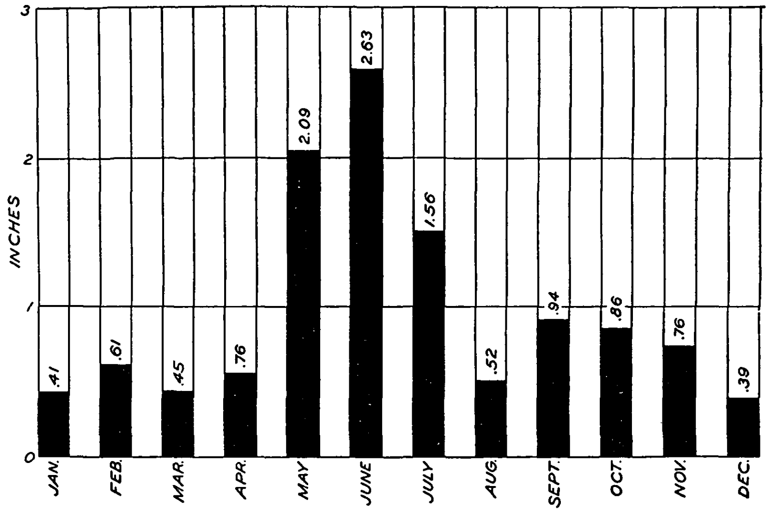
ANNUAL PRECIPITATION
BUSBY, MONT.



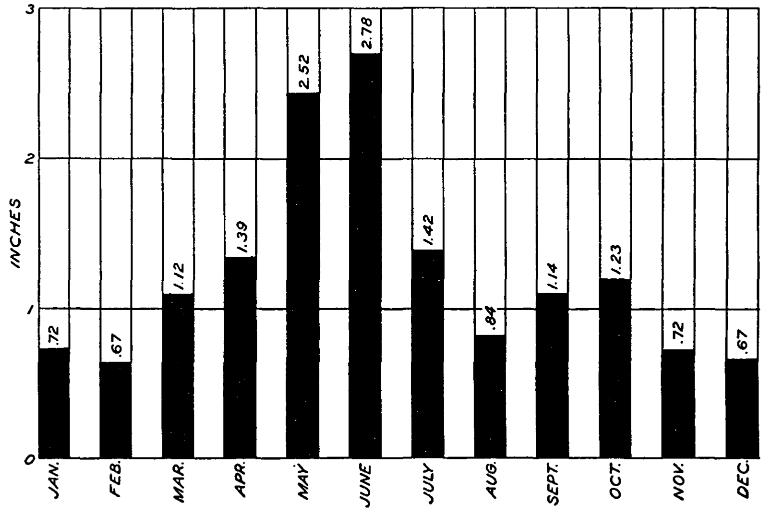
ANNUAL PRECIPITATION
FOSTER, MONT.



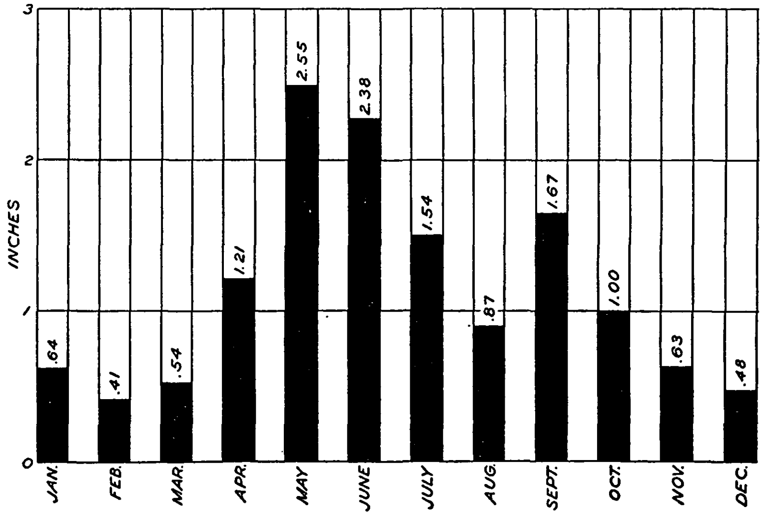
ANNUAL PRECIPITATION
CROW AGENCY, MONT.



MEAN MONTHLY PRECIPITATION
(Av. of 14 yrs.)
CROW AGENCY, MONT.



MEAN MONTHLY PRECIPITATION
(Av. of 35 yrs.)
CROW AGENCY, MONT.



MEAN MONTHLY PRECIPITATION
(Av. of 14 yrs.)
BUSBY, MONT.

since 1879 has precipitation at this station exceeded 20 inches. At Busby the greatest precipitation was 21.98 inches in 1912, and the least 8.07 inches in 1921. At Foster the greatest precipitation was 16.79 inches in 1923, and the least 7.48 inches in 1921. The annual precipitation for each of these stations is shown in plate 4.

The precipitation, though not large, is normally most abundant from April to July—that is, during the growing season. (See pl. 5.) However, it frequently occurs that the distribution is not so favorable, and crops on the nonirrigated areas suffer. Most of the precipitation from November to March falls as snow, and light snows have occurred even during the summer. Violent thunder storms, often accompanied by hail, are common in summer. The hail sometimes injuries the crops, but such damage is generally confined to small areas. The precipitation is lightest during the winter. The average snowfall for the year at Crow Agency is 43.9 inches, and at Busby 50.5 inches. Occasional heavy snow covers the entire county under a thick blanket, but usually the snow is not deep. The winter snow is usually dry, and the accompanying winds quickly blow it off the high uplands into depressions and coulees, leaving the grazing lands open and accessible to stock.

The temperature has a considerable range, both seasonal and diurnal. The mean annual temperature at Crow Agency is 44.9° F., and at Busby 41.7°. Temperatures exceeding 100° occur occasionally on several days during the summer, but protracted periods of high temperature are rare. The highest temperature recorded at Crow Agency is 106° and at Busby 105°. In winter temperatures of −40°, and lower have been recorded, but such cold periods are usually short. During the winter there are generally many consecutive clear days with temperature just below freezing. The diurnal change is frequently more than 40°, particularly in summer, and the hot days are normally followed by cool, comfortable nights. In winter even greater variations in temperature occur when storms approach.

The average date of the first killing frost in the autumn at Crow Agency is September 26, and the earliest is September 7; at Busby the average date is September 17, but it may occur as early as September 10. The average date of the last killing frost in the spring at Crow Agency is May 15, but killing frost has occurred as late as June 21; at Busby the average date is June 3, but killing frost has occurred as late as June 29. In general, the period between the first and last killing frost decreases with increase in altitude.

The prevailing direction of the wind in most parts of the county is west or northwest. Though destructive winds are uncommon, strong winds prevail throughout most of the year. During the summer the winds accompanied by high temperature cause considerable evaporation, as the air is usually dry. These drying winds frequently damage dry-land crops, but irrigated areas are little affected.

VEGETATION AND ANIMAL LIFE

The diversities of altitude and soil existing within Big Horn County and the Crow Indian Reservation are reflected in similar variations in vegetation. The upland meadows of the Big Horn Mountains support a luxuriant growth of prairie grasses during the ordinary seasons, and numerous coniferous trees grow on the higher and more rocky parts of the mountains. The sandstone hills northwest of Hardin and east of the Little Horn River also support a considerable growth of pines. Along the watercourses bluestem grass flourishes, and groves and thickets of cottonwoods, willows, and boxelders are common. On the adjacent badland and bench-land areas buffalo grass, sagebrush, greasewood, and prickly pear make up a flora characteristic of a semiarid climate.

Large game, though once abundant, now consists of a few bears, an occasional wolf, and a moderate number of deer and lynxes. Coyotes are fairly numerous, and small game is relatively abundant, including rabbits, badgers, and porcupines. Prairie chickens and sage hens were formerly plentiful, but they have been hunted until they are now very scarce. All the streams that issue from the Big Horn and Pryor Mountains once teemed with trout. Owing to over-fishing, the trout were almost exterminated and would have virtually disappeared from most of the streams but for the distribution of fry. Now the streams are kept well stocked.

Bands of wild horses formerly roamed the mountain meadows and the high divide east of Pryor Creek but have been much reduced in number as the result of determined efforts of local ranchers to free the range of these animals.

INDUSTRIES

Stock raising continues to be the principal industry of most of the area, although extensive bottom and bench lands are being cultivated under irrigation or by dry-farming methods applied on a very large scale. Horned cattle range the Crow Indian Reservation east of Pryor Creek, and sheep are pastured in its western part. Grain is grown by mass-production methods on the irrigated bench lands west of the Little Horn River between Crow Agency and Hardin and also west of the Big Horn River. Forage crops, wheat, sugar beets, and other agricultural products are grown on irrigated bottoms bordering nearly all the larger streams.

NATURAL RESOURCES

Next to agricultural land and perhaps water power and underground waters, the most valuable natural resources of the area are the coal deposits of the Rosebud Mountains. Some oil has been produced in the Soap Creek field, and a natural-gas supply for the town of Hardin is being developed by wells drilled just north of the town. Timber for fuel and some suitable for lumber, gypsum, limestone, clay, bentonite, asphaltic sandstone, sand, and gravel are all present within the reservation in quantities having either present or future value, and a little placer gold has been found in existing stream beds and may occur with some of the terrace gravel. The limestone is present in the mountains in inexhaustible quantities.

The Big Horn River and to a less degree the Tongue River and the smaller streams heading in the mountains are potential sources of hydroelectric power, and it is even possible that power for isolated ranches may be developed from artesian wells drilled near the Big Horn Mountains, as several wells near Soap and Beauvais Creeks yield flows of 1,000 to 25,000 barrels of water daily, and the casinghead pressure of two wells at Soap Creek is reported to have registered 225 and 300 pounds to the square inch.[19]

The construction of dams for power development on a large scale would also make possible the irrigation of additional extensive tracts of bench land.

RAILROADS AND ROADS

The Chicago, Burlington & Quincy Railroad extends northwest from Sheridan, Wyo., and follows the Little Horn River northward across the eastern part of the area to Hardin, at the confluence of the Big Horn and the Little Horn. At Hardin the railroad turns northwest again and runs by way of Toluca to Huntley, its junction point with the Northern Pacific Railway, and thence to Billings. A branch line built by the Chicago, Burlington & Quincy Railroad west from Toluca to Pryor Creek, thence southwest up the valley through Pryor Gap into the Sage Creek Valley and on to Warren, in Carbon County has been abandoned, the tracks have been taken up, and the roadbed has been used as a highway in many places. The Northern Pacific Railway runs parallel to the Yellowstone River just a few miles north of the northern boundary of Big Horn County, and the line of a projected railroad from Sheridan to Miles City, along the Tongue River Valley, crosses the eastern part of the county.

[19] Beecher, C. E., General report on Soap Creek oil field, Crow Indian Reservation, Mont., U.S. Bur. Mines, Dec. 10, 1921.

The Custer Battlefield Highway, a well-graded and much-traveled road between Sheridan and Billings, closely parallels the Chicago, Burlington & Quincy Railroad east and south of Toluca and Hardin, and extends westward from Toluca to Pryor Creek along the right of way of the abandoned branch line, thence over the low hills into the Yellowstone River Valley. Numerous other graded roads radiate from Aberdeen, Wyola, Lodge Grass, Crow Agency, Hardin, and St. Xavier. Although the steep-walled shallow watercourses are obstacles to vehicular traffic across the plains, many minor roads and trails make travel possible, except in wet weather, over all save the roughest and most mountainous parts of the area.

STRATIGRAPHY

Big Horn County and the Crow Indian Reservation are underlain by a thick series of bedded sedimentary formations, ranging in age from Cambrian to Recent, which rest upon pre-Cambrian granite. (See pls. 1 and 6.) Of these the pre-Colorado formations have been described in some detail by Darton,[20] whereas the field studies of the writers have been more particularly focused upon the part of the stratigraphic column between the top of the Madison limestone and the base of the Eagle sandstone. As shown by the stratigraphic table given below, the Amsden and underlying formations consist principally of limestone, with minor amounts of calcareous shale and a little sandstone. The Triassic, Jurassic, and Cretaceous rocks are almost all of marine origin and consist chiefly of shale interbedded with minor though prominent sandstone layers. The Tertiary (?) and Eocene rocks are of fresh-water origin and contain coal beds that represent flood-plain or coastal swamps; and the post-Eocene Tertiary and Quaternary deposits consist of boulders, gravel, and alluvial clay covering local areas.

[20] Darton, N. H., Geology of the Big Horn Mountains: U.S. Geol. Survey Prof. Paper 51, pp. 23–53, 1906.

Composite geologic section of Big Horn County and the Crow Indian Reservation

System	Series	Group, formation, and member		Thickness (feet)	Character	Water supply
Quaternary.				0–100±	Alluvium and lower terrace gravel.	Generally water-bearing. Shallow dug wells yield large supplies of water suitable for stock.
	Pliocene(?) to Oligocene(?).			0–30	Older terrace gravel.	Shallow wells yield adequate supplies for domestic purposes. Small areas may be drained and yield very little water to wells.
Tertiary.	Eocene.	Wasatch formation.		350±	Gray clay, yellowish sandstones, and some coal beds.	Sandstones yield small supplies to wells, but shales are less productive.
		Fort Union formation.	Tongue River member.	850–1,800	Light-colored clays, massive sandstones, and thick coal beds. Roland coal marks top of member. Thickness of member increases northward owing to interfingering with Lebo shale member.	Generally water-bearing, yielding small to medium quantities of water. Sandstone and coal are the better water-bearing strata; shales at many places are dry.
			Lebo shale member.	800–1,000	Dark "badland" clays, with minor sandstones and local coal beds. Big Dirty coal bed at base.	Wells in the shale are dry or yield meager supplies of rather highly mineralized water. It is advisable to drill through this member into the more favorable underlying Lance formation.
Tertiary(?).	Eocene(?).	Lance formation.	Tullock member.	300±	Yellow to light-gray clays, rim-forming sandstones, and thin coal beds.	Generally water-bearing. Most wells obtain supplies from sandstone. Shale is usually less productive.
			Hell Creek member.	600–650	Massive fluviatile sandstones and greenish sandy clays.	Similar to the Tullock member.
Cretaceous.	Upper Cretaceous.	Montana group.	Bearpaw shale.	500–600±	Dark marine shale, containing local channel sandstones, especially in southern part of reservation.	Generally dry. Water obtained is usually too poor for stock to use. Wells in the sandy phase of this shale in the Little Horn Valley should yield small supplies of potable water.
			Parkman sandstone.	280–350±	In northern part of reservation consists of light-colored clays and massive yellow sandstones. In southern part consists of massive basal sandstone overlain by dark sandy shales and thin sandstones with local coal near top.	Generally yields small supplies of water suitable for domestic purposes. This sandstone is the most satisfactory water-bearing bed in the Montana group.
			Claggett shale.	425–650	Dark marine shale, with sandstone bed or thin conglomerate 140 feet above base.	Generally dry. Water when obtained is usually fit only for stock.

Composite geologic section of Big Horn County and the Crow Indian Reservation—Continued

System	Series	Group	Formation and member	Thickness (feet)	Character	Water supply
Cretaceous.	Upper Cretaceous.	Montana group.	Eagle sandstone.	100–225	Massive sandstone and minor shale beds in northwestern part of reservation, merging into thin sandstone and yellow sandy shale, and southward into a single massive sandstone. Virgelle sandstone member at base in northwest corner of reservation.	The massive sandstones yield small supplies of hard water. The shales are usually dry or yield small supplies of rather highly mineralized water.
			Telegraph Creek formation.	320±	Yellow sandy shale parted in middle by a thin concretionary, rim-forming sandstone (Elk Basin sandstone member).	A poor water-bearing formation. The sandy shales yield, in some places, small supplies of highly mineralized water.
		Colorado group.	Niobrara shale.	400±	Blue limy shale, weathering yellow.	Generally dry. The small amount of water obtained is unfit even for stock.
			Carlile shale.	425	Dark marine shale containing zones of fossiliferous concretions, layers of limy shale, and bentonite beds.	
			Frontier formation.	400±	Dark marine shale containing beds of bentonite and thin conglomeratic sandstones.	
			Mowry shale.	200–300	Hard siliceous shale containing fish scales and beds of dark shale and bentonite.	
			Thermopolis shale.	525–800	Consists of a basal unit of dark marine shales with "rusty beds" at base; a middle member of ferruginous clays and bentonites, with thin sandstone at base (Birdhead sandstone member); and an upper member of gray shale containing irregular sandy beds. In part of area the "rusty beds" have for convenience been mapped with Cloverly formation.	
	Lower Cretaceous.		Cloverly formation.	320–425	Usually consists of an upper member of sandstone or sandy shale; a middle member of variegated clays; and a basal conglomerate. Apparently unconformable on Morrison.	Yields artesian flows in many wells drilled for oil. The water may contain natural gas and traces of petroleum.
			Morrison formation.	0?–400	Maroon or variegated clays; some sandstones, and yellow sandy shale near base.	Usually a poor water-bearing formation. Yields small flows in the Soap Creek oil field.

Jurassic.	Upper Jurassic.	Sundance formation.	400–680	White limestone overlain in turn by reddish sandy shale and by greenish clay interbedded with brown fossiliferous sandstone.	A good water-bearing formation. Sandstone yields fairly large supplies.
		Unconformity			
Triassic and Carboniferous (Permian)(?).		Chugwater formation.	500–655	Brilliant dark-red sandstones and sandy shales with one or two "lithographic" thin limestones, and thick local gypsum beds. Basal part includes silicified limestones locally, and may include beds of Park City age.	A poor water-bearing formation. The shales are reported to yield small supplies of very highly mineralized water in some localities.
		Unconformity			
Carboniferous.	Pennsylvanian.	Tensleep sandstone.	45–75	Coarse yellowish to white cross-bedded sandstone. Chert nodules and silicified layers in upper part.	An excellent water-bearing formation. Yields large supplies in the Soap and Beauvais Creek areas. Large flows.
		Amsden formation.	155–365	Red shale; thin red, white, or purple limestones; limy shales; and quartzitic sandstones.	An excellent water-bearing formation. The cavernous and fractured limestones yield large supplies in the Soap and Beauvais Creek areas. Large flows.
		Unconformity			
	Mississippian.	Madison limestone.	1,000±	Massive light-gray to white limestone.	An excellent water-bearing formation. The cavernous and fractured limestones yield large flows of water in the Beauvais Creek area.
		Unconformity			
Ordovician.	Upper Ordovician.	Bighorn dolomite.	300±	Chiefly massive light-colored dolomite, with a thin basal sandstone member and a top member of light-colored limestone.	Not reached in any well in this area.
		Unconformity			
Cambrian.	Upper Cambrian.	Deadwood formation.	900±	Coarse-grained to conglomeratic red-brown sandstone at base, overlain by sandy shale and thin-bedded sandstone; green shale; and an upper member of slabby limestone containing glauconite and limestone conglomerate. Rests unconformably on peneplaned surface of pre-Cambrian granite.	Not reached in any well in this area.
Pre-Cambrian.			(?)	Granite. Exposed along a canyon a short distance west of Point Lookout.	Not reached in any well in this area.

PRE-CAMBRIAN

The only rocks of pre-Cambrian age exposed in Big Horn County and the Crow Indian Reservation are gray and red granites, which crop out in the Big Horn Mountains along a canyon a short distance west of Point Lookout[21] (see pl. 1) and in the canyon of the Little Horn River, a view of which is shown in plate 7. South of the Montana-Wyoming line these granites are cut by dikes of diabase, olivine gabbro, hornblende diorite, and peridotite. The dikes do not extend into the overlying sedimentary rocks but are confined to the granite. All the igneous rocks appear to have been eroded to an almost even surface prior to the deposition of the overlying Deadwood formation.

CAMBRIAN SYSTEM

DEADWOOD FORMATION

According to Darton,[22] exposures in the canyons dissecting the Big Horn uplift show that the Deadwood formation lies upon a peneplaned surface of pre-Cambrian granite. (See pl. 7.) The thickness of the formation is about 900 feet, and the succession of its component beds is somewhat uniform. The base of the Deadwood is marked by a coarse reddish-brown sandstone containing small quartz pebbles, which is about 60 feet thick in this area. Next above this sandstone lies about 200 feet of sandy shale and thin-bedded sandstone, and above these about 400 feet of soft greenish shale containing some thin layers of limestone or sandstone. The top of the formation consists of gray to brownish-buff or flesh-colored limestone containing layers and masses of conglomerate that consists of flat limestone pebbles set in a matrix of glauconitic limestone and shaly material. Glauconite is also found in the sandstone of the lower part of the formation. Although referred by Darton to the Middle Cambrian, the Deadwood is now classified by the United States Geological Survey as of Upper Cambrian age.

Owing to its relative softness, the Deadwood is commonly exposed in rounded slopes or low saddles between bolder outcrops of the underlying granite and overlying Bighorn dolomite.

ORDOVICIAN SYSTEM

BIGHORN DOLOMITE

The Bighorn dolomite, originally described by Darton[23] as the Bighorn limestone, crops out in the walls of the canyons that cut

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[21] Darton, N. H., Geology of the Big Horn Mountains: U.S. Geol. Survey Prof. Paper 51, pp. 13–23, pl. 47, 1906.

[22] Idem, p. 24.

[23] Idem, pp. 26–29.

into the backbone of the Big Horn Mountains and in a small area near the north end of the Pryor Gap gorge. (See pl. 7.) The formation in most places consists of three members having an average combined thickness of about 300 feet, and because of its massive character it tends to stand out in bold cliffs.

As described by Darton the Bighorn dolomite was supposed to consist of a basal member of light-gray, moderately coarse grained sandstone 25 to 30 feet thick, containing Middle Ordovician fossils; a middle member of light-buff massive dolomite of lower Galena (Trenton) age; and an upper member 75 to 100 feet thick, composed of light-colored thinner-bedded limestone containing a Richmond fauna.

According to more recent studies by Kirk [24] the basal sandstone is believed to be divisible into an upper part containing an Upper Ordovician fauna and a lower part of local and irregular development containing fossils characteristic of the Harding sandstone, of Middle Ordovician age.

The present views concerning the age of the middle member of the Bighorn dolomite, as defined by Darton, have been stated by Kirk as follows:

> The lower, massive portion (so-called middle member) of the Bighorn dolomite formerly was held to be of Galena (Trenton) age. More detailed studies of formations in Texas, Colorado, Idaho, Utah, and the Great Basin region that may be correlated with the Bighorn with reasonable assurance indicate a later (Upper Ordovician) age for these beds. Recent studies of the faunas of the Manitoba Ordovician that may definitely be correlated with the lower Bighorn have led Foerste to make them as late as Richmond in age. At all events it would seem best for the present to consider the basal Bighorn as of Upper Ordovician age.

Weathered surfaces of the massive middle portion of the Bighorn dolomite commonly show in relief a coarse mat or network of less soluble siliceous material, possibly representing fossilized algal remains,[25] and in many places the upper member of the Bighorn contains a massive stratum 15 to 25 feet thick which weathers in a similar manner.

Corals are abundant in the basal part of the upper member of the Bighorn, and the species of these and other fossils obtained by Darton [26] are listed in his report.

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[24] Kirk, Edwin, personal communication.

[25] Blackwelder, Eliot, Origin of the Bighorn dolomite of Wyoming: Geol. Soc. America Bull., vol. 24, pp. 607–624, 1913.

[26] Darton, N. H., op. cit., pp. 28–29.

CARBONIFEROUS SYSTEM

MISSISSIPPIAN SERIES

MADISON LIMESTONE

The Madison limestone has a thickness of about 1,000 feet in the northern parts of the Big Horn and Pryor Mountains, and on account of its resistant character it is the formation that covers most of the surface in the higher parts of these uplifts, and is extensively exposed along their crests and in the canyons that dissect them. The Madison limestone is shown in plate 7. It consists of a lower member of moderately massive hard limestone, in part dark gray (see analysis below); a middle member about 250 feet thick of softer, purer, more massive light-colored rock that weathers into pinnacled forms and caverns; and a top member about 80 feet thick that consists of very massive, dense gray limestone locally overlain by a few feet of white, thin-bedded limestone.

Analysis of Madison limestone at mouth of Big Horn Canyon, south of Hardin, Mont.

[Sample collected by K. C. Heald from top of lower member of the limestone. Analyst, E. T. Erickson]

SiO_2	0.48	CO_2	46.91
Al_2O_3	.42	P_2O_5	Trace
FeO	.04	SO_3	.03
MgO	19.93	Cl	.06
CaO	31.72	MnO	Trace
H_2O	.02	SrO	.09
Organic matter + H_2O	.34		
TiO_2	.01		100.00

Fossils of lower Mississippian age, which are abundant at several horizons within the Madison limestone, particularly in the middle and upper part, indicate the essential equivalence of the Madison to the Pahasapa limestone of the Black Hills. Numerous fossils were obtained from the Madison by Darton,[27] and others collected within the Crow Indian Reservation by the writers have been identified by G. H. Girty as follows:

3904. Upper massive member of Madison limestone on east side of north end of Big Horn Canyon:

Campophyllum? sp.
Cliothyridina crassicardinalis?
Spirifer centronatus.
Spirifer striatus var. madisonensis.
Syringopora surcularia.
Zaphrentis sp.

[27] Darton, N. H., op. cit., p. 30.

3905 and 3906. Upper massive member of Madison and overlying limestones on east rim of Black Canyon one-half mile north of trail from Soap Creek:

Amplexus? sp.
Batostomella sp.
Bellerophon sp.
Dielasma burlingtonense.
Fenestella sp.
Platyceras sp.
Productus gallatinensis.
Productus semireticulatus var.
Schuchertella chemungensis?
Spirifer centronatus.
Spirifer striatus var. madisonensis.
Spiriferina solidirostris.
Straparollus sp.
Syringopora surcularia.
Zaphrentis sp.

At some time considerable solution cavities were formed at the contact of the upper and middle members and to a less degree along the joint and bedding planes of the upper member, which were filled by infiltered red mud, now calcareous red shale. Further evidence of solution by percolating water is apparently afforded by irregular masses of conglomerate contained in the upper massive member, which seem to represent material filling collapsed caverns or sink holes.

The upper part of the Madison has yielded some oil at Soap Creek. Hand specimens taken from the upper part of the formation exposed on the Little Horn River give an odor of petroleum when struck with a hammer, and this is more marked in samples taken from the middle member near the irrigation-ditch head gate at Big Horn Canyon.

PENNSYLVANIAN SERIES

AMSDEN FORMATION

The Amsden formation overlies the Madison limestone unconformably and is believed to be of early Pennsylvanian age. The Amsden formation is shown in plate 7. Within the Crow Indian Reservation the Amsden consists of 155 to 365 feet of red shale, thin white and red limestone, quartzitic sandstone, and chert breccia. The thickness and general lithologic composition of the formation within the reservation is indicated by the following sections, measured by Moulton and Bass, and by well records on pages 105–124.

Section of Amsden formation on south side of Little Horn Canyon

Tensleep sandstone.	
Amsden formation:	*Feet*
Red shale and gypsum	21
Red sandstone and shale	28
Purple limestone	1
White limestone	1
Pink limestone	1
Light-colored and greenish shale	23
Light-colored fine-grained sandstone	22
Light-colored sandy shale	17
Light-colored sandstone yielding petroleum odor from freshly broken surfaces	4

	Feet
Light-colored sandy shale	12
Light-colored fine-grained sandstone; very porous and also contains large cavities	7
Light-colored sandy shale	4
Light-colored sandstone with 6-inch limestone cap	7
Red limestone	1
Sandy shale	3
Gray sandstone with much pink and blue chert in upper part	9
Gray and purple shale	12
Gray cherty sandstone	8
Gray and purple shale	14
Gray sandstone and sandy limestone with cherty layers at top	33
Crystalline limestone	1
Red shale	18
Madison limestone.	
	247

Section of Amsden formation on north side of Big Horn River at mouth of Big Horn Canyon

	Feet
Tensleep sandstone.	
Amsden formation:	
Variegated yellow, maroon, and purple shale	10
White sandstone	10
Shale	2
White sandstone	14
Red, green, and yellow shale and sandstone, interbedded	34
Concealed	100
Light-gray limestone, cherty at top	10
Thin gray limestone interbedded with pink shale	13
Concealed	38
Gray limestone	5
Hard calcareous sandstone, containing solution cavities	8
Red concretionary fossiliferous sandstone interbedded with red shale	23
Concealed, principally red shale	96
Madison limestone.	
	363

Section of Amsden formation on East Pryor Creek on northeast side of Shively Hill dome

	Feet
Tensleep sandstone.	
Amsden formation:	
Concealed	20
Pink and white cherty limestone, somewhat cavernous	16
Concealed	38
White sandstone	3
Sandstone alternating with shale	26
Red sandy shale	13
Red cherty limestone	30
Red shale	10
Madison limestone.	
	156

The base of the formation is placed below a bed of red shale 15 feet or more in thickness, which seems to be invariably present at the unconformable contact between the Amsden and the Madison limestone. The oil produced at Soap Creek has been chiefly obtained from a sand 80 feet below the top of the formation, though a lower sand has also yielded some oil.

The magnitude of the unconformity separating the Amsden from the underlying Madison limestone is not yet determinable. The bedding of the two formations is nearly parallel, but from exposures in the canyon of the East Fork of Pryor Creek at the Shively Hill dome it is evident that the Madison had been folded slightly before the deposition of the Amsden, and the basal red shale and solution cavities present in the massive upper member of the Madison at Big Horn Canyon point to a period of exposure and weathering of the formation prior to or coincident with the beginning of Amsden sedimentation.

The following fossils collected from a maroon limestone just above the basal red shale at the mouth of Big Horn Canyon are reported by Girty to indicate the probable basal Pennsylvanian age of the Amsden, tending further to confirm the existence of a local hiatus corresponding to upper Mississippian time.

3903. Red limestone near base of Amsden formation on east side of lower end of Big Horn Canyon:

Schizophoria aff. S. resupinoides.	Schizodus? sp.
Derbya n. sp.?	Pleurophorus? sp.
Spirifer rockymontanus var.	Astartella? sp.
Composita subtilita.	

The Amsden, together with the overlying Tensleep sandstone, is approximately equivalent to the Minnelusa formation of the Black Hills. These two formations may also be represented partly or wholly by the Quadrant formation of the Lewistown district, but the uncertainty as to the true age of beds classed as Quadrant in that district makes a definite statement as to its age relationship impossible. It is believed probable, however, that the Quadrant of the Lewistown district includes a considerable thickness of upper Mississippian strata not represented in the Crow Reservation.[28]

TENSLEEP SANDSTONE

The Tensleep sandstone, of early Pennsylvanian age, overlies the Amsden with apparent conformity and consists of coarse yellowish or white sandstone 45 to 75 feet thick, with nodules of black chert in its upper part. The formation is in many places bedded in massive lenses and locally shows features suggestive of a dune origin.

[28] Hammer, A. A., and Lloyd, A. M., Notes on the Quadrant formation of east-central Montana: Am. Assoc. Petroleum Geologists Bull., vol. 10, pp. 986–996, 1926.

A view of the upper member of this sandstone in shown in plate 8. Numerous drusy cavities in its members, observed at Big Horn Canyon, indicate that it has been strongly affected by circulating siliceous waters. The Tensleep stands out strongly where it rises beneath the Chugwater red beds and sweeps up the steep northeast slopes of the Big Horn and Pryor Mountains. It is also well exposed where East Pryor Creek cuts through the Shively Hill dome, in sec. 26, T. 5 S., R. 27 E.

The outcrops of the Tensleep on the Little Horn River and on Lodge Grass Creek are more or less tarry, and the Tensleep has yielded shows of "dead" oil in wells drilled at Soap Creek. Some nonflammable gas has also been obtained from it in two of these wells.

No fossils were found in the Tensleep by the writers, but Darton collected a few fossils from chert nodules near the middle of the formation on the slopes west of Klondike, Wyo., among which were forms identified by Girty as *Productus cora*, *Strophostylus nanus?*, and *Pleurotomaria?* sp.[29]

TRIASSIC SYSTEM

CHUGWATER FORMATION

The Chugwater formation consists primarily of brilliant dark red sandstone and shale with thick local beds of gypsum near the top and base. One or more thin reddish limestone beds are also usually present in the upper part of the formation. The outcrop of the Chugwater is only a few hundred feet wide along the steep flank of the Big Horn fold in the vicinity of Big Horn Canyon but attains a width of several miles between the head of Soap Creek and a point near the Wyoming line, as a result of the influence exerted upon local erosion by the Sport Creek anticline. North of the Big Horn River the Chugwater is exposed over considerable areas around the north end of the Big Horn Mountains and in the vicinity of the Shively Hill dome and it is very extensively exposed in the valley of Dry Head Creek, that is, within the syncline between the Big Horn and Pryor Mountain uplifts. North of the Pryor Mountains the Chugwater is exposed within the Crow Reservation only in a small area in the southeastern part of T. 5 S., R. 25 E., as a result of branching of the Castle Butte fault, which cuts off the north end of the Pryor Mountains.

The maximum thickness of the formation observed within the reservation was 655 feet, measured by Thom and Moulton near the head of the West Fork of Soap Creek. The thickness of the formation at several other points within the reservation is shown graphically by plate 6, which also shows the decreasing thickness of the

[29] Darton, N. H., op. cit., p. 34.

formation toward the north and its inferred final disappearance south of the Molt Oil Co. well on the Hailstone dome, in Stillwater County, in the SW¼NW¼ sec. 5, T. 3 N., R. 21 E.

Near the Little Horn River thick beds of Chugwater sandstone show a greenish tint, in contrast to the normal red color of the formation, and a hand specimen taken from one of these light-colored beds shows a considerable impregnation with oil.

Similar discolored red sandstones are found on Willow Creek and Reed domes. The discoloration is confined to spots and streaks, but impregnation with oil is lacking. The change of color is due, according to Moulton,[30] to the reducing action of hydrogen sulphide, which changed the ferric iron to the ferrous condition. The green tints are most conspicuous in the vicinity of fractures along which the reducing gases may have descended. Springs in the vicinity, which discharge waters that carry hydrogen sulphide, show that the gas for the reduction was probably available.

Although the Embar formation as such is not positively recognized north or northeast of the Big Horn Mountains, the gypsum beds that occur in the basal 100 feet of red strata belonging to the Chugwater may perhaps be of the same age as the Park City formation or the lower part of the Embar. The thin limestone which lies at the base of the Chugwater at Shively Hill and in the Soap Creek field may also be of Park City age, which would give the beds of Park City age a possible local thickness of 125 feet. The Embar yields oil in several of the Wyoming fields, but the rocks possibly equivalent to it in the Crow Indian Reservation have not yet proved productive, and the silification exhibited by the upper part of the Tensleep and by the thin beds of limestone that rest upon it at some places strongly suggests that this surface was exposed to weathering during Embar time or immediately thereafter. No fossils were found in the Chugwater by the writers, but marine fossils were obtained from it by Darton in adjacent areas in Wyoming.[31]

JURASSIC SYSTEM

SUNDANCE FORMATION

The Sundance is a marine formation of late Jurassic age and seems to underlie the Morrison conformably. It consists of gray and greenish sandstones and white or pink limestones, interbedded with greater thicknesses of shale, dark or greenish in the upper part of the formation and pink or red in the lower part. The conspicuous pink or red tints may be found as high as 140 feet above the base of the formation. The top of the Sundance at many places is marked by

[30] Moulton, G. F., Some features of red-bed bleaching: Am. Assoc. Petroleum Geologists Bull., vol. 10, no. 3, pp. 304–312, 1926.

[31] Darton, N. H., op. cit., pp. 41, 42.

a fossiliferous coarse soft sandstone, from which numerous springs issue. The outcrops of the upper two-thirds of the formation are commonly featured by great numbers of the thick curved shells of *Gryphaea calceola.* The formation has a maximum thickness in the Crow Indian Reservation, as revealed in wells drilled at Soap Creek, of 650 to 680 feet; it appears to thin thence both to the north and south, apparently because of thinning of the red lower shales owing to overlap. The base of the Sundance formation is almost everywhere marked by a zone of white or light-pink limestone beds which tend to crop out as a conspicuous rim above the red strata of the Chugwater. In the folded areas the harder beds of the Sundance form conspicuous hogbacks. The lower part of the Sundance formation of this report is believed to represent the Ellis formation of central Montana.

Several sections of the Sundance were measured by Darton along the mountain slopes south of the reservation, where he obtained a considerable number of fossils from the formation.[32] Additional fossils have been identified by J. B. Reeside, Jr., from collections made by Thom, Moulton, and Bass, as follows:

10893. Upper part of Sundance formation, sec. 20, T. 7 S., R. 32 E.:
- Belemnites densus Meek and Hayden.
- Camptonectes sp.
- Ostrea sp.

10898. Sandstone mapped as top of Sundance formation, SE¼ sec. 21, T. 7 S., R. 32 E.:
- Ostrea strigilecula White.
- Belemnites densus Meek and Hayden.

10903. Basal stratum of Sundance formation 2 miles northeast of crest of Shively Hill dome:
- Ostrea strigilecula White.
- Lima occidentalis Hall and Whitfield.
- Camptonectes bellistriatus Meek and Hayden.
- Trigonia montanaensis Meek.
- Pleuromya sp.
- Pelecypods undetermined.

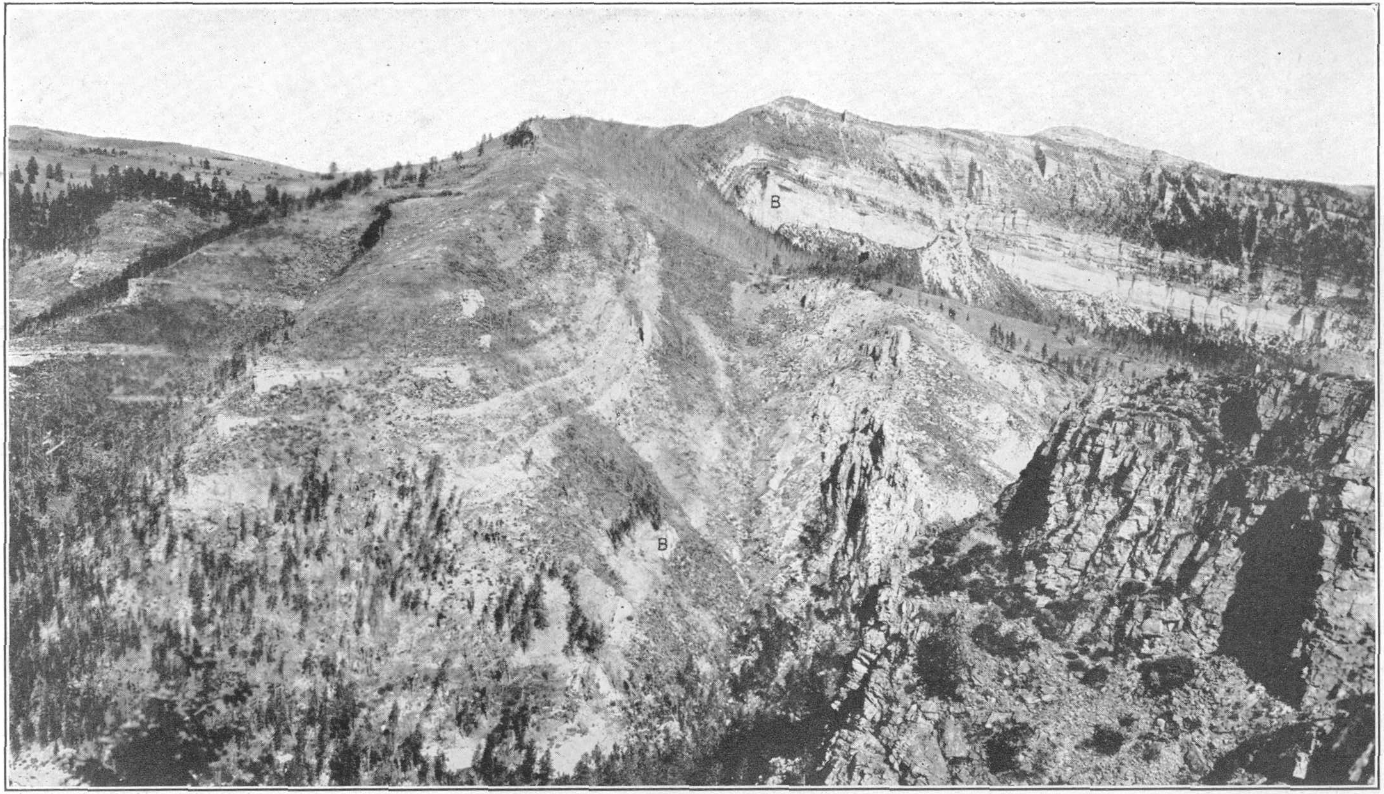
10913. Middle of Sundance formation, SW¼ sec. 14, T. 8 S., R. 33 E.:
- Gryphaea calceola var. nebrascensis Meek and Hayden.

Collection 10903 was said by Reeside to indicate Ellis rather than Sundance age, but the collections from the upper part contain a Sundance fauna which he considers younger than the Ellis fauna.

MORRISON FORMATION

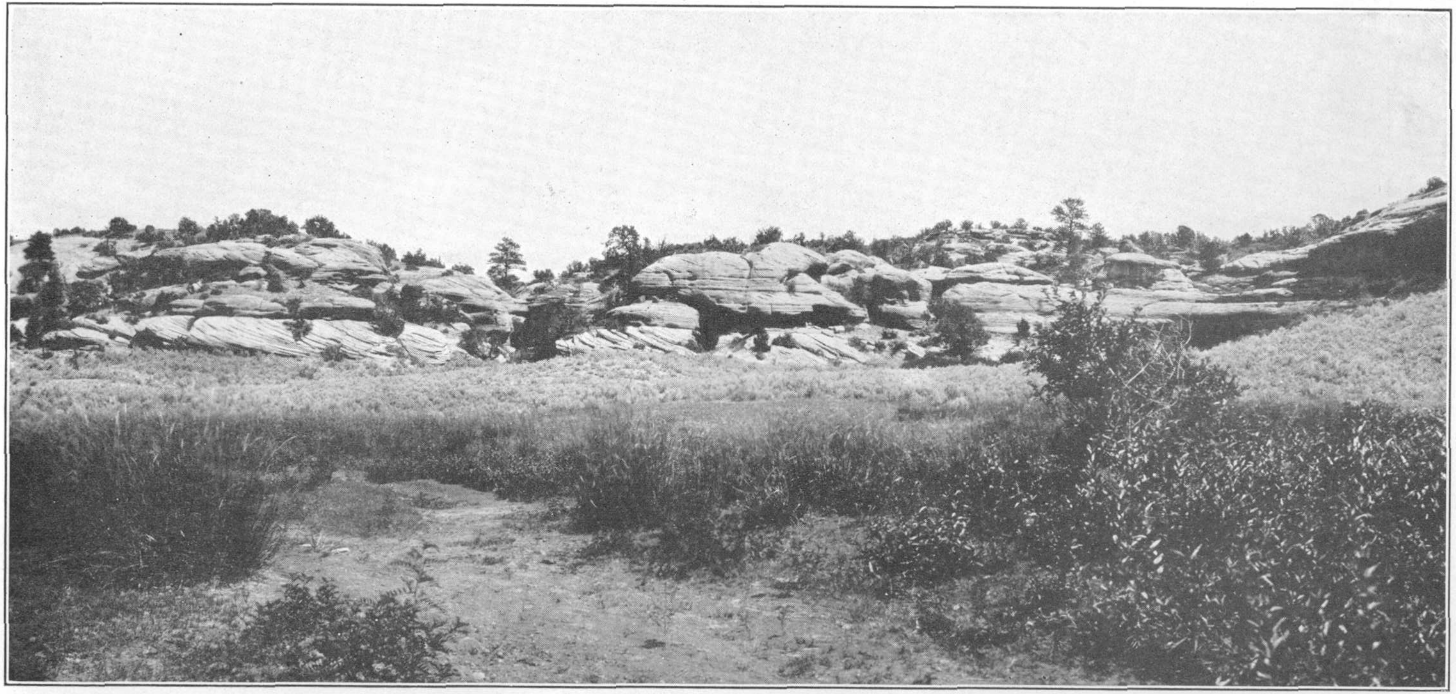
The Morrison formation is now classified as of Upper Jurassic age. It usually consists of maroon, red, or varicolored clays with minor amounts of light-colored sandstone in fairly persistent beds. Owing to the soft character of the formation it is as a rule poorly

[32] Darton, N. H., op. cit., pp. 43–46.



ANTICLINE ON EAST SLOPE OF BIG HORN UPLIFT, NORTH SIDE OF CANYON OF LITTLE HORN RIVER.

Granite to right overlain by Deadwood formation, Bighorn dolomite (*B*), and Madison limestone. Knob to right and park to left are Amsden formation. Photograph by N. H. Darton (U.S. Geol. Survey Prof. Paper 51, pl. 41, *B*).



UPPER MEMBER OF TENSLEEP SANDSTONE IN TENSLEEP CANYON.

Photograph by N. H. Darton (U.S. Geol. Survey Prof. Paper 51, pl. 16, *A*).

exposed, and its zone of outcrop is usually marked by a depression or narrow elongated valley between hogbacks formed by the upper sandstone beds of the Sundance and by the basal conglomerate of the Cloverly formation. Good exposures of complete sections of the Morrison formation are rare, and the contacts with the beds above and below are seldom well exposed. From such observations as were made it appeared probable that the Morrison formation is at least locally conformable with the underlying marine Jurassic Sundance formation, and that it quite certainly is unconformably overlain by the Lower Cretaceous Cloverly formation. No angular unconformity between the Morrison and Cloverly formations was noted in the field, but observed variations in the thickness of the Morrison seem to point to its partial or at places complete removal by erosion within the main Big Horn uplift before or during the deposition of the Cloverly formation. Thus the Morrison formation is almost 400 feet thick in the wells at Soap Creek, about 345 feet at Black Gulch and Beauvais Creek, 216 to 260 feet near Pryor, 143 feet a short distance south of the mouth of Big Horn Canyon, and 79 feet near the mouth of Grapevine Creek where measured by Moulton and Bass. Near the head of Soap Creek and at other localities farther south along the mountain upfold the Morrison is either very thin or absent. Unconformable contact of the Cloverly on the Morrison without noticeable angular discordance is reported from the west side of the Big Horn Mountains by Hewett and Lupton.[33]

Some idea of the composition and character of the Morrison formation in the Crow Indian Reservation is afforded by the following stratigraphic sections and by the well records on pages 105–124, and an idea of its variation in thickness may be obtained from plate 6. These do not, however, indicate adequately the rather abrupt appearance of beds of thick sandstone in the Morrison in the area just south and southwest of Pryor.

Section of Morrison formation 3 miles south of Fort C. F. Smith

[Measured by N. H. Darton [34]]

Cloverly formation: Basal conglomerate.	
Unconformity.	
Morrison formation:	*Feet*
Greenish-gray sandy shale, upper part soft	18
Buff sandstone	5
Massive gray sandstone	20
Variegated sandy shale; pale-red and green tints	75
Light-colored fine-grained soft sandstone	25
Sundance formation: Brown sandstone.	
	143

[33] Hewett, D. F., and Lupton, C. T., Anticlines in the southern part of the Big Horn Basin, Wyo.: U.S. Geol. Survey Bull. 656, p. 19, 1917.

[34] Darton, N. H., op. cit., p. 49.

Section in NW¼ sec. 6, T. 6 S., R. 26 E., and NE¼ sec. 1, T. 6 S., R. 25 E.

[Measured by W. W. Rubey]

	Feet
Cloverly formation: Sandstone, conglomeratic, weathering dark brown (basal member of Cloverly)	15
Morrison formation:	
Shale, red or purplish	115
Sandstone, cross-bedded, massive, light-colored, forming prominent ledge	3
Shale, purplish-gray	23
Shale, pink or red	75
	216
Sundance formation:	
Sandstone, yellow, ripple-marked, apparently by wave action	1
Shale, yellowish, sandy	32
Sandstone, brown, fossiliferous, slabby to cross-bedded and massive; forms pronounced rim	22
Concealed	145±
Bed of Plum Creek.	

Gastroliths, or polished pebbles supposedly once contained in the gizzards of ancient dinosaurs, and dinosaur bones of large size are fairly abundant in the Morrison beds exposed in the Beauvais Creek Valley but were not noted elsewhere on outcrops of the formation within the reservation. Collections of dinosaur bones obtained by Barnum Brown from Morrison outcrops along Horse Creek in the Beauvais Creek area have been described by Mook,[35] of the American Museum of Natural History.

CRETACEOUS SYSTEM

LOWER CRETACEOUS SERIES

CLOVERLY FORMATION

The Cloverly formation is exposed almost continuously in a belt along the eastern flank of the Big Horn Mountain upfold and covers large areas bordering Beauvais Creek and in the region east, north, and west of the town of Pryor. Because of its resistant character the basal conglomeratic sandstone of the Cloverly forms a conspicuous hogback ridge east of the mountains. (See pl. 2, *A*.) In some areas north of the mountains the Cloverly formation lies almost horizontal and, where it has not succumbed to erosion, it underlies extensive flats.

The basal conglomerate or coarse sandstone of the Cloverly formation is of fluviatile origin and, like most fluviatile deposits, shows

[35] Mook, C. C., The fore and hind limbs of *Diplodocus:* Am. Mus. Nat. History Bull., vol. 37, pp. 815–819, Dec. 5, 1917.

some variation in thickness as well as in the materials of which it is composed; yet it affords a definite base for the formation.

As originally defined by Darton the Cloverly formation is made up of two members. The lower member consists of 10 to 60 feet of coarse-grained buff to dirty-gray cross-bedded massive sandstone, the basal beds of which are usually conglomeratic. The upper member consists of 30 to 40 feet of clay, mostly of ash-colored and purplish or reddish tints. At the top of the upper member a few feet of massive sandstone is found in some localities. This formation is supposed to be the equivalent of the Lakota sandstone, the Fuson formation, and the Fall River sandstone (formerly called "Dakota") of the Black Hills region.

In the Big Horn Basin Hewett and Lupton [36] found the Cloverly to consist of three units, and they applied the name Greybull sandstone to the upper sandstone. This same succession of beds is shown by the formation in its extensive exposures in the western part of the Crow Indian Reservation, but toward the east the variegated shales of the middle member assume a brownish hue, and red tints are only locally exhibited along the eastern flanks of the Big Horn Mountains.

The field work done in the reservation has been insufficient to indicate with certainty the exact stratigraphic relation between the Greybull sandstone and the sandy strata included in the top part of the Cloverly as it was mapped at Soap Creek and along the east flank of the Big Horn Mountains south of the Big Horn Canyon. West of Pryor the Greybull sandstone consists of about 25 feet of coarse massive sandstone very similar to the underlying Lakota in appearance, but the unit rapidly loses its massive character as it is traced toward the north and northeast, and it is poorly consolidated and conspicuously thin-bedded in its exposures northeast of Pryor and along Beauvais Creek.

The top of the Cloverly, as the formation has been defined at the Soap Creek dome,[37] is marked by about 80 feet of yellowish sandy shale containing layers of hard, thin-bedded rusty sandstone. Similar beds in the same general position were observed east of the Sport Creek dome and at several other places along the east flank of the Big Horn Mountains. These tawny sandy shales may possibly correspond to the Greybull sandstone of areas to the west, but there is also a possibility that local lenses of coarse massive sandstone that lie a little below the tawny beds in Cloverly exposures near the head of War Man Creek and north of Rotten Grass Creek are more properly

[36] Hewett, D. F., and Lupton, C. T., Anticlines in the southern part of the Big Horn Basin, Wyo.: U.S. Geol. Survey Bull. 656, p. 19, 1917.

[37] Thom, W. T., Jr., and Moulton, G. F., The Soap Creek oil field, Crow Indian Reservation, Mont.: U.S. Geol. Survey Press Mem., Dec. 5, 1921.

to be correlated with the Greybull, whereas the tawny sandy shales lying above are probably equivalent to the "rusty beds" of Washburne,[38] which consist of dark sandy shale and thin-bedded fine-grained sandstone. These "rusty beds" were referred by Hewett and Lupton [39] to the basal part of the Upper Cretaceous Thermopolis shale and were subsequently referred by Hares [40] to the Cloverly on faunal and lithologic grounds. Hares' correlation is made doubtful, however, by the fact that Washburne [38] and Hintze [41] both believe that a stratigraphic break exists between the Cloverly and "rusty beds" in the vicinity of Greybull, Wyo. Washburne says:

> The "rusty beds" are a constant feature of the base of the marine Cretaceous. Seemingly they are as a group a true basal sandstone, resting upon a rather smooth surface of erosion. Beneath this erosional surface at some localities is a heavy sandstone, probably the lower sandstone of the Cloverly formation; but at most places the Cloverly sandstone is absent and the "rusty beds" rest upon maroon, pink, or bright-green shales which are regarded as part of the Morrison formation, though they may belong to the Cloverly. There can be no doubt as to the lenticular nature of the Cloverly sandstone and its absence over most of the area. The field evidence indicates that the sandstone was removed by erosion before the deposition of the overlying marine strata of the Upper Cretaceous.

Insofar as the writers are able to judge there is rather more likelihood that the tawny sandy shale and sandstone lying at the top of the Cloverly as mapped in the central part of the reservation are equivalent to the "rusty beds" of Washburne (which the United States Geological Survey now includes in the Thermopolis shale) than that they are equivalent to the Greybull sandstone. If the "rusty beds" represent a shore phase of deposition in the advancing Colorado sea, they are to be considered as of Upper Cretaceous age and are probably equivalent to the First Cat Creek sand of central Montana. Under such an interpretation it is believed that the Cloverly formation would be stratigraphically equivalent to the First Cat Creek sand of central Montana and the underlying Kootenai formation down to and including the persistent conglomeratic sandstone said by Calvert [42] to lie just above the coal of the Lewistown coal field and 60 to 90 feet above the Kootenai-Morrison (?) contact within the Lewistown area.

Presumably that part of the Kootenai lying below the conglomerate is lost in the Crow Indian Reservation by unconformable overlap of the Cloverly upon the Morrison, but the presence below the strata that are considered to represent the Lakota near Thermopolis, Wyo.,

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38 Washburne, C. W., Gas fields of the Big Horn Basin, Wyo.: U.S. Geol. Survey Bull. 340, p. 350, 1908.

39 Hewett, D. F., and Lupton, C. T., op. cit., pp. 19–20.

40 Hares, C. J., unpublished manuscript.

41 Hintze, F. F., Jr., The Basin and Greybull oil and gas fields, Big Horn County, Wyo.: Wyoming State Geologist's Office Bull. 10, pp. 19–20, 1915.

42 Calvert, W. R., Geology of the Lewistown coal field, Mont.: U.S. Geol. Survey Bull. 390, p. 25, 1909.

of carbonaceous beds that are probably representative of the Lewistown coal zone was recorded by Darton [43] and has also been more recently recorded by Lee [44] near both Thermopolis and Nowood, Wyo. In Lee's opinion it was at the Nowood locality that leaves identified as belonging to Kootenai species were obtained by Fisher.[45] Similarly, fossil leaves of Kootenai age, according to identifications by F. H. Knowlton, have been obtained by Wegemann from the base of the conglomerate near Mayoworth, Wyo., that is believed to correspond to Lakota sandstone. This suggests that the local coal bed present in the lower part of the Cloverly in sec. 22, T. 9 S., R. 34 E. (see p. 86), may likewise be of Kootenai age.

The general composition and thickness of the Cloverly as developed in the Crow Indian Reservation and vicinity are shown graphically in plate 6 and indicated in greater detail by the following stratigraphic sections and by the well records given on pages 105–124.

Section of the Cloverly formation in the SW¼ sec. 13, T. 5 S., R. 25 E.

[Measured by W. W. Rubey]

	Feet
Sandstone, coarse, massive, irregularly bedded (Greybull sandstone?); thin-bedded toward the east in Pryor Creek Valley	20
Shale, variegated	55
Limestone, white	1
Shale, variegated	50
Sandstone, light-colored, cross-bedded; passes laterally into more normal conglomeratic phase (Lakota? sandstone)	20
	146

Section of the Cloverly formation in sec. 22, T. 9 S., R. 34 E.

[Measured by C. H. Wegemann]

	Feet
Sandstone, shaly, gray, containing fragments of shells, indeterminable	12
Shale, gray	23
Shale, pink	4
Sandstone, white	2
Shale, soft; upper half red, gray, and purple; lower half black with 5 feet of hard white shale in middle	38
Shale, hard, splintery, white	7
Shale, gray, green, and purple	6
Shale, red, weathering purple	5
Shale, soft, light gray, containing great numbers of concretions formed of chalcedony and calcite	10
Shale, hard, gray, weathering brilliant white	6

[43] Darton, N. H., op. cit., p. 50.

[44] Lee, W. T., Continuity of some oil-bearing sands of Colorado and Wyoming: U.S. Geol. Survey Bull. 751, p. 16, 1925.

[45] Fisher, C. A., Southern extension of the Kootenai and Montana coal-bearing formations in northern Montana: Econ. Geology, vol. 3, p. 86, 1908.

	Feet
Sandstone, hard, full of worm tracks and burrows	1
Sandstone, yellow	10
Shale, gray	5
Sandstone, hard, white	5
Shale, gray	6
Coal	7
Shale, dark gray	12
Shale, dark rusty brown	2
Sandstone, dirty gray, with interbedded shale	13
Sandstone, hard, coarse, with well-rounded grains, finer toward top; contains many particles of some black mineral, probably augite or hornblende (Lakota? conglomerate)	7
Sandstone, shaly (base of Cloverly)	4
	185

The local bed of coal recorded in the foregoing section is an interesting feature, and the worm holes in the hard sandstone bed 25 feet above the coal appear to be characteristic of this particular horizon, having been noted by Wegemann at other places on the southeast flank of the Big Horn Mountains. The peculiar chalcedony concretions that occur 6 feet higher in the section were found at several places in the Crow Indian Reservation. They are smooth and partly rounded and range from white to yellow or orange. Gastroliths are also found at this horizon. Concretions of phosphate of lime, probably pseudomorphic after marcasite, are found at a horizon about 15 feet stratigraphically below the top sandstone of the foregoing section.

UPPER CRETACEOUS SERIES

COLORADO GROUP

THERMOPOLIS SHALE

As originally defined by Hewett and Lupton[46] the Thermopolis shale included in its basal part the dark sandy shales and thin-bedded fine-grained sandstones called by Washburne[47] the "rusty beds" and was terminated upward by the Mowry shale. The Thermopolis shale as mapped by the writers in the Pryor and Beauvais Creek Valleys conforms to the definition of Hewett and Lupton, but the "rusty beds" are for convenience included in the Cloverly as mapped at Soap Creek and south of the Big Horn River. (See p. 44.) The Mowry-Thermopolis contact was mapped on lithologic grounds entirely, being drawn below the lowest bed of "fish-scale" shale in the eastern part of the reservation, whereas in the western part

[46] Hewett, D. F., and Lupton, C. T., op. cit., pp. 19–20.
[47] Washburne, C. W., op. cit., p. 350.

of the reservation it was mapped at the contact between the yellow sandy beds associated with the Mowry and the dark-gray shale below. Both contacts are believed to rise and fall slightly in the geologic column but probably are not susceptible of a more precise location owing to variations in the basal part of the Mowry and to the vertical and lateral gradation of the basal part of the Thermopolis shale into the "rusty beds", which in turn, at least locally, have an appearance of conformity upon the Cloverly.

The Thermopolis of the Crow Indian Reservation is divisible into three lithologic units. As defined at Soap Creek it consists of a basal unit of 120 feet of dark shale, a middle unit of 180 feet of black ferruginous shale and bentonite beds, and a top unit 225 feet thick composed of dark-gray shale containing irregular shaly sandstone with beds of bentonite. In the valley of Pryor Creek the same three divisions are even more distinct, owing to the color contrast between the top and middle members and to the presence of a rim-forming sandstone (here named "Birdhead sandstone member") at the contact of the middle and lower members. This sandstone is believed to correspond to the Newcastle sandstone or the †Muddy sand[48] of Wyoming, and has a local thickness of 8 to 15 feet. It is named for its exposure in Birdhead Coulee, which cuts across it in T. 3 S., R. 27 E. It grows less prominent toward the east, and at Soap Creek it has disappeared except for thin local lenses of sandstone noted at the junction of the middle and lower members on the east side of the Soap Creek dome. The dark-gray shales that form the top member of the Thermopolis near Pryor Creek are noticeably lighter-colored than the underlying black shales of the middle member, and they are rather more sandy in the western part of the reservation than in the central part.

The Birdhead sandstone is commonly overlain by a thick bed of bentonite which usually contains one or two ½-inch beds of hard gray shale that weathers into splinters. This lithologic combination and the rim-forming habit of the sandstone itself make it a bed that can be readily identified and used as a key stratum for structural mapping in the Pryor Creek Valley.

The lower member of the Thermopolis is about 280 feet thick near Pryor Creek and contains in its basal part about 130 feet of beds showing the "rusty bed" phase of deposition.

In the western part of the reservation the Thermopolis has yielded poorly preserved fossil bones of marine vertebrates, apparently

[48] A dagger (†) preceding a geologic name indicates that the name has been abandoned or rejected for use in classification in publications of the U.S. Geological Survey. Quotation marks, which were formerly used to indicate abandoned or rejected names, are now used only in the ordinary sense.

from the top of the Birdhead sandstone. The following three collections of fossils were obtained from the upper, dark-gray member at Soap Creek:

10892. Upper member of Thermopolis shale, 50 feet below fossil turtle, NW¼ sec. 9, T. 6 S., R. 32 E.:
Inoceramus labiatus Schlotheim.
Modiola n. sp.
Fish teeth.

10906. Upper member of Thermopolis shale, SW¼ sec. 9, T. 6 S., R. 32 E.:
Gyrodes? aff. G. depressa Morton.
Inoceramus labiatus Schlotheim.
Fish teeth, bones, and scales.

10910. Fossils from hard dark sandstone 45 feet below top of Thermopolis shale, NW¼ sec. 35, T. 6 S., R. 32 E.:
Cardium? sp.
Entolium? n. sp.
Inoceramus sp.
Ostrea sp.
Pteria n. sp. aff. P. nebrascensis Evans and Shumard.

The third collection is reported by Reeside to represent a faunule not previously known in the Cretaceous of the Western Interior.

MOWRY SHALE

The Mowry shale conformably overlies the Thermopolis and because of its relative hardness and resistance to erosion is one of the most conspicuous formations in the Crow Indian Reservation. It consists of several beds of hard light-colored more or less sandy shale, interbedded with rather greater thicknesses of more normal dark shale. The light-colored beds commonly contain numerous impressions of fish scales from an eighth to half an inch in diameter. In the Soap Creek field the upper and lower limits of occurrence of this fish-scale shale were assumed to mark the top and bottom of the Mowry, giving the formation a thickness of 200 to 300 feet.

Like the Thermopolis shale, the Mowry seems to be more sandy toward the west, and in the basin of Pryor Creek the strata associated with the fish-scale shale beds are about 300 feet thick and are prevailingly of a yellow tint. In this locality the Mowry-Thermopolis shale contact was therefore drawn at the base of the light-colored beds. Another feature of the Mowry in the western part of the reservation is a quartzite layer 6 inches to 2 feet thick, lying about the middle of the formation, which locally contains thin streaks of coarse sand mixed with fish bones and teeth.

Hogbacks or ridges capped by the Mowry shale outline the Soap Creek dome on the east, south, and west sides, and form the outermost of the prominent hogback ridges developed east of the Big Horn Mountains between the Soap Creek field and the Montana-Wyoming line. In the central and western parts of the reservation the Mowry is even more prominently exposed, forming the rim north and east of the Crescent dome (see pl. 11) in the valleys of Beauvais and Woody Creeks and affording the protective capping of the high plateaus that feature the divides east and west of Pryor Creek in Tps. 3 to 5 S.

FRONTIER FORMATION

The Frontier formation overlies the Mowry shale and has a local thickness of about 410 feet in the Soap Creek field. In this field and elsewhere in the southern and eastern parts of the Crow Indian Reservation the Frontier consists chiefly of dark shale and beds of bentonite lithologically very similar to the lower part of the overlying Carlile shale. Because of this lithologic similarity the division of the two formations in the Soap Creek field was arbitrarily made at the top of a thick bentonite bed exposed east of the Soap Creek dome, which lies a short distance above several thin layers of coarse sandstone containing small chert pebbles and shark teeth. These sandy layers are confined to the top 100 feet of the formation at Soap Creek but apparently become thicker toward the northwest, as some gas is yielded by the Frontier north of Hardin, and fairly prominent beds of sandstone belonging to this zone are exposed in sec. 20, T. 4 S., R. 31 E., and are reported to be exposed in sec. 28, T. 3 S., R. 31 E. A still greater thickness of sandy shale in this zone is observable in the southern part of sec. 28, T. 1 S., R. 27 E., where it is sufficiently resistant to form a hogback that is traceable westward into the Frontier sandstones of the Big Horn Basin region.

CARLILE SHALE

The Carlile shale, as it has been defined within the Crow Indian Reservation,[49] overlies the Frontier formation and probably includes strata older than those included in the type Carlile. The Carlile as defined at Soap Creek has a local thickness of about 425 feet and is divisible into several zones that afford useful key beds in the large area covered by rocks of the Colorado group within the reservation. On the map (pl. 1) the Carlile and Niobrara shales are grouped together.

According to the classification used in the Soap Creek field the basal half of the Carlile shale consists of dark marine shale and interbedded layers of bentonite similar lithologically to the greater part of the rocks that make up the underlying Frontier formation. The beds 145 to 245 feet above the base of the Carlile, as here defined, usually contain two layers of bluish limy shale, which at many places along hillsides weather into conspicuous whitish streaks.

[49] Thom, W. T., Jr., and Moulton, G. F., The Soap Creek oil field: U.S. Geol. Survey Press Mem., Dec. 5, 1921. Thom, W. T., Jr., Oil and gas prospects in and near the Crow Indian Reservation, Mont.: U.S. Geol. Survey Bull. 736, pp. 38–39, 1923.

These limy beds, where exposed in the hills east of the Soap Creek oil field, contain numerous concretions, many of which inclose the fossil remains of very large ammonites of the genus *Vascoceras*, which have been described and figured by Reeside.[50] The fossils collected from this zone have been identified as follows:

10890, 10755. Limy shale zone exposed near head of ravine, sec. 36, T. 6 S., R. 32 E.:

Vascoceras thomi Reeside.
Vascoceras moultoni Reeside.
Vascoceras stantoni Reeside.
Vascoceras sp. indeterminable.
Pseudotissotia (Choffaticeras) sp.?
Helicoceras pariense White?
Inoceramus labiatus (Schlotheim).
Inoceramus sp. undetermined.
Ostrea or Exogyra sp.
Gastropod, undetermined.

Concerning these fossils Reeside stated:

These collections contain an extremely interesting fauna. Though the number of species is small they show unmistakably the presence of a Mediterranean lower Turonian fauna of world-wide distribution. The nearest and in fact only other known occurrence of this fauna in North America is in the State of Coahuila, Mexico, but it is known at many localities in southern Europe, northern Africa, northern South America, and India. The presence of this southern fauna in a region as far north as Montana presents an interesting question in paleogeography. The only other suggestion of a northward extension of the Mediterranean fauna is contained in the presence of the genus *Metoicoceras* in the Mosby sandstone and at a similar horizon at other localities in Wyoming and Montana. The correlation of the zone of *Vascoceras* with the Mosby sandstone suggested by their stratigraphic positions, is supported somewhat by the fact that both *Vascoceras* and *Metoicoceras* are of southern origin, but the difference in lithology and the complete difference in fauna otherwise are against a close correlation. The correlation of the zone of *Vascoceras* with the Greenhorn limestone of the region to the south is supported by the fact that both are the highest horizon of abundant occurrence of *Inoceramus labiatus* and that both are followed immediately by the beds containing the typical Carlile fauna. Taking into consideration that in the Plains region 300 feet or less of Graneros shale and Greenhorn limestone together lie between the beds with the Carlile fauna and the Dakota sandstone, it is likely that the typical Greenhorn limestone of the Plains represents more, perhaps much more, than the zone of *Vascoceras* in the section in southeastern Montana.

Reeside's suggestion that the *Vascoceras* zone of the Soap Creek field is at about the same horizon as the Mosby sandstone of central Montana is supported by the fact that this zone and the Mosby sandstone occupy similar positions with respect to the underlying Mowry shale and an overlying zone containing conspicuous red concretions. His additional suggestion that the *Vascoceras* zone may correspond to at least a part of the Greenhorn limestone of the Black Hills region seems reasonable after a comparison of the local stratigraphic section with that of the north end of the Black Hills, but the evidence available is not altogether conclusive.

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[50] Reeside, J. B., Jr., A new fauna from the Colorado group of southern Montana: U.S. Geol. Survey Prof. Paper 132, pp. 25–33, 1925.

The white streaks formed by the outcrop of the *Vascoceras* zone are visible in the hills about 2 miles east of the crest of the Soap Creek dome, especially in sec. 36, T. 6 S., R. 32 E. One of the light-colored lines of outcrop observable in the hills east of Pryor Creek near the former station of Coburn may also represent this zone.

About 60 feet above the *Vascoceras* zone is the base of a 30-foot shale unit of widespread development that contains thin hard rust-red concretions. This apparently corresponds in age to a similar zone of red concretions and ironstone nodules found in the Cat Creek district and elsewhere in central Montana. This zone of red concretions was seen in the southeastern part of T. 2 S., R. 32 E.; at several points a little above and a short distance east of the Big Horn Ditch; along the east side of the Soap Creek-Rotten Grass fold; in the south bank of Rotten Grass Creek in sec. 3, T. 8 S., R. 33 E.; and in a prominent ridge partly within secs. 12 and 13, T. 9 S., R. 34 E.

Many of the red concretions are fossiliferous, and from them the following collections were obtained:

10894. Red concretion zone and bed just above it, NE¼ sec. 33, T. 2 S., R. 32 E.:
- Baculites gracilis Shumard.
- Inoceramus fragilis Hall and Meek.
- Inoceramus cf. I. lamarcki Parkinson.
- Prionocyclus wyomingensis Meek.
- Veniella humilis Meek and Hayden.

10904. Float from red concretion zone, sec. 30, T. 7 S., R. 33 E.:
- Prionotropis sp., fragment of a very large specimen.

10905. Red concretion zone in Creek Bluff, sec. 3, T. 8 S., R. 33 E.:
- Inoceramus fragilis Hall and Meek.
- Lunatia? sp.
- Scaphites warreni Meek and Hayden.

10912. Red concretion zone, west of center of sec. 21, T. 7 S., R. 33 E.:
- Baculites aff. B. gracilis Shumard.
- Inoceramus fragilis White.
- Prionotropis sp.
- Scaphites warreni Meek and Hayden.
- Volutoderma? sp.

The red concretion zone is overlain, in ascending order, by about 35 feet of dark shale, a 5-foot stratum of dark shale containing large yellow sandy concretions, and about 50 feet of dark shale containing large numbers of small white concretions that yielded the following fossils:

10901. Top part of Carlile shale in hill southeast of road crossing Soap Creek Ditch, sec. 12, T. 5 S., R. 32 E.:
- Corbula aff. C. nematophora Meek.
- Fusus? sp.
- Inoceramus labiatus Schlotheim.
- Prionocyclus wyomingensis.
- Pseudomelania? sp.
- Veniella goniophora Meek.

NIOBRARA SHALE

The Niobrara shale, the top formation of the Colorado group, of Upper Cretaceous age, is about 400 feet thick in the Crow Indian Reservation and is exposed in a broad belt south and west of the Eagle and Telegraph Creek formations. The Niobrara and Carlile shales are grouped together on the map. (See pl. 1.) The top part of the Niobrara is composed of limy shale which is bright blue when fresh and weathers yellowish. The lower part of the formation also consists of blue shale. The base of the formation is placed below a very persistent zone of large yellow concretions which caps a slight escarpment near the top of the hills in sec. 36, T. 6 S., R. 32 E., and is exposed in the bluffs of Rotten Grass Creek at the south end of the Rotten Grass dome. As might be expected, this basal concretionary bed contains a fauna in which Carlile and Niobrara species are mingled.

The lower strata of the Niobrara are well exposed in ravines east of the Rotten Grass dome and contain there numerous remains of *Ostrea congesta*, adhering to fragments of thick *Inoceramus* shells. The following collections of Niobrara fossils have been made within the reservation:

10888. 100 to 200 feet above base of Niobrara shale, near center of sec. 21, T. 7 S., R. 33 E.:

Anatina aff. A. subgracilis Whitfield.
Baculites asper Morton.
Baculites sp., smooth form.
Baculites aff. B. anceps Lamarck.
Cardium n. sp.
Fusus sp.
Inoceramus aff. I. lamarcki Parkinson.
Inoceramus sp., large thick-shelled form.
Pteria aff. P. nebrascensis Evans and Shumard.
Scaphites vermiformis Meek and Hayden.
Veniella goniophora Meek.
Volutoderma sp.

10897. 100 to 200 feet above base of Niobrara shale in NW¼ sec. 4, T. 2 S., R. 31 E.:

Baculites asper Morton, var.
Inoceramus cf. I. umbonatus Meek and Hayden.
Scaphites vermiformis Meek and Hayden.

10899. Base of Niobrara shale in SW¼ sec. 19, T. 2 S., R. 32 E.:

Inoceramus sp., large thick-shelled form.
Ostrea congesta Conrad.

10900. Top of Niobrara shale in sec. 27, T. 1 S., R. 30 E.:

Inoceramus sp.
Ostrea congesta Conrad.
Uintacrinus socialis Grinnell.

10908 and 10754. Base of Niobrara shale at top of southwest slope in SW¼ sec. 36, T. 6 S., R. 32 E.:

Anomia sp.
Anchura sp.
Baculites sp.
Barbatia sp.
Callista tenuis Hall and Meek.
Corbula cf. C. nematophora Meek.
Corbula n. sp.
Dentalium sp.
Gyrodes cf. G. conradi Meek.
Gyrodes aff. G. petrosa (Morton).
Inoceramus (Actinoceramus) sp.
Inoceramus cf. I. fragilis Hall and Meek.
Inoceramus umbonatus? Meek and Hayden.
Nautilus sp.
Nemodon n. sp.
Scaphites vermiformis Meek and Hayden.
Turritella aff. T. whitei Stanton.
Turritella n. sp.
Veniella goniphora Meek.
Yoldia sp.

10909. Probably middle of Niobrara shale; east quarter corner sec. 16, T. 8 S., R. 34 E.:

Baculites asper (?) Morton, very large variety.
Baculites aff. C. anceps Lamarck.
Scaphites vermiformis Meek and Hayden.

10911. Base of Niobrara shale in center sec. 21, T. 7 S., R. 33 E.:

Inoceramus sp., fragments of thick-shelled species.
Ostrea congesta Conrad.

10749. Middle part of Niobrara shale, sec. 25, T. 2 S., R. 33 E.:

Baculites sp. cf. B. anceps.
Inoceramus sp., large thick-shelled form.
Lunatia concinna? Hall and Meek.
Ostrea sp., cf. O. congesta Conrad.
Scaphites vermiformis Meek and Hayden.
Tessarolax cf. T. hitzii White.
Yoldia sp.
Fish scales.

10751. Top of Niobrara shale, south-central part of sec. 27, T. 4 S., R. 33 E.:

Baculites asper Morton.
Inoceramus sp., large thick-shelled form.
Ostrea congesta Conrad.
Scaphites sp.
Tessarolax cf. T. hitzii White.

MONTANA GROUP

TELEGRAPH CREEK FORMATION

The Telegraph Creek formation is typically developed in T. 2 S., Rs. 28 and 29 E.,[51] and is conspicuously exposed in the cuts along the Custer Battlefield Highway east of Pryor Creek and near the

[51] Thom, W. T., Jr., Oil and gas prospects in and near the Crow Indian Reservation, Mont.: U.S. Geol. Survey Bull. 736, p. 38, 1923.

former site of Mifflin station. It consists of 320 feet of light-colored sandy shale parted in the middle by a thin concretionary sandstone (Elk Basin sandstone member) that caps a prominent escarpment, above which are other less prominent concretionary sandstone layers. The fossils in the formation are predominantly of Montana types and include a number of species found in the Eagle sandstone mingled with forms usually found in the Niobrara shale, from which it appears probable that the Telegraph Creek formation is essentially equivalent to the part of the Steele shale of the Salt Creek field which underlies the Shannon sandstone member. East of Fly Creek in Rs. 30 and 31 E. the Telegraph Creek formation and the Eagle sandstone are not differentiated but are grouped and mapped together.

Fossiliferous sandy shales belonging to this formation are exposed northeast of Hardin, along the face of the ridge on the east side of Rotten Grass Creek, and just west of the Eagle sandstone outcrops between the Little Horn River and the Wyoming boundary.

The fossils obtained from this formation within the Crow Indian Reservation are said by Reeside[52] to

> constitute a fauna which is a mixture of species usually found in the Niobrara with species hitherto thought to be confined to the Eagle. *Uintacrinus* sp., *Inoceramus deformis*, and *Marsupites* sp. would ordinarily be accepted as of Niobrara age. The fauna includes *Scaphites bassleri* and *Puzosia mancosensis*, which are elsewhere associated only with strictly Eagle species. Probably the faunule represents a border zone between Eagle and Niobrara. It is noteworthy that this occurrence of *Marsupites* is only the second that has been recorded in America, though the genus is a common guide fossil in some of the European localities and is there also associated with *Uintacrinus*.

The following collections of fossils obtained from the Telegraph Creek formation have been identified by Reeside:

10902. Base of Telegraph Creek formation, sec. 27, T. 1 S., R. 30 E.:
- Baculites asper Morton var.
- Inoceramus sp.
- Ostrea congesta Conrad.
- Pseudomelania? n. sp.
- Scaphites bassleri Reeside.
- Uintacrinus sp.

10746. Lower part of Telegraph Creek formation in creek bank near old cabin, sec. 28, T. 1 S., R. 30 E.:
- Baculites sp.
- Ostrea sp.
- Inoceramus sp.

10747. Middle part (Elk Basin sandstone member) of Telegraph Creek formation, SE¼ sec. 20, T. 1 S., R. 30 E.:
- Modiola cf. M. meeki Evans and Shumard.
- Nemodon? n. sp.

[52] Reeside, J. B., Jr., personal communication.

10750. About 50 feet below top of Telegraph Creek formation near Shoulderblade Butte, south-central part sec. 27, T. 4 S., R. 33 E.:

Baculites sp.
Inoceramus deformis Meek, var.
Scaphites bassleri Reeside.

10752. Approximate top of Telegraph Creek formation, same locality as 10750:

Baculites sp.
Inoceramus deformis Meek, var. Same as at locality 10750.
Marsupites sp. (Determined by F. Springer.)
Ostrea sp. cf. O. congesta Conrad.
Puzosia (Latidorsella) mancosensis Reeside.
Scaphites bassleri Reeside.
Fish scales.

10744. Elk Basin sandstone member in east bluffs of Pryor Creek, sec. 31, T. 1 N., R. 29 E.:

Anatina sp.
Anomia sp.
Baculites ovatus Say.
Baculites aquilaensis Reeside.
Cardium n. sp.
Cassidulus n. sp.
Cinulia sp.
Inoceramus barabini Morton.
Legumen cf. L. planulatum Conrad.
Lucina n. sp.
Mactra cf. M. formosa Meek and Hayden.
Nucula cf. N. planimarginata Meek and Hayden.
Ostrea sp.
Pteria linguaeformis Evans and Shumard.
Pteria nebrascensis Evans and Shumard.
Pholadomya n. sp.
Placenticeras planum Hyatt.
Serpula sp.
Syncyclonema rigida Hall and Meek, var.
Scaphites aquilaensis Reeside.
Tellina equilateralis Meek and Hayden.
Teredo borings.

10745. 5 feet below base of Elk Basin sandstone member, same locality as 10744:

Pholadomya n. sp.

10748. Elk Basin sandstone member in bank of Spring Creek, near west line sec. 1, T. 1 S., R. 30 E.:

Baculites asper Morton.
Baculites ovatus Say.
Cinulia cf. C. concinna Meek and Hayden.
Cuspidaria n. sp.
Lucina n. sp.
Pteria linguaeformis Evans and Shumard.
Scaphites stantoni Reeside.
Syncyclonema cf. S. rigida Hall and Meek.

11208. Middle rim-forming Elk Basin sandstone member of Telegraph Creek formation, SW¼ sec. 26, T. 1 S., R. 27 E.:

Baculites asper Morton.
Baculites ovatus Say var. haresi Reeside.
Cardium sp. undescribed.
Cinulia concinna Meek and Hayden.
Inoceramus aff. I. lobatus Goldfuss.
Lucina sp. undescribed.
Ostrea sp. undetermined.
Puzosia (Latidorsella) mancosensis Reeside.
Scaphites bassleri Reeside.
Scaphites hippocrepis (DeKay).
Teredo sp. undetermined.
Volutoderma sp. undescribed.

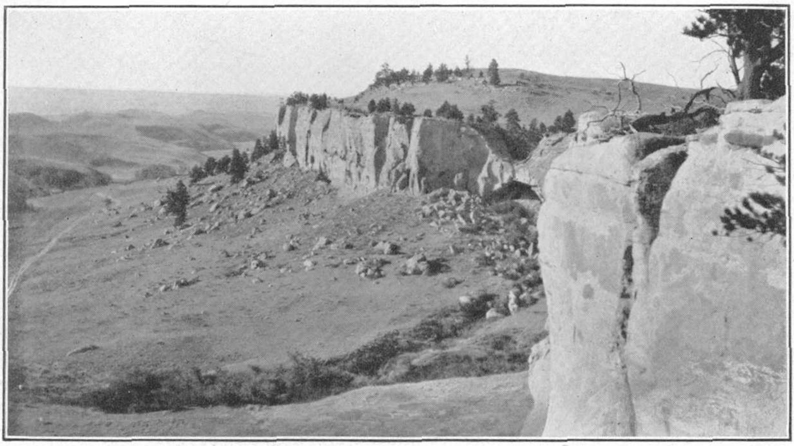
Collection 11208 was obtained from approximately the horizon of collection 10747, which is in turn correlated with the rim-forming sandstone developed below the main Eagle escarpment at Elk Basin and in the Clark Fork and Yellowstone Valleys west and northwest of Billings, to which the name Elk Basin sandstone was applied by Hares.[53] The collection is said by Reeside to be worthy of note because it shows a direct association of the *Scaphites hippocrepis* fauna of the Eagle with *Scaphites bassleri* and its usually associated forms, heretofore found below the *Scaphites hippocrepis* zone. Cephalopods from the Telegraph Creek formation have been described and figured by Reeside.[54]

EAGLE SANDSTONE

The Eagle sandstone is extensively exposed in the northwest corner of the Crow Indian Reservation, especially near the point where the Custer Battlefield Highway crosses Pryor Creek, just below the former site of Coburn station. A view of the Eagle sandstone is shown in plate 9, *A*. In this locality the Eagle consists of an upper buff massive sandstone 40 feet thick, underlain successively by 55 feet of shale, 10 to 30 feet of massive sandstone, 50 feet of shale, and 50 feet of massive sandstone (Virgelle sandstone member). The three sandstones of the formation form a southward-facing cliff on the East Fork-Telegraph Creek divide and are conspicuously exposed in the valley of the East Fork south of the Custer Battlefield Highway. The middle sandstone dies out rapidly toward the east, but the other two are traceable as far as Spring Creek, northwest of Toluca, north of which they are lost sight of beneath a cover of gravel. Near Hardin the Eagle consists of sandy shale and a few beds of thin sandstone not easily separable from the underlying Telegraph Creek

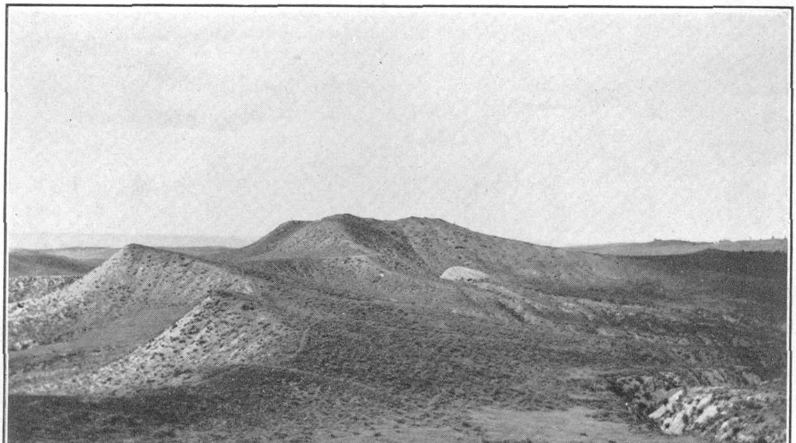
[53] Hares, C. J., unpublished manuscript.

[54] Reeside, J. B., Jr., The cephalopods of the Eagle sandstone and related formations in the Western Interior of the United States: U.S. Geol. Survey Prof. Paper 151, 1927.



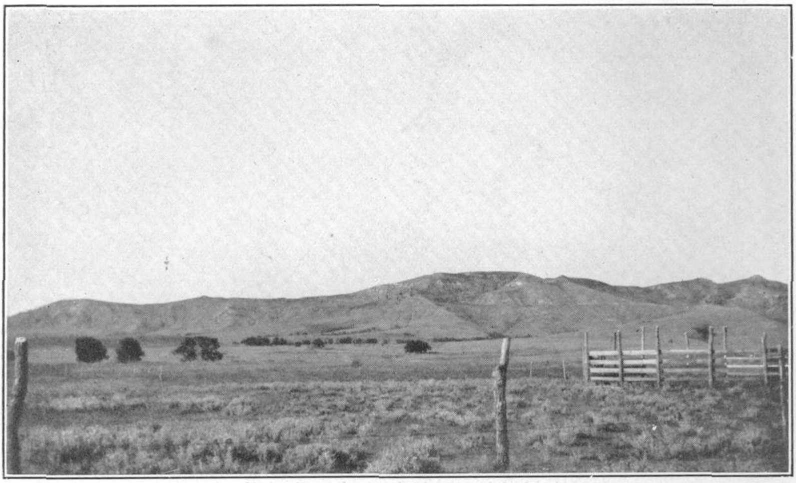
A. EAGLE SANDSTONE AS SEEN LOOKING NORTHWEST FROM TOP OF STEEP CLIFF IN THE NE¼ SEC. 19, T. 1 S., R. 27 E.

Photograph by E. T. Hancock (U.S. Geol. Survey Bull. 711, pl. 16).



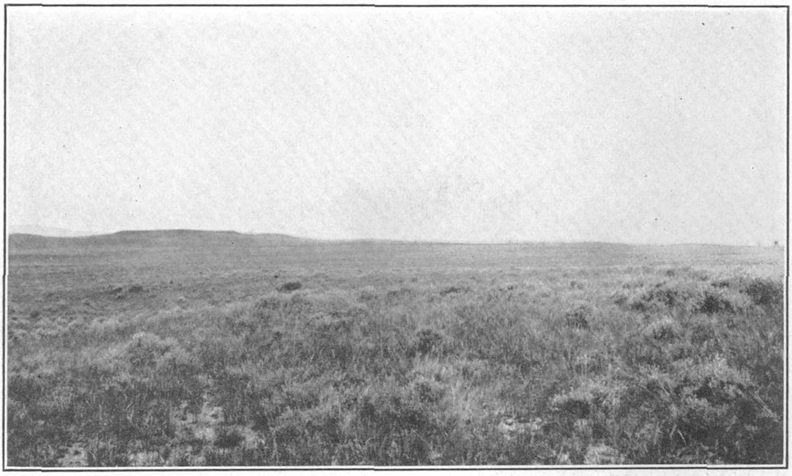
B. HOGBACK FORMED BY PARKMAN SANDSTONE, AS SEEN LOOKING NORTHWEST FROM SEC. 22, T. 1 N., R. 34 E.

Photograph by E. T. Hancock (U.S. Geol. Survey Bull. 749, pl. 1, *A*).



A. LEBO AND TONGUE RIVER MEMBERS OF FORT UNION FORMATION NORTH OF SIOUX PASS, T. 7 S., R. 37 E.

Photograph by W. T. Thom, Jr.



B. VIEW SHOWING SLIGHT RELIEF IN AREA UNDERLAIN BY WASATCH FORMATION IN T. 8 S., R. 39 E.

Photograph by A. A. Baker (U.S. Geol. Survey Bull. 806, pl. 6, *A*).

formation and it forms the upper part of the yellow hills just east of the Big Horn River. The formation extends southward as a rather indefinite unit along the Rotten Grass-Little Horn divide, and two thin beds of sandstone exposed in sec. 1, T. 3 S., R. 33 E., probably indicate its position at that locality. South of the Little Horn River in T. 9 S., R. 35 E., a massive fossiliferous sandstone reappears in the formation, and in the vicinity of Parkman, just south of the reservation, this sandstone is 125 feet thick. It is impossible to trace this sandstone in continuous outcrop between Parkman and Salt Creek, Wyo., but on the basis of contained fossils and stratigraphic position it appears that the Eagle sandstone exposed near Parkman is the stratigraphic equivalent of the Shannon sandstone of the Salt Creek oil field.

The following collections of fossils were obtained from the Eagle sandstone within the Crow Indian Reservation by Stanton and Thom:

10907. Virgelle sandstone member, sec. 2, T. 3 S., R. 28 E.:
- Acteon sp., probably n. sp.
- Anatina cf. A. doddsi Henderson.
- Anomia sp. undetermined.
- Anisomyon cf. A. subovatus Meek and Hayden.
- Baculites asper Morton.
- Cardium n. sp.
- Cinulia concinna Meek and Hayden.
- Crenella? n. sp.
- Cyprimeria n. sp.
- Dentalium sp.
- Fusus? sp.
- Inoceramus sagensis Owen.
- Legumen n. sp.
- Lucina subundata Hall and Meek.
- Mactra aff. M. formosa Meek and Hayden.
- Ostrea sp.
- Pholadomya n. sp.
- Pteria linguaeformis Evans and Shumard.
- Pteria nebrascensis Evans and Shumard.
- Syncyclonema rigida Hall and Meek.
- Scaphites hippocrepis (DeKay).
- Scaphites aquilaensis Reeside.

10756. Massive Eagle sandstone, NW¼ sec. 8, T. 9 S., R. 35 E.:
- Baculites aquilaensis Reeside.
- Baculites asper Morton.
- Baculites ovatus Say.
- Cinulia concinna Meek and Hayden.
- Crenella elegantula? Meek and Hayden.
- Cuspidaria n. sp.
- Echidnocephalus cf. E. americanus Cockerell.
- Echidnocephalus? sp.
- Eutrephoceras alcesense Reeside.
- Hypsodon sp.

Inoceramus aff. I. lobatus Goldfuss.
Lucina sp.
Lunatia sp.
Nucula sp.
Ostrea sp.
Placenticeras meeki Boehm.
Protocardia subquadrata Evans and Shumard.
Pteria linguaeformis Evans and Shumard.
Scaphites aquilaensis Reeside.
Scaphites hippocrepis (DeKay).
Syncyclonema rigida Hall and Meek.
Tellina sp.
Turritella n. sp.

10757. 50 feet lower than 10756 at same locality:
Baculites sp.
Fusus? sp.
Inoceramus sp.
Scaphites hippocrepis (DeKay).

The cephalopods of the Eagle sandstone have been described and figured by Reeside.[55]

CLAGGETT SHALE

The Eagle sandstone is overlain by dark marine shale belonging to the Claggett formation. The Claggett shale has an estimated thickness of about 650 feet near the Wyoming boundary and decreases northward to about 500 feet east of Hardin and 425 feet just north of the Crow Indian Reservation near Pryor Creek. At the last-named locality some sandstone and sandy shale are included in the upper part of the formation, and a 15-foot bed of massive sandstone occurs 140 feet above its base, apparently corresponding in stratigraphic position to a thin conglomerate bed containing shark teeth exposed in the east-central part of T. 4 S., R. 34 E.

PARKMAN SANDSTONE

The Parkman sandstone is typically exposed near Parkman, a station on the Chicago, Burlington & Quincy Railroad in Sheridan County, Wyo., about 12 miles south of Wyola, Mont.[56] It is stratigraphically closely equivalent to the Judith River formation as mapped in the Huntley field, immediately northwest of the Crow Indian Reservation. (See pl. 6.) Apparently such differences as exist between the Parkman sandstone and Judith River formation arise from the fact that the Parkman mainly represents strand or near-shore marine phases of deposition, whereas the Judith River

[55] Reeside, J. B., Jr., The cephalopods of the Eagle sandstone and related formations in the Western Interior of the United States: U.S. Geol. Survey Prof. Paper 151, 1927.

[56] Darton, N. H., and Salisbury, R. D., U.S. Geol. Survey Geol. Atlas, Bald Mountain-Dayton folio (no. 141), p. 8, 1906.

beds visible in the Huntley field and southwestern part of the Lake Basin were deposited under coastal plain or lagoon conditions. A view of the Parkman sandstone is shown in plate 9, *B*.

At its type locality the Parkman consists of a conspicuous cliff-forming basal sandstone 70 feet thick, overlain, in the order named, by 120 feet of shale, 10 feet of white fine-grained sandstone, 75 feet of shale, and 5 feet of white sandstone, giving the formation an aggregate thickness of 280 feet. North of Parkman the top sandstone is overlain by a coal bed which has burned in places, producing a clinker. A coal bed is also locally developed in the middle part of the Parkman at Lodge Grass.

The buff massive basal sandstone of the type Parkman contains marine [57] and fresh-water invertebrates, dinosaur bones, turtle-shell fragments, and many fragments of petrified wood. Because of its superior resistance to erosion this basal sandstone is an excellent horizon marker. It is continuously exposed from Parkman northward to Pass Creek, where its outcrop is shifted eastward by faulting; it extends from the vicinity of Aberdeen northward along the east side of Twin Creek and the Little Horn River almost to Lodge Grass. The lower beds of the formation also crop out in the hills west of the Little Horn River between Wyola and Bear Creek and in Tps. 3 and 4 S., R. 34 E. Beds of sandstone belonging to the Parkman are exposed locally on both sides of the Little Horn from the mouth of Shaving Creek northward to the vicinity of Crow Agency, whence its outcrop extends north and then west, reaching the bank of the Big Horn River just south of Ninemile Point. West of the Big Horn the Parkman is much obscured by terrace gravel but reappears at intervals and stands out boldly in the southwest point of Pine Ridge. At Pine Ridge the strata above the massive basal sandstone of the Parkman resemble the Judith River formation as developed northwest of Billings, and the Parkman as mapped in the reservation is here seen to be stratigraphically coextensive with the Judith River formation as mapped in the Huntley field.[58] The formation thickens northward and westward until it reaches a maximum of about 350 feet in the northwestern part of Big Horn County, where it contains thick beds of shale. South of the Crow Indian Reservation the sandstones of the Parkman can be traced definitely, though not in continuous outcrop, from Parkman to Salt Creek and other localities in central Wyoming.

It is therefore evident that the type Parkman sandstone is to be regarded as essentially equivalent to the Judith River formation as

[57] Darton, N. H., and Salisbury, R. D., op. cit., p. 8.

[58] Hancock, E. T., Geology and oil and gas prospects of the Huntley field, Mont.: U.S. Geol. Survey Bull. 711, pp. 121–124, 1920.

mapped in the Huntley and Lake Basin fields of Montana and to the Parkman sandstone member of the Mesaverde formation of the Salt Creek field. It also appears that the basal sandstone of the Parkman, though included in the Judith River formation of central Montana for convenience in mapping, is actually equivalent to the top member of the Claggett formation as originally defined by Stanton and Hatcher.[59]

BEARPAW SHALE

The marine Bearpaw shale overlies the Parkman sandstone and has a local thickness of about 600 feet northeast of Crow Agency. The base of the Bearpaw is here placed about 40 feet below a bentonite bed that makes a conspicuous and persistent line of white outcrops. East and southeast of Crow Agency a thin layer of sandstone and coarse grit is developed a short distance above this horizon and probably corresponds to a prominent sandstone in the Bearpaw in the southern part of the Lake Basin field.[60] In the southern part of the reservation and near Parkman and Dayton in Wyoming the upper part of the Bearpaw consists for the most part of fairly massive beds of sandstone whose stratigraphic position corresponds to that of the Lennep sandstone of Lake Basin, which is known to interfinger with the dark marine shale of the normal Bearpaw. The Bearpaw and the overlying Lennep sandstone and Lance formation apparently constitute the Piney formation as defined and mapped by Darton[61] in the region just south of the reservation.

A coal zone developed near the base of the Lake Basin Lennep sandstone has perhaps its local equivalent in a carbonaceous bed in the Bearpaw noted near Reno Creek.

TERTIARY (?) SYSTEM

EOCENE (?) SERIES

LANCE FORMATION

The Lance formation, of Tertiary (?) age, overlies the Bearpaw shale and has been divided by Rogers and Lee[62] into a lower (Hell Creek) member, which consists of clay and fluviatile sandstone, and an upper member, named "Tullock" by them, which contains

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[59] Stanton, T. W., and Hatcher, J. B., The stratigraphic position of the Judith River beds and their correlation with the Belly River beds: Science, new ser., vol. 18, pp. 211–212, 1903.

[60] Hancock, E. T., Geology and oil and gas prospects of the Lake Basin field, Mont.: U.S. Geol. Survey Bull. 691, p. 124, 1919.

[61] Darton, N. H., and Salisbury, R. D., op. cit., p. 8. Darton, N. H., Geology of the Big Horn Mountains: U.S. Geol. Survey Prof. Paper 51, pp. 59, 60, 1906.

[62] Rogers, G. S., and Lee, Wallace, Geology of the Tullock Creek coal field, Mont.: U.S. Geol. Survey Bull. 749, pp. 19–34, 1923.

several thin coal beds and differs from the lower member in color, lithology, and characteristic topography.

HELL CREEK MEMBER

The Hell Creek member of the Lance as mapped within the Crow Indian Reservation apparently rests conformably upon the sandy beds of the upper Bearpaw. Within the reservation the Hell Creek member consists of greenish clay and beds of massive, lenticular, fluviatile sandstone that contain fresh-water invertebrate fossils, fragments of turtle shells, and fossil bones identified as belonging to the dinosaurian genus *Trachodon*.

The basal part of the Hell Creek is well exposed just east and northeast of Lodge Grass, in the east bank of the Little Horn River, and caps the high wooded divide east of the Crow Agency and Pine Ridge northwest of Hardin. Where the basal sandstone beds of the Hell Creek exposed in the river bank east of Ionia rise northward toward the Reno Creek arch, dark shale containing typical Bearpaw fossils can be seen interlayered with what are evidently sandstone tongues filling old estuarine channels. The beds of sandstone and interbedded clay resemble the overlying Lance beds in lithology as well as in their content of turtle-shell and bone fragments and apparently indicate a gradational transition between the Lance and underlying beds in this region, as they apparently do near Salt Creek, Wyo.[63]

Within the reservation the Hell Creek member has a thickness of 600 to 650 feet, apparently growing slightly thicker toward the east or northeast.

TULLOCK MEMBER

The Tullock member was defined by Rogers and Lee[64] as the 300 feet of brownish-yellow cross-bedded and lenticular sandstone and yellow shale that is typically exposed along Tullock Creek, just north of the reservation. The upper limit of the member was placed at the top of a sandstone bed that forms a continuous rim rock below the dark shale of the overlying Lebo. Ordinarily the whole member is exposed in a distinct escarpment that rises above the hilly country surfaced by the Hell Creek member of the Lance.

The general composition of the Tullock member in the Tullock Creek field is indicated by the following composite section measured by Rogers and Lee.[65]

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[63] Dobbin, C. E., and Reeside, J. B., Jr., The contact of the Fox Hills and Lance formations: U.S. Geol. Survey Prof. Paper 158, p. 20, 1930.

[64] Rogers, G. S., and Lee, Wallace, op. cit., p. 29.

[65] Idem, pp. 70–71.

Composite section of Tullock member of the Lance formation

	Feet
Sandstone; forms rim rock, top of member	30
Coal, bed J	0–2
Shale and sandstone	100
Coal, bed I	0–3
Shale and sandstone	26
Coal, bed H	0–3
Shale and sandstone	27
Coal, bed G	0–2
Shale and sandstone	9
Coal, bed F	0–2
Shale and sandstone	17
Coal, bed E	0–2
Shale and sandstone	33
Coal, bed D	0–2
Shale and sandstone	10
Coal, bed C	0–5
Shale and sandstone	20
Coal, bed B	0–2
Shale and sandstone	15
Coal, base of member, bed A	0–4
	300±

The coal beds listed in the section above are lenticular and change laterally into carbonaceous shale.

TERTIARY SYSTEM

EOCENE SERIES

FORT UNION FORMATION

The Fort Union formation overlies the Lance conformably and is prominently exposed in the Rosebud Mountains, in the eastern part of Big Horn County and the Crow Indian Reservation. Like the Lance it is divided into two members, the Lebo shale member below and the Tongue River member above. The Lebo consists chiefly of gray, olive-drab, or black clay, whereas the Tongue River is composed of massive sandstone, light-colored to white clay, sandy shale, and numerous thick coal beds which have burned extensively along their outcrops. The two members have been separated on the basis of lithology and topographic expression, and as the coal beds and sandstones characteristic of the Tongue River member appear at progressively lower horizons in the Fort Union northward and eastward from Wyoming, the thickness of the Lebo diminishes in ratio with the increase in thickness of the Tongue River member. Regarding these relations Wegemann has prepared the following statement, largely on the basis of work done between Parkman and Salt Creek, Wyo.:

About 10 miles east of Aberdeen, in the Rosebud Mountains east of what is known as the Linerider Spring, about 800 feet of the basal part of the Fort

Union is exposed. This consists of shale of various shades of gray and black, containing many thin beds of calcareous shale which appear to contain considerable iron and on weathering become deep brick-red in color. Two thin beds of coal, one 3 to 4 inches in thickness, were noted in the middle of the formation. Above this dark shale lies a thick massive white sandstone, at the base of which is a thick coal bed associated with dark-brown carbonaceous shale. The upper part of the Fort Union at this locality (Tongue River member) is composed of massive cliff-forming sandstone with interbedded shale and numerous beds of coal. It is in this part of the formation that the coal beds mined north of Sheridan are found. Practically all the coal beds burn in outcrop, forming great masses of baked rock or slag. The sandstone is usually covered by pine trees, and this part of the formation is similar lithologically to the so-called "yellow beds", the upper member of the Fort Union, described in the report on the Miles City coal field.[66] From the lithologic appearance of the lower shaly part of the formation the writer believes that it is in part at least the equivalent of the upper part of the so-called "somber beds" described in the same report.

The relation of the beds at the Montana-Wyoming line, described above, to the Fort Union found in central Wyoming is a most interesting one. In the vicinity of the Salt Creek field the Fort Union formation appears to be represented by the beds that form the Great Pine Ridge—about 2,000 feet of fine-grained bluish-white sandstone and gray shale, which contains numerous limy beds identical in appearance with those in the lower part of the section at the Montana-Wyoming line.[67] The formation in the vicinity of Salt Creek may be traced in outcrop northward along the east front of the Big Horn Mountains. In T. 45 N., R. 18 W., the amount of the sandstone in the formation decreases until the beds no longer support a growth of pine trees. Above Trabing, on Crazy Woman Creek, and in the vicinity of the T.A. ranch the beds are well exposed and contain comparatively little sandstone, being very similar in appearance to the 800 feet of gray shale at the Montana-Wyoming line. The beds at this locality are, however, more than 800 feet thick. It is the writer's opinion that the 800 feet of beds exposed near the Linerider Spring are the equivalent of at least the lower part of the Fort Union formation, which forms the Great Pine Ridge between Sussex and Salt Creek, Wyo.

The coal bed which crops out along the west front of the Rosebud Mountains near the Linerider Spring and lies at about the division between the dark-colored shale that forms the lower 800 feet of the Fort Union and the massive sandstone and shale beds that form its upper part was traced northward by Howell across the east side of the Crow Indian Reservation. He found that as he followed this bed northward, sandstone and coal beds appeared below it—in other words, that the boundary between the somber shale that forms the lower part of the Fort Union and the yellow sandstone that forms its upper part dropped lower in the stratigraphic section as he went north, until in the vicinity of Shaving Creek, east of Lodge Grass, the beds of yellow coal-bearing sandstone were only about 350 feet above the top of the Lance formation. There can be little doubt, therefore, that the yellow sandstone and coal beds in this region of Montana are equivalent to non-coal-bearing

[66] Collier, A. J., and Smith, C. D., The Miles City coal field, Mont.: U.S. Geol. Survey Bull. 341, p. 42, 1909.

[67] Wegemann, C. H., The Sussex coal field, Johnson, Natrona, and Converse Counties, Wyo.: U.S. Geol. Survey Bull. 471, p. 446, 1912; Wasatch fossils in so-called Fort Union beds of the Powder River Basin, Wyo., and their bearing on the stratigraphy of the region: U.S. Geol. Survey Prof. Paper 108, p. 58, 1918.

sandy shale in the Sussex region of central Wyoming. The variation in the stratigraphic position of the boundary between the yellow and somber beds of the Fort Union was noted near the Montana-Wyoming line in 1907 by Taff.[68]

These general conclusions are believed to hold, although more recent work indicates that the lower part of the 800 feet of gray shale measured by Wegemann near Linerider Spring is probably to be assigned to the Tullock member of the Lance, rather than to the Fort Union.

LEBO SHALE MEMBER

The Lebo shale member consists chiefly of gray, olive-drab, or black clay that contains many ferruginous concretions and a few thin beds of sandstone that weathers to a deep brick-red color. Because of its softness the Lebo tends to form a strike valley throughout the Crow Indian Reservation between the rim on the west, which is capped by the Tullock member of the Lance, and the plateaus of the Rosebud Mountains on the east, which are capped by the clinker and resistant sandstone of the Tongue River member or the overlying Wasatch formation. A view of the Lebo is given in plate 10, *A*.

A thick bed of carbonaceous shale or impure coal is commonly present at the base of the Lebo (see pl. 6), and this bed is apparently the one referred to by Taff as occurring 800 to 1,000 feet below the Carney coal in the Sheridan field in Wyoming.[69]

TONGUE RIVER MEMBER

The Tongue River member is the lithologic equivalent of the Tongue River coal group of the Sheridan field described by Taff[70] as follows:

> The lowest workable bed of this [Tongue River coal] group is known as the Carney bed. It occurs in two benches in the Tongue River Valley. The upper bench is 4 feet 6 inches thick and the lower between 10 and 11 feet. The two benches are separated by a thin parting of shale.
>
> The next workable bed occurs about 86 feet higher in the section on Tongue River and is known locally as the "Monarch" bed. This bed also is divided into two benches. The upper one is reported to be nearly 10 feet thick and to contain partings of shale. The lower bench is 18 to 22 feet thick, as reported from drill prospecting and mine working. Part of the coal is left for roof in mining until the pillars are robbed, therefore a full section of the coal could not be seen. A large part of the rock between the Carney and Monarch coal beds consists of white massive sandstone. In the bluffs of Tongue River at Carneyville the sandstone is nearly 60 feet thick. A variable thin shale lies between it and the Carney coal, and a thicker bed of shale separates it from the Monarch bed above.
>
> Nearly 120 feet above the Monarch coal bed there is another bed, known as the "Dietz no. 3" coal. This is not exposed directly above a known outcrop

[68] Taff, J. A., The Sheridan coal field, Wyo.: U.S. Geol. Survey Bull. 341, p. 131, 1909.
[69] Idem, p. 128.
[70] Idem, pp. 129–130.

of the Monarch bed, its identity being determined from records of drilling and structural conditions between Monarch and the junction of Goose Creek on Tongue River. A prospect near the mouth of Goose Creek exposes 6 feet of the Dietz no. 3 bed, and it is reported to be 12 to 14 feet in prospect drillings. The rocks between the Monarch and Dietz no. 3 coal consist of bluish shale and thin-bedded and shaly drab sandstone.

Another coal bed, known as the "Dietz no. 2", lies about 100 feet above the Dietz no. 3. Its known thickness is 8 to 9 feet, and it is reported to thicken locally to 14 feet. Dietz coal bed no. 1, the fifth in the Tongue River coal group, counting from the base, occurs 100 to 115 feet above Dietz bed no. 2. This bed is 8½ feet thick near Dietz, and is succeeded by an upper bench 18 inches to 2 feet thick, with a gray shale of the same thickness intervening. The same bed is exposed in the bluffs of Tongue River near the mouth of Goose Creek. The rocks separating the Dietz coal beds consist of yellow to brown sandstone, bluish shale, and brown carbonaceous shale in beds of variable thickness. Certain thick sandstone beds between Dietz coals nos. 1 and 2 make bluffs along Goose Creek north of Dietz and on Tongue River east of Goose Creek.

A sixth coal bed in the Tongue River group is exposed 210 to 215 feet above Dietz bed no. 1, in the hills south of Dietz, where it is mined for local use. The coal here is nearly 5 feet thick and is referred to as the "Smith" coal, from the name of the operator of the local mine. A massive white sandstone 20 feet thick underlies the blue-shale floor of the coal. The outcrop of the sandstone makes a white band and is a marked feature of the hills northeast and south of Dietz. The rocks are chiefly shale from this white sandstone down to Dietz coal no. 1.

The uppermost bed at present known of the Tongue River coal group occurs 125 feet above the Smith coal and is separated from it by shale with a few thin sandstone beds. This coal bed has been prospected and mined for local consumption 2 miles northeast of Dietz by Mr. Roland and may be known for purposes of description as the "Roland" coal. The bed at this locality is 13 feet thick. Between Dietz and Sheridan the Roland coal bed is believed to be replaced by a thick bed of bituminous shale, with bands of bony coal 2 feet and less in thickness in its midst.

The continuity of the coal beds of the Sheridan field with those of the Rosebud Mountains has been established by Howell and, more recently in greater detail, by Baker,[71] Bass,[72] and Dobbin,[73] and some idea of the character of the Tongue River and underlying strata is given by the graphic sections of plate 6, which include the upper part of the log of the Absaroka Oil & Gas Co.'s well 1, drilled a few miles east of the southeast corner of the Crow Indian Reservation. This well started about 40 feet below the Smith coal of the Sheridan field, and although it is possible that much of the ma-

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[71] Baker, A. A., The northward extension of the Sheridan coal field, Big Horn and Rosebud Counties, Mont.: U.S. Geol. Survey Bull. 806, pp. 15–67, 1929.

[72] Bass, N. W., Coal in the Tongue River Valley, Mont.: U.S. Geol. Survey Press Mem. 16748, Feb. 12, 1924; The Ashland coal field, Rosebud, Powder River, and Custer Counties, Mont.: U.S. Geol. Survey Bull. 831, pp. 19–106, 1932.

[73] Dobbin, C. E., The Forsyth coal field, Rosebud, Treasure, and Big Horn Counties, Mont.: U.S. Geol. Survey Bull. 812, pp. 1–55, 1930.

terial logged as coal was in reality carbonaceous shale, it seems evident that several thick coal beds were penetrated.

The numerous coal beds of the Tongue River member have almost everywhere burned along their outcrops, with the production of heavy beds of slag, which strongly resist erosion. Indeed, it is to these clinker beds and to the massive sandstones of the Tongue River that the Fort Union principally owes its preservation in this area. Of the several clinker beds, the one formed by the burning of the Smith coal bed, which is crossed by the Sioux Pass-Indian Creek Road on the divide between the Little Horn River and Rosebud Creek, is one of the most useful horizon markers.

WASATCH FORMATION

According to the classification now in use the top of the Roland coal bed marks the base of the Wasatch formation, and remnants of the post-Roland strata cap the higher parts of the Rosebud Mountains and the interstream divides in the southeastern part of Big Horn County. (See pl. 1.) A detailed section of the Wasatch beds present in this area has been published by Baker,[74] who states that in this locality no marked lithologic difference exists between the Wasatch and underlying Fort Union. A view of an area underlain by the Wasatch formation is given in plate 10, *B*.

A fairly conspicuous rim-forming sandstone about 60 feet above the Roland coal caps much of the upland in T. 8 S., R. 38 E., and 300 to 500 feet of Wasatch beds cap the Badger Mountains, in the southern part of T. 9 S., R. 42 E., on the Tongue River-Hanging Woman Creek divide.

TERTIARY AND QUATERNARY SYSTEMS (UNDIFFERENTIATED)

Numerous conspicuous terraces rise in steplike fashion above the present river and creek flood plains in Big Horn County and the Crow Indian Reservation. In general there is a close parallelism of gradient between the present streams of the reservation and the older stream-laid terraces, indicating that the periodic downcutting which has taken place has been induced more by regional upwarp than by differential elevation of the mountains with reference to the adjacent plains. The terraces locally blend together, particularly toward the heads of streams where downcutting has been retarded by resistant strata, but in the main the several surfaces are distinct and are represented by erosion planes truncating resistant beds, as well as by aggraded surfaces. In the absence of immediate economic interest in the gravel deposits of the area, except as sources

[74] Baker, A. A., op. cit., pp. 28–29.

of road metal, the terraces received only incidental study in the course of local stratigraphic or structural work.

The character of the terrace gravel quickly reveals the fact that it is water-borne. The pebbles are commonly of foreign origin and not derived from the underlying rocks. Most of them are fragments of igneous rocks of various kinds, quartzite, silicified wood, and agate. Limestone, on account of its relative softness and solubility, is represented only sparingly but gradually increases in quantity toward the mountains. The well-rounded shapes of the pebbles and the uniformity of size in a particular layer are evidence that they were transported by streams. The terraces rise gradually toward the mountains, and the pebbles are made up of the rocks now found in the mountains; these facts indicate that the streams that transported the gravel flowed from the area now occupied by mountains.

As might be expected the surviving remnants of the several terraces are unequal in areal extent but seem to indicate a fairly uniform downcutting of 150 to 200 feet between one period of lateral planation and aggradation and the next. No fossils have been collected from the deposits of terrace gravel in the reservation, and consequently their ages are not definitely known.

In studying the terraces in Big Horn County and the Crow Indian Reservation, Thom found five terraces, which are described below. However, Alden [75] could not carry the five units over large areas and has found it necessary to establish three main groups.

The highest and oldest terrace surface, tentatively correlated by Alden [76] with the Oligocene of the Cypress Hills of Canada on the basis of its altitude, is well preserved on Pine Ridge, northwest of Hardin; on the plateau between Pryor and Fly Creeks; on the ridge in Tps. 1 N. and 1 S., R. 27 E.; and on the northwest side of the Shively Hill dome, in the southern part of T. 5 S., R. 27 E. The reconstructed gradient of this surface accords well with the altitude of the present divide in Pryor Gap. From these facts and from observations made by Alden in the Big Horn Basin, it seems probable that this Oligocene (?) plain was aggraded by the Clark Fork at the time when it was eroding the Pryor Gap. Renewed uplift then led to further erosion, and this may have caused the diversion of the Clark Fork to its present course by the headward cutting of a minor tributary of the Yellowstone River. This Oligocene (?) terrace is not known to be preserved east of the Big Horn River, but its approximate position is apparently indicated by an erosion plane that truncates the beds on the higher slopes of the east flank

[75] Alden, W. C., Physiography and glacial geology of eastern Montana and adjacent areas: U.S. Geol. Survey Prof. Paper 174, pp. 3–64, 1932.

[76] Alden, W. C., personal communication.

of the Big Horn Mountains, and by the eastward-sloping plateau surface of the Rosebud Mountains, which is an erosion surface of low relief. The ridges capped by the Mowry shale east and west of Pryor Creek, in the western part of the reservation, also apparently represent surviving remnants of this erosional surface.

A second terrace, about 200 feet below the Cypress (?), seems to be fairly well developed in the northwestern part of the reservation along the ridges east of Pryor Creek and less extensively on the Pryor Creek-Yellowstone divide. This terrace is strikingly developed between the Little Horn River and Lodgegrass Creek, and minor remnants of it survive upon the higher buttes along the divides between Rotten Grass Creek and the Little Horn River and between Soap and Rotten Grass Creeks and at several places in the southern part of the reservation. Apparently it was at this stage that the Black Gulch dome was truncated and the higher parts of the ridges capped with the Mowry shale and Cloverly formation on the divides between Soap Creek and the Wyoming line were planed off to their present level.

This terrace and the next lower are tentatively correlated by Alden with the late Miocene or early Pliocene Flaxville gravel [77] of northeastern Montana. The lower of these two terraces is the one most extensively developed within the reservation. These two are grouped together on plate 3 as no. 1 terrace. Large gravel-covered uplands belonging to this lower surface form the even tops of the higher hills west of the Big Horn River and south of Williams Coulee, and the same terrace level is well marked both by gravel beds and by erosion surfaces in the valley of the East Fork and elsewhere in the drainage basin of Pryor Creek, as, for example, near the site of the former station of Coburn. The ridge capped with Mowry shale between Woody Creek and the Big Horn River was truncated at this place, as were the similar ridges surrounding the Soap Creek dome and the Cloverly ridge east of Limekiln Creek. Remnants of the Flaxville (?) are present upon the north end of the Big Horn-Little Horn divide and cover considerable areas on the low part of the Little Horn-Tongue River divide just southwest of Parkman, Wyo.

A fourth terrace lies about 200 feet below the Flaxville (?) and is well developed west of Pryor Creek and somewhat less so southwest of Hardin. This terrace is shown on plate 3 as part of no. 2 and no. 3 terraces. This surface is also well developed in the Beauvais Creek Valley within the Mowry rim that curves around the north end of the Big Horn Mountains and within the Mowry hogbacks that

[77] Collier, A. J., and Thom, W. T., Jr., The Flaxville gravel and its relation to other terrace gravels of the northern Great Plains: U.S. Geol. Survey Prof. Paper 108, pp. 179–184, 1918.

surround the Soap Creek dome. Alden[78] regards this terrace as probably the correlative of the upper level of the second set of terraces developed on the Yellowstone River and as of early Pleistocene age.

A fifth terrace, believed by Alden to be of early or middle Pleistocene age (pre-Iowan), lies about 150 feet lower than the fourth terrace and, on the average, about 150 feet above present stream grade. This terrace is a conspicuous feature of the west bank of the Big Horn River and of Pryor Creek and covers a considerable area at the north end of the Big Horn-Little Horn divide. It is shown on plate 3 as part of no. 2 and no. 3 terraces. Remnants of it are also present a short distance above stream grade in the Beauvais Creek Valley within the Mowry shale escarpment and within the valleys of most of the other streams of the reservation. According to Alden, this terrace probably corresponds to the lower level of the second set of terraces on the Yellowstone. Hardin is built on the eroded or aggraded surface of the fifth terrace, which lies principally on the west side of the Big Horn River below the Two Legging bridge and on its east side between the bridge and the mouth of Big Horn Canyon. The Big Horn River has apparently been slowly reducing the area of this terrace by lateral planation and down-cutting during later Pleistocene and Recent time, and as a result the river is bordered on one side or the other by a sloping plain that descends from the fifth terrace level down to the present alluvial bottom lands, in which the river is now slightly entrenched.

STRUCTURE

The Big Horn and Pryor Mountains, outposts of the Rocky Mountains, extend northward from Wyoming into the western part of the Crow Indian Reservation, in Montana, where they are the major structural features. In the plains, which form the greater part of the reservation, the rocks are generally flat-lying, but there are numerous minor domes and anticlines and several belts of faulting in the western, southern, and northern parts.

BIG HORN AND PRYOR MOUNTAIN UPLIFTS

The Big Horn and Pryor Mountain uplifts are essentially parts of one great anticlinal fold or arch. The axis of these mountains strikes N. 40° W. in Wyoming, but in Montana it swings more and more to the west until in the Pryor Mountains it strikes N. 60° W. The stratified formations slope away on the east, north, and west with dips that range from 15° to 90° but are generally more than

[78] Alden, W. C., personal communication.

45°. Surrounding the mountain mass on practically all sides is a narrow belt of foothills or hogbacks in which the beds are usually tilted 45° to 90°. In some places there are several lines of hogbacks; the outer one is usually formed by the sandstone in the Cloverly formation, and the inner one, which is normally double, is formed by hard beds in the Sundance formation. A typical hogback of the Cloverly formation northwest of Sheridan, Wyo., is shown in plate 2, *A*. At relatively short distances from this belt of highly inclined rocks, the strata lie nearly horizontal, both in the mountains and in the plains. These abrupt changes of dip are best seen along the mountain front and in the canyons, where numerous exposures of the Tensleep sandstone afford excellent opportunity for the study of the structure. In many places this resistant sandstone forms the dip slope of the mountain, and changes of slope are the result of changes of dip. At the mouth of Big Horn Canyon the Tensleep sandstone emerges from beneath the younger formations at a steep angle, but within a short distance it flattens out and forms the rim of the canyon.

The main part of the Big Horn Mountain uplift has its structural apex near Cloud Peak, Wyo., and diminishes northward both in height and width to its rather abrupt termination south of the Beauvais Creek Valley; however, as this part diminishes toward its northern termination, the structural spur shown by Darton [79] to project northwestward from Bald Mountain becomes correspondingly more pronounced and culminates in the Pryor Mountains. Although the two uplifts are very similar, the structure of the northern part of the Big Horn Mountain uplift within the area covered by this report is more complicated than the structure of the northern part of the Pryor Mountain uplift. The almost flat-lying beds that cap the central part of the Big Horn Mountain uplift descend to the little-disturbed plains area either by a single monocline or by a series of nearly vertical monoclinal pitches and almost flat-lying terrace levels, in steplike alternation. This uplift is traversed by two prominent east-west monoclines, down-rolled to the north, one of which causes a reduction in the height of the range near the Wyoming-Montana line, and the other its northward termination. The east flank is marked by a northward-flexed monocline with a southeast trend. A very steep monocline forms the west flank of the mountains near the mouth of Dry Head Creek. In the Pryor Mountain uplift monoclines divide the mountain mass into quadrants, each segment tilted to the southwest and bounded by nearly vertical monoclines on the east and north. (See fig. 3.)

[79] Darton, N. H., op. cit. (Prof. Paper 51), p. 92.

Indeed, movement on the flexure at the north end of the Pryor Mountains has been so great as to cause it to rupture, with the consequent production of the Castle Butte fault.

Darton,[80] Werner,[81] and Thom [82] have discussed the origin of the Big Horn and Pryor Mountain uplifts. They consider them to be the result of forces acting vertically, with very slight modification by tangential compressive forces. The folds and faults suggest that the rocks have been bent and lifted by the rotation and elevation of blocks of the granitic basement.

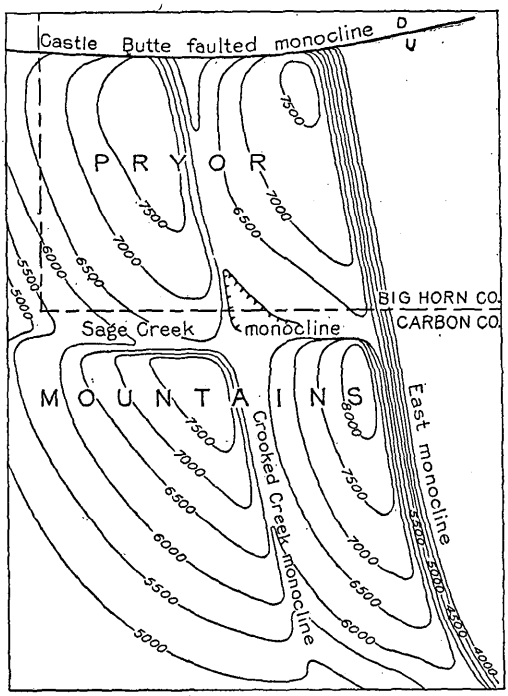

FIGURE 3.—Diagrammatic sketch illustrating by structure contour lines the configuration of the Madison limestone in the Pryor Mountain uplift.

MINOR STRUCTURAL FEATURES

During the formation of the Big Horn and Pryor Mountain uplifts smaller structural features were developed in the surrounding area; some of these are apparently the result of the same forces that caused the main uplifts, but the relationship of others is obscure. The descriptions of these features vary in completeness, depending on the field work—that is, the more detailed the examination the more complete the description.

Plum Creek anticline.—The Plum Creek anticline is a rather complex structural uplift in the valleys of Plum and Pryor Creeks, a little west of the town of Pryor. Its major axis trends about N. 30° W. and is intersected near the southwest corner of sec. 6, T. 5 S., R. 26 E., by a minor cross flexure that trends about northeast. The intersection of these two folds is believed to have produced a slight dome having a structural closure of about 150 feet,

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[80] Darton, N. H., op. cit., p. 92.

[81] Werner, W. C., personal communication.

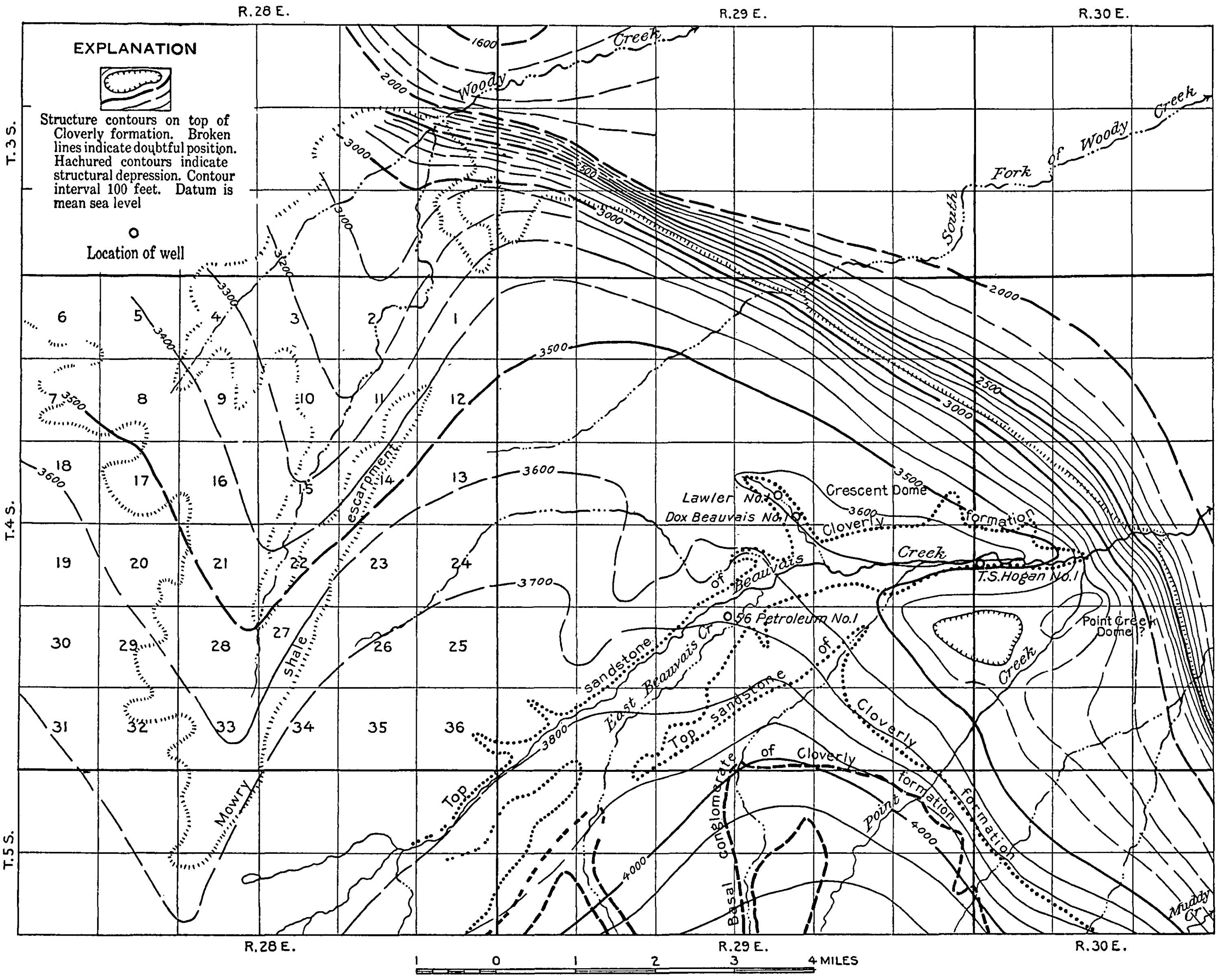
[82] Thom, W. T., Jr., The relation of deep-seated faults to the surface structural features of central Montana: Am. Assoc. Petroleum Geologists Bull., vol. 7, pp. 1–13, 1923.

although this belief is based only upon indirect evidence, as the southeast side of the supposed dome is concealed by terrace gravel. It is possible that the uplift is a complex plunging anticline rather than a dome. The Cloverly and Morrison formations and the upper part of the Sundance are exposed north, west, and southwest of the inferred high point of the dome on the Plum Creek anticline, and the top member of the Cloverly formation as here delimited projects through the terrace gravel east and south of it.

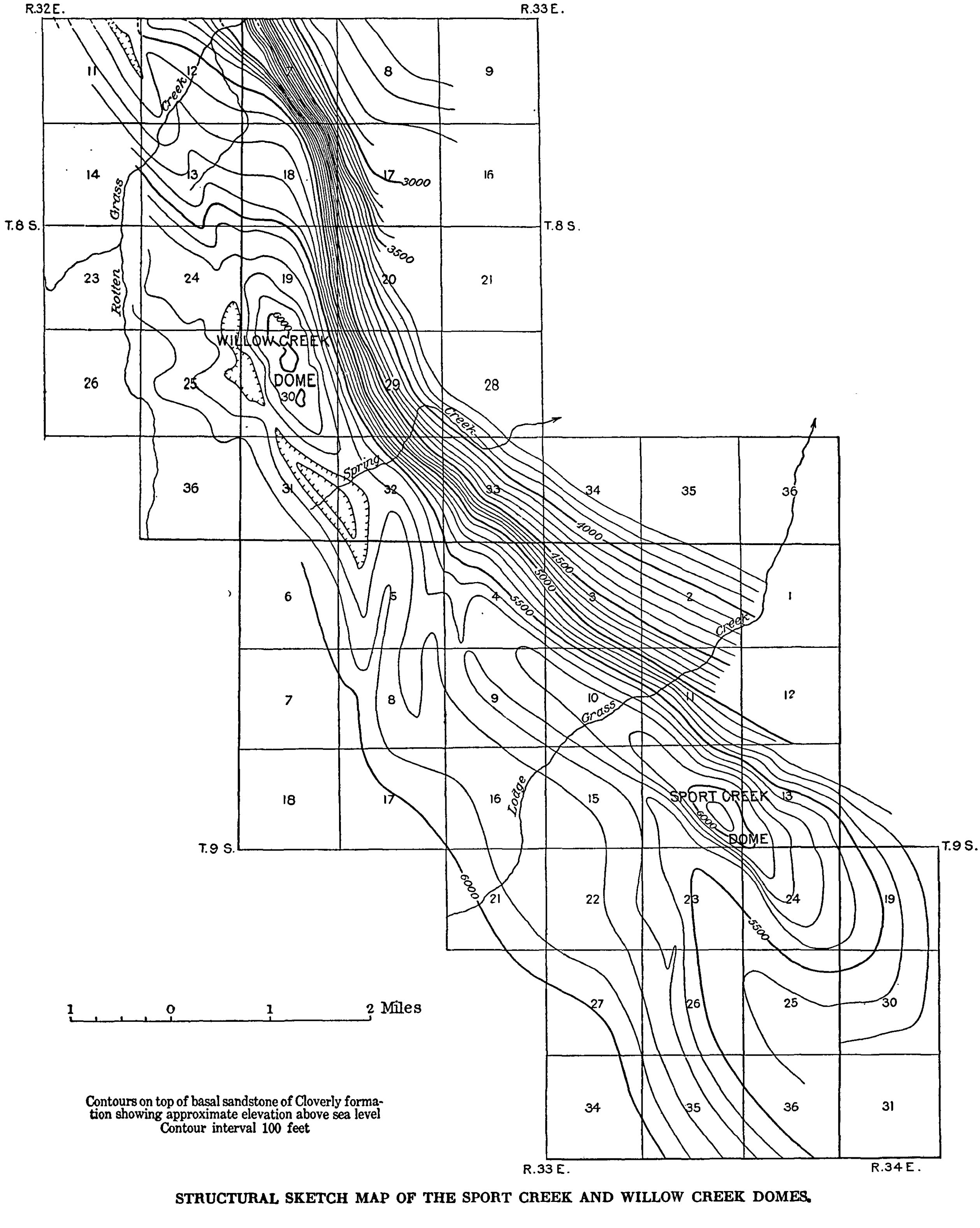
Shively Hill dome.—The Shively Hill dome is a large uplift lying south of the east end of the Castle Butte fault. It is developed at the intersection of an anticline that trends east-southeast with another that trends south and gradually approaches the east monocline of the Pryor Mountains. The center of the uplift falls in sec. 27, T. 5 S., R. 27 E., and is arched over by the Tensleep sandstone. A few feet of somewhat silicified limestone overlies the Tensleep on the south flank of the dome, apparently representing a surviving remnant of the Embar formation. The Amsden formation and upper part of the Madison limestone are exposed in the gorge that the East Fork of Pryor Creek has cut across the east flank of the dome, and from their relations it appears that the Madison was somewhat folded and eroded before the Amsden was deposited.

Birdhead dome.—The general northward slope of the beds lying north of the Castle Butte fault and Shively Hill dome is modified by several minor anticlinal flexures (see pl. 1), and the Birdhead dome constitutes a local accentuation of one of these anticlinal uplifts that centers in the south-central part of sec. 22, T. 3 S., R. 27 E. The Mowry shale escarpment and the rims formed by the Birdhead sandstone, in the lower part of the Thermopolis shale, outline the eastern and northern parts of this uplift, and dips apparent in the Birdhead sandstone outline the south and west sides of the dome. The minimum structural closure of the dome (to the south) is about 50 feet. The "rusty beds" of the Thermopolis shale (which in part of the area are for convenience mapped with the Cloverly) are exposed in the valley of Birdhead Coulee east of the uplift and along Pryor Creek and the East Fork of Pryor Creek near their confluence. They aid in the revelation of the local structure.

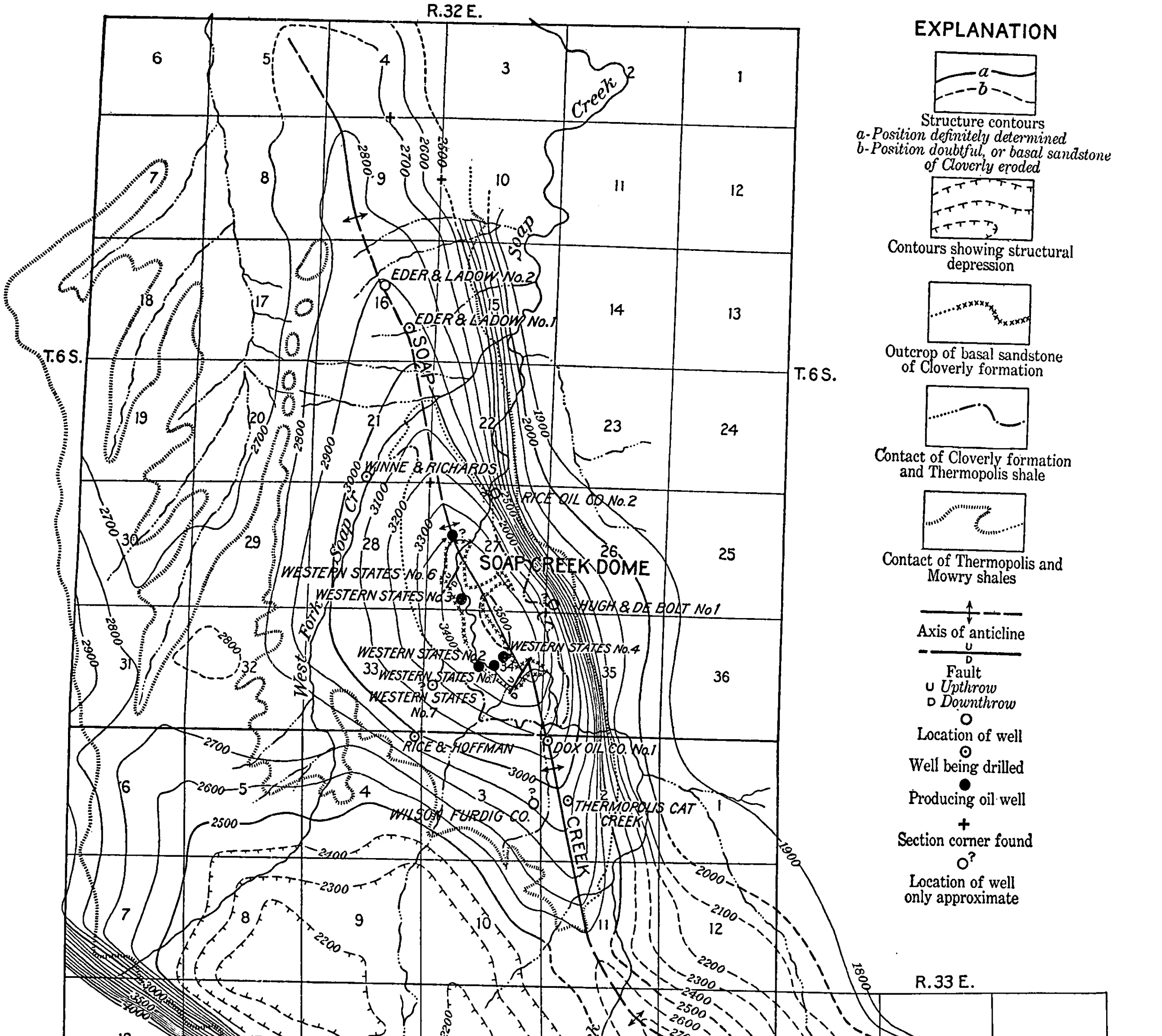
Boundary dome.—The Boundary dome apparently owes its existence to the intersection of the north-south anticline that passes through the Birdhead dome with the Mifflin anticlinal flexure, which has its most pronounced development near the east line of T. 2 S., R. 28 E. These two flexures intersect near the northwest corner of sec. 4, T. 2 S., R. 27 E., the result being a dome that has a minimum closure of about 50 feet toward the south. The dome is largely surfaced by the Frontier formation, which dips as much as 30°



STRUCTURAL SKETCH MAP OF THE BEAUVAIS CREEK AREA.



STRUCTURAL SKETCH MAP OF THE SPORT CREEK AND WILLOW CREEK DOMES.



STRUCTURAL SKETCH MAP OF THE SOAP CREEK, ROTTEN GRASS, AND REED DOMES.

along the north flank of the dome but much more gently on the other flanks, particularly near the structural saddle that closes the structure to the south.

Mifflin anticline.—The Mifflin anticline lies just south of the former site of Mifflin station, on the abandoned railroad grade now traversed by the Custer Battlefield Highway, and has its most pronounced development near the east line of T. 2 S., R. 28 E. It is part of the same general line of flexure as the Boundary and Woody Creek domes and is separated from the northward continuation of the eastern monocline of the Big Horn Mountain by a pear-shaped basin within which extensive remnants of the Eagle sandstone are preserved along the middle course of the East Fork of Pryor Creek. The anticline is mainly outlined by escarpments and dip slopes of the Telegraph Creek formation and is distinctly developed between the southeast corner of sec. 4, T. 2 S., R. 28 E., and the central part of T. 2 S., R. 29 E., its structural high point lying in the west-central part of sec. 17, T. 2 S., R. 29 E. The fold is unsymmetrical, having dips of 1° to 5° on its northeast flank and considerably steeper dips on its southwest flank.

Telegraph Creek plunging anticline.—The Telegraph Creek plunging anticline extends northeastward from the apex of the Mifflin anticline as a broad, low swell, the crest of which passes just east of the northwest corner of T. 2 S., R. 29 E., and extends thence toward the northeast corner of T. 1 S., R. 28 E. The outline of this anticlinal nose is irregular, and it is possible that a minor cross flexure may produce a small area of structural closure in T. 1 S., R. 29 E. The surface rocks over the crest of this area of possible closure belong to the Eagle sandstone and lower part of the Claggett shale.

Beauvais Creek uplift.—The Beauvais Creek uplift is a minor cross flexure that locally modifies the plunging north end of the Big Horn Mountain anticlinal axis, the result being the production of the Crescent and Point Creek domes. (See pl. 11.) The uplift is generally considered to embrace the area along Beauvais Creek south of and within the crescent-shaped ridge formed by the Mowry shale. (See pl. 1.) Within the greater part of the area so outlined the beds rise gently southward, but there are local reversals of dip that give the Crescent dome a structural closure of 60 to 70 feet and the Point Creek dome a somewhat smaller closure. The variegated clays of the middle member of the Cloverly formation are exposed along Beauvais Creek across the greater part of the uplift, and progressively older formations are encountered toward the south as the influence of the Grapevine dome becomes stronger.

Grapevine dome.—The Grapevine dome is a large uplift that centers in secs. 36 and 25, T. 5 S., R. 29 E., occupying a position on the Big Horn axis intermediate between the mountains proper and the Beauvais Creek area. Apparently the dome may be regarded as due to the influence of the same east-west cross fold that aided in producing the Shively Hill dome. The greater part of the dome is surfaced by the Tensleep sandstone and thin remnants of Embar(?) limestones. Dissection of the crest has locally laid bare the Amsden and topmost part of the Madison limestone.

Sport Creek anticline.—The Sport Creek anticline is a narrow compound anticlinal fold which follows the upper limit of the monocline that forms the flank of the Big Horn Mountains between Soap Creek Canyon and the Montana-Wyoming line, its presence being reflected by the increased width of outcrop of the Chugwater and Sundance within the area indicated. Three areas of structural closure known as the Sport Creek, and Reed domes (see pls. 1, 12, and 13) are developed upon the Sport Creek anticlinal axis.

Sport Creek dome.—The Sport Creek dome (see pls. 1 and 12) is a small elongated dome imposed upon the Sport Creek anticlime and extending from the south-central part of sec. 4, T. 9 S., R. 33 E., to the central part of sec. 30, T. 9 S., R. 34 E. Its apex lies in the SE¼ sec. 14, T. 9 S., R. 33 E., and its structural closure amounts to about 400 feet. The Chugwater red beds cover the crest of the dome but have been cut through by the Little Horn River at the south end of the uplift, where oil-impregnated sandstones belonging to the Tensleep are exposed locally in the river bank. Some oil saturation is also shown by a light-colored sandstone developed in the upper part of the Chugwater near the high point of the dome;[83] this sandstone is readily recognizable because of the color contrast it presents to the dark reds of the normal Chugwater beds.

The west limb of the Sport Creek dome dips about 50° opposite its high point, and its outline is clearly defined throughout the greater part of its length. The test well of the Mid-Northern Oil Co. in sec. 14 was abandoned at a depth of 487 feet, after having penetrated 39 feet into the Madison limestone. (See log, p. 123.) A sand that apparently represents the productive sand of the discovery well at Soap Creek was penetrated between 320 and 326 feet, or 159 feet below the base of the Chugwater red beds, and the base of the Amsden at Sport Creek was marked by beds interpreted by the driller as red quartz sand (390–402), red sandy shale (402–445 feet), and quartz sand (445–448 feet). The aggregate thickness of the Tensleep and Amsden at Sport Creek is therefore apparently 287

[83] Moulton, G. F., Some features of red-bed bleaching: Am. Assoc. Petroleum Geologists Bull., vol. 10, pp. 304–312, 1926.

feet, compared with 325 feet at Soap Creek, some of the basal Amsden beds of the Soap Creek section apparently being absent at Sport Creek.

Willow Creek dome.—The Willow Creek or Big Rim dome (see pls. 1 and 12) is a local uplift in secs. 30 and 19, T. 8 S., R. 33 E., imposed upon the Sport Creek anticline, which in its northern extension also passes through the Reed dome. The Willow Creek uplift has a structural closure of about 250 feet. The basal part of the Sundance formation and the upper part of the Chugwater red beds are exposed in its crest. A test well was drilled on this dome in the northern part of sec. 30 by the C. M. Bair and Mid-Northern Oil Co. and was abandoned at 576 feet. (See log, p. 123.) The exact horizon reached by this well is not known, as the record for the lower 116 feet is reported to have been lost, but a study of the portion of the log available indicates that the lower 20 feet of the Amsden was not penetrated by this well.

Reed dome.—The Reed dome is a small, sharp uplift centering near the north line of sec. 2, T. 8 S., R. 32 E. (See pls. 1 and 13.) The Chugwater and Sundance formations are exposed near its crest, and its structural closure amounts to about 200 feet.

Soap Creek anticline.—The Soap Creek anticline is most pronouncedly developed between the Big Horn River in sec. 36, T. 5 S., R. 31 E., and Rotten Grass Creek in sec. 34, T. 7 S., R. 33 E., being marked in this distance by the Soap Creek and Rotten Grass domes. (See pls. 1 and 13.) The same general uplift probably continues southeastward as far as Lodegrass Creek and apparently divides northward, one fork extending north through the Woody Creek dome and Two Legging uplift, the other fork trending northeast along the Big Horn River as the major element of the broad, low swell that connects the Big Horn Mountains with the Porcupine dome in Rosebud County.

Soap Creek dome.—The Soap Creek dome has its apex near the north line of sec. 34, T. 6 S., R. 32 E. (see pls. 1 and 13) and has been described in detail elsewhere.[84] The uplift is strongly asymmetrical, having a maximum dip of 30° on the east flank and 7° on the west, with a structural closure of more than 700 feet. The general outline of the dome is revealed by escarpments and outcrops of the Mowry shale; red shales belonging to the Morrison formation are the oldest strata exposed on the uplift and crop out in the gorge cut by Soap Creek across its higher part. Oil found in the dome has been ob-

[84] Thom, W. T., Jr., and Moulton, G. F., The Soap Creek oil field, Crow Indian Reservation, Mont.: U.S. Geol. Survey Press Mem., Dec. 5, 1921; Recent drilling in the Soap Creek oil fields: U.S. Geol. Survey Press Mem., May 3, 1922. Thom, W. T., Jr., Oil and gas prospects in and near the Crow Indian Reservation, Mont.: U.S. Geol. Survey Bull. 736, p. 42, 1923.

tained from sands in the Amsden formation and in the upper part of the Madison limestone. The wells drilled for oil afforded much information concerning the structure and local subsurface stratigraphy. (See pl. 6; also logs, pp. 111–119.)

Rotten Grass dome.—The Rotten Grass dome (see pls. 1 and 13), like the Soap Creek dome, is strongly asymmetrical, showing very gentle dips on the west flank and an abrupt monoclinal down-roll along its eastern edge. The structural closure of this dome amounts to about 125 feet. It is surfaced by the Carlile shale.

Woody Creek dome.—The Soap Creek anticline apparently extends northward past a possible area of closure between Hay and Beauvais Creeks, in T. 4 S., R. 31 E., and expands to form the Woody Creek dome. This dome is a broad, low uplift centering in sec. 28, T. 3 S., R. 31 E., and is reported to have a structural closure of about 300 feet. Shales and thin sandstones belonging to the Frontier formation are exposed near its crest.

Two Legging uplift.—Low dips in shale indicate the presence of a low anticline, the Two Legging uplift, extending northeastward through the center of sec. 34, T. 1 S., R. 31 E., and it seems probable that a slight structural closure exists in the west-central part of T. 2 S., R. 31 E., where this anticline appears to diverge from a western fork of the Woody Creek-Soap Creek axis of uplift. The presence of closure has not been proved, however, mainly because of the relatively poor exposures afforded by the upper Carlile and lower Niobrara shales, which cover the surface of the uplift.

Tenmile plunging anticline.—The Tenmile plunging anticline as mapped by Hancock[85] is a strongly marked anticline associated with the Lake Basin-Huntley fault zone. This fold plunges eastward, extending past the southwest corner of sec. 7, T. 1 N., R. 30 E., into the west-central part of sec. 9 of the same township. The Parkman sandstone (Judith River formation) and basal part of the Bearpaw shale crop out within the area of the uplift. (See pl. 1.)

Pine Ridge area.—Little is known regarding the so-called "Pine Ridge field" in T. 1 N., R. 32 E., except that a minor structural uplift appears to be present in the area and that a well was begun in sec. 15 of the township but was not completed. Apparently a slight anticline extends southwestward from the northeast corner of the township, probably being directly related to faults belonging to the Lake Basin-Huntley zone, which extends southeastward across the township. The surface formations of the area are the Claggett shale and Parkman sandstone.

Ninemile and Dry Creek areas.—The Ninemile "field" lies just north of the Crow Indian Reservation near the center of the south

[85] Hancock, E. T., Geology and oil and gas prospects of the Huntley field, Mont.: U.S. Geol. Survey Bull. 711, pl. 14, 1920.

line of T. 1 N., R. 34 E.; and the Dry Creek "field" is supposed to lie north of the point where Dry Creek crosses the east line of T. 1 S., R. 34 E. No detailed structural study of these two areas has been made by the writers. It is reported that slight faults belonging to the Lake Basin-Huntley zone produce small areas of structural closure in the Ninemile and Dry Creek "fields." Apparently the fault zone terminates near the heads of Ninemile and Dry Creeks, a little farther east. The Superior Oil & Coal Co. drilled a well on Ninemile Creek in the NE¼ sec. 33, T. 1 N., R. 34 E., and, according to unconfirmed trade-journal reports, obtained about 1,000,000 cubic feet of gas at 750 feet, a good showing of gas at 1,950 feet, and a small flow of water at 2,450 feet. This well was probably begun just below the base of the Eagle sandstone and the reported flow of water at 2,450 feet presumably came from the Cloverly formation.

East Tullock Creek dome.—A small, low dome or anticline called the East Tullock Creek dome is supposed to extend southeastward across the southeastern part of T. 1 S., R. 37 E., and the southwestern part of T. 1 S., R. 38 E., following the northeast side of a fault which is reported to extend from the northwest part of sec. 4, T. 1 S., R. 36 E., to the southeast corner of T. 1 S., R. 37 E. The beds exposed in the area belong to the upper part of the Lance and the lower part of the Fort Union.

East Sarpy anticline.—According to the mapping of Rogers and Lee[86] a broad, low upfold extends southeastward across T. 2 N., R. 36 E., becoming narrower and plunging sharply southeastward within the valleys of Sarpy and East Sarpy Creeks in T. 1 N., R. 37 E. (See pl. 1.) This fold is revealed by outcrops of Fort Union sandstones and clinker beds and is of interest mainly because it is a minor upfold at the low point of the structural saddle between the Porcupine dome on the northeast and the Big Horn Mountains on the southwest.

Hardin gas field.—A small gas field is being developed in the lowlands bordering Whitman Coulee, about 2 miles northwest of Hardin. The gas accumulation may be due either to the effects of faults connected with the Lake Basin-Huntley fault zone or to a slight northwest-southeast fold, the presence of which seems to be indicated by the configuration of structure contours near Hardin. (See pl. 1.) It may, however, be due to the lenticular character of the Frontier sands and sandy shales from which the gas is apparently obtained.

Black Gulch dome.—The Black Gulch dome, which was mapped by Moulton, lies about 3 miles south of the Little Horn River, its

[86] Rogers, G. S., and Lee, Wallace, Geology of the Tullock Creek coal field, Rosebud and Big Horn Counties, Mont.: U.S. Geol. Survey Bull. 749, pl. 10, 1923.

highest point being in the SE¼ sec. 24, T. 9 S., R. 34 E. (See pl. 1.) This dome is defined by sharp dips. It is separated from the monoclinal flank of the mountains by a closed structural depression and lies on the dropped south side of a fault having a maximum throw of 1,000 feet. The only test yet made of the dome is a well drilled by the Producers & Refiners Corporation in the NE¼SW¼ sec. 24, T. 9 S., R. 34 E. This well was located on the surface axis of the dome about 1,000 feet northwest of the apex and about 100 feet structurally below it. The character of the strata penetrated by this well is shown graphically by plate 2. The depth to the top of each of the formations penetrated by the well is as follows: Cloverly, 495 feet; Morrison, 890 feet; Sundance, 1,235 feet; Chugwater, 1,810 feet; Tensleep, 2,535 feet; and Amsden, 2,655 feet.

Aberdeen uplift.—The Aberdeen uplift lies southeast of a fault parallel to that northwest of the Black Gulch dome, and it appears to be situated on the same east-west anticlinal flexure as the Black Gulch uplift. Its highest part is in the wedge-shaped fault block lying just east of the confluence of East and West Pass Creeks, and from that point it plunges eastward. The northern fault here, as at Black Gulch, is down-thrown to the south, bringing the Eagle sandstone north of the fault into contact with the top sandstone of the Claggett south of it. The southern fault is of less displacement and is likewise down-thrown to the south, thus possibly producing an area between the forking faults (see pl. 1) within which the Eagle sandstone might yield some oil and gas at a depth of a few hundred feet. The faults die out at the line of the railroad or just east of it, but the general influence of the uplift on the north side of the Black Gulch-Aberdeen fault zone is evident in the dips and crescentic outcrops of the formations exposed in Tps. 8 and 9 S., Rs. 36 and 37 E.

The divergences in trend of the folds of the northern and southern parts of southeastern Big Horn County east of the Crow Indian Reservation apparently are due to the operation of the same forces that produced the Black Gulch-Aberdeen uplift.

Faults.—The faults visible within Big Horn County and the Crow Indian Reservation are proportionately neither so large nor so numerous as in the southern part of the Big Horn Mountain uplift. This is probably due partly to a greater intensity of the deformative force applied to the southern part of the range, but under the assumption that surface monoclines reflect subsurface faults it may also be due partly to the less depth to which erosion has cut within the Montana part of the uplift. The larger faults seem to be direct products of block movement and are intimately related to the major folding and warping of the region, whereas the smaller faults appear to be due mainly to local torsional effects, those of the Lake Basin-

Huntley fault zone apparently being induced by horizontal slippage of the basement rocks along a major subsurface rift.

The Castle Butte fault, which terminates the Pryor Mountains at their north end in T. 5 S., Rs. 25, 26, and 27 E., is the most conspicuous fracture in the area here described, having a linear extent of about 14 miles and a maximum throw of some 2,000 feet, whereby the Madison limestone and Cloverly formation are brought into contact with each other just north of Castle Butte. (See pl. 1.) What is essentially a compound branch of this fault extends northwestward across T. 5 S., R. 25 E., and movement on it, on the north-south monoclines of the Pryor Mountains, was downward on the east.

The Lake Basin-Huntley fault zone is a belt of en échelon faulting[87] that extends across Big Horn County from the northwest corner of T. 1 N., R. 30 E.,[88] at least as far as the Ninemile uplift, in T. 1 N., R. 34 E. Owing to poor exposures and the reconnaissance character of the work in part of the belt, by no means all of the faults occurring in the eastward prolongation of this fault zone have been mapped, but enough has been done to show that it has a length of 30 miles within the area described and a total known length of about 105 miles. The faults of this belt trend northeastward at angles of about 45° to the main axis of the belt and apparently have resulted from lateral movement on a rift in the basement rocks, as has been pointed out by Chamberlin.[89] Stratigraphic variations and relations of formations on opposite sides of the fault zone indicate that this rift has long been a major tectonic line.[90]

The Black Gulch fault zone in T. 9 S., Rs. 34 to 36 E., has been described at some length in the discussion of the Black Gulch and Aberdeen uplifts. Of the other faults found in the Crow Indian Reservation or Big Horn County, five of some magnitude were found by Rogers and Lee[91] in the Tullock Creek field in the northeastern part of the county; four of these are in Tps. 1 and 2 N., R. 36 E., occurring in a north-south zone, and the fifth, which has an eastward trend, is in the eastern part of T. 3 N., R. 34 E.

Sandstone dikes.—Numerous sandstone dikes occur in the Soap Creek field a short distance above the Birdhead (?) sandstone in the lower part of the Thermopolis shale, and apparently have been produced as the result of faulting which occurred while this sandstone

[87] Hancock, E. T., Geology and oil and gas prospects of the Lake Basin field, Mont.: U.S. Geol. Survey Bull. 691, pp. 136–141, 1919.

[88] Hancock, E. T., Geology and oil and gas prospects of the Huntley field, Mont.: U.S. Geol. Survey Bull. 711, pp. 134–140, 1920.

[89] Chamberlin, R. T., A peculiar belt of oblique faulting: Jour. Geology, vol. 27, pp. 602–613, 1919.

[90] Thom, W. T., Jr., The relation of deep-seated faults to the surface structural features of central Montana: Am. Assoc. Petroleum Geologists Bull., vol. 7, pp. 1–13, 1923.

[91] Rogers, G. S., and Lee, Wallace, op. cit., pl. 10.

was yet in an unconsolidated and saturated state. Evidently the sand was injected upward into fissures attending earthquakes that presumably were related to faulting, as the dikes appear to be absent except within a short distance above the particular sandstone bed mentioned.

GEOLOGIC HISTORY

The rocks exposed in Big Horn County and the Crow Indian Reservation consist of pre-Cambrian granites overlain by a thick series of limestones, shales, and sandstones, upon which rest superficial deposits of stream gravel, sand, and alluvium. These rocks afford a fairly complete record of the local geomorphology from Upper Cambrian time to the present. Parts of this record are plain; some phases of it remain in doubt for lack of more detailed studies; and some chapters are missing by reason of hiatuses in the local record of sedimentation.

Prior to the deposition of the Upper Cambrian Deadwood formation the granite surface of this area had been reduced by erosion to an almost level plain across which the Upper Cambrian sea transgressed. Toward the end of the Cambrian period the sea once more became shallow, probably as a preliminary to the emergence of the area during the earlier part of Ordovician time. This was followed by regional submergence and the deposition of the Bighorn dolomite in the later part of the Ordovician; this dolomite apparently was deposited only in the area south of the Lake Basin-Huntley fault zone, suggesting a differential vertical movement on the basement fault underlying that zone in Ordovician time.

In contrast with central Montana areas no local record of the Silurian and Devonian systems remains in the Pryor and northern Big Horn Mountains. Although the absence of Silurian and Devonian beds suggests emergence during those periods, it could conceivably be due to post-Devonian erosion. So far as known, no evidence of any considerable uplift or depression during that time is afforded by the rocks of the northern part of the Big Horn Mountains, but in the part of the mountains lying some distance south of the Wyoming line there is evidence of considerable post-Ordovician and pre-Carboniferous erosion. Early in Carboniferous time a general depression of the Rocky Mountain region, accompanied perhaps by local uplift in some areas, again admitted the sea, which attained a considerable depth, as is indicated by the 1,000-foot thickness of the massive Madison limestone, of lower Mississippian age, which apparently was deposited over the whole of eastern Montana. At or near the end of lower Mississippian time part or all of the Big Horn uplift rose above the sea, and the Madison limestone was somewhat folded, eroded, and weathered during the deposition of upper Mississippian beds in central Montana[92] and prior to the local resubmergence which initiated the deposition of the early Pennsylvanian Amsden formation. The basal red shale of the Amsden formation apparently represents the reworked residual soil derived from the weathered surface of the Madison limestone during the gradual encroachment of the Amsden sea, in which sandstones, shales, and limestones were deposited as the waters increased in depth. The deposition of the Amsden was followed by the deposition of the extensive coarse-grained Tensleep sandstone, which is apparently of shallow-water origin or perhaps partly a dune accumulation. After a probable minor elevation and emergence that lasted through much of Pennsylvanian time the area was again at least partly submerged and an indeterminate thickness of Permian (?) limestones was laid down. Silicified remnants of limestones overlying the Tensleep at Soap Creek and Shively Hill and the silicification and chert development within the Tensleep sandstone both indicate prolonged weathering of this surface before the beginning of saline lagoon deposition and the laying down of the thick local gypsum beds, possibly representative of a part of the Permian, followed by the thicker and more wide-spread Triassic red beds of the Chugwater formation. The fossils found in the Chugwater and the persistence and uniformity of thickness of its component strata indicate its marine deposition; but its red color and the chemical precipitation of its component beds of gypsum and perhaps some of its limestone point to deposition in bodies of supersaline waters, probably under " salt pan " conditions developed in proximity to an arid region within which red soils or lateritic deposits had previously accumulated. It is probable that movements producing elevation and resubmergence took place in the period between Chugwater time and the inception of Sundance deposition, as Darton[93] reports that in many localities the Chugwater was eroded somewhat prior to the deposition of the Sundance, and apparently the Chugwater beds, if any were deposited north of the Lake Basin-Huntley fault zone, were eroded from that area prior to the laying down of the Jurassic beds found there. Likewise the general pink or red color shown by the lower part of the Sundance in the southern part of the reservation may be due to the erosional derivation of Sundance sediments from the Chugwater, although possibly attributable to a slight recurrence in Jurassic time of conditions similar to those governing Chugwater deposition. The presence of thin beds of gypsum in the Sundance rather supports the latter hypothesis.

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[92] Hammer, A. A., and Lloyd, A. M., Notes on the Quadrant formation of east-central Montana: Am. Assoc. Petroleum Geologists Bull., vol. 10, pp. 986–996, 1926.

[93] Darton, N. H., op. cit. (Prof. Paper 51), p. 108.

So far as may be judged, no erosional break intervenes between the Sundance and the overlying Morrison formation, which is also of Upper Jurassic age. During Morrison time there was apparently a gradual transition from marine or littoral conditions into fluvial or continental disposition.

Prior to the development of the fluvial basal conglomerate of the Lower Cretaceous Cloverly formation, which unconformably overlies the Morrison, there seems to have been a relatively strong elevation of local areas, probably within the Yellowstone Park region or regions a little farther west, with the consequent derivation of much of the basal conglomerate of the Cloverly from the cherts and sandstones of the Tensleep formation. Conditions of fresh-water deposition prevailed during the greater part of Cloverly time, but toward its end the initial stage of the Upper Cretaceous marine submergence had begun. The deposition of the marine shales of the Thermopolis, Frontier, Carlile, and Niobrara formations was apparently interrupted during short periods of time by local uplift of the areas supplying the sediment, with the resultant development of the sandy tongues in the Thermopolis shale, the Frontier sandstones, and the Mowry shale. The recurrence of volcanic outbursts within the region undergoing erosion is likewise shown by the numerous beds of bentonite that occur in the Thermopolis, Frontier, and Carlile. Alternating with this local elevation of the land areas there seems to have been periodic subsidence of the sea floor, with the consequent development of limy shale beds in the Carlile and Niobrara. In Telegraph Creek time the sedimentary filling of the sea basin within the local area had progressed so far that wave action was able to give wide distribution to beds of sandy shale and thin concretionary sandstone layers. This silting up of the sea became extensive in Eagle time, with the development of the carbonaceous beds and littoral or near-shore marine sandstones and sandy shales of the Eagle, the actual beach line in Eagle time apparently coinciding very closely with the monoclinal flexures east of the Big Horn Mountains, the Beauvais Creek uplift, and the Boundary dome.

During Claggett time renewed depression again permitted the sea to transgress westward and attain a considerable local depth, although the abundance of littoral sandstones developed in the Claggett near the 109th meridian shows that the Claggett shore line lay but a short distance west of the region here described. Again during Parkman (or Judith River) time near-shore, delta, and coastal-plain deposits were laid down eastward for long distances across the western part of the interior sea basin, the shore line lying near Toluca—that is, a few miles east of the position of the Eagle strand. The Claggett-Parkman cycle of depression and sedimentation was followed by a similar cycle during Bearpaw time, after which, during Lance and Fort Union time, sedimentation so gained upon depression that no further recurrence of marine conditions took place in the local area, although the Lebo shale member of the Fort Union formation is a continental accumulation developed, in the opinion of some geologists, synchronously with the upper part of the marine Cannonball member of the Lance formation, which was deposited in a remnant of the interior sea still surviving in North and South Dakota.

The character and thickness of the sedimentary rocks of Big Horn County and the Crow Indian Reservation indicate that periodic earth movements of progressively greater intensity affected this area during Upper Cretaceous and Eocene time, and that these orogenic movements had become strong prior to the deposition of the Fort Union formation.

Evidence from nearby areas in Wyoming indicates that the repeated diastrophic movements that affected the eastern Rocky Mountains reached their climax in lower or middle Eocene time, as the various major uplifts seem to have been truncated and reduced approximately to the present general configuration prior to White River (Oligocene) time. A large proportion of the older sedimentary rocks was stripped from the Big Horn arch during the early stages of its elevation, and this erosional degradation may have reached an advanced stage in late Lance time. It certainly had done so in early Eocene time, as the Fort Union and Wasatch formations of the Big Horn Basin show by their lithology and discordant relation to underlying formations that the Big Horn uplift had been greatly eroded prior to their deposition.[94] Similarly, erosion had laid bare the granite core of the Big Horn uplift during or prior to Wasatch time, as the Kingsbury conglomerate member of the Wasatch, which is essentially equivalent to the Intermediate coal group (Wasatch) of the Sheridan coal field, consists largely of limestone and chert boulders and pebbles, with some granite[95] and quartz.[96] From the relation of these several formations to the Big Horn Mountains it seems that a drainage divide had been developed before Fort Union time on the hard rocks of the Big Horn axis, from which streams flowed outward to the Big Horn, Tongue, and Powder Rivers, which had been established upon the relatively soft rocks of the Upper Cretaceous coastal lowlands. The channel and estuarine sandstones of the upper Bearpaw of the Lake Basin field

[94] Hewett, D. F., and Lupton, C. T., Anticlines in the southern part of the Big Horn Basin, Wyo.: U.S. Geol. Survey Bull. 656, pp. 28–29, 1917. Hewett, D. F., Geology and oil and coal resources of the Oregon Basin, Meeteetse, and Grass Creek Basin quadrangles, Wyo.: U.S. Geol. Survey Prof. Paper 145, p. 134, 1926.

[95] Darton, N. H., Geology of the Big Horn Mountains: U.S. Geol. Survey Prof. Paper 51, pp. 60–61, 1906.

[96] Taff, J. A., The Sheridan coal field, Wyo.: U.S. Geol. Survey Bull. 341, p. 131, 1908.

and southern Crow Indian Reservation suggest that the Yellowstone and Big Horn Rivers were probably established in their present general courses in Lance time, and that the Big Horn River was able to maintain its course by canyon cutting that kept pace with the rise of the mountain arch across its path.

From Lance time until the Big Horn arch had reached its greatest elevation, in middle Eocene time, the earth movements that affected the Big Horn Mountains chiefly tended to produce an elevation of the mountains relative to the adjacent basins, and in consequence of the irregular and intermittent rise of the mountains there were periods of alternating erosion and deposition in the basins and the foothill belts, with the balance in favor of deposition.

After the mountain uplift in middle Eocene time considerable erosion must have ensued during late Eocene and early Oligocene time, as a result of which the hard rocks forming the higher slopes of the mountain were extensively planed off at the level now represented by the remnants of the White River formation and by the Oligocene (?) gravel benches and related erosion surfaces that form the highest terraces of the Crow Indian Reservation, which presumably indicates the development of a partial baselevel in Oligocene time. This Oligocene (?) stage of erosion was terminated by regional as contrasted with local differential uplift and warping, which led to further erosion. This may have caused the diversion of the Clark Fork from the Pryor Gap gorge into its present course by the headward cutting of a minor tributary of the Yellowstone.

Throughout later Tertiary and Quaternary time there seems to have been a more or less periodic upwarping or upbowing of the Big Horn arch and the adjacent region, attended by downcutting and terrace development. Of the terraces so produced in post-Oligocene time the oldest is the most extensively developed of those within Big Horn County and the Crow Indian Reservation, and it has been tentatively correlated by Alden [97] with the Miocene or early Pliocene Flaxville gravel. Renewed uplift and erosion followed Flaxville (?) time and led to the development in early Pleistocene time of a fourth terrace tentatively correlated with the upper level of the main or second set of terraces as preserved on the Yellowstone River. By similar processes a fifth terrace, thought to be of early or middle Pleistocene (pre-Iowan) age [97] was produced. This probably corresponds to the lower or main level of the second set of terraces on the Yellowstone River. The most recent cycle of erosion and deposition appears to have progressed so far as to produce broad bottom lands by late Pleistocene time, and the streams of the area are now slightly intrenched in their alluvial plains.

[97] Alden, W. C., personal communication.

The geologic history of the Big Horn and Pryor Mountains is summarized on pages 69–71. The Tertiary and Quaternary terraces are described further on pages 18, 66–69.

ECONOMIC GEOLOGY

COAL

DISTRIBUTION AND CORRELATION OF THE COAL BEDS

Immense reserves of coal exist in the eastern parts of Big Horn County and the Crow Indian Reservation. The following pages summarize the facts contained in United States Geological Survey publications covering parts of Big Horn County [98] (see fig. 1), with a tabulation of such facts as are in hand concerning the coal resources of the Crow and Tongue River (Northern Cheyenne) Indian Reservations.

These coals occur in the Cloverly, Parkman, Bearpaw, Lance, Fort Union, and Wasatch formations. The coal-bearing rocks have a general eastward inclination, which causes the different beds to crop out in regular order one above another from the lowlands east of the Big Horn Mountains to the summit of the Rosebud Mountains. The coals of the Cloverly, Parkman, and Bearpaw formations and the Hell Creek member of the Lance are of small extent and negligible present interest. Those of the Tullock member of the Lance and the Lebo member of the Fort Union, though persistent, are generally too thin and impure to be of value.

From the work of Rogers and Lee, Dobbin, Bass, and Baker, it is known that about 10 coal beds may be present in the Tullock member of the Lance and 3 in the Lebo member of the Fort Union. About 20 thick coal beds, some of them of great lateral extent, occur in the Tongue River member of the Fort Union, and 2 or 3 may be present in the remnants of the Wasatch formation preserved on the summit of the Rosebud Mountains and in higher divides bordering the Tongue River Valley near the Wyoming line.

In the reconnaissance examinations of the coals within this area, which were made by Howell, Collier, and Wentworth and their assistants, the principal attention was given to mapping the lowest

[98] Rogers, G. S., Geology and coal resources of the area southwest of Custer, Yellowstone, and Big Horn Counties, Mont.: U.S. Geol. Survey Bull. 541, pp. 316–328, 1914. Rogers, G. S., and Lee, Wallace, Geology of the Tullock Creek coal field, Rosebud and Big Horn Counties, Mont.: U.S. Geol. Survey Bull. 749, 1923. Bass, N. W., Coal in Tongue River Valley, Mont.: U.S. Geol. Survey Press Mem. 16748, Feb. 12, 1924. Bass, N. W., The Ashland coal field, Rosebud, Powder River, and Custer Counties, Mont.: U.S. Geol. Survey Bull. 831, pp. 19–106, 1932. Baker, A. A., The northward extension of the Sheridan coal field, Big Horn and Rosebud Counties, Mont.: U.S. Geol. Survey Bull. 806, pp. 15–67, 1929. Dobbin, C. E., The Forsyth coal field, Rosebud, Treasure, and Big Horn Counties, Mont.: U.S. Geol. Survey Bull. 812, pp. 1–55, 1929. Pierce, W. G., The Rosebud coal field, Mont.: U.S. Geol. Survey Bull. — (in preparation).

thick coal bed in the Tongue River member of the Fort Union and measuring in section the higher coals cropping out along the western scarp of the Rosebud Mountains.

Coal in the Cloverly formation.—The single local lens of coal found in the Cloverly formation within the Crow Indian Reservation is probably thick enough to be of slight commercial value within the NW¼ sec. 22, T. 9 S., R. 34 E. Its thickness is shown by the following section measured at an abandoned prospect:

Section of coal bed in NW¼ sec. 22, T. 9 S., 34 E.

	Ft.	in.
Shale, gray.		
Coal	4	2
Bone		3½
Coal	1	
Bone		3½
Coal	1	3½
	7	3½

This bed persists for only a short distance along its outcrop, and because of this fact and its impure character it is believed to be of slight present or prospective value.

Coal in the Parkman sandstone.—A coal bed in the middle part of the Parkman was once mined in a small way at Lodge Grass, in sec. 13, T. 6 S., R. 35 E. The mine is reported to have been abandoned partly because of the competition of coal from the Sheridan field and partly because of difficulties in mining due to weakness of the shale overlying the coal. When it was visited the mine entrance had caved in and no measurement of the thickness of the coal was obtainable, but the bed was reported to be 8 feet thick where penetrated by domestic wells within the town. In view of the facts that the clay above the coal does not afford a good mine roof and that the cover above the bed is only a few feet thick over a considerable area it seems probable that this bed may eventually be mined by stripping, although such an operation probably could not now successfully meet the competition of mines in the Sheridan field.

Coal in the Bearpaw shale.—A bed of coal about 3 feet thick lies about 435 feet above the base of the Bearpaw shale in the vicinity of Aberdeen and underlies a small area in secs. 25 and 36, T. 9 S., R. 35 E. The bed was once mined in a small way for the local market but has not been worked for a considerable period, owing to the successful competition of the mines on the Chicago, Burlington & Quincy Railroad near Sheridan, Wyo. The precise extent of the area within which this coal is of workable thickness is not known but probably is not large. The presence of another lens of coal at the same general horizon is apparently indicated by a small clinker developed locally near the mouth of Sioux Pass Creek, east of Lodge Grass.

Coal in the Lance formation and the Lebo member of the Fort Union formation.—A few thin and local lenses of coal occur in the Hell Creek member of the Lance formation within the Crow Indian Reservation but probably are without present or prospective value. Rather more extensive coals are probably present in the Tullock member of the Lance within the reservation, but they are believed to be too thin to be of economic importance. The same may be true of the Lebo member of the Fort Union, in which no large beds were seen.

Coal in the Tongue River member of the Fort Union formation and in the Wasatch formation.—The Tongue River member of the Fort Union formation and the Wasatch formation contain the main coal resources of Big Horn County. A generalized section based on the work of Dobbin, Bass, Baker, and Rogers in nearby areas is given below, showing the number, relative position, and thickness of the coal beds. In considering this section it must be remembered that the contact between the coal-bearing Tongue River member and the barren Lebo member is gradational, the thickness of the Tongue River decreasing westward and southward as the thickness of the Lebo increases, so that near Sheridan, Wyo., the Carney coal is the lowest workable bed.

Generalized section of Wasatch formation and Tongue River member of Fort Union formation in eastern Big Horn County and Crow Indian Reservation, Mont.

	Feet
Wasatch formation:	
Badger bed	7
Interval	180
Local bed	5±
Interval	140
Local bed	5±
Interval	40
Tongue River member of Fort Union formation:	
Roland bed	0–13
Interval	195
Smith bed	7–20
Interval	70
Powers bed	0–10
Interval	60
Anderson bed	3–27
Interval	65
Dietz No. 1 bed	0–47
Interval	110
Dietz No. 2 bed	0–15
Interval	100
Dietz No. 3	0–6
Interval	50
Canyon bed	6–24
Interval	180
Monarch bed	0–25

	Feet
Interval	50
Davis, Carney, Wall, or Richard bed	3–32
Interval	100
Carlson or Proctor bed	3
Interval	90
Brewster-Arnold, Sawyer, or R bed	0–20
Interval	50
Popham bed	3
Interval	175
Knoblock or Lee bed	0–20
Interval	60
Schoedel bed	0–14
Interval	40
Rosebud or Q bed	0–28
Interval	7–30
Holt or McKay bed	0–7
Interval	50
Stocker Creek or P bed	0–9
Interval	35–50
Graham or O bed	0–7
Interval	30–65
N bed	0–7
Interval	25–40
Robinson, M, or Colman bed	0–23
Interval	43
Burley bed	0–5
Interval to base of Tongue River member	130

The thickness of beds and intervals and the correlations made in this section are approximate rather than exact and definitely proved. Moreover, as mapping of coal outcrops in the Crow Indian Reservation had to be done rapidly, correlations with this section must, for the greater part, be tentative rather than definite; it is even probable that, when more careful tracing of the beds has been found possible, lines shown on the coal map (pl. 14) as representing continuous outcrops may prove to represent different horizons along different parts of their length.

PHYSICAL PROPERTIES

With the possible exception of the local lens of coal in the Cloverly formation, which may be of higher rank, the coal is of subbituminous rank, closely resembling that mined near Sheridan, Wyo., and at Colstrip, in the adjacent Forsyth field. It lies in thick beds, usually free from partings, and the ash content is believed to be small. It has a conchoidal fracture, is shiny black on freshly exposed surfaces, and slacks after a short exposure to the weather. It can be stored for a time in a tight bin but if stored in large quantity is liable to spontaneous combustion. The coal makes a satisfactory fuel if used promptly in specially constructed boiler sets and locomotives.

CHEMICAL PROPERTIES

In the absence of fresh samples from localities within Big Horn County, the best index available to the quality of the local coals is afforded by analyses of samples from the Colstrip mine and from the mines in the Sheridan field. Typical analyses from these and other nearby localities are included in the table given below, together with four analyses of local coal (nos. 14755, 17711, 26149, and 95879), which are of doubtful value because of uncertainty as to freshness of the samples. Analyses of a typical coal from Pittsburgh, Pa., are included for the sake of comparison. All the analyses given were made in the laboratory of the United States Bureau of Mines at Pittsburgh.

Analyses of samples of coal from Big Horn County and from some productive coal fields nearby

Location	Laboratory no.	Form of analysis [a]	Proximate				Ultimate					Heating value	
			Moisture	Volatile matter	Fixed carbon	Ash	Sulphur	Hydrogen	Carbon	Nitrogen	Oxygen	Calories	British thermal units
Acme mine, Wyo	25258	A	25.4	31.2	40.5	3.3	0.3					5,071	9,130
		C		41.8	53.7	4.5	.5					6,799	12,240
		D		43.8	56.2		.5					7,118	12,810
Mine 1, Carneyville, Wyo	25305	A	22.1	31.2	43.7	2.9	.3					5,157	9,280
		C		40.1	56.1	3.8	.4					6,621	11,920
		D		41.7	58.3		.4					6,880	12,380
Mine 7, Dietz, Wyo	25294	A	24.6	31.3	40.2	4.0	.3					5,076	9,140
		C		41.4	53.2	5.3	.5					6,729	12,110
		D		43.8	56.2		.5					7,109	12,800
Mine at Monarch, SE¼ sec. 24, T. 57 N., R. 85 W., Wyo.	25313	A	20.8	33.8	41.5	3.9	.3					5,337	9,610
		C		42.6	52.5	4.9	.3					6,743	12,140
		D		44.8	55.2		.4					7,091	12,760
Prospect in sec. 33, T. 7 S., R. 37 E., Mont	26149	A	22.5	32.2	40.2	5.1	.3					5,050	9,090
		C		41.6	51.9	6.5	.4					6,518	11,730
		D		44.5	55.5		.4					6,972	12,500
Brewster-Arnold mine, sec. 23, T. 6 S., R. 42 E., Mont.	95879	A	27.3	28.9	39.2	4.6	.6	6.4	51.4	1.0	36.0	4,917	8,850
		C		39.8	53.9	6.3	.8	4.7	70.7	1.4	16.1	6,761	12,170
		D		42.5	57.5		.9	5.0	75.5	1.5	17.1	7,217	12,990
Strip mine at Colstrip, sec. 34, T. 2 N., R. 41 E., Mont.	A10685	A	22.3	28.9	41.2	7.6	.8	6.0	54.2	.8	30.6	5,161	9,290
		C		37.2	53.0	9.8	1.1	4.5	69.7	1.0	13.9	6,633	11,940
		D		41.2	58.8		1.2	5.0	77.3	1.2	15.3	7,356	13,240
Bear Creek, sec. 31, T. 7 S., R. 21 E., Mont	18694	A	11.7	34.1	45.8	8.4	1.7	5.5	60.6	1.6	22.2	5,977	10,760
		C		38.6	51.9	9.5	1.9	4.8	68.6	1.9	13.4	6,772	12,190
		D		42.7	57.3		2.1	5.3	75.8	2.0	14.8	7,484	13,470
Mine 4, Red Lodge, sec. 27, T. 7 S., R. 20 E., Mont.	29468	A	11.2	35.1	40.4	13.3	1.2					5,623	10,120
		C		39.5	45.5	15.0	1.4					6,332	11,400
		D		46.5	53.5		1.6					7,450	13,410

Big Vein mine, Roundup, SE¼ sec. 4, T. 7 N., R. 26 E., Mont.	A2839	A	15.7	31.4	46.2	6.7	1.0	5.9	61.2	1.0	24.2	5,956	10,720
		C		37.2	54.9	7.9	1.2	4.9	72.6	1.2	12.2	7,061	12,710
		D		40.4	59.6		1.2	5.4	78.8	1.3	13.3	7,667	13,800
Shields mine, near Gillette, sec. 28, T. 50 N., R. 71 E., Wyo.	87553	A	30.8	30.3	33.9	5.0	.3	6.7	47.8	.7	39.5	4,511	8,120
		C		43.8	49.0	7.2	.4	4.7	69.1	1.0	17.6	6,528	11,750
		D		47.3	52.7		.4	5.1	74.5	1.1	18.9	7,033	12,660
Tullock Creek field, bed C, sec. 2, T. 4 N., R. 35 E., Mont.	14755	A	19.8	30.7	35.2	14.3	1.5					4,765	8,580
		C		38.2	43.9	17.9	1.9					5,940	10,700
		D		46.6	53.4		2.3					7,235	13,030
Tullock Creek field, bed P, sec. 30, T. 1 N., R. 38 E., Mont.	17711	A	22.6	31.9	39.5	6.0	0.5					4,895	8,810
		C		41.2	51.1	7.7	0.7					6,325	11,380
		D		44.6	55.4		0.7					6,855	12,340
Pittsburgh coal, Fayette County, Pa.	23097	A	2.5	35.7	53.6	8.2	1.8					7,585	13,650
		C		36.6	55.0	8.4	1.8					7,780	14,000
		D		40.0	60.0		2.0					8,490	15,290

[a] A, Coal as received; C, moisture free; D, ash and moisture free.

BURNING OF THE COAL BEDS

Extensive burning of the coal beds along their outcrops and beneath areas of thin cover has caused the production of great quantities of "clinker," "slag," or "lava," as it is locally called, which gives a characteristic red banding to the landscape where the Tongue River member of the Fort Union crops out. The clinker has been studied by Rogers,[99] who reports that decided changes of mineral composition result from the baking and fusing of the overlying rocks. These changes, however, are not visible to the naked eye. The clinker is the most conspicuous rock in the area, and except where the coal beds lie so close together that their individual clinkers merge into an indivisible mass, the burned outcrops afford easy means for tracing the lateral extent of the coal beds, though they may completely prevent the determination of the local thickness of the bed traced.

DEVELOPMENT

Wagon mines have been opened at various points in Big Horn County and the Crow Indian Reservation to provide coal for local domestic use; but it will probably be many years before more extensive mining operations will be justified economically, except perhaps in certain areas along the Tongue River should a railroad be built from Sheridan to Miles City. This is partly because of the existence of well-equipped mines at Colstrip, in the Forsyth field; at Sheridan, just south of the Wyoming line; and at other nearby coal-mining centers already provided with railroad transportation. It is also due partly to the fact that the position of the coals in the high ridges and plateau east of the Little Horn River makes them relatively inaccessible by railroad spurs except such as would traverse similar coal-bearing areas lying east of the Crow Indian Reservation.

TOWNSHIP DESCRIPTIONS

In the following pages are presented, by townships from north to south, the local details of structure, stratigraphy, thickness of coal beds, and other data from which have been drawn the general conclusions already given. The topography, geology, and accessibility of each township are also noted briefly. On plate 14, to which repeated reference will be made, the outcrops of the several coal beds are shown, with numbers indicating the locations at which their thickness was measured. The details of the sections measured, correspondingly numbered, are plotted graphically on plate 15.

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[99] Rogers, G. S., Baked shale and slag formed by the burning of coal beds: U.S. Geol. Survey Prof. Paper 108, pp. 1–10, 1918.

The townships of Big Horn County that are outside the Crow Indian Reservation have been described in an earlier publication,[1] and their descriptions will not be repeated in this report.

T. 1 S., R. 37 E.

Only the five southern tiers of sections in T. 1 S., R. 37 E., lie within the Crow Indian Reservation; secs. 1 to 6 are included in the Tullock Creek coal field, which was examined by Rogers and Lee.[2] The divide between Sarpy Creek and East Tullock Creek crosses the center of this township from southeast to northwest. The greater part of the township consists of a gently sloping plain developed upon the Lebo shale that rises toward the south and is broken here and there by clinker-capped buttes that rise abruptly several hundred feet above the general upland surface. A fault mapped by Rogers and Lee in sec. 4, T. 1 S., R. 36 E., continues an indeterminate distance southeastward and possibly extends into T. 1 S., R. 37 E., from the west-central part of sec. 18 to the southeast corner of sec. 36. The beds are downthrown south of this fault and appear to be arched slightly north of it, with the production of what is called the East Tullock Creek dome. (See pl. 1.)

Coal sections measured during the reconnaissance examination of this township by Collier and Wentworth indicate the presence of three coal beds of workable thickness, doubtfully correlated with the Burley, Robinson, and Rosebud beds. The coal outcrop lines as sketched are shown in plate 14. Measurements of the thickness of the coal made at locations 1 to 4, 9, and 11 to 14 in this township are shown graphically on plate 15.

T. 1 S., R. 38 E.

Only about 14 square miles in the southwest corner of T. 1 S., R. 38 E., lies within the Crow Indian Reservation. The township is drained by Sarpy and Little Sarpy Creeks. Its surface consists of a rather undulating plain, which is broken by buttes and slag-capped pinnacles and rises sharply along the east boundary of the reservation to the high slag-capped divide separating the Sarpy and Rosebud Creek drainage basins.

Reconnaissance work by Collier and Wentworth shows that the rocks exposed in this township belong to the Tongue River member and consist principally of yellow shales and sandstones, only the lower part of the member showing somber colors. A local upfold probably related to the East Tullock Creek dome lies in the southwest corner of this township, as a result of which a coal bed, possibly at the Robinson horizon, is extensively exposed along Sarpy Creek. Two coal beds of some thickness were found to crop out in the township, and a local bed crops out in sec. 14. (See pl. 14.) A clinker, probably formed during the burning of the Sawyer bed, is also exposed along the east reservation line. The thickness of the beds was measured at locations 5 to 8, 10, 15 to 20 (see pl. 15), and other, higher coal beds are presumably present in the Rosebud Mountains, within the eastern, unmapped part of this township.

TPS. 1 AND 2 S., R. 39 E.

No detailed examination has been made of the parts of Tps. 1 and 2 S., R. 39 E., that lie within the Crow Indian Reservation, but from observations

[1] Baker, A. A., The northward extension of the Sheridan coal field, Big Horn and Rosebud Counties, Mont.: U.S. Geol. Survey Bull. 806, pp. 15–67, 1929.

[2] Rogers, G. S., and Lee, Wallace, The Tullock Creek Coal field, Mont. U.S. Geol. Survey, Bull. 749, p. 150, 1923.

in nearby areas it is evident that a considerable thickness of Tongue River beds, including some above the Sawyer coal, is present in the Rosebud Mountains, which extend northeastward across this area. Because of the roughness of the region and its remoteness from main trails, extensive coal-mining development within it is unlikely for a long time to come.

T. 2 S., R. 37 E.

The principal drainage lines of T. 2 S., R. 37 E., are the West and East Forks of Tullock Creek, which cross, respectively, the southwestern and northeastern corners of the township. Beds belonging to the Tongue River and Lebo members of the Fort Union are exposed in the central and eastern parts of the township, and the Tullock member of the Lance is exposed southwest of the Middle Fork of Tullock Creek, as a result of the gentle and comparatively uniform northeast dip prevailing in this township.

Two coal beds tentatively correlated with the Burley and Robinson were sketched in parts of this township by Collier and Wentworth (see pl. 14), and the thickness of the coals was measured at locations 21 to 23, 25, and 26 (pl. 15).

T. 2 S., R. 38 E.

T. 2 S., R. 38 E., which lacks the western tier of sections, lies partly in the Crow Indian Reservation, partly in the Tongue River Indian Reservation, and partly outside the reservations in Big Horn County. (See pl. 1.) The drainage of this district is divided between the Tullock and Sarpy Creek Basins, the divide extending from northwest to southeast through the center of the township. The surface is much dissected along the watercourses and rises abruptly to a high slag-capped ridge in the central part. The township is mainly or entirely covered by beds belonging to the Tongue River member. The East Tullock Creek fault may continue across sec. 5 of this township and die out in sec. 8, the associated uplift on the northeast extending into secs. 3 and 4. As a result of these interruptions to the regional dip toward the northeast a shallow syncline parallel to the trend of the fault crosses the central part of the township.

The Burley coal bed presumably underlies the western part of T. 2 S., R. 38 E., at a relatively shallow depth, but does not crop out within it. Beds corresponding in horizon to those containing the coals as high as and including the Sawyer crop out within the township, but of these the Sawyer has been almost, if not quite, destroyed by burning, and measurements were made only on coals tentatively correlated with the Robinson and Lee beds. The outcrop of these beds as sketched by Collier and Wentworth is shown on plate 14, and the thickness of the coal beds measured at locations 24, 27, and 28 is shown graphically on plate 15.

T. 3 S., R. 37 E.

The divide between the West Fork of Tullock Creek and Rosebud Creek drainage basins crosses the extreme southeast corner of T. 3 S., R. 37 E. Dissection along the streams is considerable, but the surface of the greater part of the township consists of an undulating upland that rises rather abruptly to clinker hills in its southeast corner. The township lies just north of the crest of the broad anticlinal upwarp, followed approximately by Reno and Davis Creeks, and in consequence of these flexures the dominant dips are to the northeast, though local variations were noted. Beds belonging to the Hell Creek and Tullock members of the Lance cover the western half of the township, and the Lebo and Tongue River members of the Fort Union cover the remainder. The coal outcrop lines sketched by Collier and Wentworth are shown on plate 14, and coal sections measured at localities 35, 36, and 39 are shown graphically on plate 15.

T. 3 S., R. 38 E.

Only 18 sections constituting the western part of T. 3 S., R. 38 E., lie within the Crow Indian Reservation, and the drainage of this part flows in about equal amounts to Tullock and Davis Creeks. The divide between these two drainage basins extends from sec. 29 to sec. 3 and is featured by a few low hills and buttes that rise from the undulating plain that is developed over nearly all of the area.

The surface rocks of the township belong to the Tongue River member and for the most part dip gently toward the southeast or east, although numerous local variations were noted due to the presence of minor flexures imposed upon the broad, low arch that crosses the district. The eastward slope of the strata is not so steep as the stream gradients of the tributaries of Rosebud Creek, and in consequence the coal beds crop out on both sides of the Tullock-Rosebud divide. The outcrops of the coal beds sketched by Collier and Wentworth are shown on plate 14, and coal sections measured at locations 29 to 34, 37, and 38 are shown on plate 15. Small areas beneath the higher hills are believed to be underlain by yet another coal bed 30 to 40 feet above the upper one mapped.

T. 4 S., R. 37 E.

The divide separating the basins of Tullock and Reno Creeks extends from the northwest corner of T. 4 S., R. 37 E., to the center, where it merges with the Tullock Creek-Rosebud Creek divide at the north end of the plateau of the Rosebud Mountains. The surface of this plateau slopes gently eastward in conformity with the attitude of its component strata, and this eastern slope has been deeply trenched by tributaries of Rosebud Creek. The western edge of the plateau lies just west of the Rosebud-Little Horn divide and is featured by short, deep valleys and abrupt escarpments several hundred feet high. Minor hills and clinker buttes dot the divides in the northern part of the township, but the main escarpment marking the northern termination of the Rosebud Mountains extends approximately parallel to the valley of Davis Creek, passing near the southeast corners of secs. 33 and 24.

The outcrops of the lower coal beds found in this township were sketched by the party in charge of Howell (see pl. 14), and coal sections measured in the course of this work at locations 45 to 49 are shown graphically on plate 15. Higher coal beds undoubtedly underlie the high divide in the southeastern part of the township.

T. 4 S., R. 38 E.

Only 18 sections in the western part of T. 4 S., R. 38 E., are included in the Crow Indian Reservation. The whole of this area lies within the valleys of Davis and Thompson Creeks, which are tributary to Rosebud Creek. The relief is about 1,000 feet. North of Davis Creek the surface consists of an undulating plain dotted with minor buttes and pinnacles, but east of Thompson Creek and between Thompson and Davis Creeks abrupt slopes rise to outlying remnants of the Rosebud Mountain plateau. These remnants owe their preservation to the resistance to erosion afforded by the massive sandstone of the Tongue River member and to the massive clinker beds formed by the spontaneous burning of coal beds along their outcrops. These clinker beds are very prominent in the Rosebud Mountains and give the upland a decided red tint when viewed from a distance.

Outcrops apparently representative of three coal beds 35 to 50 feet apart have been sketched by Howell and Wentworth (see pl. 14) and coal sections measured at locations 40 to 44 are shown graphically on plate 15. Prospects in secs. 3, 4, and 9 showed thicknesses, respectively, of 9, 6, and 5 feet of coal, and a 2-foot bed crops out at the northeast corner of sec. 10. The coal bed mapped across the southern part of the township is probably near the Lee horizon, and other coals higher in the section presumably underlie the high divide north of Thompson Creek.

T. 5 S., R. 36 E.

Reno Creek drains the northeast corner of T. 5 S., R. 36 E., and Shaving Creek drains the greater part of the remainder, the divide between these two creeks extending from sec. 5 southeast into sec. 36. The surface of the greater part of the township is featured by steep slopes broken by hills of sandstone and clinker. Several large buttes 300 or 400 feet high are clustered on the Reno-Shaving Creek divide in the southwest part of the township, at the head of the Long Otter Creek, and a prominent northwest spur of the Rosebud Mountain plateau extends along the divide into the southeast corner of the township. Tongue River coal-bearing rocks occur only in the southeast corner of the township.

The general position of the lowest mappable coal bed is indicated by the outcrop lines sketched by members of Howell's party. (See pl. 14.) It may be, however, that the outcrop line drawn is a composite rather than a simple one. Coal thicknesses were measured at locations 54 to 58 (see pl. 15), and higher beds undoubtedly underlie the uplands southeast of the mapped outcrop.

T. 5 S., R. 37 E.

The Rosebud Mountains, which form the main divide separating the Little Horn drainage from that of Rosebud Creek, cross T. 5 S., R. 37 E., from north to south, extending in a fairly straight line from sec. 32 into secs. 3 and 4. The west slope of the divide drops abruptly nearly 1,000 feet and is indented by short, deep canyons cut by tributaries of Reno Creek. East of the divide the eastward slope of the surface conforms fairly closely to the nearly level sandstone and clinker beds of the Tongue River member, and in consequence the country has the character of a plateau trenched by the valleys of Corral, Thompson, and Little Thompson Creeks, which are tributaries of Rosebud Creek.

The geologic structure of this township has not been studied in detail, but it is believed that the gentle regional dip toward the east may be interrupted locally in secs. 14 and 23. The Lebo member of the Fort Union and the upper part of the Tullock member of the Lance crop out in the northwest corner of the township, and rocks belonging to the Tongue River member of the Fort Union crop out upon and east of the main divide of the Rosebud Mountains.

Little detailed study was made of the coal beds in this township, but all of the township except the northwest corner is underlain by workable coal beds and the outcrop line and thickness of the lowest one found are shown on plates 14 and 15 (locations 50 to 53). Other thick coal beds doubtless underlie the highlands in the southeastern part but have not been mapped or sectioned.

Corral Creek flows eastward across the southern part and Thompson Creek crosses the northwest corner. These two streams and their numerous local tributaries have greatly dissected and reduced the former plateau surface and have produced a local relief of about 1,000 feet.

No measurements were made of the thickness of coal beds cropping out in this township, but it is believed that the whole area is underlain by workable coal beds, which crop out on the west slope of the Rosebud Mountains or along Rosebud Creek in Tps. 4 and 5 S., R. 38 E. The Sawyer coal bed passes below valley grade just south of the mouth of Corral Creek.

T. 6 S., R. 36 E.

The Little Horn River meanders back and forth across the west line of T. 6 S., R. 36 E., and the river course is bordered by minor alluvial flats east from which irregular sandstone hills rise to progressively greater heights as the Rosebud Mountains are approached. The valley of Gray Blanket Creek extends westward across the north-central part of this township, and Owl Creek and its tributary, Sioux Pass Creek, drain the southern part. Surface relief within the township amounts to about 1,300 feet, and the erosional dissection of the surface approaches the mature stage.

Sandstones and shales belonging to the Bearpaw formation crop out in the western part of this township, and the Tullock member of the Lance forms a fairly continuous escarpment between the irregular hills marking the outcrop of the Hell Creek member and the strike valley formed by the Lebo outcrop. Minor areas of Tongue River beds are present on the Sioux Pass-Gray Blanket divide and on the ridge north of Gray Blanket Creek. In general, the rocks show a gentle regional dip to the east, much modified by local structural irregularities.

Minor coal beds are present below the Tongue River member but were not examined in detail, although small clinker hills noted near the mouth of Sioux Pass Creek indicate that a bed probably at the horizon of the Teapot sandstone member of the Mesaverde formation of Wyoming is possibly of some thickness in that vicinity. With the exception just noted, however, the area underlain by workable coal beds in this township is believed to be restricted to parts of secs. 1, 2, 12, and 25. Outcrop lines sketched by Howell's party indicating the position of the lower coal beds of local value are shown on plate 14, and the thickness as measured at locations 59 and 60 is shown on plate 15.

T. 6 S., R. 37 E.

The Rosebud Mountains, which form the main divide between the Little Horn River and Rosebud Creek, extend nearly north and south across the central part of T. 6 S., R. 37 E. Gray Blanket Creek drains the northwestern part of the township; Sioux Pass Creek drains the southwestern part; and Corral, Cache, Spring, and Indian Creeks, tributaries of Rosebud Creek, named in order from north to south, drain the eastern half. This township has a maximum surface relief of about 1,200 feet. The westward slope from the Rosebud Mountain divide is everywhere abrupt and is locally featured by high escarpments. East of the main divide the interstream ridges rise to approximately equal altitudes and show level surfaces closely conforming to the attitude of the massive sandstone and clinker beds that form their protective cappings.

Beds belonging to the Tongue River member cap the main divides, the underlying Lebo member appearing only in the valleys of Gray Blanket and Sioux Pass Creeks, near the west township line. In general the rocks in this township dip gently toward the east, but this regional dip seems to be modified in a measure by a low plunging anticline which extends southeastward from the central part of the township, and possibly by a fault, which may extend eastward across secs. 7 and 8.

Except for the area of Lebo outcrop, essentially the whole township is underlain by coral beds of workable thickness. The outcrops of the lower coals sketched by Howell's party are shown on plate 14, and the clinker formed by the burning of the Smith bed is believed to cap the high divide that extends northwestward across the township. The thicknesses of coals measured at locations 61 to 65 are shown on plate 15.

T. 6 S., R. 38 E.

The eastern boundary of the Crow Indian Reservation passes through the center of the east tier of sections of this township, and the township lacks a tier of sections on the west; the part within the reservation has an area of about 27 square miles. The township is drained by Cache, Spring, and Indian Creeks, which flow slightly north of east to join Rosebud Creek. The stream valleys are 700 to 800 feet deep, and the total surface relief is more than 1,000 feet. The crests of the major divides, which are relatively flat and lie at about the same altitude, are developed in essential conformity with the slope of the resistant sandstone and clinker beds that cap them.

A reconnaissance examination of this township indicates that the whole of it is underlain by thick coal beds in the Tongue River member. The Wall, Canyon, and Anderson beds were mapped as far as the east reservation line by Baker.[3]

T. 7 S., R. 37 E.

The Rosebud Mountains rise more than 1,000 feet above the lowest point in T. 7 S., R. 37 E., and cross it from north to south near its eastern edge, forming the high divide that separates the drainage basin of the Little Horn River from that of Rosebud Creek. The headwaters of Sioux Pass Creek and the tributaries of Owl Creek have dissected the western part of the township. The crest of the main divide is relatively flat and slopes gently eastward in conformity with local rock structure. Other remnants of this upland surface persist upon the higher divides between Indian Creek and the forks of Rosebud Creek, which drain the eastern part of the township. The valley slopes bordering these last-named streams are steep and of considerable height but are in few places so abrupt as to give the valleys a canyonlike character.

The Tullock member of the Lance and the upper part of the Hell Creek member crop out along the lower slopes in the southwestern part of this township, and the Lebo member of the Fort Union is exposed in a narrow belt that crosses the township in a strike valley partly occupied by Little Owl Creek. Rocks belonging to the Tongue River member of the Fort Union and the basal Wasatch cover the remainder of the township. In the main the rocks of this township dip gently toward the southeast.

The outcrop line is shown on plate 14. The thickness of the coal was measured at locations 66 to 71. (See pl. 15.) Location 71 marks an old drift prospect from which a sample of coal for analysis was cut. The analysis subsequently made (no. 26149, p. 90) indicates the subbituminous character of the coal and its general equivalence in rank and heating value to the coal of the Sheridan field. In addition to the coal bed whose outcrop was mapped across this township, two higher beds, 9 and 14½ feet in thickness, were re-

[3] Baker, A. A., The northward extension of the Sheridan coal field, Big Horn and Rosebud Counties, Mont.: U.S. Geol. Survey Bull. 806, pp. 47–48, 1929.

vealed by the measurements made at location 67, on the west slope of a high hill in sec. 16. The presence in the eastern part of the township of a thick bed at the Smith horizon and of some coal at the Roland horizon is indicated by clinkers.

T. 7 S., R. 38 E.

The east boundary of the Crow Indian Reservation bisects the eastern tier of sections of T. 7 S., R. 38 E.; the part of the township within the reservation has an area of about 27 square miles. The township is drained by Indian Creek and the North and South Forks of Rosebud Creek. The interstream divides rise 400 to 500 feet above the adjacent valley bottoms, giving the area a total surface relief of about 800 feet. North of the North Fork of Rosebud Creek the upward slope from the valley is relatively gentle, but elsewhere the slopes are steep and locally become abrupt. The crests of the major divides of this district are relatively flat and are remnants of a once continuous plateau surface that sloped slightly eastward, in which the tributaries of Rosebud Creek have intrenched themselves. The upper part of the Tongue River member of the Fort Union and remnants of the Wasatch are exposed in this township. South of Indian Creek a sandstone rim a little above the Roland coal bed is caused by a conspicuous exposure of the Wasatch. The rocks of this area seem to have a gentle regional dip toward the southeast, which is to some extent modified by local folds plunging southeast.

No measurements of coal beds were made by Howell within this township, but the Roland, Smith, and Anderson beds are known to crop out, and lower coals undoubtedly underlie it.[4]

Access to the township is given by the trail that follows the divide between the forks of Rosebud Creek and connects with the main Sheridan-Forsyth highway near Kirby, or, less directly, by the road to Lodge Grass that follows Indian and Sioux Pass Creeks.

T. 8 S., R. 37 E.

The Rosebud Mountains cross the central part of T. 8 S., R. 37 E., from north to south, forming part of the main divide between the Little Horn and Tongue River drainage basins and descending by an abrupt escarpment to a steep and thoroughly dissected slope that extends downward to the valley of Owl Creek. East of the divide a comparatively level plateau slopes gently eastward in essential conformity with the dip of the resistant sandstone and clinker beds that form the protective capping of the mountains. Squirrel, Tanner, and Young Creeks, tributaries of the Tongue River, drain the eastern part of the township and have somewhat dissected the main plateau surface. Little Owl Creek, Bear Creek, and other minor streams drain the western half of the township into Owl Creek, which in turn joins the Little Horn River just above Lodge Grass.

The Hell Creek and Tullock members of the Lance and the Lebo shale member of the Fort Union are exposed west of the lower part of the Rosebud Mountain escarpment, and a section of the Tullock and Lebo measured near Linerider Spring in sec. 30 gives them a combined local thickness of about 800 feet of somber shale, with minor beds of somber sandstone and numerous ledges of concretionary masses of ironstone that weathers to a conspicuous red color. The whole of the Tongue River member and minor remnants of the Wasatch are present on the higher divides. Throughout the greater part of the township the rocks have a general easterly slope, and a fault may cut the escarpment in sec. 4.

[4] Baker, A. A., op. cit., pp. 52–53.

A coal bed tentatively correlated with the Carney has been traced across this township from sec. 4 to the southeast corner of sec. 33, and the area east of its outcrop, amounting to about 19 square miles, is all believed to be coal land. The Carney (?) was measured in this township at locations 72, 73, 75, 77 to 81. (See pl. 15.) A higher coal, tentatively correlated with the Monarch bed of the Sheridan field, was the only other bed measured in this township. At location 74, in sec. 9, this bed contained at least 14 feet of coal, and at location 76, in sec. 16, an incomplete measurement of the bed showed 9 feet of coal.

T. 8 S., R. 38 E.

The east line of the Crow Indian Reservation passes near the north quarter corner of sec. 2, T. 8 S., R. 38 E., and the northeast corner of sec. 35; the part of the township within the reservation has an area of about 28 square miles.

The divide between the Tongue River and Rosebud Creek drainage basins extends eastward across the north-central part of this township. The South Fork of Rosebud Creek drains the extreme northern part of the township, and Squirrel Creek, a tributary of the Tongue River, drains nearly all of the remainder. The higher interstream divides have relatively even plateaulike surfaces surmounted by two large buttes, one in the north-central part of the township and one in the south-central part, which rise above the general upland level, giving a local surface relief of nearly 1,000 feet. It seems evident that the interstream plateaus are remnants of a much more extensive antecedent plain, developed in essential conformity with the gentle eastward slope of the resistant sandstone and clinker beds which form the protective cappings of the ridges, and that this older plateau has been dissected by the subsequent drainage lines of the present creeks. On the southwest side of Squirrel Creek the valley walls are locally steep but in few places become bluff-like, but on the northeast side of the creek there is an extensive escarpment several hundred feet high. The slopes adjacent to a minor tributary of the South Fork of Rosebud Creek that crosses secs. 3 and 4 of this township are also so steep as to give the valley a canyonlike character. The rocks exposed in this township probably all belong to the Tongue River and basal Wasatch.

No measurements of coal beds were made within this township, but it is known that the Roland coal is extensively exposed along the valleys in the eastern and southern parts,[5] and several thick coals are undoubtedly present below the Roland.

T. 9 S., R. 36 E.

The maximum surface relief of T. 9 S., R. 36 E., amounts to about 800 feet. The divide between Owl and Twin Creeks extends north and south across the township just west of its center and is featured by short, abrupt slopes on its west side and much more gentle descents eastward to Owl Creek. Sandstones and shales belonging to the upper part of the Parkman sandstone and the Bearpaw shale crop out along the west township line, west of the Owl Creek-Twin Creek divide; the Hell Creek and Tullock members of the Lance and the Lebo and basal Tongue River crop out in the extreme southeast corner. The Aberdeen flexure plunges slightly toward the east, crossing the west line of the township near Aberdeen and extending southeastward across the township.

[5] Baker, A. A., op. cit., pp. 57–58.

The western part of this township is probably underlain at depths of 100 to 700 feet by a coal bed that was formerly mined in a small way near the railroad, half a mile west of this township. This coal bed is believed to occur in the Bearpaw.

Minor coals may also occur in the lower members of the Lance, but it is probable that the only other coal beds that attain workable thickness in the township occur near the base of the Tongue River member of the Fort Union and underlie a few acres in secs. 25, 35, and 36. (See pl. 14.) The lower of these two beds, tentatively correlated with the Rosebud bed of the northern part of the reservation, was mapped along the south line of secs. 35 and 36. This bed shows several benches of coal; the largest is a little over 2 feet thick at location 91, just south of sec. 36, but it seems to die out south of the north line of sec. 36.

The upper bed present in the township seems to be equivalent to the Lee bed, also mapped in the northern part of the reservation. This bed, as mapped, underlies a few acres in the eastern part of sec. 36 and the southeast corner of sec. 25, and probably is of workable thickness in both sections, as the bed is about 6 feet thick at locations 89 and 90, which are situated, respectively, in secs. 30 and 31, T. 9 S., R. 37 E.

T. 9 S., R. 37 E.

T. 9 S., R. 37 E., is crossed from north to south by the Rosebud Mountains, which form the divide between the Little Horn and Tongue River drainage basins. The western slope of this divide is an abrupt and continuous escarpment that locally attains a height of as much as 1,000 feet. The total surface relief in the township is more than 1,600 feet. East of the main divide the larger interstream divides show relatively even clinker-capped surfaces which appear to have been formerly parts of a continuous plateau surface but are now dissected by the valleys of Young, Little Young, and Ash Creeks.

A small area of the Hell Creek member of the Lance is probably exposed in sec. 6 of this township, and the Tullock and Lebo crop out in belts along the base of the main Rosebud Mountain escarpment. Strata belonging to the Tongue River member of the Fort Union and the basal part of the Wasatch cap the Rosebud Mountains in this township and, in the main, show gentle dips to the east. This regional slope is, however, modified in the southern part of the township by the eastward extension of the Black Gulch-Aberdeen flexure.

As shown by plates 14 and 15, considerably more than half of this township is underlain by coal beds of workable thickness. A heavy clinker believed to have been formed by the burning of the Carney coal bed caps the plateau at its southwestern point at the Wyoming line, and successively higher beds appear northward along the divide, beds as high as the Roland probably being present on the divide northward from sec. 21. A section measured by Collier and Wentworth is as follows:

Section at west face of Rosebud Mountains near northwest corner of sec. 32, T. 9 S., R. 37 E.

	Feet
Clinker, forming mountain top	35
Sandstone and shale	102
Coal, Carney (?) bed	9
Shale and sandstone, with thin coals	187
Coal, Sawyer (?) bed	9
Shale and sandstone	195
Coal, Lee (?) bed	10
Sandstone, shale, and thin coals	150+

The lowest coal bed believed to be of value in this township is tentatively correlated with the Lee bed as mapped in the northern part of the Crow Indian Reservation. It is probably the one measured at locations 89 and 90, in secs. 30 and 31.

A second coal, perhaps to be correlated with the Sawyer bed, was measured at location 88, in section 29, but probably was not measured elsewhere in the southern part of the reseervation, uncertainty on this score being due in part to the possible presence of a fault extending northeastward across secs. 29 and 30. A coal bed, probably at the Carney horizon, was measured at locations 82 to 87. (See pls. 14 and 15.) The presence of yet higher beds beneath small tracts along the higher divides is apparently indicated by the prominent clinker beds there locally developed.

T. 9 S., R. 38 E.

Slightly more than the five western tiers of sections of T. 9 S., R. 38 E., are within the Crow Indian Reservation. These sections lie on the east slope of the Rosebud Mountain divide and are drained by Tanner, Young, Little Young, and Ash Creeks, which are tributaries of the Tongue River. The main interstream divides have a fairly even and gradual slope to the east and apparently are remnants of a once continuous plateau surface, now dissected by the existing creek valleys. The even slope of the assumed ancient plateau surface is interrupted in the north-central part of the township by a large butte that rises 200 feet or more above the general plain, giving to the township a total surface relief of about 900 feet.

Strata belonging to the upper part of the Tongue River member of the Fort Union and the basal Wasatch crop out within this township and in general dip gently toward the northeast, although minor folds trending northeast seem to be present, and the Black Gulch-Aberdeen flexure extends southeastward across the extreme southwest corner of the township.

Baker's studies[6] just east of the reservation line and outcrops just south of T. 9 S., R. 38 E., show that the whole of the township is underlain at moderate depths by several thick coal beds, the Smith and Roland coals having been mapped up to the east reservation line. Two beds of coal from 5 feet to more than 13 feet thick, one of which probably is at the Roland horizon, have been prospected in secs. 9 and 10, and another bed 3½ feet thick occurs about 60 feet higher.

Roads and trails along the creek valleys and main divides make this township accessible with relative ease from Sheridan by way of the Tongue River Valley.

T. 10 S., R. 38 E.

About 5 square miles of land forming parts of secs. 1 to 6, T. 10 S., R. 38 E., is included in the Crow Indian Reservation. The divide between Ash and Little Young Creeks occupies nearly the whole of the area, and its higher part rises rather abruptly from the creek valleys, the total surface relief of the area being about 700 feet. The eastward extension of the Black Gulch-Aberdeen flexure crosses this area, approximately coinciding with the divide north of Ash Creek.

The whole of this fractional township is believed to be coal land, as a coal bed probably at one of the Dietz horizons is reported to be 19 feet thick at the Lupton mine, about a mile south of sec. 4, and a partial section of the bed at an old prospect, just a few hundred feet south of sec. 5, showed

[6] Baker, A. A., op. cit., pp. 62–63.

more than 8 feet of coal. The probable existence of workable coal beds beneath the area from which this bed has been eroded is also apparently indicated by exposures a few miles farther east and northeast.[7]

WESTERN PART OF TONGUE RIVER INDIAN RESERVATION

The part of the Tongue River Indian Reservation within Big Horn County includes Tps. 3 to 5 S., Rs. 39 and 40 E., and parts of T. 2 S., Rs. 38 to 40 E., and Tps. 3 to 5 S., R. 38 E. It is drained by Rosebud Creek and the Tongue River and is featured by narrow valleys separating high ridges or plateau surfaces to which the light-colored clays and sandstones of the Tongue River member and associated zones and masses of coal clinker give a characteristic appearance. Work within the area has been limited to a reconnaissance along the Forsyth-Sheridan road, which follows the Rosebud Valley.

The clinker of the Sawyer coal bed makes a prominent rim about 200 feet above creek level at the big bend just northwest of Lame Deer and rises gently westward, gradually retreating from the creek in consequence.

The following section was obtained opposite the mouth of Thompson Creek, in T. 4 S., R. 38 E.:

Section of beds exposed on east side of Rosebud Creek opposite mouth of Thompson Creek

	Feet
Small clinker.	
Shale and sandstone	70
Coal, impure	2
Shale, white	22
Coal, impure	2
Shale and sandstone	155
Coal, Rosebud (?) bed	9
Shale and sandstone	51
Coal, Stocker Creek (?) bed	7
Shale and sandstone	20
Coal, somewhat impure, Graham (?) bed	7
Shale, to creek level	12

A coal bed, presumably one of the foregoing, is also exposed near Davis Creek, in the eastern part of sec. 11, T. 4 S., R. 38 E., as follows:

Section of coal bed exposed three-quarters of a mile west of mouth of Davis Creek

	Feet
Shale.	
Coal, somewhat impure	5
Shale, sandy, and sandstone	12
Coal, top irregular, thin bone partings; country bank	5–7
Shale, sandy, and sandstone	10
Shale, carbonaceous, and coal	2

Apparently the Rosebud coal bed passes beneath the bed of Rosebud Creek a short distance south of the mouth of Thompson Creek, the low dip in this region being principally east. Owing to an increase in the southward component of the dip, the Sawyer bed passes beneath creek grade just south of the mouth of Corral Creek. A short distance beyond this point the beds rise gradually southward, with the result that the clinkers of the Wall coal bed are conspicuous along the valley sides as far south as the mouth of Indian

[7] Baker, A. A., op. cit., pp. 61–63.

Creek. Clinkers representative of the Smith bed are at least locally present along the higher parts of the Rosebud-Tongue River divide. It is therefore evident from the work of Baker [8] that great tonnages of coal must be present within the part of the Tongue River Indian Reservation included in Big Horn County.

OIL AND GAS

Wells drilled a little north and west of Hardin about 1915 encountered some natural gas,[9] and oil was discovered in the Crow Indian Reservation when the Western States Oil & Land Co., of Denver, Colo., brought in a well on the Soap Creek dome [10] in February 1921. Additional wells have since been drilled in the Soap Creek field,[11] and a considerable amount of exploratory drilling has been done within the reservation, but no producing oil wells have been developed other than that at Soap Creek. The local uplifts that have seemed to indicate the possible occurrence of oil and gas have been described in connection with the structure, on pages 71–79.

The gas at Hardin, obtained from several wells in secs. 11 to 14, T. 1 S., R. 33 E., apparently comes from thin sandstones and sandy shales in the Frontier formation, and the oil produced at Soap Creek comes from the Amsden formation and topmost part of the Madison limestone. (See pl. 6.)

Wells drilled, mostly during the period 1920–25, on the Black Gulch, Sport Creek, Willow Creek, Reed, Rotten Grass, Beauvais Creek, Woody Creek, Mifflin, Boundary, and Ninemile domes, either have yielded water or have been unproductive, apparently indicating that the artesian circulation of waters taken in along the Big Horn Mountains has dispersed such accumulations of oil as may have once existed within Big Horn County and the Crow Indian Reservation at localities other than Soap Creek. Some gas may, however, yet be found in the Frontier and higher sands but will not occur in great amount or under high pressure, as the wells near Hardin give yields of about 100,000 cubic feet of gas a day, with rock pressures of about 140 pounds to the square inch.

Logs of some of the wells in Big Horn County and nearby parts of Yellowstone and Stillwater Counties are given on pages 105–124. A few others are shown graphically on plate 6. The geologic interpretation of some of these logs may be open to question, for the geologists who correlated them were dependent, in part, on the drillers' descriptions. The water-bearing zones in the Cloverly formation,

[8] Baker, A. A., op. cit., pp. 61–62.

[9] Thom, W. T., Jr., Oil and gas prospects in and near the Crow Indian Reservation, Mont.: U.S. Geol. Survey Bull. 736, pp. 49, 50, 1923.

[10] Thom, W. T., Jr., and Moulton, G. F., The Soap Creek oil field, Crow Indian Reservation, Mont.: U.S. Geol. Survey Press Mem., Dec. 5, 1921.

[11] Thom, W. T., Jr., Recent drilling in the Soap Creek oil field, Crow Indian Reservation, Mont.: U.S. Geol. Survey Press Mem., May 3, 1922.

Tensleep sandstone, Amsden formation, and Madison limestone, are as a rule sharply defined and easily recognized. With these key zones established, it is possible to determine approximately the boundaries of the formations.

Log of Broadview well, Stillwater County, Mont.

[NE¼SW¼ sec. 13, T. 3 N., R. 22 E.]

Formation	Driller's description	Thickness (feet)	Depth (feet)
Eagle sandstone.	"Eagle sandstone"	60	60
	Blue sandy shale	45	105
	Blue sand (Eagle?)	40	145
	Hard sandstone	36	181
	Sandy shale	19	200
	Hard sandstone	16	216
Niobrara and Carlile shales.	Hard shale	19	235
	Sandy shale	38	273
	Blue and gray shale	943	1,216
	Shell	2	1,218
	Blue shale	293	1,511
	Shale	17	1,528
Frontier formation.	Shell	3	1,531
	Sand; trace of oil, no water	8	1,539
	Hard shell, white	2	1,541
	Bentonite, hard, cavy	20	1,561
	Sandy shell, hard; oil showing	10	1,571
	Bentonite	2	1,573
	Slate and shale	18	1,591
	Bentonite (?) (bentonite and shale)	19	1,610
	Gas and water sand	2	1,612
	Hard sandy shell, brown; trace of oil	2	1,614
	Black shale	61	1,675
	Hard shell	1	1,676
	Record lost	25	1,701
	Hard shell; showed trace of oil by chloroform test	8	1,709
	Gray shale	12	1,721
Mowry shale.	Shell	4	1,725
	Slate	8	1,733
	Limestone shells and shale	8	1,741
	Water sand, coarse; water	16	1,757
	Bentonite	2	1,759
	Water sand, fine; gas, small amount	12	1,771
	Shells and sandy shale	15	1,786
	Sandy shale and slate	25	1,811
	Hard slate, sandy shale, gray shale, hard slate	14	1,825
	Hard slate, caving	17	1,842
	Slate, caving	25	1,867
	Slate, some caving	34	1,901
	Slate	30	1,931
Thermopolis shale.	Slate, flaky	37	1,968
	Slate and shale	31	1,999
	Shale and shells	42	2,041
	Shale	25	2,066
	Shale and shells	120	2,186
	Shale	65	2,251
	Shale and shells	140	2,391
	Shale	70	2,461
	Shale and shells	85	2,546
	Shale	25	2,571
Cloverly formation.	Limestone shells and gray sandy lime	10	2,581
	Sandy lime	35	2,616
	Sand (?) fine gray to brown	20	2,636
	Shale	15	2,651
	Pink shale	45	2,696
	Red shale	25	2,721
	Sand	20	2,741
	Shale	15	2,756
	Red shale	10	2,766
	Gray shale	10	2,776
	Gray shale, cavy	25	2,801
	Gray and pink shale	10	2,811
	Gray shale	10	2,821

Log of Broadview well, Stillwater County, Mont.—Continued

Formation	Driller's description	Thickness (feet)	Depth (feet)
Cloverly formation.	Gray shelly shale	30	2,851
	Gray shale	3	2,854
	Hard shell	5	2,859
	Pink shale and sandy shell	17	2,876
	Dark limy sand; water	5	2,881
	White sand; water	10	2,891
	White and gray sand	15	2,906
	Gray sand	15	2,921
	Dark gray sand	20	2,941
	Sandy lime	6	2,947
	Black sand and shale	9	2,956
	Black sandy lime	20	2,976
	Gray shale and lime	3	2,979
	Sandy lime	7	2,986
	Sand	17	3,003
	Sand, white then dark, limy	48	3,051
	Dark shale	50	3,101
Morrison formation.	Reddish shale	10	3,111
	Gray sand; dry	8	3,119
	Reddish shale to black shale with some shell	52	3,171
Sundance formation.	Gray sand	4	3,175
	Gray shaly, limy sand; dry	46	3,221
	Gray sand; dry	35	3,256
Chugwater.	Black shaly lime; effervesces strongly in vinegar	145	3,401
	Dark shale with white specks, limy	10	3,411
	Reddish shale with white specks	5	3,416
	Reddish limy shale with more white specks	65	3,481
	Gray limy shale	17	3,498
	Hard brownish sandy lime	53	3,551
	Black sandy shale	10	3,561
	Brownish sand	12	3,573
	White sand	12	3,585
	Reddish sandy shale and white quartz; hole cavy	6	3,591
	Reddish sandy shale and shells and white quartz; hole cavy	25	3,616
	Reddish limy shales and shells, sandy with white quartz; hole caving	35	3,651

Logs of wells in Yellowstone County, Mont.

C. J. Carter well, Duck Creek anticline

[Southwest corner NE¼ sec. 27, T. 2 S., R. 25 E.]

Formation	Driller's description	Thickness (feet)	Depth (feet)
	Surface	15	15
Mowry shale.	Sand, yellow	15	30
	Sand, yellow, very hard	18	48
	Sand, yellow, hard	22	70
	Sand, yellow; set 15½-inch casing	5	75
	Sand, yellow	15	90
	Shale, gray	5	95
	Shell	20	115
	Shale, black	70	185
	Shale, blue	10	195
	Shell and slate	8	203
	Shale, blue	10	213
Thermopolis shale.	Shale, black	5	218
	Shale, blue	12	230
	Shale, black	10	240
	Shale, blue	17	257
	Shale, black	13	270
	Lime shell, hard	10	280
	Shale, blue	30	310
	Shale, black	25	335
	Shell, hard	5	340

Logs of wells in Yellowstone County, Mont.—Continued

C. J. Carter well, Duck Creek anticline—Continued

Formation	Driller's description	Thickness (feet)	Depth (feet)
Thermopolis shale.	Shell, shale, gray	40	380
	Shale, buff	25	405
	Shale, gray	35	440
	Shale, sandy, gray	65	505
	Shell	15	520
	Shale, gray	339	859
	Lime	4	863
	Shale, gray	32	895
Cloverly formation.	Lime	9	904
	Shale, gray	36	940
	Shale, white	15	955
	Rock, red	7	962
	Shale, white	6	968
	Shale, red	27	995
	Rock, red	31	1,026
	Shale, white	24	1,050
	Shale, pink	18	1,068
	Shale, red	5	1,073
	Shale, white	44	1,117
	Shell	2	1,119
	Shale, pink	15	1,134
	Shale, white	16	1,150
	Shale, pink	8	1,158
	Sand	18	1,176
Morrison formation.	Shale, gray	15	1,191
	Shale, sandy, white, hard	25	1,216
	Shale, white	11	1,227
	Sand	24	1,251
	Shale, white	39	1,290
	Rock, red	138	1,428
	Shale, white	20	1,448
Sundance formation.	Sand	5	1,453
	Lime, sandy, hard	7	1,460
	Sand	6	1,466
	Shale, gray; caving slightly	16	1,482
	Shale, gray	214	1,696
	Shale, white; set 8¼-inch casing	6	1,702
	Shale, gray	15	1,717
	Shale, pink	63	1,780
	Shale, gray	12	1,792
	Lime	12	1,804
	Shale, gray	44	1,848
	Shale, pink	62	1,910
Chugwater formation.	Rock, red	29	1,939
	Lime	6	1,945
	Rock, red	90	2,035
	Shale, white	27	2,062
	Lime	14	2,076
Tensleep sandstone.	Sand; water	24	2,100

Bitter Creek Oil Co.'s Bitter Creek well

[NW¼SE¼ sec. 2, T. 2 S., R. 26 E.]

	Surface materials; water	10	10
Mowry shale.	Sand rock	10	20
	Blue shale	5	25
	Gray shale	115	140
Thermopolis shale.	Brown shale	125	265
	Bentonite	20	285
	Black shale	35	320
	Gray shale	20	340
	Brown shale	25	365
	White shale	20	385
	Brown shale	25	410
	Hard gray shale	70	480
	Sandy lime	5	485
	Brown shale	15	500
	Gray shale	30	530

Logs of wells in Yellowstone County, Mont.—Continued

Bitter Creek Oil Co.'s Bitter Creek well—Continued

Formation	Driller's description	Thickness (feet)	Depth (feet)
Thermopolis shale.	Brown shale	15	545
	Gray shale	65	610
	Brown shale	2	612
	Gray shale	78	690
	Dark-gray shale	5	695
	Brown shale	55	750
	Muddy sand	62	812
	Pink shale	11	823
	White shale	7	830
	Red shale	8	835
	Gray sandy shale	22	860
Cloverly formation.	Light sandy lime	50	910
	White sandy lime	50	960
	White shale	5	965
	Red shale	15	980
	Sand; no water	20	1,000
	Red shale	10	1,010
	White sand; water	20	1,030
	Black shale		

About 1,200 barrels of water with considerable gas. Flow decreased about 20 percent in 2 weeks, then stopped running over casing head.

Prairie Oil & Gas Co.'s well no. 1, Mifflin anticline

[SW¼NE¼ sec. 18, T. 2 S., R. 29 E. (230 feet north and 1,560 feet west from east quarter corner). Commenced Sept. 23, 1925; abandoned Mar. 19, 1926]

Formation	Driller's description	Thickness (feet)	Depth (feet)
Telegraph Creek formation.	Clay, white	15	15
	Clay, gray	33	48
Niobrara and Carlile shales.	Shale, blue	287	335
	Gravel	10	345
	Shale, blue	420	765
	Shale, sandy	125	890
Frontier formation.	Shale, sandy, blue	100	990
	Bentonite	20	1,010
	Shale, blue	210	1,220
	Sand, coarse; show of gas at 1,220 feet	60	1,280
Mowry shale.	Sand and shale, sand broken	90	1,370
	Shell, hard	3	1,373
	Shale, sandy	97	1,470
Thermopolis shale.	Shale, sandy, blue	170	1,640
	Shale, blue	380	2,020
	Shell, lime	5	2,025
	Shale, blue	225	2,250
	Sand (muddy sand)	30	2,280
Cloverly formation.	Rusty beds; drills pink	10	2,290
	Shale, brown	130	2,420
	Shale, light	15	2,435
	Shale, blue	88	2,523
	Sand; Dakota, water at 2,550 feet	35	2,558
Morrison formation.	Shale, blue	7	2,565
	Sand, dry	25	2,590
	Shale, pink, top Kootenai	35	2,625
	Sand, dry	8	2,633
	Shale, maroon	67	2,700
	Shale, blue	60	2,760
Sundance formation.	Sand, dry	45	2,805
	Sand, broken	25	2,830
	Shale, gray	80	2,910
	Sand	5	2,915
	Shale, gray	175	3,090
	Shale, maroon	75	3,165
	Shale, blue	20	3,185
	Shale, red	90	3,275
	Shell, sandy	10	3,285
Chugwater formation.	Red beds	120	3,405

Casing record: 20-inch 90-pound, 38 feet; 15½-inch 70-pound, 708 feet; 12½-inch 50-pound, 1,457 feet; 10-inch 45-pound, 2,488 feet; 8¼-inch 32-pound, 2,624 feet; 6⅝-inch 24-pound, 3,150 feet.

Logs of wells in Big Horn County, Mont.

Mid-Northern Oil Co.'s well no. 1, Woody Creek dome

[NW. corner NE¼NE¼ sec. 33, T. 3 S., R. 31 E.]

Formation	Driller's description	Thickness (feet)	Depth (feet)
Frontier formation.	Thin sandstones at the surface	20	20
	Blue shale	120	140
Mowry and Thermopolis shales.	Brown sandy shale	10	150
	Blue shale	515	665
	Sand	15	680
	Gray shale	75	755
	Sand	45	800
	Gray shale	160	960
Cloverly formation.	Sandy shale	60	1,020
	Sandstone	85	1,105
	Gray sandy shale	17	1,122
	Pink and gray shale	21	1,143
	Sandstone, conglomeratic streaks in lower part	127	1,270
Morrison formation.	Blue shale	15	1,285
	Red and blue shale	20	1,305
	Red shale	35	1,340
	Sandstone; water, streaks of coal	23	1,363
	Red and green shale	49	1,412
Sundance formation.	Lime shell	3	1,415
	Sandstone	75	1,490
	Blue and green shale	90	1,580
	Sandstone	20	1,600
	Dark-gray and blue shale, containing *Gryphaea calceola*	175	1,775
	Pink shale	30	1,805
	Gray shale with thin streaks of limestone	55	1,860

"56" Petroleum Corporation's well no. 2, Beauvais Creek uplift

[SE¼NW¼ sec. 9, T. 4 S., R. 29 E. (444 feet north from south line and 651 feet west from east line). Commenced Aug. 13, 1922; completed Sept. 25, 1922. Drillers, E. J. Fisher and W. C. Hoover]

Formation	Driller's description	Thickness (feet)	Depth (feet)
Thermopolis shale.	Shale and sandy rock	40	40
	Shale, dark	95	135
	Shale, sandy	5	140
	Shale, gray	80	220
Cloverly formation.	Shale, sandy	10	230
	Shale, red	50	280
	Shale, gray; caves	20	300
	Shale, gray, hard	40	340
	Shale, pink	30	370
	Shale, variegated	15	385
	Shale, white	13	398
	Shell, lime	2	400
	Sand	10	410
	Shale, light	45	455
	Lime, sandy	30	485
	Lime, shell	5	490
	Shale, gray, shell	10	500
Morrison formation.	Shale, gray	120	620
	Lime, red	10	630
	Shale, gray	15	645
Sundance formation.	Shale, blue	10	655
	Shale, sandy	10	665
	Shale, red, limy	35	700
	Shale, gray	10	710
	Shale, gray, shelly	90	800
	Shale, white	10	810
	Shell, gray	127	937
	Red beds	108	1,045
	Shale, red	5	1,050
	Lime, gray	20	1,070
	Shale, soft, gray	30	1,100
	Lime, gray	40	1,140

Logs of wells in Big Horn County, Mont.—Continued

"56" Petroleum Corporation's well no. 2, Beauvais Creek uplift—Continued

Formation	Driller's description	Thickness (feet)	Depth (feet)
Chugwater formation.	Shale, red	50	1,190
	Lime, hard	25	1,215
	Shale, red	15	1,230
	Lime, dark	70	1,300
	Lime, hard	70	1,370
	Lime, red	40	1,410
	Shale, red, sandy	130	1,540
	Lime, hard, white	22	1,562
Tensleep sandstone.	"Embar sand"; water	3	1,565
	Sand; more water	13	1,578
	Lime	12	1,590
	Sand, white, soft	20	1,610
Amsden formation.	Lime, shell; more water	77	1,687

Casing record: 12½-inch 45-pound D.B.X. casing set at 540 feet; 10-inch 40-pound D.B.X. casing set at 1,142 feet. All casing pulled out.

"56" Petroleum Corporation's well no. 1, Beauvais Creek uplift

[SW¼NE¼ sec. 28, T. 4 S., R. 29 E.]

Formation	Driller's description	Thickness (feet)	Depth (feet)
	Soil	20	20
Cloverly formation.	Sand, water	5	25
	Shale, red	20	45
	Shell, lime	3	48
	Shale, red	22	70
	Shale, sand, pink	12	82
	Shale, gray	23	105
	Shale, blue	10	115
	Shale, gray	33	148
	Shell, lime	6	154
	Sand, light, gray; no water	94	248
Morrison formation.	Lime, pink	40	288
	Shale, gray	7	295
	Shale, red	5	300
	Shale, blue	45	345
	Sand, gray	28	373
	Shale, gray	9	382
Sundance formation.	Shell, lime	4	386
	Shale, gray	64	450
	Shale, sandy, blue	5	455
	Sandy, light, gray, and hard	5	460
	Lime	23	483
	Shale, blue	181	664
	Red beds	22	686
	Shell, lime	16	702
	Lime	90	792
Chugwater formation.	Red beds, small shells, sandy	45	837
	Shale, red, streaks of lime	433	1,270
	Lime, pink	14	1,284
Tensleep sandstone.	White sand; first big water	16	1,300
	Lime, sandy	22	1,322
Amsden formation.	Gray sand; big water	70	1,392
	Lime, white	13	1,405
	Sand, gray; more water	12	1,417

Estimated flow of water 64,800 barrels.

Logs of wells in Big Horn County, Mont.—Continued

Record Petroleum Co.'s Edgar no. 1 well

[NE¼ sec. 21, T. 5 S., R. 25 E.]

Formation	Driller's description	Thickness (feet)	Depth (feet)
	Surface (?)	20	20
Sundance formation.	Limestone, gray	20	40
	Shale, gray	35	75
Chugwater formation.	Shale, red	75	150
	Shale, sandy, red	33	183
	Sand, water	2	185
	Rock, red, sandy	55	240
	Shale, sandy	10	250
	Limestone, red	15	265
	Shale, sandy, red	10	275
	Shale, red	8	283
	Shale, sandy, red	182	465
	Gypsum, white	10	475
	Shale, red	20	495
	Shale, sandy, red	5	500
	Gypsum and sandy shale	5	505
	Gypsum, white	10	515
	Gypsum and shale	25	540
Tensleep sandstone.	Sandstone, gray, and lime	5	545
	Sand, gray	10	555
	Sand, brown	10	565
	Sand, gray	10	575
	Lime, gray, sandy	10	585
	Sand, gray	5	590
Amsden formation.	Lime, sandy, gray	20	610
	Lime, light gray	15	625
	Lime, sandy, light gray	15	640
	Lime, sandy, light brown	12	652
	Lime, sandy, gray, and shale, pea-green	10	662
	Shale, pea-green	13	675
	Shale, green, and lime, gray	5	680
	Lime, light gray	15	695
	Lime and shale, green	15	710
	Lime, gray	8	718
	Gypsum, white	14	732
	Lime, gray	5	737
	Shale and lime, red	5	742
	Lime, white	10	752
	Shale and gypsum, red	13	765
	Shale, red	35	800
Madison limestone.	Lime, gray	45	845
	Lime, white	25	870
	Lime, brown	10	880
	Lime, gray	45	925
	Lime, brown	25	950
	Lime, white	20	970
	Lime, gray	15	985
	Lime, light gray	20	1,005
	Lime, black	40	1,045
	Lime, brown	35	1,080
	Lime, soft, brown	25	1,105

B. E. Ladow & Co.'s well no. 1, Soap Creek dome

[SE¼SE¼ sec. 16, T. 6 S., R. 32 E.]

	Surface materials	15	15
Thermopolis shale.	Clay	25	40
	Black shale	150	190
	Blue shale; a little gas at 200 feet	180	370
	Sandy shale	40	410
	Blue shale	16	426
Cloverly formation.	White sand; artesian water, 1,000 barrels	60	486
	White and pink shale	49	535
	Hard, coarse sand	12	547

Logs of wells in Big Horn County, Mont.—Continued

B. E. Ladow & Co.'s well no. 1, Soap Creek dome—Continued

Formation	Driller's description	Thickness (feet)	Depth (feet)
Cloverly formation.	Red shale	13	560
	Variegated shale with white sand and sandy lime	10	570
	White sand; artesian water at 578 feet	49	619
Morrison formation.	Blue and brown shale	3	622
	Variegated shaly sand and lime	9	631
	Red shale	4	635
	Black lime (?), sandy	12	647
	Variegated shale with hard streaks, mostly greenish	43	690
	Hard gray shale, lime (?)	5	695
	Pink shale	6	701
	Green shale, hard on top, limy (?)	14	715
	Red shale	10	725
	Blue shale	20	745
	Brown shale	4	749
	Blue shale	76	825
	White sand; artesian water at 825 feet	18	843
	White shale	22	865
	Green sandy shale; at 872 feet hard, appears like lime	20	885
	Greenish-gray sand	10	895
Sundance formation.	Greenish-gray lime, small shells	20	915
	Greenish-gray sand	5	920
	Greenish-gray shale; shows dark-green sand and belemnites	140	1,060
	Green lime	3	1,063
	Brown sandy lime; oyster shells	20	1,083
	Greenish-gray shell; oyster shells	7	1,090
	Gray sand, dry	10	1,100
	Greenish-gray shale	157	1,257
	Reddish-brown shale	25	1,282
	Red shale	28	1,310
	Variegated lime and chert with soft spots	20	1,330
	Lost (?)	600	1,930
Chugwater formation.	Hard gray lime	6	1,936
	Fine white sand, brownish; puff of gas and show of oil	4	1,940
	Reddish sand with some green shale	5	1,945
	Grayish-brown sand with some green shale	5	1,950
Tensleep sandstone.	Fine white sand	4	1,954
	Fine grayish hard sandy lime	6	1,960
	Coarse greenish-gray sandy lime	4	1,964
	Fine brownish-white sand; show of oil at 1,971 feet	27	1,991
	Variegated sandy and limy shale	15	2,006
	Fine white sand; strong odor of oil and show at 2,006 feet	4	2,010
Amsden formation.	Coarse gray sandy lime; larger show at 2,012 feet	6	2,016
	Brown-gray sandy lime	6	2,022
	Grayish shaly sand	6	2,028
	Darker and coarser shaly sand	10	2,038
	Hard shell lime	2	2,040
	White sand, some shale, good show	1	2,041
	Coarse hard variegated shale	3	2,044
	Coarse hard variegated shale with coarse sand and lime	4	2,048
	Broken sandy lime and shale; show at 2,052 feet	5	2,053
	Variegated sandy shale	6	2,059
	Fine brownish-white sand; good showing of oil	1	2,060
	Variegated sandy shale	14	2,074
	Variegated sandy shale with lower part reddish sandy lime	26	2,100
	Hard shell, lime, and chert	2	2,102
	Gray lime (?); warm artesian water	5	2,107
	Strong flow of water; no samples	13	2,120
	(?)	38	2,158
	Gray lime	30	2,188
	Sandy lime	2	2,190
	Dolomite and chert	21	2,211
	Red limy shale, soft; small chert, lime, and siliceous pebbles; caves badly.	18	2,229
	Shaly and quartzitic red lime: some iron; last 5 feet very hard	20	2,249
	Soft red and yellowish clay (?); some chert, cavy	7	2,256
	Shale, lime, chert, and quartz. Fresh water at 2,257 feet; heaved in like quicksand around 2,257-2,258 feet; may possibly come from above.	4	2,260

Logs of wells in Big Horn County, Mont.—Continued

Western States Oil & Land Co.'s well no. 6, Soap Creek dome

[SW¼NW¼ sec. 27, T. 6 S., R. 32 E.]

Formation	Driller's description	Thickness (feet)	Depth (feet)
	Surface	40	40
Cloverly formation.	Brown sandstone; some water	40	80
Morrison formation.	White shale	30	110
	Gray shale	40	150
	Dark-gray shale	105	255
	Dark shale	60	315
	Gray shale	75	390
	White hard shell	10	400
	Sand	5	405
	Sand and water	20	425
	Dark shale	5	430
Sundance formation.	Gray shale	110	540
	Hard limestone shell	14	554
	Gray shale	136	690
	White lime shell	20	710
	White muddy lime	100	810
	Brown shale, cavy	10	820
	White muddy lime	55	875
	Red beds	40	915
	Soft red shale	35	950
	Red sandstone	25	975
Chugwater formation.	White lime shell	15	990
	Red sandstone	95	1,085
	Red sandstone, softer	210	1,295
	Red sandstone	225	1,520
	Red beds, sandy	65	1,585
	Hard limestone shell	10	1,595
	Hard pink lime	35	1,630
Tensleep sandstone.	Sand showing oil	12	1,642
	Hard lime shell	28	1,670
Amsden formation.	Sandy red shale	44	1,714
	Red shale	21	1,735
	Oil filled up 280 feet	10	1,745
	Oil filled up 900 feet	5	1,750

Casing record: 15½-inch 70-pound 10-thread casing, 109 feet 6 inches, of which 40 feet was pulled out after well was completed; 12½-inch 36½-pound 11½-thread, 255 feet, all of which was pulled; 10-inch 45-pound 10-thread, 540 feet 2 inches; 8¼-inch 28-pound 10-thread, 974 feet 3 inches; 6⅝-inch 20-pound 10-thread, 1,716 feet.

Hole filled and flowed over top of casing. Shot well with 60 quarts of nitroglycerin, and well now produces 25 barrels a day. Oil seems to be heavier and thicker than that of any of the other wells in the field.

Western States Oil & Land Co.'s well no. 7, Soap Creek dome

[NW¼SW¼ sec. 34, T. 6 S., R. 32 E. Commenced Apr. 8, 1922; abandoned August 1922]

Cloverly formation.	Shale, blue	80	80
	Shell, hard	6	86
	Shale, blue	69	155
	Shale, light blue	15	170
	Shale, gray	20	190
	Sand; some water	4	194
	Shale, white sandy	16	210
Morrison formation.	Shale, red, soft	5	215
	Shale, muddy	20	235
	Shale, pink	10	245
	Shell, hard	3	248
	Shale, soft, red	24	272
	Shale, white, muddy	3	275
	Shell, hard	3	278
	Shale, light gray	17	295
	Shale, gray	45	340
	Shell, hard	3	343

Logs of wells in Big Horn County, Mont.—Continued

Western States Oil & Land Co.'s well no. 7, Soap Creek dome—Continued

Formation	Driller's description	Thickness (feet)	Depth (feet)
Morrison formation.	Shale, gray	22	365
	Shale, red	25	390
	Sand, dry	15	405
	Sand, water	10	415
	Shale, gray	103	518
	Shell, hard	10	528
	Shale, gray	2	530
	Shell, hard	5	535
	Shale, gray	40	575
	Sand; some water	5	580
	Shale, gray, muddy	40	620
Sundance formation.	Shell, hard	5	625
	Shale, sandy, gray	45	670
	Sand, dry	15	685
	Shale, gray	35	720
	Shale, soft, blue	130	850
	Shell, hard, lime	15	865
	Shale, white, soft	160	1,025
	Shale, light blue	10	1,035
	Red beds	45	1,080
	Lime, hard	65	1,145
Chugwater formation.	Shale, red, soft	35	1,180
	Shale, red, sandy	565	1,745
Tensleep sandstone.	"Embar sand"	75	1,820
Amsden formation.	Shale, pink	15	1,835
	Shell, hard	5	1,840
	Shale, pink, soft	15	1,855
	Shale, red	5	1,860
	Shale, pink; showing of oil	10	1,870
	Shell, lime, hard	10	1,880
	Shale, pink	16	1,896
	Shell, hard	1	1,897
	Tensleep sand; water	3	1,900
	Shell, hard	15	1,915
	Lime, white	10	1,925
	Shale, pink	5	1,930
	Shale, light pink	20	1,950
	Lime, hard	15	1,965
	Shale, red	70	2,035
	Shale, red, sandy; good showing of oil	5	2,040
	Shale, light red, sandy; showing of oil	10	2,050
	Shell, hard	10	2,060
	Water sand	5	2,065
	Shale, dark, pink	3	2,068
	Lime, hard	2	2,070
	Lime, white, muddy	25	2,095
Madison limestone.	Lime, white, hard, Madison	15	2,110
	Lime, hard, white, Madison; water	5	2,115

Western States Oil & Land Co.'s well no. 1, Soap Creek dome

[Sec. 34, T. 6 S., R. 32 E.]

	Soil	10	10
	Gravel	4	14
Morrison formation.	Soft white shale	96	110
	Blue and brown shale; water	5	115
	Red beds	45	160
	Soft white shale	20	180
	Shale streaks and sand streaks	20	200
	White shale	35	235
	Red, soft, sandy shale	15	250
Sundance formation.	Water sand; fresh water at 260 feet	10	260
	Green lime	5	265
	Light-green lime	45	310
	Brown sandy shale	30	340
	White lime	10	350
	Red shale	15	365
	White lime	25	390
	Hard lime	10	400

Logs of wells in Big Horn County, Mont.—Continued

Western States Oil & Land Co.'s well no. 1, Soap Creek dome—Continued

Formation	Driller's description	Thickness (feet)	Depth (feet)
Sundance formation.	Hard white lime	123	523
	White lime	27	550
	Gray shale	50	600
	Shale	5	605
	Hard lime shell	10	615
	Gray shale	25	640
	Light-gray shale	90	730
	Lime shell	5	735
	Light-gray shale	25	760
	White shale	20	780
	Reddish-brown shale	15	795
	Light-red shale	35	830
	Lime shell	5	835
	Pink lime	5	840
	White lime	5	845
	Pink shale	55	900
Chugwater formation.	Hard red shale, soft streaks	20	920
	Hard red shale	60	980
	Light-red shale	5	985
	Red shale	15	1,000
	Red shale, hard and soft streaks	40	1,040
	Red shale	30	1,070
	Red shale, light	30	1,100
	Hard red sandy shale	30	1,130
	Hard shell	5	1,135
	Red shale	5	1,140
	Red sandy shale; varies in hardness but uniform in color	40	1,180
	Red shale, sandy, hard	5	1,185
	Red sandy shale, dark	35	1,220
	Red shale, light	15	1,235
	Red shale, dark	15	1,250
	Red shale, varies in color and hardness	45	1,295
	Sandy shale	40	1,335
	Red sandy shale	85	1,420
	Red sandy shale, darker, softer	30	1,450
	Red shale, darker	60	1,510
	Hard pink lime	5	1,515
	Hard pink lime, lighter	5	1,520
Tensleep sandstone.	Oil sand, hard. Could detect smell of oil when pulling bailer; struck oil at 1,530 feet, 10 feet in sand; sand very hard, softer at oil.	10	1,530
	Oil sand, softer	2	1,532
	Oil sand, soft	2	1,534
	Fine-grained white sand	16	1,550
	Hard sand, brown	20	1,570
Amsden formation.	Variegated gypsum and lime	5	1,575
	Very hard shell	5	1,580
	Hard shell, streaks of gypsum and shale	20	1,600
	Soft shale and gypsum	5	1,605
	Very hard streak of lime	5	1,610
	Variegated lime and shale, hard and soft streaks	20	1,630
	Soft variegated shale and gypsum	7	1,637
	Hard shell	5	1,642
	Oil sand, soft drilling	3	1,645
	Oil sand	2	1,647

Estimated 200-barrel well. Well flowing Feb. 11, 1921. Casing head put on Mar. 16, drilled 2 feet in sand. Production 400 barrels. Well was deepened but data are not available.

Western States Oil & Land Co.'s well no. 2, Soap Creek dome

[SE¼ sec. 34, T. 6 S., R. 32 E. (380 feet from east line and 250 feet from south line) John Alden farm]

	Soil	10	10
	Gravel	10	20
Morrison formation.	Light shale	5	25
	Gray shale	85	110
	Pink shale	5	115
	Red shale	10	125
	Brown shale	15	140
	Lime shell	5	145
	Shale	5	150
	White shale	15	195
	Brown shale, soft	10	175

Logs of wells in Big Horn County, Mont.—Continued

Western States Oil & Land Co.'s well no. 2, Soap Creek dome—Continued

Formation	Driller's description	Thickness (feet)	Depth (feet)
Morrison formation.	Lime shell	5	180
	Green shale	22	202
	Lime shell	8	210
	Lime	30	240
Sundance formation.	White shale	25	265
	White sand, water	10	275
	Brown shale	10	285
	White lime	25	310
	Lime shell	5	315
	White shale	55	370
	Pink shale	25	395
	Lime shell	5	400
	Dark-gray shale	25	425
	Lime shell	5	430
	Light shale	15	445
	Sand, light-colored, full of small black specks; small flow of water.	5	450
	Light sand	10	460
	Green sandy shale	5	465
	White shale	10	475
	Slate-colored shale	15	490
	Blue shale	70	560
	White shale	12	572
	Soft white shale	43	615
	White lime	11	626
	Blue shale	14	640
	White sandy shale	25	665
	Brown shale	5	670
	White shale	105	775
	White shale, harder	11	786
	White shale	4	790
	Green variegated shale	10	800
	Red beds (red shale)	30	830
	Lime shell	2	832
	Blue shale	18	850
	Pink lime, hard	65	915
	Pink lime, softer	5	920
Chugwater formation.	Red shale	30	950
	Red shale, harder	50	1,000
	Hard red shale	5	1,005
	Red shale	70	1,075
	Lime, pink	10	1,085
	Lime, softer	10	1,095
	Red shale	35	1,130
	Lime shell	5	1,135
	Red shale	150	1,285
	Light shell, pink	10	1,295
	Red shale	55	1,350
	Red shale, softer	20	1,370
	Red shale, soft	15	1,385
	Red shale	127	1,512
	Red sand	5	1,517
Tensleep sandstone.	Hard sand	4	1,521
	Lime	21	1,542
	White oil sand	4	1,546
	Soft sand, streaks of green shale	7	1,553
	Variegated lime and sand	7	1,560
	White sand	8	1,568
	Sand	6	1,574
Amsden formation.	Fine-grained hard sand	6	1,580
	Variegated sand, gypsum, and lime	10	1,590
	Sand and lime	5	1,595
	Pink sandy lime	5	1,600
	Sandy lime	10	1,610
	Variegated lime shell	4	1,614
	Sandy lime	36	1,650
	Hard shell	1	1,651
	Sand	1	1,652

Logs of wells in Big Horn County, Mont.—Continued

Western States Oil & Land Co.'s well no. 4, Soap Creek dome

[SW¼NE¼ sec. 34, T. 6 S., R. 32 E]

Formation	Driller's description	Thickness (feet)	Depth (feet)
	Surface	50	50
Morrison formation.	Broken sandstone	10	60
	Soft light sandy shale	20	80
	Soft pink shale	30	110
	Soft white shale	35	145
	White lime shell	4	149
	Soft pink shale	11	160
	Brown shale	5	165
	Gray shale	10	175
	Pink shale	5	180
	Sand and water	20	200
	Light-gray shale	30	230
Sundance formation.	Green soft shale	5	235
	Hard shell	5	240
	White shale	20	260
	Soft white shale	10	270
	Water sand	20	290
	Soft red shale	11	301
	White shale; "drills good"	19	320
	Blue shale	45	365
	Pink shale; "loads up on bit"	20	385
	Gray shale	65	450
	Hard shell	10	460
	Sand; water	10	470
	Grainy shale	25	495
	Hard shell	3	498
	Gray shale	22	520
	Dark shale	55	575
	Blue shale	40	615
	Light-gray shale	10	625
	Hard lime shell	8	633
	White lime	17	650
	Hard shell	4	654
	White shale	71	725
	Gray shale	75	800
	Shell	5	805
	Pink shale	15	820
	Soft red shale	20	840
	Red sand shell	20	860
Chugwater formation.	Soft red shale	10	870
	Red sandstone	45	915
	Light-gray sandstone	5	920
	Red shale	40	960
	Red sandstone	140	1,100
	Hard light or gray sandstone	20	1,120
	Red sandstone with soft streaks of red mud	55	1,175
	Red shale	90	1,265
	Red sandstone	40	1,305
	Hard shell	10	1,315
	Soft red shale	5	1,320
	Red shale	75	1,395
	Red sandy shale	120	1,515
	Hard lime	25	1,540
Tensleep sandstone.	Showing of oil in "Embar sand." "Showing colors up good"	25	1,565
	Hard shell	5	1,570
	White lime	25	1,595
	Hard shell	3	1,598
Amsden formation.	Red shale	4	1,602
	Hard shell	1	1,603
	Hard red lime	41	1,644
	Hard shell	9	1,653
	Oil sand. "Hole filled with oil in 1 hour"	2	1,655

Casing record: 2 joints of 15½-inch casing, which was pulled when well was completed; 14 joints of 12½-inch, 169 feet, pulled when well was complete; 3 joints of 10-inch 45-pound 10-thread and 35 joints of 10-inch 35-pound 8-thread, total 629 feet; 35 joints of 8¼-inch 28-pound 8-thread and 43 joints of 8¼-inch 28-pound 10-thread, total 1,605 feet.

Logs of wells in Big Horn County, Mont.—Continued

Dox Oil Co.'s well no. 1, Soap Creek dome

[NW¼NW¼ sec. 2, T. 7 S., R. 32 E.]

Formation	Driller's description	Thickness (feet)	Depth (feet)
	Surface	10	10
Thermopolis shale.	Red shale	8	18
	Gravel	12	30
	Blue shale	10	40
	Black mud	20	60
	Brown shale	30	90
	Sandy lime; water	10	100
	Light shale	20	120
	Black mud	30	150
	Dark shale	100	250
Cloverly formation.	Light shale	20	270
	Brown shale	40	310
	White sand	10	320
	Pink shale	58	378
	Red shale	15	393
	White shale; set 12½-inch casing	45	438
	White sandy lime	44	482
	Pink shale	20	502
	White lime	12	514
	White sand; a little water	20	534
	White shale	26	560
	Brown sandy shale	10	570
	Big water sand	20	590
Morrison formation.	White shale	20	610
	Blue shale	10	620
	Lime shell	2	622
	Brown shale	25	647
	Light lime	35	682
	Brown shale	10	692
	Lime shell	2	694
	Red shale	5	699
	Lime shell	4	703
	Light shale	15	718
	Light lime	7	725
	Blue lime	25	750
	Brown shale	15	765
Sundance formation.	Gray lime	25	790
	Gray slate	15	805
	White lime; water	25	830
	Light shale	15	845
	Gray lime	10	855
	Gray shale	105	960
	White lime	50	1,010
	White shale	95	1,105
	Lime shell	5	1,110
	White shell; set 8¼-inch casing at 1,185 feet	30	1,140
	Top of red beds	57	1,197
	Lime shell	5	1,202
	Pink lime	65	1,267
	Red shale	28	1,295
	Lime shell	5	1,300
Chugwater formation.	Tough red shale	40	1,340
	Lime shell	5	1,345
	Hard sandy shale	40	1,385
	Red shale	60	1,445
	Pink lime	10	1,455
	Red shale	75	1,530
	Lime shell	10	1,540
	Red shale	30	1,570
	Lime shell	5	1,575
	Red shale	20	1,595
	Red lime	5	1,600
	Red shale	125	1,725
	Lime shell	5	1,730
	Red shale	30	1,760
	Lime	8	1,768
	Red shale	95	1,863
	Pink lime	10	1,873
Tensleep sandstone.	White sand; showing of oil 10 feet in sand at 1,883 feet	20	1,893
	Gray lime	37	1,930
	Sand; oil	3	1,933
Amsden formation.	Gray lime; set 6⅝-inch casing at 1,985 feet	52	1,985
	Top cap rock	3	1,988
	Brown sand	5	1,993

Logs of wells in Big Horn County, Mont.—Continued

Dox Oil Co.'s well no. 1, Soap Creek dome—Continued

Formation	Driller's description	Thickness (feet)	Depth (feet)
Amsden formation.	Red sandy shale } Big flow of water	10	2,003
	Fine white sand } Big flow of water	7	2,010
	Hard white lime	26	2,036
	Brown sandy lime	7	2,043
	Oil sand; oil	5	2,048
	Very hard white lime	2	2,050
	Hard lime	11	2,061
	Lime and chert, slightly pink, showing oil saturation	9	2,070
	Whitish pink lime	6	2,076
	Brown sugar sand	3	2,079
	Hard white lime	1	2,080
	Still drilling.		

Thermopolis Cat Creek Corporation's well, Soap Creek dome

[NW¼SW¼ sec. 2, T. 7 S., R. 32 E.]

	Surface	15	15
	Gravel	5	20
Thermopolis shale.	Black shale	25	45
	Water sand	5	50
	Black shale	500	550
Cloverly formation.	Water sand	25	575
	Red shale	50	625
	Pink shale	105	730
	White shale	60	790
	Dry sand	15	805
	White shale and lime	55	860
	Sand, dry	25	885
Morrison formation.	White lime streaks, shale	105	990
	Pink shale	20	1,010
	Brown shale	25	1,035
	Shale and shell	20	1,055
	Sand with a little water	15	1,070
	Shale and shell	30	1,100
Sundance formation.	Shell and blue shale	55	1,155
	Blue shale	50	1,205
	Lime	7	1,212
	Shell and blue shale	18	1,230
	Blue shale	15	1,245
	Lime	5	1,250
	Blue shale	30	1,280
	Gray shale and shells	35	1,315
	Blue shale	30	1,345
	Gray muddy shale	35	1,380
	Pink shale	20	1,400
	Red beds	60	1,460
	Pink lime streak and red beds	40	1,500
Chugwater formation.	Red beds	519	2,019

Yellowstone Oil & Gas Co.'s well no. 3, Hardin area

[SW¼NW¼ sec. 2, T. 1 S., R. 33 E. Commenced July 15, 1915; completed August 7, 1915]

	Shale	23	23
	Gravel; water	15	38
Niobrara and Carlile shales.	Shale. Put in 41 feet of 10-inch casing; shut off gravel and water.	22	60
	Shale	65	125
	Shale. Heavy storm broke water ditch; no water	50	175
	Shale. Commenced to haul water; had hole to clean out after standing.	25	200
	Shale	50	250
	Shale. Bothered with water supply	40	290
	Shale. Cased with 8¼-inch casing to 548 feet. Commenced to clean out cavings; blew up bull wheels. Repaired wheels. Fished for tools.	258	548
	Shale	77	625

Logs of wells in Big Horn County, Mont.—Continued

Yellowstone Oil & Gas Co.'s well no. 3, Hardin area—Continued

Formation	Driller's description	Thickness (feet)	Depth (feet)
Frontier formation.	Shale. Got ready to set 6⅝-inch casing	75	700
	Shale. Finished 6⅝-inch casing at 748 feet	48	748
	Shale. Cleaned out small amount of gas at 765 feet	17	765
	Brown sand	20	785
	Shale. Put in 17 feet more 6⅝-inch casing; casing went down the hole. No more gas than at 765 feet; sand looked fair.	25	810
	Shale; hole caving	30	840

Grimstad & Brown well, Hardin area

[Sec. 5, T. 1 S., R. 33 E.]

Formation	Driller's description	Thickness (feet)	Depth (feet)
	Surface; set 15½-inch casing at 42 feet		
Niobrara and Carlile shales.	Shale, dark	215	215
	Shale, light	35	250
	Shale, blue; set 12½-inch casing at 521 feet; hole caving badly.	250	500
	Shale, blue	116	616
	Lime shell, blue, hard	4	620
	Shale, blue; hole caving badly; set 10-inch casing at 820 feet	200	820
Frontier formation.	Shale, blue	35	855
	Sand; showing of oil	3	858
	Shale, blue	32	890
	Sand; good show of oil	5	895
	Shale, blue, hole caving badly	105	1,000
	Sand; gas and oil showing	10	1,010
	Shale, brown	25	1,035
	Shale, blue, soft and cavy	65	1,100
	Shale, sandy, gray	25	1,125
	(?)	20	1,145
	Shale, blue, soft and cavy	140	1,285
Mowry shale.	Lime shell, hard	3	1,288
	Shale, blue, soft; reset 10-inch casing	40	1,328
	Shale, sandy, medium	57	1,385
	Shale, dark, sandy, limy; oil show	30	1,415
	Shale, blue	30	1,445
	Shale, light brown, soft, caving badly	20	1,465
	Shale, white, very soft, caving badly	10	1,475
Thermopolis shale.	Shale, blue, very soft, cavy	85	1,560
	Shale, dark, blue, soft; set 8¼-inch casing, at 1,591 feet 7 inches	40	1,600
	Lime shell, hard	5	1,605
	Shale, blue, soft	15	1,620
	Sand, muddy, hard on top with black lime cap	35	1,655
	Shale, black	10	1,665
	Shale, gray, sandy	60	1,725

Yellowstone Oil & Gas Co.'s well no. 2, Hardin area

[SW¼ sec. 10, T. 1 S., R. 33 E.]

Formation	Driller's description	Thickness (feet)	Depth (feet)
	Surface material; water at 40 feet	40	40
	Gravel and sand	10	50
Niobrara and Carlile shales.	Shale	50	100
	Light shale; a little gas at 160 feet	60	160
	Light shale	40	200
	Dark shale	50	250
	Light shale	70	320
	Dark shale	30	350
	Light shale	25	375
	Hard slate	50	425
	Sand and water	3	428
	Sandy lime	7	435
	Hard slate	15	450
	Dark slate	100	550
	Light lime	10	560
	Light slate	95	655
	Dark slate	45	700

Logs of wells in Big Horn County, Mont.—Continued

Yellowstone Oil & Gas Co.'s well no. 2, Hardin area—Continued

Formation	Driller's description	Thickness (feet)	Depth (feet)
Frontier formation.	Limestone shell	2	702
	Dark shale	73	775
	Sand and gas	28	803
	Dark shale	47	850
	Sand	5	855
	Light slate	55	910
	Mud	30	940
	Light shale	50	990
	Gray sand	6	996
	Slate	60	1,056
	Shale	194	1,150
Mowry shale.	Shale	95	1,245
	Sand	3	1,248
	Slate	52	1,300
	Lime	3	1,303
	Slate	20	1,323
	Brown shale	107	1,430
Thermopolis shale.	Gray slate	70	1,500
	Brown shale	35	1,535
	Slate	45	1,580
	Black slate	45	1,625
	Black lime	5	1,630
	Blue slate	81	1,711
	Brown shale	19	1,730
	Hard gray slate	71	1,801
	Blue slate	24	1,825
	Black lime	3	1,828
	Blue slate	4	1,832
	Black lime	10	1,842
	Slate	58	2,000
	Black sandy lime	39	2,039
	Black shale	6	2,045
	Gray sand	20	2,065
	Black, shale	8	2,073
	Hard gray lime	10	2,083
	Black shale	6	2,089
	Gray sand	11	2,100
	Black shale	60	2,160
	Red mud	50	2,210

Big Horn Oil & Gas Development Co.'s well no. 2, Hardin area

[NE¼NE¼ sec. 14, T. 1 S., R. 33 E.]

	Clay	8	8
	Gravel	20	28
Niobrara and Carlile shales.	Light-blue shale	62	90
	Dark muddy shale	10	100
	Light-gray shale	40	140
	Dark-gray shale	20	160
	Light-gray muddy shale	75	235
	Light-gray shale	45	280
	Bentonite	3	283
	Light-gray shale	42	325
	Light-brown shale	90	415
	Blue muddy shale	85	500
	Light-gray muddy shale	60	560
	Dark-gray muddy shale	60	620
	Light-gray muddy shale	15	635
	Bentonite	10	645
	Light-gray shale	20	665
	Very muddy soft light shale	15	680
Frontier formation.	Bentonite	20	700
	Dark soft muddy shale	32	732
	Gas sand	23	755

Shot with 20 pounds of 40 percent dynamite. Pressure 140 pounds.

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Logs of wells in Big Horn County, Mont.—Continued

Yellowstone Oil & Gas Co.'s well no. 1, Hardin area

[NE¼NE¼ sec. 27, T. 1 S., R. 33 E. Commenced Apr. 8, 1915; completed May 3, 1915]

Formation	Driller's description	Thickness (feet)	Depth (feet)
Quaternary alluvium.	Surface soil	22	22
	Surface soil; 10-inch casing put in	8	30
	Gravel; water at 40 feet; put 10-inch casing in gravel at water	12	42
Colorado group.	Blue shale	373	415
	Blue shale, caving	105	520
	Blue shale, caving badly	30	550
	Blue shale, caving badly; put in casing	20	570
	Blue shale; small amount of gas in shale at 590 feet; 8¼-inch casing put in 60 feet	60	630
	Blue shale, caving badly. At 630 feet ran tools and got fast; had to cut rope and fish out tools. Pulled out casing and found bottom collapsed. Put casing in again. Had to clean out cavings	40	670
	Blue shale; cleaned out	10	680
	Blue shale; caving badly	70	750
	Blue shale; put casing in and started underreaming	10	760
	Blue shale; underreaming and cleaning out	130	890
	Blue shale	140	1,030
	Brown shale; underreamed to 1,032 feet	30	1,060
	Brown shale	130	1,190

Casing record: 15½-inch casing, 9 feet; 10-inch, 42 feet; 8¼-inch, 1,032 feet.

Western States Oil & Land Co.'s well no. 1, Rotten Grass dome

[SW¼ sec. 28, T. 7 S., R. 33 E.]

Formation	Driller's description	Thickness (feet)	Depth (feet)
Frontier formation.	Yellow clay	23	23
	Blue mud	7	30
	Blue shale	70	100
	Gray shale	30	130
	Blue shale	17	147
	Gray shale	58	205
	Light-gray shale	10	215
	White soft shale	15	230
	Blue shale	70	300
	Black shale	65	365
	White soft shale	4	369
	Black shell	3	372
	Black shale	23	395
	Black sandy shale	50	445
	Soft shale	40	485
	Black shale	7	492
Mowry and Thermopolis shales.	Sandy shale	3	495
	Gray shale	3	498
	Hard black shale	5	503
	Black shale	37	540
	Sandy gray shale	25	565
	Black sandy shale	8	573
	Brown sandy shale	22	595
	Dark-brown shale	65	660
	White lime shell	4	664
	Brown shale	111	775
	Gray shale	5	780
	Brown shale	60	840
	Gray shale	3	843
	Blue shale	57	900
	Gray shale	40	940
	Blue shale	20	960
	Gray shale	33	993
	Blue shale	92	1,085
	Blue shale, cavy	93	1,178
	Brown-gray sand	7	1,185
	Blue sandy shale	25	1,210
	Blue shale	115	1,325
	Light-brown sand and shale	35	1,360
	Brownish-blue shale and shells	135	1,495
	Hard black shell	10	1,505
	Gray shale	25	1,530

Logs of wells in Big Horn County, Mont.—Continued

Western States Oil & Land Co.'s well no. 1, Rotten Grass dome—Continued

Formation	Driller's description	Thickness (feet)	Depth (feet)
Cloverly formation.	Sand; water	13	1,543
	Pink, break	4	1,547
	Hard gray shell	5	1,552
	Pink shale	8	1,560
	Gray sand; water	12	1,572
	Blue, break	3	1,575
	White sand	130	1,705
	Sticky blue shale	17	1,722
	Hard pink shell	2	1,724
	Pink break	1	1,725
	Hard white lime shell	3	1,728
	Pink shale	16	1,742
	White sandy lime	33	1,775
	White water sand	30	1,805
Morrison formation.	Pink shale	5	1,810
	Sticky blue shale; water flowing	10	1,820
	Pink shale	5	1,825
	Variegated shale, sticky	30	1,855
	Hard sand shell	5	1,860
	Hard gray shale	8	1,868
	Gray shale	12	1,880
	Pink shale	1	1,881

C. M. Bair & Mid-Northern Oil Co.'s Willow Creek well, Willow Creek dome

[NE¼NW¼ sec. 30, T. 8 S., R. 33 E., Willis Spear farm]

Chugwater formation.	(?)	4	4
	Red rock	26	30
	Lime shell	6	36
	Red rock	56	92
	Gray lime	8	100
	Red sandy shale; carries a little water	45	145
	Red beds, muddy	15	160
	Red sandy shale and clay	140	300
	Red rock, hard	23	323
	Flint and quartz, hard	11	334
	Red lime	26	360
	Sandy shale-lime; "show oil"	18	378
	Soft red shale	13	391
	Gypsum, red shale	4	395
	Hard shell	8	403
	Soft red shale	5	408
	Hard shell	14	422
	Red shale	18	440
	Red shale, thin lime shells	20	460
	Record of last 116 feet lost; total depth 576 feet	116	576

Mid-Northern Oil Co.'s well, Sport Creek dome

[Sec. 14, T. 9 S., R. 33 E.]

Chugwater formation.	Red beds	44	44
	Shell	2	46
	Red beds	57	103
	Shell	9	112
	Red beds	49	161
	Shell	12	173
	Carbon streaks	8	181
	Red shale	25	206
Tensleep sandstone and Amsden formation.	Sand and lime alternating	53	259
	White and gray lime	24	283
	Green shale	8	291
	Lime shell	29	320
	Fetid sand	6	326
	Sandy shale	24	350
	Lime, gray-pink	30	380
	Gray shale	10	390
	Red quartz sand	12	402
	Red sandy shale	43	445
	Quartz sand	3	448
Madison limestone.	Lime, white to gray	39	487

Logs of wells in Big Horn County, Mont.—Continued

Superior Oil & Coal Co.'s well, Ninemile dome

[NE¼ sec. 33, T. 1 N., R. 34 E. Commenced Sept. 4, 1921; abandoned June 1922. Drilled by J. Burton Wood]

Formation	Driller's description	Thickness (feet)	Depth (feet)
	Soil	4	4
Colorado group.	Shale	47	51
	Gravel	1	52
	Shale	3	55
	No record	745	800
	Colorado shale. Underreamed 10 inches from 1,060 to 1,360 feet; set 10-inch casing at 1,360 feet.	560	1,360
	Colorado shale. Put in 1,895 feet of 8¼-inch casing	535	1,895
	Colorado shale. Underreamed 8¼ inches to 2,102 feet	207	2,102
	Colorado shale	300	2,402
Cloverly formation.	Dakota sand; water (?)	48	2,450
	Lime, white	10	2,460
	Shale, pink	5	2,465
	Shale, variegated (green, white, and other colors). Set 6⅝-inch casing at 2,480 feet	15	2,480
	Lime, white	5	2,485
	Shale, green, mixed	10	2,495
	Shale, variegated	10	2,505
	Lakota sand	3	2,508
	Shale	42	2,550
	Lime, dark-gray, hard	23	2,573
	Shale, dark-blue, sandy	11	2,584

GROUND WATER

By George M. Hall

WATER-BEARING PROPERTIES OF THE ROCK FORMATIONS

The preceding pages have been devoted to a description of the stratigraphic and structural geology of Big Horn County and the Crow Indian Reservation and its bearing upon the coal, oil, and gas resources; the following pages present information on the ground-water resources.

Big Horn County is underlain by a series of sedimentary rocks about 12,000 feet in total thickness, resting on granite, which is exposed in the Big Horn Mountains. (See pls. 1 and 6.) The sandstones, in general, will yield sufficient water for domestic purposes, but they do not usually yield large quantities of water, and public waterworks may have difficulty in obtaining large supplies where wells obtain their water from rock of this type. Where the sandstones are shaly or deeply covered by shale the water may be of poor quality. The shales are usually poor water bearers and at best yield only meager supplies; the quality of the water is generally too poor for domestic purposes, and much of it is so poor that stock refuse it. Limestone, where dense, yields small supplies, but where it is cavernous or where joint planes are well developed, it yields large supplies. The limestone formations are so deeply buried, except along the mountains, that they have not been encountered in the wells drilled save in a few areas along the foothill belt of the Big Horn and Pryor Mountains. The sedimentary rocks below the Madison limestone and the granitic basement rocks have not yet been penetrated by wells.

A generalized section giving a summary of the thickness and character of the formations that may be encountered by wells is given on pages 29–31; additional information concerning their character and stratigraphic relations is given on pages 32–69, and a more detailed description of their water content is given below.

ALLUVIAL AND GRAVEL DEPOSITS

Alluvium, ranging from very coarse gravel to the finest silt, is found on the bottom lands of both the Big Horn and Little Horn Rivers and some of their tributaries, as well as along Pryor Creek. These alluvial deposits yield considerable quantities of water; only in a few places is the alluvium so fine-grained that it does not yield adequate supplies of water. In most places, however, this ground water is not suitable for domestic use and is used only for stock. Most of the inhabitants of the valleys of perennial streams prefer stream water on account of its lower mineral content and store it in cisterns which are either filled from irrigation ditches or by hauling. The Indians much prefer river water to ground water.

The quantity of water present in the alluvium in the irrigated areas is dependent not only on the usual sources of ground water but also on the amount of water used in irrigation. Many ranches use a great excess of water when irrigating their crops. A portion of this excess runs off and a portion evaporates, but a considerable amount soaks through the soil and joins the general body of ground water, raising the water table. This causes a seasonal change in level of the water in wells, amounting to several feet or more. The water rises in late spring and early summer and drops in the autumn, with a slight lag behind the irrigating season. Some of the shallowest wells are dry in winter, but as the wells are deepened water is encountered. In some places so much water has been run on the land that the subsoil is saturated and the water table almost coincides with the land surface, producing areas of evaporation. As the water evaporates the dissolved solids are deposited on the surface and the productivity of the land is destroyed. The productivity can be restored by installation of drains.

The shallow dug well, rarely exceeding 25 feet in depth and usually less, is the common type of well in the alluvium. It is cheap to dig and easily dug by unskilled labor. Usually it is lined with wood on account of the low cost and ease of construction. Such dug wells are suited for obtaining water from this formation, but a better type of casing than wood is preferable. In constructing wells in the alluvium the driven sand points are rarely used because occasional gravel beds interfere with driving them.

The quality of the water in alluvium is dependent in part on the underlying rocks, the water in the alluvium that rests on the shale being in general more highly mineralized than that in the alluvium that rests on the sandier formations. However, there are great variations in quality within short distances, and wells only a few yards apart may yield waters showing great differences in content of dissolved solids.

The water in the Pleistocene terrace gravel resembles that obtained from the alluvium in the stream valleys.

The late Tertiary terrace deposits are preserved at many places within Big Horn County and cover a large aggregate area. The materials underlying these terraces range in size from minute particles of sand and clay to cobbles 12 inches in diameter. The thickness of the deposits ranges from a few inches to 35 feet or more. The underlying rocks are beveled, and the rock surface is concealed by the gravel, so that in many places it is impossible to trace contacts without subsurface data. For a fuller discussion of these beds see pages 66–69.

Adequate supplies of water for domestic purposes are usually obtainable from the terrace deposits, but much of the water is highly mineralized and can be used only for stock. The degree of mineralization depends in part on the underlying formation. The depth to water depends on the thickness of the gravel cover, as most of the water occurs in the lower part of the gravel bed. Where a terrace is thoroughly dissected the water will drain out rapidly after rainy periods, and wells will not be very successful. The analyses of waters from these upper terraces are grouped with those of the Quaternary deposits.

WASATCH FORMATION

The basal beds of the Wasatch formation remaining within Big Horn County closely resemble in color, composition, and content of coal the underlying Tongue River member of the Fort Union formation. They are preserved in small areas in the southeastern part of the county. (See pl. 1.)

Where the beds are sandy good water supplies adequate for domestic purposes should be available at depths not exceeding 300 feet for drilled wells, but in shale areas water will be scarce and wells will yield only small quantities of poor water, high in dissolved mineral matter. Absence of extensive sandstones in the Wasatch formation may partly account for the reported difficulty in obtaining water supplies in the part of Big Horn County east of the Tongue River. Deeper wells that penetrate the underlying Tongue River member may yield adequate supplies of fairly good water. However, if care is taken to select a site in a steep coulee dug wells not generally exceeding 25 feet in depth may yield an adequate supply for a small ranch, but the water may be rather highly mineralized.

FORT UNION FORMATION

Tongue River member.—The Tongue River member of the Fort Union formation, with its large number of sandstones, affords supplies of fairly good water, and drilled wells usually obtain adequate supplies for domestic purposes at depths not exceeding 300 feet. The water is usually mineralized but not too highly so for domestic use. A few wells yield poor water. In the steeper valleys, which contain some alluvial material as well as disintegrated rock, shallow dug wells not exceeding 25 feet in depth, if favorably located, will yield adequate supplies for domestic use. Most wells will not yield supplies sufficient to water large herds of stock. The shallow supplies are usually hard. Deeper wells in this formation may yield softer water. Renick[12] discusses the occurrence and origin of the soft waters found in the Fort Union and Lance formations. He shows that the calcium and magnesian radicles are replaced by sodium and in some cases by potassium, with the natural softening of the waters.

Lebo shale member.—The Lebo shale is a poor source of water. Occasional springs occur, but much of the water is highly charged with iron. Wells, either drilled or dug, rarely obtain good supplies from this shale. However, within the areas of more extensive outcrop of the Lebo in the northeastern part of the county, the greater part of the shale has been eroded and the depth is not great to the sandstones in the underlying Lance formation, which yield fairly good domestic supplies. In the southern part of the county the thickness of the Lebo is much greater, and this makes the cost of drilling into the Lance formation high. In that area shallow dug wells in the coulees may yield water which, though hard and highly mineralized, can be used for domestic purposes.

LANCE FORMATION

Tullock member.—The sandstones in the Tullock member of the Lance formation usually yield small supplies of water that are usable for domestic purposes. Most well owners consider the waters from this source fairly satisfactory. In Rosebud County these sandstones, as well as some in the underlying Hell Creek member, yield large

[12] Renick, B. C., Base exchange in ground water by silicates as illustrated in Montana: U.S. Geol. Survey Water-Supply Paper 520, pp. 53–72, 1925.

artesian flows. There are no flowing wells from the Tullock member in Big Horn County, and wells ending in its sandstones rarely yield more than 25 gallons a minute, usually 10 gallons or less. Few wells exceed 200 feet in depth. Dug wells in the coulees are rarely more than 25 feet deep but yield adequate domestic supplies. The water from these shallow sources is usually somewhat harder than that from the deeper ones. Renick [13] shows that the exchange of bases takes place in the first 125 feet below the surface.

Hell Creek member.—The thick sandstone in the Hell Creek member of the Lance formation yields adequate domestic supplies of water, but the shale yields very little. The water obtained from the shale is usually much inferior in quality to that obtained from the sandstone. Drilled wells usually encounter supplies sufficient for domestic needs in the first 200 feet, but yields exceeding 25 gallons a minute are rare. In the steeper coulees, where beds of sandstone are prominent, dug wells usually find adequate supplies at depths of less than 25 feet. Sandstones in the basal part of the Hell Creek member yield adequate supplies of water to wells starting in the shaly middle beds of the member.

MONTANA GROUP

Bearpaw shale.—The dense marine Bearpaw shale is a very poor water-bearing formation. It yields only very small amounts of water that is generally to highly mineralized for any use. Wells in the shale are nearly always failures. In the southern part of the county the sandy beds in the upper part of the Bearpaw shale, which thickens southward, are reported to yield small water supplies that can be used for domestic purposes, although the content of dissolved solids is commonly high. In the areas underlain by the shale it may be advisable to drill through into the underlying Parkman sandstone. However, few attempts have been made to obtain supplies from the Parkman sandstone where it is covered by Bearpaw shale, and little can be said concerning the quality of the water that it may yield. Where it lies under a deep cover of shale the water may be very poor.

Parkman sandstone.—The Parkman sandstone is a water-bearing formation that has not been developed to any great extent in this county. In general it should be a fairly good source of water. Wells penetrating this sandstone generally yield adequate supplies for domestic purposes. In some localities the quality of the water is rather poor, but some wells, such as the Community well, in sec. 8, T. 1 S., R. 35 E., yield water that is considered good by the users. The total thickness of this formation is only 280 feet. The wells supplied by

[13] Renick, B. C., op. cit., p. 69.

this sandstone in general are not more than 200 feet deep and many of them encounter water at shallower depths. If the drill passes through the basal sandstone without finding an adequate supply, the well should be abandoned and a new location sought, because the shales in the underlying Claggett formation yield but small amounts of poor water. Where the Parkman sandstone is overlain by the Bearpaw shale it may be possible to obtain fair supplies by drilling through the shale into the sandstone.

Claggett shale.—The sandstones so conspicuous in the Claggett shale in some areas in the Lake Basin [14] are absent in Big Horn County, where the formation consists almost entirely of dark marine shale, with some concretions. In contrast to the bolder topography of areas underlain by the more resistant overlying beds of the Parkman sandstone, which forms hills and cliffs, the softer shales of the Claggett formation make more open and rolling lowlands.

The Claggett formation is a poor source of water. Its dark-gray marine shales yield little or none. The small amounts of water obtainable in some areas, derived chiefly from the few sandstone lenses, are commonly so highly mineralized that they cannot be used for any purpose. Some dug wells in the valleys yield small amounts of water which can be used for stock. Wells which yield water that can be used for domestic consumption are rare.

Eagle sandstone.—Only a few attempts have been made to obtain water supplies from the Eagle sandstone in the western part of Big Horn County, but drilled wells, about 100 feet deep, in this sandstone should obtain small supplies of water that is hard but can be used for domestic purposes. In the vicinity of Hardin and thence southward to the Little Horn River, where the formation contains sandy shale only, very few wells have obtained adequate supplies of water suitable for domestic purposes, but it may be possible to develop small supplies from shallow wells dug in the coulees. This coulee water may be so highly mineralized, however, that it can be used only for stock.

Telegraph Creek formation.—The water-bearing properties of the Telegraph Creek formation are not well known. Some wells have been put down in these sandy shales, but most of them were apparently failures. Most of the homesteads in the areas where the shales are at the surface have been abandoned, and many of them do not have wells. The formation apparently yields only meager supplies of poor water. Dug wells in coulees may yield small supplies of rather poor water for a few head of stock. Only rarely will a dug well yield water that can be used for domestic purposes.

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[14] Hancock, E. T., Geology and oil and gas prospects of the Lake Basin field, Mont.: U.S. Geol. Survey Bull. 691, pp. 116–117, 1919.

COLORADO GROUP

The Colorado group crops out over an extensive area around the Big Horn Mountains and has been divided within this region into five formations, which are, from top to bottom, the Niobrara shale, Carlile shale, Frontier formation, Mowry shale, and Thermopolis shale. These formations are described further on pages 48–53. All are similar in their water-bearing properties.

Drilled wells in the Colorado group are usually failures. In few if any of the many wells drilled in this area for oil was water reported in any of these formations. Shallow dug wells in the coulees at some places yield small supplies that can be used for domestic purposes, although the water is nearly always highly mineralized. In a few small areas on the interstream divides, where the sandy layers are only a few feet below the surface, dug wells have obtained small supplies that were used for domestic purposes.

Where the thickness of the Colorado group is not very great it is practicable to drill through it into the underlying Cloverly formation, in which fairly good supplies of water, under more or less artesian head, are available.

CLOVERLY FORMATION

The Cloverly formation is an excellent source of water. The top sandstone, where present, yields small supplies of water suitable for most purposes, but this top sandstone is lacking in places. The shales, which comprise the middle member of this formation, normally yield very little water. The basal conglomeratic sandstone of the formation usually yields more abundant supplies. This basal sandstone is wide-spread, and almost every well that has penetrated it has encountered water in sufficient amounts to arouse interest in the possibility of irrigating " dry land " areas with well water.

In many lowland places the wells overflow, but nowhere was the flow observed by the writer adequate to irrigate as much as an acre of land. Most of the flowing wells yielded less than 5 gallons a minute. No tests were made to determine the yield by pumping. Most of the wells have been drilled in the valleys, and these overflow; but in wells situated on the uplands, several hundred feet above the valleys, the water level may stand at a considerable depth below the surface. The cost of pumping the water would probably prevent the development of irrigation on the uplands.

The water from this conglomeratic sandstone at many places contains considerable amounts of natural gas and, in some wells, traces of petroleum. These materials give the water a peculiar taste and make it unfit for domestic uses and particularly for cooking. In general, the deeper this sandstone is beneath the surface the higher is its content of natural gas. The water is in general fairly soft.

MORRISON FORMATION

The Morrison formation consists chiefly of variegated shales and is usually a poor water-bearing formation. In the Soap Creek oil field this formation contains some beds of sandstone that yield small flows of water. These beds are not wide-spread and are lacking in most areas. In general it is necessary to drill through the Morrison formation into the Sundance formation in search of water supplies.

SUNDANCE FORMATION

The Sundance formation, which consists of sandstone, limestone, and shale, is an excellent water-bearing formation. The bulk of the water obtained from it, however, comes from the fossiliferous sandstone near its top. This formation, except in the vicinity of the Pryor and Big Horn Mountains, is deeply buried and is penetrated only by wells drilled in search of oil. In the vicinity of the mountains very few wells have been dug or drilled. In the future, when wells become necessary, little difficulty should be experienced in obtaining adequate supplies for domestic purposes from this formation. Wells in the valleys usually yield small artesian flows inadequate for irrigation.

CHUGWATER FORMATION

The Chugwater formation, which underlies the Sundance, is a very poor source of water. It consists chiefly of thin red sandstone and red shale with local beds of gypsum and a few thin beds of reddish limestone. In places small springs yield a little water which contains large amounts of calcium sulphate in solution. It is almost impossible to obtain from this formation water suitable for domestic purposes.

TENSLEEP SANDSTONE

The Tensleep sandstone is 45 to 75 feet thick and consists of fine to coarse yellow to white sandstone, which varies greatly from place to place in the degree of cementation. In some places it is very hard, dense, and thoroughly silicified and, except where thoroughly fractured, a poor water-bearing formation; but in other areas the sandstone is porous and yields large supplies of water. In some places the water contains hydrogen sulphide, which is undesirable for domestic purposes. This excellent water-bearing formation is everywhere deeply buried, except where it comes to the surface at the edges of the Big Horn and Pryor Mountains. Its water-bearing properties have been revealed by wells drilled in search of oil. Some of these wells have yielded more than 500 gallons a minute, with sufficient pressure to lift the water several hundred feet above the valleys in which they are situated. The wells in Soap Creek and Beauvais Creek Valleys have yielded the largest flows.

In view of these large flows under high head, many people have advocated drilling wells into the Tensleep sandstone and the underlying Amsden formation and Madison limestone to obtain a large supply for irrigating the uplands. The shallowest of these wells is more than 1,400 feet deep, and in most places where it is proposed to use wells for irrigation these formations lie from 1,000 to 2,000 feet deeper. Until more profitable crops can be raised in this area than those which are now harvested, the cost of such deep wells will probably be too great to make it profitable to drill them for irrigation. The yield of the wells in Beauvais Creek Valley did not diminish greatly during 1921 and 1922.

AMSDEN FORMATION

The Amsden formation, which consists of limestone, quartzitic sandstone, and red shale, is an excellent water-bearing formation. The deep wells drilled into this formation all encountered large volumes of water, chiefly in limestone. The formation is so deeply buried that the cost of drilling wells into it in search of water is high; in most parts of the reservation it is more than 2,500 feet below the surface.

MADISON LIMESTONE

The Madison limestone is composed of a series of beds of massive light-colored limestone cut by numerous solution channels. In the Soap and Beauvais Creek Valleys it yields large supplies of water. Some of the wells yield over 250 gallons a minute. In most parts of Big Horn County this formation is more than 2,500 feet below the surface. The yield of any well is dependent upon finding solution channels filled with water, as solid, unbroken limestone is almost impervious and yields very little water.

BIGHORN DOLOMITE

None of the wells drilled in this area have penetrated the Bighorn dolomite, and no information concerning its water-bearing properties is available.

DEADWOOD FORMATION

The wells drilled in this area have not been deep enough to enter the Deadwood formation. No information concerning its water-bearing properties is available.

IGNEOUS ROCKS

The principal igneous rock exposed in this area is the pre-Cambrian granite, which crops out in the Big Horn Mountains. This part of the area has no permanent inhabitants, and the mountain springs are adequate to supply the demands of people who visit it.

RELATION OF ROCK STRUCTURE TO WATER SUPPLIES

The rock formations that underlie Big Horn County have been warped, tilted, folded, and faulted until they lie in every position from horizontal to practically vertical. The areas in which the rocks are nearly horizontal are small, but there are large areas where the dip is gentle. Along the edges of the Big Horn Mountains the rocks stand almost on end.

After the deformation of the rocks the region suffered severe erosion, and the edges of the formations are now exposed. The amount of erosion that has occurred varies from place to place. In the Big Horn Mountains thousands of feet of sediments have been removed, and near the Wyoming State line the pre-Cambrian rocks

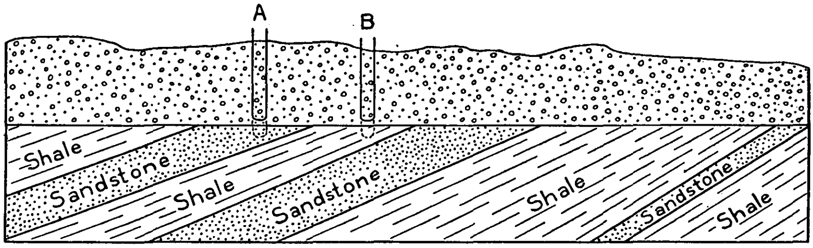

FIGURE 4.—Section illustrating ground-water conditions in unconsolidated terrace deposits and alluvium in their relation to the underlying rock formations. See text for explanation.

are exposed; but in the plains the erosion has been much less, and the oldest rocks exposed are those of the Chugwater formation, of Triassic and Permian (?) age. Where the sandstones come to the surface they generally form ridges, but where the shales crop out they generally weather away and form open valleys. The sandstones are commonly more favorable as sources of potable water, but in most places yield only meager supplies of poor water, and wells in them are usually failures.

The tilted, warped, folded, and faulted rock formations of Big Horn County are covered, in places, by terrace deposits and alluvium, which range in depth from a few inches to 50 feet or more. The silt and gravel are spread over the underlying rocks like a blanket, as shown in figure 4, without respect to the nature of the underlying rock. Wells in such materials generally obtain their supplies of water from the lower part of the unconsolidated beds near the contact with the underlying rock. In general, the largest and best supplies obtainable at a place underlain by terrace deposits or alluvium of considerable thickness will be in the loose materials near the contact with the underlying rocks. The underlying rocks will usually yield less water than the unconsolidated deposits, and the water is likely to be of poorer quality. At location *B*, figure 4, a well should not penetrate the underlying shale, because the water in shale probably would not be as good as that in the loose sand, silt, and gravel. At location *A* a more desirable supply might be obtained by digging or drilling into the sandstone, because the water from the overlying loose beds may have percolated into the sandstone. If the water in the sandstone at *A* is found to be of better quality than water in the sand and gravel above, the upper water will have to be cased out.

As the covering of terrace deposits or alluvium obscures the underlying geology, it is difficult at many places to predict whether a well will encounter shale or sandstone. In general, it is unwise

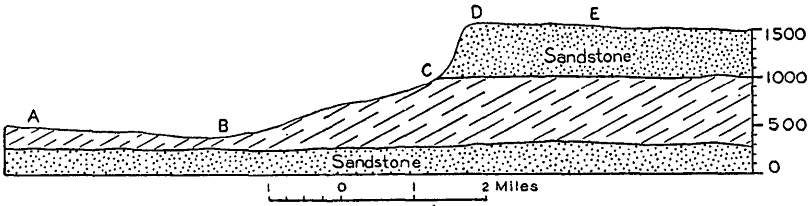

FIGURE 5.—Section illustrating ground-water conditions in nearly horizontal beds of sandstone and shale. See text for explanaton.

to penetrate the beds underlying the terrace gravel and alluvium unless the driller is prepared to case out the upper water and to continue drilling until a favorable water-bearing bed is encountered.

In areas where the rocks lie almost horizontal it is of great importance to determine the depth to water-bearing beds. If a water-bearing sandstone is at the surface, successful wells can generally be had at small cost unless the sandstone is so thoroughly dissected by streams that the water escapes into the valleys. But where shale is at the surface the depth to a favorable sandstone is of great importance. In figure 5 shale is shown at the surface from *A* to *C* and sandstone from *D* to *E*. From *A* to *B* the sandstone is about 300 feet below the surface, but from *B* to *C* the surface rises steeply and the depth to the sandstone increases from 300 feet to 700 feet, the latter figure representing the total thickness of the shale. The cost of sinking a well to the sandstone would be much less between *A* and *B* than between *B* and *C*. Consequently, wells should preferably be located between *A* and *B;* moreover, in some areas the quality of water in a sandstone is poorer under deeper cover, making it advisable to sink wells between *A* and *B*. It is generally unwise to drill wells close to sandstone that crops out in the form of rim rocks, as at *D*, in figure 5, because wells near the edge of a rim rock are usually dry; a well at *E* would have a far better chance of obtaining an adequate supply.

In areas where the rocks are considerably warped and tilted the geologic conditions change greatly from place to place, and these changes must be considered in selecting well sites. The geologic map (pl. 1) will therefore be helpful in locating wells. Figure 6 illustrates conditions in rather steeply dipping beds of alternating sandstone and shale (*A* to *F*). The prospects of wells drilled at sites 1 to 10 are as follows:[15] At site 1 the well will be in shale *A* to great depth, and prospects of obtaining a good well, even by deep drilling, are poor. At site 2, in sandstone *B*, a satisfactory

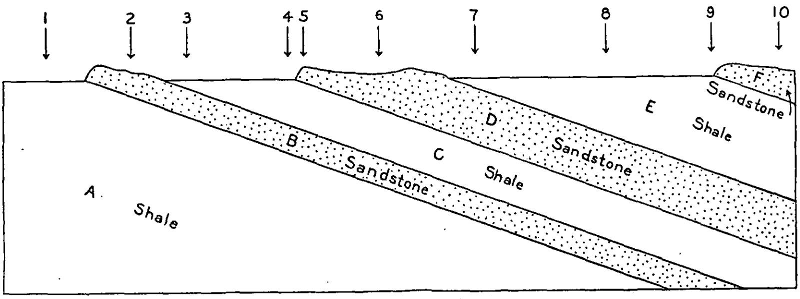

FIGURE 6.—Section illustrating ground-water conditions in tilted beds of sandstone and shale. See text for explanation.

supply will probably be obtained at a moderate depth, but if the drill should pass through sandstone *B* and enter shale *A* without finding a satisfactory supply the prospects of obtaining one by deeper drilling would be very poor. At site 3 the drill will first encounter shale *C*, but without going to very great depth it will penetrate sandstone *B*, in which a satisfactory supply will probably be found. At site 4 the drill will enter shale *C* at the surface and will have to pass entirely through the shale, obliquely to the bedding, before it reaches a sandstone; a very deep well would probably find water in sandstone *B*, but the water might not be good enough to use. At site 5 the drill will penetrate a considerable thickness of sandstone *D* before it reaches shale *C*; the lower part of the sandstone may here be saturated and furnish a satisfactory supply of water, or the formation may be drained dry from the top down to the shale below. At site 6 sandstone *D* extends to a greater depth than at

[15] Ellis, A. J., and Meinzer, O. E., Ground-water in Musselshell and Golden Valley Counties, Mont.: U.S. Geol. Survey Water-Supply Paper 518, p. 24, 1924.

site 5, and the prospects are accordingly better. At site 7 the conditions are similar to those at site 3. At site 8 the drill will be in shale to a great depth; it will have to penetrate about half of shale *E* before reaching the underlying sandstone *D*, in which it might perhaps find a satisfactory supply. At site 9 the conditions are like those at site 8, except that a thickness of shale about twice as great will have to be penetrated before the underlying sandstone will be reached; moreover, the prospects of getting satisfactory water from the sandstone will be poorer. At site 10 the surface formation is sandstone *F*, which is not found at any of the other sites; however, if sandstone *F* has water-bearing characteristics similar to those of sandstones B and D, the conditions at site 10 will be much like those at sites 2 and 6.

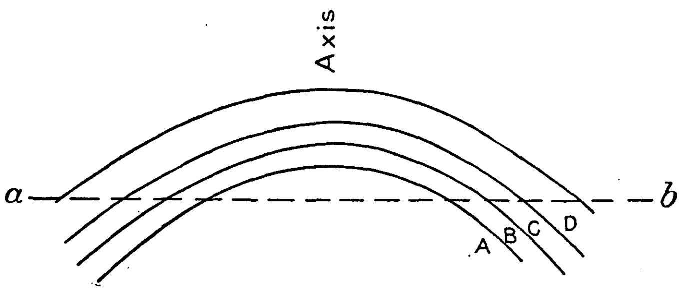

FIGURE 7.—Section showing a series of beds (*A* to *D*) that have been arched up to form an anticline. If they are eroded down to the broken line (*ab*) the oldest formation (*A*) is at the surface along the axis of the anticline, and successively younger beds appear at the surface on both sides.

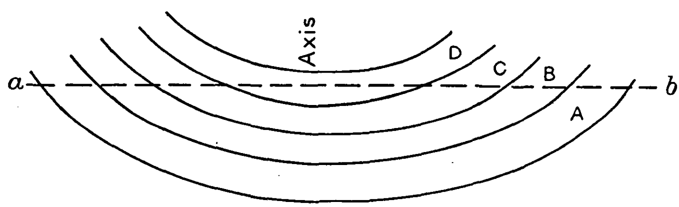

FIGURE 8.—Section showing a series of beds (*A* to *D*) that have been bent down to form a syncline. If they are eroded down to the broken line (*ab*) the youngest formation (*D*) is at the surface along the axis of the syncline, and successively older beds appear at the surface on both sides.

Where the formations have been warped up they form anticlines; in such places there has been much erosion, and the oldest formations are likely to be at the surface along the axes of the anticlines, as shown in figure 7. Where the formations have been warped down they form synclines, and the youngest formations are likely to be at the surface along the axes, as shown in figure 8.

In Big Horn County there are mountains formed in areas of upwarped rocks and others formed in areas of downwarped rocks. The Big Horn and Pryor Mountains are examples of mountains resulting from the uplift of the rock formations. The Big Horn Mountains are the largest and most conspicuous anticline. Here the rocks have been folded into a lofty arch that has been deeply eroded, exposing very old rocks. The limbs of this arch are very steep, and the eroded remnants form the hogbacks that parallel the mountains. In some parts the dip is less than 45°, and figure 7 gives an idea of the conditions that exist beneath the surface. The rocks underlying the plains dip gently away from the mountains, as shown in plate 1. The rocks exposed in these mountains range from pre-Cambrian to late Paleozoic. The greater mass of the mountains is limestone, a type of rock which is rare in the Great Plains province. In limestone, water occurs chiefly in solution cavities, and the influence of structure is subordinate.

The Rosebud Mountains, in the eastern part of the county, are an example of mountains formed as a result of downwarping of the rocks. Here the resistant beds of the Lance and Fort Union formations have remained in a large syncline while the same beds in the Big Horn anticline, a little farther west have been removed by erosion. The rocks have a general easterly dip, and east of Big Horn County flowing wells are common in the river bottoms, but in these mountains the artesian pressure is not sufficient to produce flowing wells.

The structure of the rocks underlying Big Horn County has a far-reaching effect on the availability of ground water. The movements which produced the Big Horn uplift and the Rosebud Mountain syncline, together with the subsequent erosion, have brought large areas of non-water-bearing strata to the surface, as shown by the large area of formations of the Colorado group which surrounds the Big Horn Mountains and comprises a large part of the total area of the county. Surrounding this area is a band made up of the formations of the Montana group, some of which are fair sources of water. Around these are the Lance formation and in the deeper synclines the Fort Union formation. Among the minor structural features are such uplifts as the Soap Creek and Beauvais Creek domes. Plates 11, 12, and 13, which show some of these minor structural features, give an idea of the abrupt changes in the areal geology in relatively short distances.

ARTESIAN CONDITIONS

In many wells the water rises by artesian pressure above the level at which it enters. If the pressure is sufficiently great, the water rises to the surface and overflows. The principal conditions favorable for producing artesian pressure are a permeable bed that is overlain and underlain by beds that are relatively impermeable and

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that crops out at a relatively high altitude in a region of abundant precipitation. These conditions are illustrated by figures 9–11.

Though the stratigraphy and structure of the rocks underlying Big Horn County are favorable for artesian wells, only the deeper beds yield flowing wells. However, practically all wells drilled in this region, except those in the alluvium and the terrace material, show considerable artesian pressure. The deeper beds do not furnish flowing wells on the higher upland, because both the Big Horn and the Little Horn Rivers have cut deep notches in the upturned ends of the strata in and along the Big Horn Mountains. Consequently, the difference in altitude between the intake of the bed and the surface of the ground at the well is not enough to yield a flow.

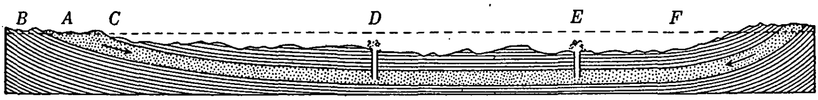

FIGURE 9.—Section illustrating the chief requisite conditions for artesian wells. *A*, Permeable bed; *B, C*, impermeable beds above and below *A*; *D, E*, flowing wells from bed *A*. (After Chamberlin.)

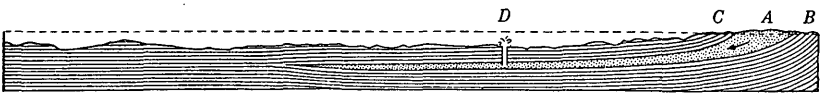

FIGURE 10.—Section illustrating the thinning out of a permeable water-bearing bed (*A*). Bed *A* is enclosed between impermeable beds *B* and *C*, thus furnishing the conditions for artesian flow *D*. (After Chamberlin.)

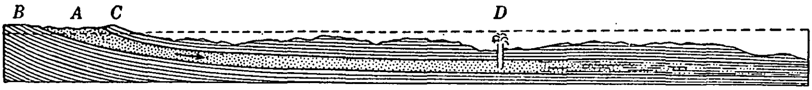

FIGURE 11.—Section illustrating the transition from a permeable water-bearing bed (*A*) into a close-textured impermeable bed. Bed *A* is enclosed between impermeable beds *B* and *C*, thus furnishing the conditions for artesian flow *D*. (After Chamberlin.)

The source of the water is the precipitation falling on the upturned edges of the beds and also possibly the rivers that flow over these outcrops. The major streams run for the most part over beds of alluvium that do not lie directly on the rocks that form the adjacent hills, but the alluvium is in most places permeable and should permit percolation of the river waters into the underlying permeable rocks. In general, the water-bearing formations crop out only in narrow ridges or hogbacks, which form small intake areas with relatively high run-off and apparently not any great amount of ground-water recharge. The flow from most wells does not exceed a few gallons a minute, but the flow from others may exceed 1½ second-feet, or more than 675 gallons a minute.

WATER SUPPLIES

The problem of water supplies in Big Horn County is concerned with the use of water for domestic and stock supplies, irrigation, public supplies and railroad supplies. These groups are not mutually exclusive, as water supplies which may be primarily intended for one purpose are frequently used for other purposes.

DOMESTIC AND STOCK SUPPLIES

The Big Horn, Little Horn, and Tongue Rivers and Pryor Creek are the principal sources of water for domestic purposes in their respective valleys, although many people living in these valleys use wells and springs. The river water is readily available to the inhabitants of the river valleys, particularly in the irrigated areas, where water from the ditches is run directly into cisterns. Even where the ranchers haul water the distance is usually short. Wells dug in the alluvium of the river valleys are inexpensive and furnish adequate supplies, but in general they yield water that is more highly mineralized than the river water. On account of the lower mineral content and less hardness, river waters are generally preferred by the inhabitants, particularly by the Indians, who seem to have an aversion to well water. Even if the water in a well that obtains its supply from the alluvium is too highly mineralized for domestic use, it may be valuable for stock, particularly during the winter, when the irrigation ditches are dry.

On the uplands people must depend on springs and wells or haul water from the rivers—a laborious and time-consuming task. In places on the uplands where springs are not available wells must be sunk by one of several methods. Drilled wells are more expensive, but they are also more sanitary and more durable. Some dug wells are excellent producers, but they are easily contaminated and may go dry during droughts.

Whether a water is suitable for domestic uses depends to a very large extent on the person using the water. Of course, there is a limit to the total dissolved solids for potable water, but habit is a great factor in the determination of potability. Many waters are drunk in this region that would be rejected in regions where the inhabitants have less highly mineralized waters available. Also, members of one household will drink without complaint water that is condemned by others on the ranch as unfit for human consumption. This observation applies to the residents of the uplands as well as to those of the river valleys. The tolerance of animals for highly mineralized water is much greater than that of human beings. However, some ground waters in this region are so highly mineralized that even the stock accustomed to the region refuse to drink them.

Formerly, the entire region was open range, and the Big Horn River and other perennial streams were available for watering stock, but now fences block public access to the streams at most places. Outside of the reservations practically all lands are fenced. Within the reservations the uplands are open, but considerable areas in the valleys are fenced, and running water in many places is less easily accessible than formerly.

On the uplands outside of the reservations there were before the advent of the homesteader sufficient springs, supplemented by some wells, to water the stock on the range. As the land was fenced and the springs were enclosed, it became necessary to provide water supplies for stock; however, the number of animals in a herd was greatly reduced, so that the problem was one of watering a few animals rather than large herds.

On most small ranches, other than those in the unfavorable shale areas, sufficient water for 50 or 100 head of stock can be obtained from one or more wells. On the shale areas the rancher must either arrange to have his grazing area include a well or spring that obtains its water from some more favorable formation, or he must have water for the cattle stored in tanks. Although most of the springs in the unfavorable areas yield highly mineralized water, at only a few of them is the water refused by cattle. Wells capable of watering more than 100 head of cattle a day are not common, except the flowing wells drilled in search for oil.

IRRIGATION SUPPLIES

In Big Horn County water for irrigation is available from the Big Horn River, the Little Horn River, and their perennial tributaries Soap, Rotten Grass, and Lodgegrass Creeks; also from the Tongue River and Rosebud, Tullock, Sarpy, and Pryor Creeks. In addition there are numerous irrigated tracts along the Pryor and Big Horn Mountains, some of them aggregating several hundred acres, which obtain their water from small streams that are perennial at the canyon mouths; these tracts are used chiefly to grow alfalfa for winter feeding of cattle.

The inhabitants of the valleys of some of the intermittent streams take advantage of the flood water for irrigation. The streams are high in the spring, owing to rain and melting snow, and overflow their banks. The fields that are overflowed but not washed are used to grow crops. If the spring floods are not high enough, the crop may be lost through lack of moisture; if they are too high, it may be washed out. This precarious method of irrigation is now but little used.

The irrigation in this region is accomplished mostly by diversion of the natural stream flow. Storage has not been provided except to a very small extent. The Big Horn River furnishes water to several large ditches, into which it is turned by low diversion dams. In the past the supply of water has been ample to irrigate all the lands in the main stream valleys that can be brought under the ditch at a relatively low cost. However, plans have been made to build a very high dam near the mouth of Big Horn Canyon to store the flood waters that now go to waste, in order that they may be available when needed both for the development of power and for the irrigation of additional tracts that lie too high for the present ditches.

On the uplands, where the cost of elevating the river waters is generally excessive, the ranchers and homesteaders have hoped that ground water would be obtainable for irrigation. The amount of ground water available, however, is not sufficient for irrigation except on a very small scale; moreover, pumping water from wells is very expensive. Some large artesian flows of water were encountered in drilling for oil along Soap and Beauvais Creeks, but these wells are in the valleys and obtained their supplies from formations that are so deeply buried in most of the region that the cost of drilling to them would be large. Where sufficient water is obtainable, attempts should be made to irrigate small garden tracts by pumping from wells with windmills or gasoline or oil engines. Irrigated tracts of only one-tenth of an acre add materially to the variety of the food supply by furnishing fresh vegetables.

PUBLIC SUPPLIES

The only town in Big Horn County that has a public water supply is Hardin, which draws its supply from the Big Horn River. There are few if any upland towns that will require a water supply in the near future. The towns in the valleys can develop supplies from wells or use stream water after proper treatment.

The modern filtration plant of the municipally owned and operated water system of Hardin is in the northeastern part of the town. The water is taken from the Big Horn River by two electrically driven pumps with a capacity of 400 gallons a minute each and is piped through 500 feet of 10-inch main to a 120,000-gallon settling basin at an altitude of 29 feet above the pumps. While the river silt is settling alum ($Al_2(SO_4)_3$) and calcium hydroxide are added. The water is then filtered through rapid sand filters, chlorinated, and pumped to an elevated tank. There are two electrically driven pumps with a capacity of 500 and 600 gallons, and one driven by an oil engine which is held in reserve. The steel tank has a capacity of 72,000 gallons and is on a steel tower 160 feet high. The water is distributed by gravity from this elevated tank at a pressure of 45 pounds or more to the square inch. In 1921 there were 57 fire hydrants and 335 service outfits connected to the 6- and 8-inch distribution mains.

The maximum consumption is about 280,000 gallons a day in the hot, dry season, when a considerable amount of water is used for irrigating lawns and gardens. The average consumption is about 180,000 gallons a day, or a per capita consumption of 137 gallons. The city is metered, and about 90 percent of the total amount consumed is used for domestic purposes.

The turbidity of the river water varies greatly. In the spring and early summer the river is high and very muddy. During the remainder of the year the water is as a rule fairly clear. Thunderstorms in the mountains as well as on the plains increase the turbidity at a very rapid rate. The Big Horn River drains a large area, and cloudbursts in remote regions frequently make the river muddy, even when there has been no precipitation in the vicinity of Hardin.

RAILROAD SUPPLIES

The Chicago, Burlington & Quincy Railroad uses surface water from the Big Horn and Little Horn Rivers, except at Corinth, where a spring that issues from the Parkman sandstone is piped to a water tank. The yield of the spring ranges from 1,000 to 16,000 gallons a day.

METHODS OF OBTAINING GROUND-WATER SUPPLIES

SPRINGS

Most of the older ranches were located at or near springs that supplied water for all purposes. On some ranches small intermittent springs or seeps of ground water were excavated and suitably walled to form dug wells, which are commonly called "springs" in this region. At times they overflow, but during most of the year the water level is from 1 to 6 feet below the surface of the ground. Wells of this type usually furnish perennial supplies, though they may fail in dry years. Few of them will yield more than 10 gallons a minute, and most yield less than 2 gallons a minute. If considerable volumes of water are required in a short time, large holes should be excavated in order to have ample reservoirs for storage.

In many parts of the county little or no attention is paid to the care of springs. Ranch owners should improve springs to prevent pollution by foreign objects or surface wash and filling in with silt. A spring, no matter how small, is a valuable asset and should be cared for in the proper manner. Wooden boxes provided with light covers are better than nothing, but more permanent material, such as brick, stone, or concrete, is preferable. For sanitary reasons, the spring openings should be tightly covered and the water should be allowed to discharge through a pipe. More elaborate improvements, such as piping the water to the house, are desirable. A hydraulic ram would be useful where the flow of the spring is sufficiently large. Otherwise a gasoline engine, or in some places an electric motor, can be used to raise the water to the desired height. Most springs used only for stock are not fenced, and the area around the spring is badly trampled. At many of these the water might be conserved by fencing the spring off and piping the water to a trough.

WELLS

It was early seen that the springs would not supply sufficient water, and therefore settlers began to put down wells. Several types of wells are in use, as described below.

Drilled wells.—All the wells in this region which are drilled for water are sunk with portable percussion rigs, driven by steam or gasoline engines. Formerly there were some drilling outfits operated by horse power, but they are now abandoned. Most of the drilled wells are 6 inches in diameter, but some are only 4 inches. The 6-inch wells are better adapted to the conditions of this region than wells of smaller diameter, and in many places 8-inch holes would be desirable because of the larger reservoirs that they would afford.

The amount of casing necessary for the protection of a well varies with the formation. Wells drilled through shale must be cased, because even if the walls seem firm at the time the well is completed they will ultimately cave and cause the loss of the well. Sandstone walls will stand up almost indefinitely. Casing is necessary for the prevention of surface pollution and to prevent access to the well by burrowing animals. However, unless properly installed, casing does not prevent surface pollution from entering the well. Many ranchers think they are saving money when they do not case a well, but the cost of casing is much less than the cost of drilling a new well. One casing should not be expected to last indefinitely, and renewals should be made before the original casing disintegrates completely. The life of the casing depends on such factors as its type and quality, the chemical character of the water with which it comes into contact, and the rock in which it is set.

Dug wells.—Dug wells are most common in the alluvium and terrace material, but they are also numerous in the coulees in the upland areas. Shallow wells can be dug with little equipment and no great expenditure of money or labor. They afford a large reservoir for water, but on the other hand they are difficult to keep clean and free from pollution. The reservoir capacity of a well of this type is determined by the depth to which it is sunk below the water table and its diameter. In places, wells as much as 20 feet in diameter have been dug. Great difficulty is experienced in keeping the curbing tight enough to prevent small rodents in search of water from falling into the well and drowning. Several kinds of casing or curbing are used for dug wells, but wood, brick, stone, terra-cotta pipe, concrete, and large culvert pipe are the most common. So far as holding up the walls is concerned all are equally good, but concrete, terra-cotta pipe, and brick (laid with cement above the water table) are tight and very durable. Culvert pipe is satisfactory at first but soon rusts and disintegrates. The highly mineralized water frequently hastens its disintegration. Rock casing properly set with an impervious cement above the water table is very good and, where rock is available, is cheap. However, rock casings are frequently poorly laid and settle, leaving open spaces. These spaces afford access to burrowing animals. Wooden casing, "curbing" or "cribbing" as it is frequently called in this region, is cheap and easily made, but it rots and requires renewal so frequently as to be expensive over a term of years. It is almost impossible to make a wooden casing tight, and even if it is tight, rodents can cut through it and get into the well. Frequently the wood used in the casing will give the water a peculiar taste.

Dug wells are usually boarded over, and a pump is placed on the platform. The boards soon warp, leaving cracks through which dust, dirt, filth, and small animals can enter the well. This should be prevented by calking the cracks, or by using tongue and groove boards, or, preferably by constructing a tight platform of concrete or using a cast-iron platform. The old-style method of lifting the water with a rope and bucket is cumbersome, laborious, and insanitary and is now rarely used except in isolated wells used for watering a small herd of cattle. Wells of this type are with great difficulty kept free from pollution.

In completing dug wells care must be exercised to see that the space between the walls and curbing is back-filled with impervious material, and that surface drainage is directed away from the well. Many dug wells in this region have become polluted and abandoned because these simple precautions were not taken.

Dug wells should be cleaned at least once a year. They should be pumped dry, or lowered as much as possible, and all foreign material removed. An annual cleaning is usually sufficient, if the well is tightly covered, to prevent the water from becoming foul.

Bored wells.—In the areas underlain by alluvium, wells can be bored with a hand auger to a depth of 25 or 30 feet with considerable ease, except where coarse gravel is encountered. This method is not much used in this region; though the well so produced is almost as satisfactory as can be obtained by digging, it lacks the reservoir capacity of the dug well. Bored wells must be cased, and galvanized-iron well casing is the type most commonly used. Concrete casing perforated below the water level is strong and durable.

Driven wells.—Driven wells are rare in this county, because in most places the alluvium contains coarse gravel and hardpan, which interfere with the driving. A driven well has at its bottom a point with a strainer above, connected to a pipe. In constructing it the point, strainer, and pipe are driven into the ground with a sledge hammer, and additional pipe is added until the strainer enters the water-bearing material. Where the alluvium is fine-grained and not too compact, a well can be developed in this way at small cost. The pump is fastened to the top of the pipe and should be tightly clamped to a solid foundation, or pumping will soon loosen the pipe and permit pollution to enter the open space between the pipe and the earth.

STORAGE OF SURFACE WATER

In a region such as Big Horn County where large areas are underlain by thick unproductive shales, such as the Bearpaw shale and the Colorado group, the storage of surface water is necessary. Few of the smaller streams, except where they issue from the mountains, contain enough water at all seasons of the year to afford a continuous water supply. Flood waters are frequently so muddy that most people would not want to store them except in tanks for cattle. The larger streams are perennial and afford a continuous supply. Rain water from the roofs of the ranch buildings or sheds especially constructed for the purpose can also be stored. Water derived from melting snow is saved in some parts of the United States, but in this region the wind frequently blows the snow away. If precautions are taken to provide suitable storage for surface water from streams or rain from roofs, it is possible to operate a ranch without a spring or a well.

CISTERNS

Cisterns are used to store water for domestic purposes on many ranches in Big Horn County and in many places in the irrigated districts. They are filled directly from irrigation ditches or, in a few places, by hauling water from the river. On the uplands there are a few cisterns filled with water hauled in tanks or barrels from distant wells, springs, or streams, as well as a few which are filled with rain water.

Cisterns are easily constructed[16] and have many advantages as well as some disadvantages. In many places the shales are so impervious that the cistern will hold water even though it is unlined, but the water will dissolve the mineral matter in the shales and become hard and undesirable. Moreover, the shale walls will slough off into the cistern and make the water muddy. Burrowing animals cannot be excluded from an unlined cistern.

The use of untreated surface water for domestic purposes may lead to typhoid fever or other enteric diseases. It is therefore recommended that no surface water stored in cisterns be used until it has been treated to destroy harmful bacteria. Dr. W. M. Cobleigh,[17] of the Montana State Board of Health, has devised the following method of purifying cistern water:

When surface water obtained at a point below human habitations or other sources of contamination is used for domestic purposes a decided risk is involved. Water of this character should be purified before it is used for human consumption. The following method for treating contaminated water by the addition of a solution of chloride of lime or bleaching powder is recommended.

Procure a can of fresh bleaching powder or chloride of lime and break up all lumps in a portion of the powder. Under ordinary conditions one level teaspoonful of the dry powder will disinfect about 315 gallons of water. Calculate the number of gallons of water in the cistern and the number of teaspoonfuls of bleaching powder necessary to disinfect it. In measuring the bleaching powder fill a teaspoon even full by leveling off with a small stick or lead pencil. To the measured quantity of bleaching powder add a few drops of water, stir, and make a thick paste. This operation can be conveniently carried out in an ordinary bowl. Then dilute the paste with water and pour this thinner paste into a 5- or 10-gallon pail of water. Allow the sediment in this solution to settle for a few minutes. Then pour the solution into the cistern and thoroughly mix it with the cistern water. This can be done by means of a pail attached to a rope. The pail can be alternately filled with cistern water and emptied back in, or it can be filled with water and then dropped from a convenient height into the cistern, the process being repeated several times.

After thoroughly mixing the bleaching-powder solution with the cistern water allow the action to continue for 10 minutes. Fill a drinking glass with water from the cistern, add a few drops of orthotolidin solution, and place the glass in front of a sheet of white paper. If the water assumes a slight yellow color then it is certain that the proper amount of bleaching powder has been added. When this color appears, it means that there is an excess of chlorine in the water sufficient to destroy germs of the intestinal type in a very few minutes. If no yellow color appears, then a little more of the bleaching-powder solution should be added to the cistern water, and the color test with the orthotolidin should be repeated. If this procedure is properly carried out there will be no disagreeable odor and taste left in the water. This method of disinfection does

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[16] Fuller, M. L., Underground waters for farm use: U.S. Geol. Survey Water-Supply Paper 255, pp. 54–58, 1910. Ellis, A. J., and Meinzer, O. E., Ground water in Musselshell and Golden Valley Counties, Mont.: U.S. Geol. Survey Water-Supply Paper 518, pp. 43–46, 1924.

[17] Personal communication.

not introduce poisonous chemical substances into the drinking water and is perfectly safe and effective when controlled by the orthotolidin test.

Citizens of the State desirous of using this method of disinfecting cistern water may obtain the necessary orthotolidin on application to the Montana State Board of Health.

The storage of rain water caught from roofs of buildings is not common in this region, possibly owing to the scantiness and irregularity of the rains. However, a few ranches use this method effectively, and the practice should be more wide-spread. An inch of rain produces about 60 gallons of water from each 100 square feet of roof. Rain water is the softest of all natural waters and can be stored for long periods. It is very valuable for numerous domestic uses in a region where hard water is so common.

TANKS FOR STOCK

Settlers in areas where successful wells are difficult to obtain and springs are rare, as in areas where the Colorado group and the

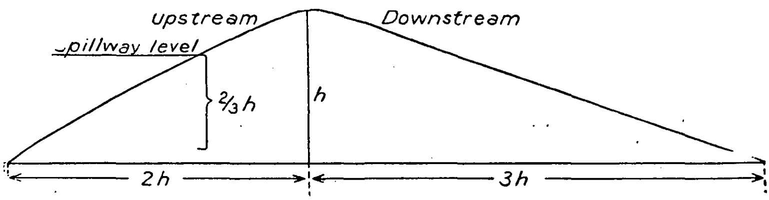

FIGURE 12.—Section of a tank dam. See text for explanation.

Bearpaw shale are at the surface, frequently construct "tanks" by damming small washes. These tanks hold enough water to supply herds of moderate size. Even in hot, dry summers they hold water for a considerable period, in spite of large losses by evaporation.

The rancher should select a small wash or coulee with relatively low sides and construct a dam at a point where the wash narrows slightly. Great care must be used in selecting the wash and the best location for the dam. If the drainage area is too large or the fall of the stream at the point selected is too great, the dam will be swept away by the first heavy rain. It is advisable to watch the coulees during storms and to note the relative amount of water and the rate of flow at different points along them. The aim should be to find the place in which the minimum of work in the construction of embankments is required to impound the maximum quantity of water.

The dam should be a relatively low and broad dike or embankment of earth. It can be most easily constructed by plowing up the soil and shale above the site selected and putting it in place with scrapers and scoops. The tramping of the animals' hoofs and the dragging of the scrapers and scoops pack the earth. The height of the dam should rarely be more than 6 feet. In figure 12 the height is shown as h and the thickness between the upstream and downstream edges of the base is given as five times the height. The spillway should lead off the water when the water level reaches two-thirds the height of the dam. Great care must be exercised to keep trash, rocks, roots, sagebrush, and greasewood from getting mixed with the earth used for the dam, because if this precaution is not taken water will percolate along the foreign objects, move the fine particles surrounding them, and finally wash out the dam. The fine particles of disintegrated shale are very small and extremely light, consequently even water moving with very low velocity is an active agent of erosion, and every precaution must be taken to reduce percolation. A spillway is essential for tank dams; if the dam is not equipped with a spillway, the water flowing over the top will quickly erode the embankment and the water in the tank will be lost. The spillway can be riprapped with coarse stone or can be constructed of concrete or stone. Wooden spillways are effective but short-lived. The stone spillways are secure and durable, and if stone is available in the vicinity they are inexpensive. Concrete spillways are the most expensive but also the most satisfactory.

A tank having an area of 10,000 square feet and averaging 4 feet in depth will hold about 300,000 gallons of water. If the bottom is shale it is almost impervious, and the only considerable loss is by evaporation. If two-thirds of the water were lost by evaporation and seepage there would be left 100,000 gallons, which would be sufficient to supply 65 head of cattle for 100 days, allowing 15 gallons a day for each animal.

Some people report that the cattle trample the dams seriously during wet spells. This difficulty can be overcome by placing a fence that will keep the cattle off the top and downstream side of the dam.

The cost of constructing such a tank is difficult to estimate. The average rancher would have no expense except for labor in plowing and scooping the dirt, because the teams could be used for this work when not needed for other duties about the ranch. If stone is not available in the vicinity, the hauling of the stone necessary for the spillway may be an item of expense. A concrete spillway will add to the cost an amount varying with the price of cement at the railroad station and the distance it must be hauled as well as the cost of the sand and aggregate.

STORAGE OF ICE

In many parts of Montana the ranchers near streams or lakes cut ice and store it in ice houses. Many groups of neighbors combine efforts in harvesting and storing the ice. In some places tanks are used as ice ponds, but most tanks are too small and shallow for this purpose, though tanks constructed especially for ice ponds would be excellent. The ice is usually stored in holes dug in the ground, and either straw or sawdust is used for insulation. In general, straw is much more readily available in this area than sawdust. The ice is removed from storage in summer and used both as a cooling agent and as a source of water for domestic purposes. The water obtained from ice generally contains less mineral matter than it had before it froze.

In some regions where ice is not available, owing to lack of streams, lakes, or favorable situations for the construction of tanks, snow has been used. The snow is usually taken from drifts or coulees into which the wind has driven it and is hauled to cisterns into which it is dumped. The snow is dug out the next summer and used like ice. Some ranchers are reported to place a pole upright in the middle of the cistern before filling it with snow. When hot weather arrives the pole is withdrawn; the snow, which has packed, does not slump down into the hole but stands up, leaving a hole into which is inserted a pump; then the ice water that is formed as the snow slowly melts can be pumped off as needed. This method furnishes a good supply of cold water.

In the work of storing ice and snow, care must be taken not to harvest polluted material. Ice cut from a body of polluted water or snow that has picked up surface filth may be polluted and dangerous to health.

QUALITY OF WATER

The quality of ground water from 36 sources in Big Horn County is shown by the analyses given in the table on pages 152–155. The mineral constituents reported in these analyses affect the value of waters for domestic and industrial uses and for irrigation. These constituents do not give much indication of the sanitary quality of waters, which depends upon their freedom from pollution by disease-bearing organisms. The sanitary quality is likely to change much more quickly than the mineral character, so that statements in regard to the sanitary character of a water at a given time may be altogether inapplicable a few weeks later. Some of the waters analyzed contained so much mineral matter as to be unsatisfactory for drinking, and others were so highly mineralized as to be unfit for practically all purposes.

The analyses available for this county have been compared with analyses of waters from nearby areas[18] so as to have a broader

[18] Renick, B. C., Geology and ground-water resources of central and southern Rosebud County, Mont.: U.S. Geol. Survey Water-Supply Paper 600, 1929. Riffenburg, H. B., Chemical character of ground waters of the northern Great Plains: U.S. Geol. Survey Water-Supply Paper 560, pp. 31–52, 1925. Hall, G. M., and Howard, C. S., Ground water in Yellowstone and Treasure Counties, Mont.: U.S. Geol. Survey Water-Supply Paper 599, 1929.

basis for the prediction of the quality of water to be found in the various formations.

The usefulness of a water for any purpose depends on the amount and nature of the dissolved materials. Waters that are considered unsatisfactory by some people are not objectionable to others, so that it is difficult to make a rigid classification of waters. Waters having more than 2,500 parts per million of dissolved solids are not satisfactory for domestic purposes. Waters containing chiefly magnesium sulphate and sodium sulphate or chloride may be objectionable if the mineral content is greater than 1,500 parts per million. Many waters that are objectionable to human beings because of their mineral content can be used for watering stock, but waters containing as much as 10,000 parts per million of dissolved solids are not satisfactory even for stock. The extent of the damage caused by waters used for irrigation depends upon the drainage and nature of the soil as well as on the chemical character of the waters. The most soluble salts (the alkalies) cause the most damage.

Analyses representing different types of waters in Big Horn County are given in the table on pages 152–155, and some of them are shown graphically in figure 13. Analyses 3 and 6, shown in figure 13, represents waters from terrace deposits, no. 3 being water from a terrace deposit on the Sundance formation and no. 6 from a terrace deposit on shale of the Colorado group. The latter has about five times as much dissolved material as the former. Analysis 8 represents water from a 486-foot well drawing from the Cloverly formation. This water is soft with a moderate mineral content that is considerably less than the average for six waters from this formation in Yellowstone and Treasure Counties.[19] Analyses 11 and 21 represent waters from the Lance formation that show a considerable range in mineral content but are both only moderately hard. Some waters from the Lance formation may have considerably less dissolved mineral matter than no. 21, but these analyses are probably fairly representative of waters from this formation. Analysis 30 represents a rather highly mineralized water from the Fort Union formation. This water comes from shale and is probably typical of waters from the shaly beds of the Fort Union. The average of total dissolved solids in eight waters from the Fort Union formation in Yellowstone and Treasure Counties was 702 parts per million.[20]

Statements in regard to the quality of water from other wells are given in the descriptions of ground-water conditions by townships.

[19] Hall, G. M., and Howard, C. S., op. cit., p. 42.
[20] Idem, p. 35.

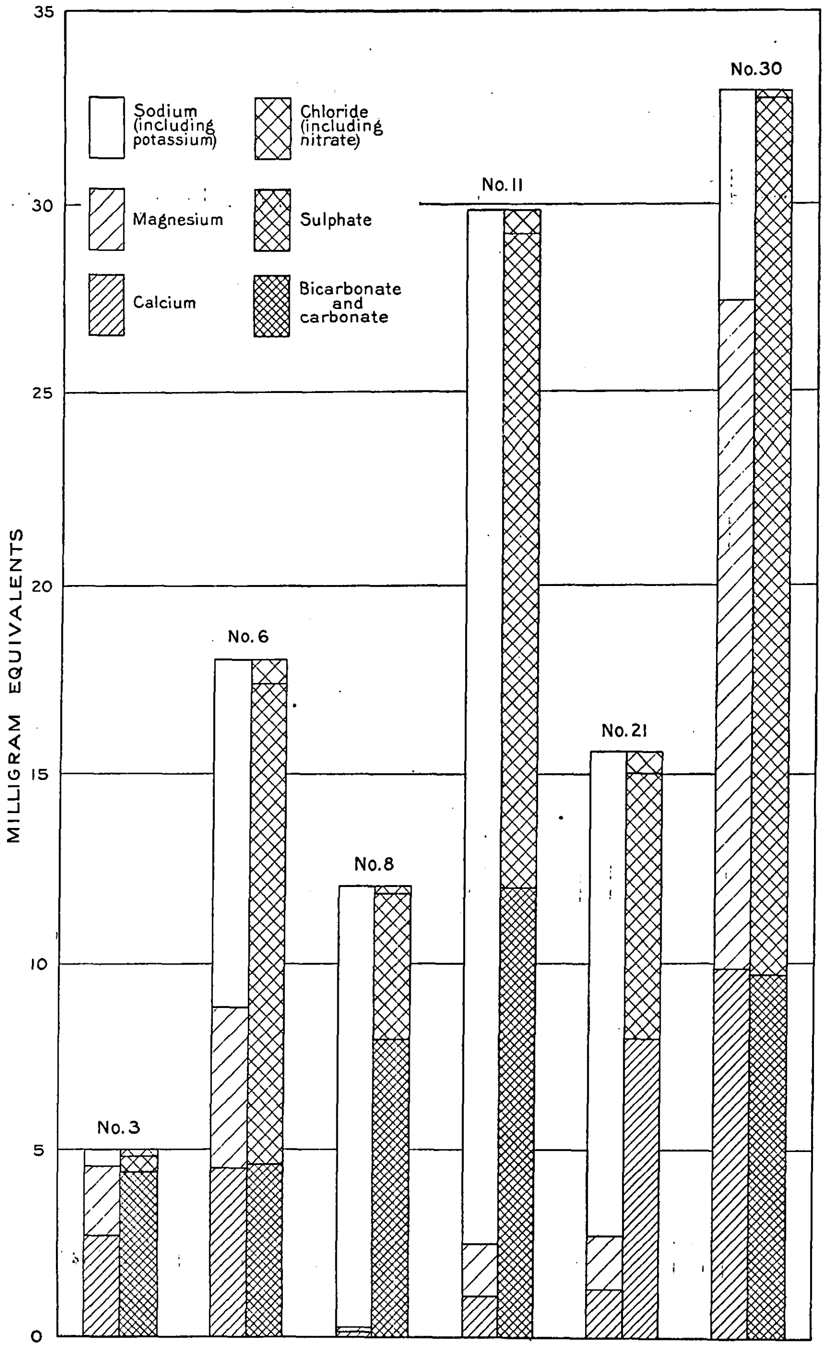

FIGURE 13.—Analyses of waters from Big Horn County, Mont. Numbers refer to analyses in the table on pages 152–155.

Analyses of waters collected in Big Horn County, Mont.

[Analytical results in parts per million]

No.	Location					Owner or name of well	Type of well or source of water	Depth of well (feet)	Diameter of well	Water-bearing formation		Water level above or below surface (feet)	Use of water
	Nearest post office	Quarter	Sec.	T.	R.E.					Character of material	Geologic horizon		
1	Pryor	NE	27	4 S.	26	Frank Hawk	Spring			Gravel	Terrace deposits on Morrison formation.	Flows	Domestic.
2	do	NE	5	5 S.	26	Lee Simeonsen, Thermopolis, Wyo.	Dug	25	4 feet	do	do	−23	Do.
3	do	NE	18	5 S.	26	Indian School	Spring				Terrace deposits on Sundance formation.	Flows	Do.
4	Toluca	NE	24	1 S.	30	C. J. Kelly, Hardin	Drilled	371	4 inches		Colorado group	−10	Not used.
5	Hardin	NE	26	2 S.	32	T. McKittrick	Dug	21	2 feet	Gravel and sand	Terrace deposits on Colorado group.	−14 to −15	Domestic.
6	do	SW	29	2 S.	32	Bird Head ranch	Spring			Gravel	do	Flows	Domestic and irrigation.
7	St. Xavier	SE	23	4 S.	32	St. Xavier Mission	Dug	45	6 feet	do	Alluvium on Colorado group.	−25 to −35	Domestic.
8	do	SE	16	6 S.	32	B. E. Ladow & Co., Fredonia, Kans.	Drilled	486	15½ inches	Sandstone	Cloverly formation	At surface	Not used at time of collection.
9	Hardin		16	1 N.	33	Charles Lee	do	190	4 inches	Shale	Bearpaw shale		Not used.
10	do	NW	27	1 N.	33	C. M. Evers	Dug	12	3 feet		Alluvium on Eagle sandstone or Telegraph Creek formation.		Domestic.
11	Foster	NE	10	2 N.	33	H. N. Garrison, Hardin	Drilled	202	4 inches	Sandstone and shale from 58 to 202 feet.	Lance formation	−25	Do.
12	do	NW	15	2 N.	33	George Mehling	do	81	4 inches		do		Do.
13	do		15	2 N.	33	do	do	375	4 inches	Sand and gravel	Alluvium on Bearpaw shale.		Stock.
14	Hardin			1 S.	33		do	60			Alluvium on Colorado group.		
15	do	SE	27	1 S.	33	H. C. McCune	do	37	4 inches	Sand and gravel	do	−34 to −35	Domestic.
16	do	SW	21	1 S.	33	S. Dyvig	Dug	27	4 by 4 feet	Shale	do	−17	Do.
17	do	NE	30	1 S.	33	C. Torski	do	18	4 by 4 feet	Sand and gravel	Terrace deposits on Colorado group.	−16	Do.
18	do	SW¼NW	9	3 S.	33	Montana Farms Corporation.	Drilled	52	4 inch	Gravel	do	−22	Not used.
19	Lodgegrass	SW	28	7 S.	33	Western States Oil & Land Co.	do	1,881	15 inches	Sand	Morrison formation	+3 to +4	

No.	Owner or name	Date of collection	Total dissolved solids	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium and potassium (Na+K)	Carbonate (CO_3)	Bicarbonate (HCO_3)	Sulphate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Total hardness as $CaCO_3$ (calculated)	Analyst
1	Frank Hawk	Aug. 23, 1921	442	17	Trace	38	25	[a] 97	23	337	84	5.0	Trace	198	C. S. Howard.
2	Lee Simeonsen, Thermopolis, Wyo.	do	307	14	.14	49	34	24	13	305	20	3.0	Trace	262	Do.
3	Indian school	do	256	11	Trace	56	26	[a] 4.0	0	282	22	1.0	Trace	247	Do.
4	C. J. Kelly, Hardin	Oct. 10, 1921	24,706	6.5	12	280	329	7,186	0	1,436	14,199	1,328	1.6	1,970	Margaret D. Foster.
5	R. McKittrick	Oct. 11, 1921	1,227	35	.12	91	54	215	0	285	630	22	1.3	449	Do.
6	Bird Head ranch	do	987	33	.05	72	43	190	0	246	509	17	.48	356	Do.
7	St. Xavier Mission	Oct. 18, 1921	2,547	21	1.6	286	114	275	0	425	1,376	22	Trace	1,180	C. S. Howard.
8	B. E. Ladow & Co., Fredonia, Kans.	Oct. 12, 1921	734	25	4.6	3.3	1.6	284	37	420	179	6.0	.9	15	Margaret D. Foster.
9	Charles Lee	Sept. 9, 1916	4,774	18	[b] 11	62	18	[a] 1,706	0	396	105	2,484		229	W. M. Cobleigh.
10	C. M. Evers	Sept. 18, 1916	864	22	[c] 2.4	183	23	[a] 72	0	317	392	28	.06	552	Do.
11	N. H. Garrison, Hardin	Oct. 17, 1921	1,906	12	.50	23	17	628	0	731	814	23	1.0	127	C. S. Howard.
12	George Mehling	Dec. 2, 1914	1,438	[d] 48		33	22	[a] 427	0	654	527	12		173	W. M. Cobleigh.
13	do	Sept. 19, 1916	1,396	15	[c] 1.0	40	26	[a] 171	0	616	53	13	.82	207	Do.
14		Aug. 16, 1917	2,388	29	[c] 2.4	165	70	449	0	244	1,321	72	.2	700	Do.
15	H. C. McCune	Oct. 20, 1921	1,489	28	.12	103	39	329	0	325	771	43	Trace	417	C. S. Howard.
16	S. Dyvig	Oct. 21, 1921	607	13	.29	60	25	131	0	403	162	15	Trace	252	Do.
17	C. Torski	Oct. 10, 1921	605	30	1.3	74	35	70	0	270	202	20	3.0	328	Margaret D. Foster.
18	Montana Farms Corporation	Oct. 20, 1921	6,540	16	[e] 33	322	248	1,255	0	333	3,918	137	.57	1,820	C. S. Howard.
19	Western States Oil & Land Co.	Oct. 13, 1921	395	19	1.0	5.9	3.1	140	22	293	52	2.0	Trace	27	Margaret D. Foster.

[a] Calculated.
[b] Fe + Al.
[c] $Fe_2O_3 + Al_2O_3$
[d] Includes iron and aluminum (Fe + Al).
[e] Includes 32 parts per million Fe precipitated at time of analysis.

Analyses of waters collected in Big Horn County, Mont.—Continued

[Analytical results in parts per million]

No.	Location					Owner or name of well	Type of well or source of water	Dept of well (feet)	Diameter of well	Water-bearing formation		Water level above or below surface (feet)	Use of water
	Nearest post office	Quarter	Sec.	T.	R. E.					Character of material	Geologic horizon		
20	Hardin	SW	33	1 N.	34	Superior Oil & Coal Co., Terre Haute, Ind.	Dug	20	4 by 4 feet	Shale	Colorado group	−15	Industrial.
21	Custer	SE	18	3 N.	34	G. T. Van Cleve	Drilled	62	6 inches	Gravel, sandstone, and shale.	Lance formation	−15	Domestic.
22	do	SE	18	3 N.	34	do	Dug	18	3 feet	Gravel	Alluvium on Lance formation.	−15	Do.
23	Hardin	SW	11	2 S.	34	W. A. Peden	do	35	3 by 3 feet	do	Alluvium on Eagle sandstone or Telegraph Creek formation.	−25	Domestic and stock.
24	Crow Agency	NE	1	3 S.	34	U.S. Government	Dug	12	20 feet	Sand and gravel	Alluvium on Claggett shale.	−10	Domestic.
25	do	NE	1	3 S.	34	do	do	18½	30 feet	Gravel	do		Do.
26	do	NE	1	3 S.	34	Logan Morris	do	30			do		Do.
27	Bighorn	SE	2	1 N.	35	L. S. Perkins	Drilled	77	6 inches	Shale	Lance formation	−27	Do.
28	Hardin	NW¼SW	8	1 S.	35	U.S. Government	do	110		Sandstone	Parkman sandstone	−40	
29	Wyola	NE	32	8 S.	35	Harry Throssell	Dug	21	4 by 4 feet	Gravel	Alluvium on Claggett shale.	−16	Do.
30	Sarpy	NE	24	1 N.	36	A. E. Hubbard, Bighorn	Drilled	300	6 inches	Shale and coal at 157 to 159 feet.	Fort Union formation	−150	Do.
31	do	NE	36	1 N.	38	W. G. Cooley	do	180	4 inches	Shale	do	−30	Irrigation.
32	Busby	SE¼NE	31	3 S.	38	U.S. Government	do	295	8 inches		do	−25	Domestic and stock.
33	Kirby		32	6 S.	39	Ben Sullivan	Dug	22		Quicksand	Alluvium		
34	Decker	SE	12	8 S.	39	Frank Robke	Drilled	106	3 inches	Blue clay	Fort Union formation	−100	Domestic.
35	Wyola	NE	9	9 S.	40	D. Herrington, Decker	do	150	4 inches	Sandstone	do	−100	Do.
36	Decker		16	9 S.	40	J. W. Thompson	Spring				do	Flows	

No.	Owner or name	Date of collection	Total dissolved solids	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium and potassium (Na+K)	Carbonate (CO_3)	Bicarbonate (HCO_3)	Sulphate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Total hardness as $CaCO_3$ (calculated)	Analyst
20	Superior Oil & Coal Co., Terre Haute, Ind.	Oct. 19, 1921	9,299	10	2.7	276	285	2,123	0	543	5,609	155	Trace	1,860	C. S. Howard.
21	G. T. Van Cleve	Oct. 17, 1921	965	33	.07	27	18	295	28	431	338	15	Trace	141	Do.
22	do	Sept. 18, 1916	2,965	24	[c] 1.2	123	89	[a] 804	0	1,156	1,337	48	18	672	W. M. Cobleigh.
23	W. A. Peden	Oct. 19, 1921	1,948	22	.87	275	125	105	0	411	1,028	12	.81	1,200	C. S. Howard.
24	U.S. Government	do	535	11	.39	80	35	40	0	274	195	5.0	Trace	344	Do.
25	do	Sept. 21, 1916	540	13	[c] .84	82	34	[a] 28	0	256	180	6.0	.30	344	W. M. Cobleigh.
26	Logan Morris	do	1,864	24	[c] .04	160	82	[a] 336	0	552	943	21	4.0	736	Do.
27	L. S. Perkins	Oct. 3, 1921	1,566	7.2	.18	28	15	[a] 499	14	554	694	12	.62	132	C. S. Howard.
28	U.S. Government	Oct. 6, 1921	322	19	.92	43	28	42	0	298	51	4.0	1.5	222	Margaret D. Foster.
29	Harry Throssell	Oct. 15, 1921	756	16	.12	136	52	49	0	517	221	3.0	Trace	553	C. S. Howard.
30	A. E. Hubbard, Bighorn	Oct. 6, 1921	2,014	11	.49	201	214	133	0	592	1,089	4.0	Trace	1,380	Do.
31	W. G. Cooley	do	2,026	24	.42	167	173	173	0	525	1,079	6.0	Trace	1,130	Do.
32	U.S. Government	July 17, 1923	1,182	23	82.4	85	87	145	0	505	452	4.0	2.0	569	H. B. Riffenburg.
33	Ben Sullivan	Sept. 3, 1916	1,024	27	[c] 1.2	131	115	[a] 26	0	644	272	27	8.6	799	W. M. Cobleigh.
34	Frank Robke	do	3,236	18	[c] 3.0	154	280	[a] 410	0	558	1,884	5.8	.5	1,633	Do.
35	D. Herrington, Decker	Oct. 14, 1921	2,550	20	1.3	77	114	652	0	1,008	1,179	16	5.2	660	Margaret D. Foster.
36	J. W. Thompson	1916	464	19	[c] 3.2	60	40	[a] 16	0	244	137	3.3	1.9	314	W. M. Cobleigh.

[a] Calculated.
[c] $Fe_2O_3+Al_2O_3$.

TOWNSHIP DESCRIPTIONS

Only those townships or parts of townships that lie in Big Horn County are described here. The townships in the northwestern part of the Crow Indian Reservation that lie wholly or in part in Yellowstone County have been described in another report.[21] The order of description in the following pages is by range and township, from west to east.

T. 4 S., R. 25 E.

The northern two-thirds of T. 4 S., R. 25 E., is in Yellowstone County, but most of the southern third is in Big Horn County. The area is hilly and thinly settled, and little effort has been made to develop ground-water supplies.

The Sundance formation is the oldest formation cropping out in the area and is exposed along Macheta Creek in sec. 34. This formation contains several sandstones that are usually water-bearing, but no attempts have been made to develop water supplies from them. When supplies are sought in this township and are not found in overlying formations drilling should not be abandoned until these sandstones have been tested, except where depth makes the cost prohibitive.

The Morrison formation, which overlies the Sundance formation, consists chiefly of variegated shales and clays, which will probably yield but small quantities of water too highly mineralized for domestic use.

The Cloverly formation, overlying the Morrison formation, has sandstone at the bottom and top with shale between that greatly resembles the underlying Morrison shales and clays. The shales are practically impervious. The sandstones yield a considerable supply of relatively good water to deep wells, but in some areas the water contains much natural gas.

T. 5 S., R. 25 E.

The Castle Butte fault (see p. 79) crosses the southern tier of sections in T. 5 S., R. 25 E., in a general east-west direction and doubtless materially disturbs the groundwater circulation, but owing to the lack of wells in the vicinity, little can be said concerning the disturbance. There are no large springs along the fault. Another fault trends about N. 30° W. from the Castle Butte fault in sec. 35 and doubtless further complicates ground-water circulation. The township is thinly settled, and the southern part, which is in the Pryor Mountains, is extremely rough. In this township no attempt has yet been made to develop ground-water supplies from wells, because springs furnish sufficient water for present demands.

The massive Tensleep sandstone, which forms such conspicuous ledges and cliffs, is the oldest formation that crops out in this township. The Tensleep and the underlying Amsden formation and Madison limestone have yielded considerable flows of water in many of the deeper wells drilled in search of oil especially in the Soap Creek and Beauvais Creek areas. The log of the Record Petroleum Co.'s well in this township (see p. 111) does not contain any information concerning ground water, but it is probable that deep wells will obtain large supplies from these formations.

The Chugwater formation overlies the Tensleep sandstone, and its red sandstones and shales form conspicuous, brilliantly colored cliffs along the moun-

[21] Hall, G. M., and Howard, C. S., Ground water in Yellowstone and Treasure Counties, Mont.: U.S. Geol. Survey Water-Supply Paper 599, 1929.

tains. This formation is normally a poor water bearer, and in some places the small quantities of water yielded are rather highly mineralized. Wells drilled through these sandstones and shales into the underlying Tensleep sandstone may obtain adequate supplies of potable water.

The Sundance formation, which overlies the Chugwater formation, is a favorable water-bearing formation and should yield adequate supplies for domestic purposes to dug and drilled wells. The top of this formation is marked by a fossiliferous sandstone from which springs issue. In sec. 11 a dug well 12 feet deep is reported to yield an adequate supply of water that is used for domestic purposes. The water rises within 1 foot of the surface in this well.

The Morrison formation, immediately overlying the Sundance formation, consists essentially of variegated clay and shale and is a very poor source of water. Where wells are necessary in an area in which these shales are at the surface, it is advisable to drill through the Morrison formation, which rarely exceeds 250 feet in thickness, into the more promising fossiliferous top sandstone of the Sundance formation, which should supply potable water.

The Cloverly formation overlies the Morrison formation and consists of an upper zone of sandstone, a middle zone of bright variegated shale resembling the Morrison formation, and a basal zone of coarse conglomeratic sandstone. The conglomeratic sandstone in most areas yields considerable volumes of water, at many places, charged with natural gas. It is improbable that the shales will yield much water.

T. 6 S., R. 25 E.

All of T. 6 S., R. 25 E., except the western tier of sections is in the rugged Pryor Mountains and is unsurveyed. The only formations cropping out in the western tier of sections are the Tensleep sandstone and the Amsden formation. No attempts have been made to develop ground-water supplies in this part. Some excellent springs issue from the Madison limestone.

The most striking and beautiful feature of this region is Pryor Gap, a magnificent canyon several miles in length, cut through the Pryor Mountains. The Tensleep sandstone, the Amsden formation, and the Madison limestone are all well exposed in the gap, and at its north end a small area of Bighorn dolomite is reported.

T. 7 S., R. 25 E.

Only 15 sections of T. 7 S., R. 25 E., are in Big Horn County, the southern and western parts being in Carbon County. The formations cropping out in Big Horn County are the Madison limestone, Amsden formation, Tensleep sandstone, and Chugwater formation. The area has no permanent inhabitants. Sage Creek, a favorite fishing stream, and its tributaries supply water for stock and occasional campers.

T. 4 S., R. 26 E.

Only the southern third of T. 4 S., R. 26 E., lies in Big Horn County, the remainder being in Yellowstone County. The oldest formation cropping out in the township is the Sundance formation, which is at the surface in sec. 31. It is normally a good water-bearing formation and should yield small supplies that can be used for domestic purposes. The fossiliferous top sandstone is usually water-bearing. Where the Morrison formation, consisting essentially of shales and clays, is at the surface, wells should be drilled through it into the underlying Sundance formation. The Morrison formation rarely exceeds 250 feet in thickness and in many places is thinner. The Cloverly formation, which overlies the Morrison, consists of an upper zone of sandstone, a middle zone of shales, and a lower zone of conglomeratic sandstone. The sandstones yield fairly large supplies of water.

A gravel terrace is well developed along Pryor Creek, particularly along the east bank. It yields some water to springs, one of which, on the property of Frank Hawk in the NE¼ sec. 27, yields several gallons a minute of water that contains 442 parts per million of total dissolved solids and 198 parts per million of hardening constituents. (See analysis 1, p. 153.) This water has a good taste but is fairly hard. The terrace gravel is not of great extent but locally should yield small supplies to dug wells.

T. 5 S., R. 26 E.

The town of Pryor, one of the subagencies of the Crow Indian Reservation, is in sec. 5, T. 5 S., R. 26 E., and is the trading center for the western part of the reservation. The town does not have a public water supply but is supplied by shallow dug wells.

The Castle Butte fault cuts across the southern part of this township and probably disturbs the ground-water circulation to a considerable degree, but because of the lack of wells and springs in the vicinity there is little opportunity for estimating the amount of this disturbance.

The Madison limestone, which crops out so conspicuously in the mountains, is a fairly good source of water, but as there are few inhabitants in this rugged region the demand for water is slight. Wells drilled into this formation in other areas in search of oil have yielded good flows of water. In the mountains numerous springs issue from this limestone, and some of them furnish enough water for irrigation of fields in front of the mountains.

The Madison limestone is overlain by the Amsden formation, the Tensleep sandstone, and the Chugwater formation, in the order named. The water-bearing properties of these formations have been noted under T. 5 S., R. 25 E.

The Sundance formation, which overlies the Chugwater, is exposed in Pryor Creek Valley and some of its tributaries, but in many places it is concealed by terrace gravel. It yields supplies for domestic purposes to both dug and drilled wells. As the Morrison formation will yield little or no water, wells should be drilled through it into the underlying Sundance formation.

The Cloverly formation, overlying the Morrison, has sandstones at the top and bottom which usually yield adequate supplies. This formation has a greater areal exposure than any other formation in the township but is in places more or less obscured by terrace gravel.

The Colorado group is at the surface over the larger part of the two eastern tiers of sections. As its thickness in this township is generally less than 300 feet, drilling through it into the sandstones of the Cloverly formation is advisable.

At the police headquarters in Pryor a dug well 20 feet deep in terrace material yielded a small quantity of water but is now abandoned and covered over. In the rear of the store of Lee Simeonsen a dug well 25 feet deep obtains its water from the gravel terrace. It is reported that the well cannot be pumped dry with the hand pump now in use. The water, which is used for domestic purposes, contains 307 parts per million of total dissolved solids and 262 parts per million of hardness. (See analysis 2, p. 153.) The Indian school obtains its supply from a spring that issues from the terrace gravel in the NE¼ sec. 18 and is piped 8,800 feet to the school, which is 88 feet lower than the spring. This water, which is used for all purposes about the school, contains 256 parts per million of total dissolved solids and 247 parts per million of hardness. (See analysis 3, p. 153.) The gravel in this township can be depended upon to yield adequate domestic supplies.

There is some Quaternary alluvium along Pryor Creek and also some older terrace deposits at a slight altitude above the creek. The water from these sources has been developed at Pryor. At the Indian farmer's residence in Pryor, a dug well 24 feet deep in the Quaternary alluvium yields a little hard water. It was dry in August 1921. At the mill an 18-foot dug well in the Quaternary alluvium yields an adequate supply. There is also a spring at the mill which yields considerable water.

T. 6 S., R. 26 E.

Only six sections in T. 6 S., R. 26 E., have been surveyed, as the rest of the township lies in the rugged Pryor Mountains. The surveyed sections lie at the entrance to Pryor Gap, and the only formations at the surface are the Bighorn dolomite and Madison limestone. In this vicinity Pryor Creek, which issues from the mountains, furnishes sufficient water for all present needs. Numerous excellent springs issue from the Madison limestone in the Pryor Mountains. The temperature of the water in several of these springs was 41° F. when visited in August 1921.

T. 7 S., R. 26 E.

The north half of T. 7 S., R. 26 E., is in Big Horn County and is a part of the Crow Indian Reservation. The area is in the Pryor Mountains and has not been divided into sections.

T. 4 S., R. 27 E.

Only the southern third of T. 4 S., R. 27 E., is in Big Horn County, the northern two-thirds forming a part of Yellowstone County. The Cloverly formation, which is the oldest formation cropping out in the township, is at the surface in Pryor Creek Valley. It should yield adequate water supplies for domestic uses except in its shaly middle member.

The overlying shales of the Colorado group yield only small quantities of very poor water. Except in secs. 25, 26, 27, 34, 35, and 36, where the thickness of the Colorado group probably exceeds 500 feet, the best plan is to drill through the shale into the upper sandstone of the Cloverly formation. In the shale area shallow dug wells favorably located in coulees may yield a little water that can be used for household needs.

T. 5 S., R. 27 E.

The Castle Butte fault, which crosses the southern part of T. 5 S., Rs. 25 and 26 E., enters T. 5 S., R. 27 E., and curves northward through secs. 30, 29, 28, 21, and 22, ending apparently in sec. 23, west of the East Fork of Pryor Creek. This fault brings the Colorado group and the Madison limestone into contact in sec. 30.

The oldest formation cropping out in the township is the Madison limestone, which forms the main mass of the Pryor Mountains and is exposed in the valley of the stream that cuts through the Tensleep sandstone on the Shively dome. The water from numerous springs in the Madison limestone flows out of the small canyons and is utilized to irrigate small areas.

The Amsden formation and the Tensleep sandstone, which overlie the Madison, are mapped together for convenience. Owing to its more resistant character, the Tensleep sandstone caps much of the combined area. The Amsden formation is exposed only in the valleys and canyons and as a narrow belt between the Tensleep sandstone and the Madison limestone along the flank of the mountains. The Amsden formation has yielded large flows of water in the Soap Creek oil field, but no attempts have been made in this thinly inhabited area to develop any water supplies from it. The Tensleep sandstone caps the Shively dome and is well exposed in the valley that crosses the edge of the dome. In this township it is a coarse, porous sandstone which should yield considerable water, except on top of such structural features as the Shively dome, where much of the ground water doubtless drains to lower levels.

The Chugwater formation is not a good source of water, and in this township, where it is less than 500 feet thick, drilling through it into the underlying Tensleep sandstone or Amsden formation is advisable. The Sundance formation generally contains water, but it has not been tested in this township. The Morrison formation, which yields little water, crops out in a long, narrow valley parallel to the mountain. It is wise to drill through this shaly formation into the more favorable underlying Sundance formation. The Cloverly formation, which overlies the Morrison formation, crops out in a narrow belt parallel to the mountains, where it forms the first hogback and is very conspicuous. Overlying the Cloverly formation are the shales of the Colorado group, which in this township do not exceed 500 feet in thickness. It is advisable, where wells are needed, to drill into the Cloverly formation, in which water suitable for domestic purposes should be obtainable.

T. 6 S., R. 27 E.

Only 14 sections of T. 6 S., R. 27 E., have been surveyed; the remaining 22 are in the Pryor Mountains and are too rough for cultivation. Only the formations from the Madison limestone to the Sundance crop out in this township. The remarks concerning the water-bearing properties of these rocks made under T. 5 S., R. 27 E., apply also to this township. The Shively dome extends southward into this township.

T. 7 S., R. 27 E.

T. 7 S., R. 27 E., is in the Pryor Mountains and is unsurveyed. Only half of the township is in Big Horn County.

T. 4 S., R. 28 E.

The southern two-thirds of T. 4 S., R. 28 E., is in Big Horn County, and the northern third is in Yellowstone County. The township is open range, where stock can obtain water from the perennial streams and small springs. The oldest formation cropping out is the Cloverly formation, which is at the surface in sec. 36. This formation is usually water bearing, except that little water is available in the shaly middle member. The shales of the Colorado group are at the surface over the rest of the township. Unfortunately, over the larger part of the township, the underlying Cloverly formation is more than 500 feet below the surface, making it expensive to drill wells into this more favorable formation.

T. 5 S., R. 28 E.

The Chugwater formation, which is at the surface in T. 5 S., R. 28 E., in parts of secs. 25, 26, 31, 32, 33, 35, and 36, yields only small amounts of highly mineralized water, but it is underlain by the Tensleep sandstone, which will probably yield supplies for domestic purposes. The overlying Sundance formation is also a better water-bearing formation, but owing to the steep dip at the outcrop it may be necessary to sink the wells fairly deep to insure their being below the lowest level of the water table in dry seasons. The Morrison formation is a poor source of water, but as it is probably less than 250 feet thick in this township, wells should be drilled through it into the underlying Sundance formation. The Cloverly formation, which overlies the Morrison formation, crops out in a narrow band in the southern part of the township and forms the outermost hogback. It is overlain by the shales of the Colorado group over a considerable part of the township. In the northern part the depth to the Cloverly formation probably exceeds 500 feet, making it expensive to drill to this usually favorable formation, but over the remainder of the shale area the Cloverly formation is rather readily accessible.

T. 6 S., R. 28 E.

The oldest formation cropping out in T. 6 S., R. 28 E., is the Chugwater formation, which contains relatively little water of poor quality but is underlain by the Tensleep sandstone and Amsden formation in which large supplies of water are usually available. Unless the Tensleep sandstone is dense and compact it should yield adequate supplies of water, making it unnecessary to drill into the Amsden. The Sundance formation, which overlies the Chugwater, is at the surface over most of the township. It is a good water-bearing formation, especially in the sandstone near its top. In the center of the township, where it is overlain by the Morrison formation, wells should be sunk through the Morrison to the sandstone of the Sundance.

The Cloverly formation, which overlies the Morrison, is usually a good water-bearing formation; but owing to its occurrence in isolated high tracts in this township it may be drained and may consequently contain little or no water. If the Cloverly formation is dry it will be necessary to drill through the Morrison formation into the Sundance formation. The depth to the top of the Sundance should not exceed 300 feet.

T. 7 S., R. 28 E.

Only secs. 1 to 12 and the northern part of secs. 13 to 18 of T. 7 S., R. 28 E., are in Big Horn County. The Tensleep sandstone, which is a fairly good source of water, crops out in a small area along Dry Head Creek. Elsewhere the Chugwater formation overlies the Tensleep sandstone. It consists essentially of alternating red sandstone and shale, which in the vicinity of Dry Head Creek have been eroded to steep cliffs and striking pinnacles, made more beautiful by their brilliant color. The Chugwater is a poor source of water, and wells should be drilled through it into the Tensleep sandstone or the underlying Amsden formation.

T. 4 S., R. 29 E.

Where the Morrison formation is at the surface in T. 4 S., R. 29 E., in parts of secs. 33, 34, and 35, wells should be drilled through it into the Sundance formation, which in this vicinity should not be more than 300 feet beneath the surface. But if possible, wells should be drilled farther north on the more favorable Cloverly formation, which overlies the Morrison formation.

In sec. 15 the Dox-Beauvais Oil Syndicate (see fig. 4) drilled a well 1,447 feet deep, which started in the Cloverly and ended in the Amsden formation and obtained a large flow, probably over 50,000 barrels a day, at the time it was drilled. This well was flowing vigorously in 1922. The

Decker Collins well in the same section also obtained a large flow. The 56 Petroleum Corporation drilled a well in the SW¼NE¼ sec. 28 and obtained a heavy flow at 1,400 feet. The water probably comes from the Tensleep sandstone and the Amsden formation. The same company drilled another well in the SE¼NE¼ sec. 9 and obtained a large flow of water at a depth of 1,562 feet from the same formation.

Shales of the Colorado group are at the surface over more than half the township, but except in the northeastern part the Cloverly formation is less than 500 feet below the surface.

T. 5 S., R. 29 E.

The Madison limestone is at the surface in T. 5 S., R. 29 E., in the center of the so-called "Grapevine dome" (see p. 74), and is overlain by the Amsden formation and the Tensleep sandstone, which are usually good water-bearing formations. The Chugwater formation is not a good source of water, and where it occurs at the surface wells should be drilled into the underlying Tensleep or perhaps into the more favorable Amsden formation. The depth to the Tensleep sandstone probably does not exceed 650 feet in this township and generally is less. Overlying the Chugwater formation is the Sundance formation, which is normally a fairly good source of water. The Morrison formation is at the surface over a relatively large area in this ownship; where it occurs it is advisable to drill wells into the more favorable underlying Sundance formation. The depth to the sandstone of the Sundance formation will probably not exceed 250 feet. The Cloverly formation, the youngest one cropping out in the township, is usually a good water-bearing formation.

T. 6 S., R. 29 E.

The oldest formation exposed in T. 6 S., R. 29 E., is the Tensleep sandstone, which forms bold cliffs along the streams and flat areas between them. In the area in which the sandstone crops out both dug and drilled wells should be successful. Where the Chugwater formation lies at the surface, wells should be drilled into the Tensleep sandstone or the underlying Amsden formation. In most places the Tensleep sandstone is less than 500 feet below the surface, but in some places it may lie somewhat deeper. Where the Sundance formation is at the surface wells can probably be obtained in it.

T. 7 S., R. 29 E.

Only the northern half of T. 7 S., R. 29 E., is in Big Horn County. The Madison limestone is strikingly exposed in Big Horn Canyon. Above the Madison limestone are the Amsden formation, which is exposed in Big Horn Canyon and along Dry Head Creek, and the Tensleep sandstone, which forms the steep vertical rims of Big Horn Canyon and Dry Head Canyon. Where the Chugwater formation lies at the surface it is advisable to drill to the underlying Tensleep sandstone.

T. 1 N., R. 30 E.

The Telegraph Creek formation is the oldest one cropping out in T. 1 N., R. 30 E.; it consists essentially of yellow sandy shale with a little concretionary sandstone near the middle. This formation has not been thoroughly tested for its water-bearing possibilities, but owing to the presence of so much shale it is probably poor. Where it occurs, dug wells in the coulees are recommended in preference to the more expensive drilled wells.

The Eagle sandstone which overlies the Telegraph Creek formation, consists, in this township, essentially of thin sandstones and sandy shales and will probably yield only small supplies of rather highly mineralized water. In the SW¼ sec. 32, on the ranch of G. C. Shottmiller, a small spring in the Eagle sandstone flows about 2 gallons a minute of water that is used for domestic purposes and is considered good by those who use it.

The Claggett shale, which overlies the Eagle sandstone, is also a poor source of water. It may supply dug wells in the coulees with sufficient water for a few head of stock, but only rarely can water from such wells be used for domestic purposes.

The Parkman sandstone, overlying the Claggett shale, is not a very good water-bearing formation in this area but is much more favorable than either the underlying Claggett formation or the overlying Bearpaw shale.

A fairly good spring in sec. 9 is piped by the Chicago, Burlington & Quincy Railroad to the water tank at Corinth for locomotive use. The yield of this spring is reported to range from 16,000 gallons a day in wet seasons to only 1,000 gallons a day in dry seasons. The inhabitants of Corinth, a settlement of about 50 people, obtain their supply from this tank and consider it good water.

A dug well in a small coulee in the NW¼ sec. 10 is only 7 feet deep and yields an adequate supply of water that is considered fairly good by the users. The well was dug through surface materials, and the water is found at the contact with the underlying unaltered Bearpaw shale. A spring in sec. 15 yields a small supply of water reported as high in "alkali." Usually the Bearpaw shale is a poor water-bearing formation and the water yielded is rarely fit for domestic purposes.

A small area of terrace gravel is preserved in the northern part of the township. Small but perennial springs issue from beneath the gravel in secs. 10 and 15. The one in sec. 10 is used for domestic purposes, and it is reported that the water from the other is equally satisfactory. A dug well 20 feet deep on the property of William Patefield yields a small supply of water that is used for domestic purposes. The well is dug through the gravel into the underlying Bearpaw shale but derives its water from the gravel. The springs and the successful well show that the terrace gravel, although of small extent, is a valuable source of ground water in this township.

The zone of faulting that crosses Yellowstone County is very conspicuous in this township. The spring in sec. 9 rises in this zone.

The Tenmile plunging anticline (see p. 76) crosses secs. 7, 8, and 9, but it probably has little influence on the ground-water supplies except in the areas where most of the Bearpaw shale has been removed and it may therefore be possible to obtain small supplies of potable water by drilling into the Parkman sandstone.

T. 2 N., R. 30 E.

The oldest formation cropping out in the 12 sections of T. 2 N., R. 30 E., within Big Horn County, is the Parkman sandstone, which is preserved in the zone of faulting. It is at the surface over so small an area that it is of little value as a source of ground water. The Bearpaw shale, which is at the surface over a large part of this township, is a very poor water-bearing formation. A dug well 40 feet deep in sec. 35 was entirely dry.

A narrow belt of terrace gravel extends north across secs. 27 and 34. Shallow wells dug in this gravel should obtain small supplies of potable water. There is considerable fluctuation of the water table, as shown by the small springs around the edges of this gravel area, and hence wells may fail during dry years.

T. 1 S., R. 30 E.

The Colorado group, the oldest series of formations cropping out in T. 1 S., R. 30 E., is a very poor source of water. A drilled well in the SE¼ sec. 12 is 358 feet deep and yields water unfit for any purpose. A drilled well in the NE¼ sec. 24, on the property of C. J. Kelly, is 371 feet deep and yields water that cannot be used, as it contains 24,706 parts per million of total dissolved solids and has a most disagreeable bitter taste. (See analysis 4, p. 153.) This well is reported to have yielded some natural gas when first drilled. The exact depth at which water was encountered could not be ascertained, but the water is under sufficient pressure to rise within 10 feet of the surface. Shallow dug wells in sec. 29 yield water that is considered by the owners to be unfit for domestic use.

The Cloverly formation, the favorable formation that lies beneath the shales of the Colorado group, is about 2,000 feet below the surface. In the township to the west, the Prairie Oil & Gas Co.'s well encountered water in the base of the Cloverly at 2,550 feet. Many wells that obtain water supplies from the Cloverly formation where it is so deeply covered, as in this township, yield water that is charged with natural gas.

Overlying the Colorado group is the Telegraph Creek formation, which consists essentially of sandy shale, the water-bearing properties of which are not well known. A dug well 16 feet deep in the SW¼ sec. 1, on the property of W. Speidel, yields an adequate supply of water that is considered good and is used for all domestic purposes. On the other hand, Mr. Speidel reports that he has dug several wells about 15 feet deep in sec. 29 and none of them yield water suitable for domestic use. The Eagle sandstone, which overlies the Telegraph Creek formation, consists chiefly of sandy shales that do not yield much water. The Claggett shale, overlying the Eagle sandstone, also yields but little water of poor quality.

T. 2 S., R. 30 E.

T. 2 S., R. 30 E., is almost all open range, and the cattle obtain their water from small springs in the coulees. Shale of the Colorado group, an extremely poor source of water, is the only formation cropping out in the township. The conditions here are similar to those in the area of outcrop of the Colorado group in T. 1 S., R. 30 E., except that the depth of the underlying Cloverly formation is somewhat less.

T. 3 S., R. 30 E.

Shale of the Colorado group is at the surface over all of T. 3 S., R. 30 E. The township is open range, and the stock obtain their water from a few small springs of rather highly mineralized water. In the southern tier of sections wells should strike the top of the water-bearing Cloverly formation about 500 to 1,000 feet below the surface, the depth decreasing from east to west.

T. 4 S., R. 30 E.

The Cloverly formation is well exposed in the valley of Beauvais Creek, in the western part of T. 4 S., R. 30 E., but shales of the Colorado group are at the surface over most of this township. The depth to the underlying water-bearing Cloverly formation will be considerable, except near its outcrop, owing to the fairly steep dip of the rocks away from the Beauvais Creek uplift. At a distance of a mile from its outcrop, the Cloverly formation is probably 1,000 feet beneath the surface. Secs. 28 and 32 appear to be a favorable area for drilling to the Cloverly formation. The depth to water-bearing beds here probably would not exceed 500 feet. The Hogan Oil Co. drilled a well 1,300 feet deep in the NW¼ sec. 19 and obtained a flow of water, probably from the Tensleep sandstone.

T. 5 S., R. 30 E.

The Tensleep sandstone is at the surface in the southwestern part of T. 5 S., R. 30 E., on the flanks of the Grapevine dome. This sandstone yields large flows to wells only a few miles north, in the Beauvais Creek Valley, but has not been tested in this township. In the area covered by the Chugwater formation wells should be drilled to the Tensleep sandstone, which lies less than 500 feet beneath the surface, except near the contact of the Chugwater, with the overlying Sundance formation. The Sundance formation probably will yield fairly large supplies of potable water to both dug and drilled wells. Above the Sundance formation are the Morrison and Cloverly formations and the Colorado group. The Cloverly formation is usually a good source of water, but the Morrison formation and the Colorado group yield little water. Unfortunately the rocks dip so steeply northeastward that the depth to the top sandstone of the Cloverly formation, except near its outcrop, amounts to several hundred feet.

T. 6 S., R. 30 E.

The Madison limestone and the Amsden formation are exposed along the Big Horn Canyon in T. 6 S., R. 30 E. The Tensleep sandstone forms massive, high cliffs at the top of the canyon and is conspicuously exposed on the steep slopes along the front of the mountains. All these formations generally yield water to wells, but they have not been tested in this township. The Chugwater formation, which farther south forms the striking "red wall", yields little or no water.

TPS. 7, 8, AND 9 S., R. 30 E.

Tps. 7, 8, and 9 S., R. 30 E., lie in the mountains and have not been surveyed.

T. 1 N., R. 31 E.

The oldest rocks cropping out in T. 1 N., R. 31 E., are the undifferentiated Telegraph Creek formation and Eagle sandstone. Although no definite information is available, it is reported that efforts to obtain water supplies from the sandy shales of these formations have been disappointing. The overlying Claggett shale also affords little chance of obtaining supplies that can be used for domestic purposes, although shallow wells may yield small amounts of water for stock. The Parkman sandstone, which overlies the Claggett shale, will generally yield small supplies that can be used for domestic purposes. The Bearpaw shale, which overlies the Parkman sandstone, is very unfavorable for water supplies. The Hell Creek member of the Lance formation, overlying the Bearpaw shale, crops out in the northern part of the township, where the rough upland topography contrasts sharply with the shale valley; it will usually yield potable water to dug or drilled wells. The zone of faulting so conspicuous in the township to the west cuts across this one. Terrace gravel in the northern part of the township may yield small supplies of water.

T. 2 N., R. 31 E.

The Hell Creek member of the Lance formation is at the surface over all of the part of T. 2 N., R. 31 E., that lies in Big Horn County, except in the southwest corner of sec. 31, where the Bearpaw shale crops out. Drilled wells in the sandstone beds of the Lance formation should yield fair supplies of water at depths of less than 200 feet, and dug wells properly located in the coulees should be successful at depths not exceeding 30 feet. Near the outcrop of the Bearpaw shale care must be taken not to drill through the Lance into the Bearpaw.

T. 1 S., R. 31 E.

The shales of the Colorado group are at the surface over the southern two-thirds of T. 1 S., R. 31 E. A drilled well 375 feet deep on the property of A. N. Crosby, in the SW¼ sec. 15, yields a small quantity of water that is highly colored with hydrated iron oxide and unfit for any purpose. Nearly all wells that end in this shale are dry or yield water too highly mineralized for domestic use or for stock. The overlying Telegraph Creek formation and Eagle sandstone are also poor sources of water.

The village of Toluca is without a water supply and is dependent upon water hauled in tank cars by the railroad from Sheridan, Wyo. Some residents use rain water stored in cisterns.

T. 2 S., R. 31 E.

T. 2 S., R. 31 E., is largely open range, and the stock obtain water from a few small springs. The shale of the Colorado group, which underlies the township, yields only meager supplies of water, much of which is too highly mineralized even for stock. The Cloverly formation, from which water is normally obtainable, is more than 1,500 feet below the surface. In the deep coulees the water from the Cloverly formation may flow over the top of the casing, but on the uplands it would have to be pumped from the wells. The terrace gravel should yield small supplies of water to shallow dug wells.

T. 3 S., R. 31 E.

Shales of the Colorado group are at the surface in most of T. 3 S., R. 31 E., or are overlain by terrace gravel, hence the conditions resemble those in T. 2 S., R. 31 E.

The Woody Creek dome (p. 76) centers in sec. 28. It has not been deeply dissected, and the favorable water-bearing formations lie more than 1,000 feet below the surface. The log of a well of the Mid-Northern Oil Co. in the NE¼NE¼ sec. 33 shows that the conglomeratic basal sandstone of the Cloverly formation was penetrated between the depths of 1,143 and 1,270 feet. It is reported that very little water was encountered at this horizon. Unconfirmed reports indicate that larger flows were encountered at greater depths.

T. 4 S., R. 31 E.

Shales of the Colorado group underlie all of T. 4 S., R. 31 E. In some places the shales are covered with terrace gravel of an average thickness of not more than 25 feet. The gravel should yield small supplies of potable water.

T. 5 S., R. 31 E.

The only formations cropping out in T. 5 S., R. 31 E., are the shales of the Colorado group. Terrace gravel covers a large part of the western half of the township. Dug wells in the gravel should yield small supplies of water that can be used for domestic purposes.

T. 6 S., R. 31 E.

In T. 6 S., R. 31 E., the Madison limestone and the overlying Amsden formation crop out in Big Horn Canyon. On the west side of the canyon near its mouth several large springs issue from the Amsden formation and cascade down the steep slope into the river. This formation, where encountered in wells drilled for oil, is usually a good source of water.

The Tensleep sandstone, one of the most conspicuous formations in the region, overlies the Amsden formation and forms prominent cliffs at the rim of the canyon near its mouth. At the mouth of the canyon a spring that apparently obtains its water from the upper part of this sandstone flows about 40 gallons a minute. This water is considered excellent by numerous camping parties.

The overlying Chugwater, Sundance, Morrison, and Cloverly formations and the shales of the Colorado group appear in succession at the surface in this township away from the mountains. The Morrison formation seems thin along the mountain front, and in some places it appears to pinch out completely, but the logs of the oil wells drilled a few miles northeast of this township apparently show about 325 feet of these beds. The best prospects for water supplies are afforded by the Cloverly and Sundance formations and the sandstones below the Chugwater formation. In the stream valleys the artesian pressure may be sufficient to cause flowing wells.

T. 7 S., R. 31 E.

The major part of T. 7 S., R. 31 E., is sectionized, but 16 sections lying in the more rugged part of the Big Horn Mountains have not been surveyed. Even the area that has been sectionized is very rough, with deep canyons and bold ridges. The oldest formation cropping out in the township is the Madison limestone, so well exposed in the mountains, which is in turn overlain by the Amsden formation. From both of these formations issue numerous springs which give rise to many streams that flow out of the canyons upon the plains. The lower reaches of these streams are intermittent, and many of them dry up before joining the main drainage system. The Amsden formation is overlain by the Tensleep sandstone, the Chugwater formation, the Sundance formation, and the Morrison formation, in the order named. The best prospects for wells are in the Amsden, Tensleep, and Sundance.

TPS. 8 AND 9 S., R. 31 E.

Tps. 8 and 9 S., R. 31 E., are in the Big Horn Mountains and have been considered too rough and rugged to be surveyed. They are practically uninhabited.

T. 1 N., R. 32 E.

The oldest formations cropping out in T. 1 N., R. 32 E., are the Eagle sandstone and the Telegraph Creek formation, which have not been separated. They consist of a mass of sandy yellow shales which are not good water-bearing beds. However, wells dug into them may yield small quantities of water that can be used for domestic purposes. The overlying Claggett formation consists chiefly of shales which yield little or no water suitable for domestic use.

The Parkman sandstone, which overlies the Claggett shale, crops out in a narrow belt extending from west to east across the middle of the township.

It is probably the most favorable water-bearing formation in the township except the Lance, but little definite information concerning its water-bearing qualities is available. The Bearpaw shale, which overlies the Parkman sandstone, is very unfavorable for water. The more favorable Lance formation, overlying the Bearpaw shale, is at the surface in the extreme northwest corner of the township.

T. 2 N., R. 32 E.

The Bearpaw shale, with its unfavorable water conditions, forms the open lowlands in the southeastern part of T. 2 N., R. 32 E.

The Lance formation, which overlies the Bearpaw in the rest of the township, gives rise to small springs in some of the coulees. Wells drilled into the Lance formation should generally find water at depths of less than 200 feet. A narrow strip of terrace gravel extends across the township from southwest to northeast, with a branch that extends northward into T. 3 N., R. 32 E. The terrace gravel will in some places furnish small supplies of water that can be used for domestic purposes.

T. 3 N., R. 32 E.

Only the southern third of T. 3 N., R. 32 E., is in Big Horn County. The township is underlain by the Lance formation, which generally yields potable water. Terrace gravel is wide-spread in the township, but little is known of its water-bearing properties.

T. 1 S., R. 32 E.

The unproductive shales of the Colorado group are at the surface in T. 1 S., R. 32 E., except in the northern part, where the undifferentiated Telegraph Creek formation and Eagle sandstone crop out. The conditions are unfavorable for water.

T. 2 S., R. 32 E.

T. 2 S., R. 32 E., is underlain by unproductive shales of the Colorado group. The depth to the water-bearing Cloverly formation is more than 1,750 feet. In parts of this township the shales are overlain by terrace deposits of sand and gravel, which yield considerable quantities of fairly good though hard water. In the NE¼ sec. 26 R. McKittrick has a dug well 21 feet deep, which yields a large supply of water used for domestic purposes. This well is reported to have been pumped by windmill for 20 hours at the rate of 8 gallons a minute without going dry. The water, which is considered good by the users, contains 1,227 parts per million of total dissolved solids and 449 parts per million of hardness. (See analysis 5, p. 153.) The Eagle Spring, at the Bird Head ranch, in the SW¼ sec. 29, flows several gallons a minute from the base of the terrace gravel. The spring is improved with a concrete box and is piped to several tanks nearby. The water, which the users consider excellent though hard, contains 987 parts per million of total dissolved solids and has a hardness of 356 parts per million. (See analysis 6, p. 153.)

T. 3 S., R. 32 E.

T. 3 S., R. 32 E., is underlain by shales of the Colorado group, from which little or no water can be obtained that is fit for use. Terrace deposits of sand and gravel may yield considerable quantities of fairly good though hard water. Careful search in the coulees may reveal small springs that can be developed to furnish supplies sufficient for a ranch. The Big Horn River crosses the southeast end of the township and has a broad flood plain. On the east side of the river there is a wide strip of alluvium that yields considerable volumes of water, much of which, however, is too highly mineralized to be used for household purposes. Dug wells are commonly used for obtaining water from the alluvium, but some wells have been drilled. Driven wells would probably be successful.

T. 4 S., R. 32 E.

T. 4 S., R. 32 E., is underlain by shales of the Colorado group. Wells ending in these shales are usually failures. The terrace deposits on the hills west of the river should yield water supplies for domestic purposes. The Big Horn River flows almost due north across the eastern half of the township. The west bank of the river has high bluffs of Colorado shale; the east bank is fairly low and is flanked by a strip of alluvium. The dug well at St. Xavier's Mission, in the SE¼ sec. 23, is 45 feet deep and obtains an abundant supply of water from the sand and gravel in its lower 20 feet. This well water is reported as good by the users; it contains 2,547 parts per million of total dissolved solids, and its hardness is 1,180 parts per million. (See analysis 7, p. 153.) Several other dug wells in this vicinity yielded water too highly mineralized for use and were abandoned. A well 500 feet deep at St. Xavier's Mission in sec. 26 was dry except for a small amount of water obtained from the alluvium. It is now abandoned. The village of St. Xavier has no public water supply.

T. 5 S., R. 32 E.

T. 5 S., R. 32 E., is underlain by shales of the Colorado group, from which little or no potable water is obtainable. The water-bearing Cloverly formation is more than 1,500 feet beneath the surface in this township. The terrace deposits west of the Big Horn River may yield considerable water, but no attempts have been made to develop supplies from them. The Big Horn River flows in a general northerly direction across the township, and the greater part of the valley alluvium is on the east side of the river. A few wells have been dug or drilled in the alluvium, but most of the inhabitants prefer the less mineralized ditch or river water.

T. 6 S., R. 32 E.

The oldest formation cropping out in T. 6 S., R. 32 E., is the Morrison formation, which is exposed in the center of the Soap Creek uplift (pl. 13). Although the Morrison is usually a poor source of water, some of the wells drilled for oil in this area yield small flows of water that could be used for domestic purposes. Where water is not encountered in this formation wells should be drilled through its shales into the more favorable Sundance formation.

The Cloverly formation, which overlies the Morrison, is a fairly good water bearer, and practically all the wells in the Soap Creek oil field that start in shale of the Colorado group obtain small flows of water from one or more of its several sandstones. The Colorado group, which overlies the Cloverly formation, is exceedingly unpromising as a source of water. Close to the Soap Creek uplift water can readily be obtained by drilling through the Colorado into the Cloverly formation, but the beds dip so steeply away from the axis of the uplift that the depth to the Cloverly increases greatly within a relatively short distance.

Practically every well drilled in the Soap Creek oil field struck one or more flows of water, from the Cloverly, Morrison, or Sundance formations, the Amsden formation, or the Madison limestone, the three upper formations furnishing small flows, the two lower ones large flows in some places.

The well of B. E. Ladow, in the SE¼SE¼ sec. 16 (see log, pp. 111–112), obtained an artesian flow of 10 to 15 gallons a minute from a sandstone 426 to 486 feet below the surface, probably from the top of the Cloverly formation. This water contains 734 parts per million of total dissolved solids and has a hardness of only 15 parts per million. (See analysis 8, p. 153.) Other flows were encountered at 825, 920, and 2,102 feet, but samples could not be obtained. The small flow at 920 feet apparently comes from the Sundance formation. A large flow of warm water comes from the Amsden formation at a depth of 2,102 to 2,120 feet, and more water was encountered in the Amsden at 2,256 to 2,260 feet.

The Fifty Unit Syndicate well, drilled by Winnie & Richards in the SE¼SW¼ sec. 21, struck a small flow of water from Cloverly sandstone at 416 to 450 feet below the surface. The water, which was not used, was reported as soft by the drillers. This well is reported to have yielded a large flow of warm water from the Amsden formation.

The Western States Oil & Land Co.'s well no. 1, in sec. 34, yielded a small artesian flow from a sandstone, probably Sundance, at a depth of 250 to 260 feet. The log of the well (pp. 114–115) stops at 1,647 feet, but the well was later deepened. A large flow of warm sulphur water was encountered in the Amsden formation a short distance above the oil sand. The Madison limestone was penetrated at 1,794 feet, and at 1,950 feet more water was encountered. In well 2 of the same company, also in sec. 34 (see log, pp. 115–116), a sandstone at a depth of 265 to 275 feet yielded some water, but the pressure was not sufficient to cause an overflow. Another sandstone at 445 to 450 feet yielded a small flow. Both sandstones are probably in the Sundance formation. In well 3 of the same company, in the SW¼ sec. 27, a sandstone 12 feet thick at a depth of 147 to 153 feet yields a flow of about 15 gallons a minute. This water probably comes from the Sundance formation. In the same well another flow was encountered at 375 feet in a greenish-gray sandstone 41 feet thick, at a depth of 340 to 381 feet. When first struck this flow is reported to have exceeded 300 gallons a minute, but in a few months it dwindled to about a gallon a minute. This well also obtained a flow of 15 gallons a minute from the Madison limestone, the water being reported as fresh and soft. The bottom of the hole was plugged to shut off the water and to prevent injury to adjacent oil wells. Well 4 of the same company, in the SW¼NE¼ sec. 34 (see log, p. 117), encountered some water in a Sundance sandstone at a depth of 272 to 280 feet, which rose 100 feet in the casing but did not have sufficient pressure to overflow. In well 6 of the same company, in the SW¼NW¼ sec. 27, water was encountered at depths of 80 and 405 feet, but it is not reported that the water flowed. The log of this well (see p. 113) ends at 1,750 feet, but it is reported that a strong flow of sulphur water was encountered at 1,960 to 1,975 feet. The log of well 7 of the same company, in the NW¼SW¼ sec. 34 (see pp. 113–114) shows that water was encountered in the Cloverly formation at a depth of 190 feet, in the Morrison formation at 575 feet, in the Amsden formation at 1,897 and 2,060 feet, and in the Madison limestone at 2,110 feet. The water at 1,897 feet was warm sulphur water that flowed in large volume.

T. 7 S., R. 32 E.

The Soap Creek uplift extends into T. 7 S., R. 32 E. The oldest formation cropping out in the township is the Amsden formation, which is exposed in Soap Canyon. Higher formations exposed are the Tensleep sandstone, the Chugwater, Sundance, Morrison, and Cloverly formations, and the shaly formations of the Colorado group. The water-bearing properties of these formations are indicated by the wells that have been described under T. 6 S., R. 32 E.

The drilling activities in the Soap Creek field extended into this township, and although oil was not found in commercial amounts, considerable information concerning the ground water was obtained. The Dox Oil Co.'s well no. 1, in the NW¼NW¼ sec. 2 (see log, p. 118), struck water at 100, 534, 590, and 830 feet, but at none of these depths was the pressure sufficient to give rise to flows. At 2,003 to 2,010 feet a bed in the Amsden formation yielded about 100 gallons a minute of warm sulphur water with a closed-in pressure of 225 pounds to the square inch, according to C. E. Beecher of the United States Bureau of Mines. The log of the Thermopolis-Cat Creek Corporation's well (p. 119) in the same section affords little information concerning the availability of ground water. The Rice & Hoffman well, in the northeast corner of sec. 4, encountered a large volume of water at 2,342 to 2,345 feet and a large flow of warm sulphur water at 2,402 feet.

T. 8 S., R. 32 E.

All but the four southwestern sections of T. 8 S., R. 32 E., have been surveyed, the unsurveyed section being in the rugged Big Horn Mountains. The Madison limestone, which crops out so conspicuously in the mountains, is the oldest formation at the surface. It is well exposed along the upper part of Rotten Grass Creek. The limestone is overlain by the Amsden formation which in turn is overlain by the Tensleep sandstone. The two lower formations furnished flows of water in the wells drilled for oil in T. 6 S., R. 32 E.

The Chugwater, Sundance, Morrison, and Cloverly formations follow in the order named. The descriptions of the water-bearing properties of the rocks given under T. 6 S., R. 32 E., are applicable also to this township, except that here the formations have steep dips and narrow outcrops; consequently in drilling, the vertical depth through a formation may be somewhat greater than its stratigraphic thickness. The Colorado group is at the surface in sec. 1, but the depth to the Cloverly formation is less than 500 feet.

The Reed Creek dome, with its center in sec. 2, has not been tested. It is probable that small flows of water may be obtained from drilled wells, but the artesian pressure may not be sufficient to force the water to the surface.

T. 9 S., R. 32 E.

The only part of T. 9 S., R. 32 E., that has been sectionized embraces secs. 1 to 4, 9, 10, and 12 to 16. The Madison limestone, the Amsden formation, the Tensleep sandstone, and the Chugwater formation crop out in the order named around the core of the mountains.

T. 1 N., R. 33 E.

The oldest rocks cropping out in T. 1 N., R. 33 E., are the yellow sandy shales of the undifferentiated Eagle sandstone and Telegraph Creek formation, which may yield a little highly mineralized water. These beds are visible in the bluffs along the river, where their light color is very conspicuous. The overlying Claggett shale yields practically no water for domestic use but may furnish small supplies for stock. The Parkman sandstone, which overlies the Claggett formation, usually yields small supplies. A well drilled into the Claggett formation, 60 feet deep, on the property of Charles Lee, in sec. 16, yields an adequate supply of water that is used for domestic purposes. The Bearpaw shale, overlying the Parkman sandstone, yields only meager supplies of water unfit for any ordinary use. Another well on the property of Charles Lee, in sec. 16, is 190 feet deep and ends in the Bearpaw shale. It yields water with a decidedly salty taste that contains 4,774 parts per million of total dissolved solids. (See analysis 9, p. 153.)

Along the west side of the Big Horn River there is a broad strip of alluvium, which is irrigated. A 4-inch drilled well 16 feet deep on the property of E. C. Brown, in sec. 16, yields an adequate supply of water. In summer, during the irrigation season, the water is used for domestic purposes, but when winter comes the dissolved mineral content rises and the water can be used only for stock. In sec. 27 a dug well 3 feet in diameter and 12 feet deep, on the property of C. M. Evers, yields an adequate supply of water that is used for domestic purposes. The users consider this water "fair", although it contains 864 parts per million of total dissolved solids and has a hardness of 552 parts per million. (See analysis 10, p. 153.)

T. 2 N., R. 33 E.

The unfavorable Bearpaw shale is the oldest formation cropping out in T. 2 N., R. 33 E. The Lance formation, which overlies the Bearpaw shale, is a fairly good water-bearing formation. Along the river it forms prominent rim rocks, which in some places approach the river closely, but in others are separated by broad stretches of alluvium. Back of these rim rocks are some high-level areas of land that is good for farming but difficult of access because of the steep coulees. A 4-inch well drilled 81 feet deep into the Lance formation in the NW¼ sec. 15, on the property of George Mehling, is reported to yield a large supply when pumped. The water, which contains 1,438 parts per million total dissolved solids, is used for domestic purposes. (See analysis 12, p. 153.) A 4-inch drilled well 202 feet deep in the NE¼ sec. 10, on the property of N. H. Garrison, yields an adequate supply for domestic purposes. The water, which contains 1,906 parts per million of total dissolved solids, is considered good by the users. (See analysis 11, p. 153.) Two other wells in the same quarter section were less successful because they end in the Bearpaw shale.

In the broad bottom of the Big Horn River considerable alluvium has been deposited, covering the older formations to a maximum depth of perhaps 75 feet. The alluvium furnishes fairly large supplies of water that can be used for stock but in many places is too highly mineralized for domestic use. In the SW¼ sec. 22 a dug well 16 feet deep on the property of Perry Young yields an adequate supply of water for domestic use which is reported as good, although having an "alkali taste." In the NW¼ of the same section a drilled well yields water too highly mineralized for household use. In sec. 27 a drilled well 40 feet deep yields water that is reported as having a "soda taste." Two other wells in this township are reported to yield water unfit for drinking and are now abandoned.

A drilled well in sec. 15 is 375 feet deep; the first 60 feet is in the alluvium, which yields a large supply of poor water, and the last 315 feet is in the shale, which is dry. The water obtained from the alluvium contains 1,396 parts per million of total dissolved solids. (See analysis 13, p. 153.)

Terrace gravel usually less than 25 feet thick occurs in isolated patches; it appears to be well drained and consequently may not yield water to wells.

T. 3 N., R. 33 E.

The oldest formation at the surface in T. 3 N., R. 33 E., is the Lance formation, which consists chiefly of sandstones and shales with a few thin coal beds.

The sandstones usually yield moderate supplies of water that can be used for household purposes. Pine Ridge is capped with a layer of gravel that is probably a remnant of an Oligocene plain. This gravel yields large supplies of water in some places, but in this township it is probably too badly dissected to yield much water. The Big Horn River flows across the southeast corner of the township with a strip of alluvium along its west bank.

T. 1 S., R. 33 E.

Shales of the Colorado group are at the surface over a considerable part of T. 1 S., R. 33 E. Several wells have been drilled in these shales for oil and gas, and none of them encountered supplies of potable water. In some places shallow dug wells may produce small quantities of water that can be used, if necessary, for household purposes. The overlying yellow sandy shales of the Telegraph Creek formation and Eagle sandstone also yield a little water.

An area of considerable extent west of Hardin is underlain by a terrace of Pliocene (?) gravel that yields supplies ample for domestic needs, although the water is commonly hard. In the SW¼ sec. 21, on the property of S. Dyvig, a dug well 27 feet deep yields an adequate supply of water for domestic purposes that is reported to be good. The water contains only 607 parts per million of total dissolved solids but has a hardness of 252 parts per million. (See analysis 16, p. 153.) Mr. Dyvig also has in the same quarter section a spring that flows several gallons a minute. This spring, which obtains its water from the gravel, is boxed and used for stock, although it is considered good for domestic use. In the NE¼ sec. 30 C. Torski has a dug well 18 feet deep, which ends in the sand and gravel of the terrace and supplies an adequate amount of water reported as good and used for domestic purposes. This water contains only 605 parts per million of total dissolved solids but has a hardness of 328 parts per million. (See analysis 17, p. 153.) Wells here should not be dug below the gravel into the underlying shale, because the water obtained from the shale would be inferior to that in the gravel.

The Big Horn River flows along the eastern boundary of this township, except where it meanders into the township to the east. The broad stretch of alluvium along the river is irrigated. The alluvium yields considerable water, but in many places it is highly mineralized. An abandoned well near Hardin which is 60 feet deep in the alluvium yielded water that contains 2,388 parts per million of total dissolved solids and has a hardness of 700 parts per million. (See analysis 14, p. 153). In the SE¼ sec. 27, on the property of N. C. McCune, a 4-inch well 37 feet deep ends in alluvial sand and gravel that yield a large supply of water used for domestic purposes. This water contains 1,489 parts per million of total dissolved solids and has a hardness of 417 parts per million. (See analysis 15, p. 153.)

T. 2 S., R. 33 E.

The unpromising shales of the Colorado group underlie T. 2 S., R. 33 E. The depth to the water-bearing Cloverly formation is everywhere more than 1,750 feet. The alluvium, which forms a broad level plain on the west bank of the river north of the Two Legging bridge and on the east side south of the bridge, yields fairly large supplies of water, which, however, may be highly mineralized. A dug well 12 feet deep in sec. 10 ends in gravel and yields an ample supply of water that is considered good by the users. A dug well

32 feet deep on the property of F. M. Mills in the NE¼ sec. 16 yields an adequate supply of water for domestic purposes.

T. 3 S., R. 33 E.

The unpromising shales of the Colorado group occur at or near the surface in T. 3 S., R. 33 E. They are well exposed in the bluffs along the west bank of the Big Horn River and less prominently in the hills east of the river. Along the eastern edge of the township, in secs. 1, 12, and 13, the yellow sandy shales of the undifferentiated Eagle sandstone and Telegraph Creek formation overlie the drab shales of the Colorado group. These sandy shales are also unpromising for water supplies.

The Big Horn River crosses the northwest corner of the township and is bordered by a broad strip of alluvium along its east side. This alluvium furnishes considerable water, which is usually highly mineralized. In the SW¼ NW¼ sec. 9, on the property of the Montana Farms Corporation, a 4-inch well, 52 feet deep, yields a large supply of water that is reported to be so poor that stock will not drink it. This water contains 6,540 parts per million of total dissolved solids. (See analysis 18, p. 153.) In the NW¼ sec. 16, on the property of the same corporation, a drilled well 60 feet deep yields a large supply of water that is reported to be very bitter. In the NW¼ sec. 29 a drilled well 52 feet deep on the property of J. E. Koebbe obtains a large supply from the gravel, but the water is so poor that the well has been abandoned. In the NE¼ sec. 29, on the same property, a small spring from the terrace gravel flows less than 1 gallon a minute. The water, which issues at a temperature of 56° F., is reported by users as good. In the same section a dug well 18 feet deep yields water that is used for stock, but the cattle prefer river water. Where the alluvium yields highly mineralized water, cisterns filled from the irrigation ditches are used for domestic supplies. In sec. 30 a drilled well 36 feet deep on the property of the Montana Farms Corporation yields a large supply of water. Some people drink this water and consider it fairly good, though high in "alkali." Another drilled well nearby was a failure.

T. 4 S., R. 33 E.

T. 4 S., R., 33 E., like T. 3 S., R. 33 E., is underlain by shales of the Colorado group and the undifferentiated Eagle sandstone and Telegraph Creek formation. A drilled hole in sec. 6 is 237 feet deep and dry. The stock on the range find sufficient water at a few small springs in the coulees. The alluvium covers the Colorado deposits in the western part of the township to depths ranging from only a few inches to 50 or 60 feet and contains sand and gravel that yield abundant supplies of water, which, unfortunately, may be highly mineralized. In sec. 7 the dug well of George Kinch is 60 feet deep and ends in gravel from which is obtained a large supply of water that is used for domestic purposes, although the water is reported by the users as only fair. In most places the wells in the alluvium will strike water at shallower depths.

T. 5 S., R. 33 E.

T. 5 S., R. 33 E., like the two townships north of it, is underlain by unpromising shales of the Colorado group and the undifferentiated Eagle sandstone and Telegraph Creek formation. Rotten Grass Creek, a perennial stream, drains most of the township and supplies most of the stock on the open range with water.

T. 6 S., R. 33 E.

The only formations at the surface in T. 6 S., R. 33 E., are the unpromising shales of the Colorado group. As in T. 5 S., R. 33 E., Rotten Grass Creek furnishes water for the cattle on the range.

T. 7 S., R. 33 E.

The unpromising Colorado group is the only deposit that crops out in T. 7 S., R. 33 E. The Rotten Grass uplift, in the southern part of the township, brings the Cloverly formation within 1,500 feet of the surface, but elsewhere the depth to this normally favorable formation exceeds 1,800 feet. In the SW¼ sec. 28 the well of the Western States Oil & Land Co. (see log, pp. 122–123) encountered water at 1,530 to 1,543 feet, 1,560 to 1,572 feet, and 1,775 to 1,805 feet in the Cloverly formation and at 1,810 to 1,820 feet in the Morrison formation. The water from all except the first water-bearing bed overflowed at the surface. The flow from the second measured 3 gallons a minute. The water had a temperature of 58.5° F. on October 13, 1921, contained only 395 parts per million of total dissolved solids, and had a hardness of only 27 parts per million. (See analysis 19, p. 153.) At the time of the writer's visit the two lower flows were cased off.

In the SE¼ sec. 34, a small spring flows a few gallons of water a minute, the temperature of which is 48.5°. This spring is boxed and piped to the barnyard. The water is reported as hard but satisfactory for most purposes.

T. 8 S., R. 33 E.

The formations cropping out in T. 8 S., R. 33 E., are the Chugwater, Sundance, Morrison, and Cloverly formations, and the Colorado group. The Sundance and Cloverly are normally good water-bearing formations. The Morrison formation is missing in places along the mountain front; it is usually a poor source of water, but if the water-bearing bed encountered in the well on the Rotten Grass dome continues toward the south it may yield water.

The Willow Creek dome was tested for oil and gas by the C. M. Bair & Mid-Northern Oil Co., which drilled a well 576 feet deep in the NE¼NW¼ sec. 30. The log of this well (see p. 123) does not give much information concerning ground-water conditions. The driller reported that a little water was encountered in a bed of "red sandy shale" in the Chugwater formation.

T. 9 S., R. 33 E.

The oldest formation cropping out in T. 9 S., R. 33 E., is the Madison limestone, which is found in the canyon of Lodgegrass Creek. No wells have been sunk in this limestone, but some excellent springs issue from it. The Amsden formation overlies the Madison limestone and in turn is overlain by the Tensleep sandstone. The Madison limestone and the Amsden formation have yielded flows of water in the Soap Creek oil field, but in this township they crop out in a rough region where no wells have been drilled. The Chugwater formation overlies the Tensleep sandstone and is in turn overlain by the Sundance, Morrison, and Cloverly formations.

The Sport Creek dome is an upwarp of the strata that brings the older formations nearer the surface. A well drilled on this dome penetrated the Madison limestone at 448 feet below the surface, but the log does not give any information on ground-water conditions.

T. 1 N., R. 34 E.

The Ninemile area, in the southern part of T. 1 N., R. 34 E., is an area of uplift in which erosion has exposed the Niobrara shale of the Colorado group. A well was drilled by the Superior Oil & Coal Co. in the NE¼ sec. 33 and obtained a small flow of water from the Cloverly formation at a depth of 2,450 feet. This well was started somewhere near the top of the Niobrara shale, the uppermost formation of the Colorado group. This oil company also dug a well 20 feet deep in the SW¼ sec. 33, in the expectation of using the water for the boiler while drilling an oil well, but the water rapidly corroded the boiler tubes and could not be used. The water contains 9,299 parts per million of total dissolved solids and has a hardness of 1,860 parts. (See analysis 20, p. 155.) Many wells drilled in the shales of the Colorado group yield so little water that it is necessary to add water while drilling.

The Colorado group is overlain by the undifferentiated Telegraph Creek formation and Eagle sandstone and the unpromising Claggett shale. The Parkman sandstone, which overlies the Claggett shale, crops out in a narrow hilly zone that crosses the township in a generally east-west direction. Usually this sandstone will yield adequate domestic supplies, although some wells furnish water too highly mineralized for that purpose. Drilled wells should be successful at depths not exceeding 150 feet, and dug wells located in coulees at less than 30 feet. The Bearpaw shale, overlying the Parkman sandstone, is very unfavorable for water supplies.

The Lance formation, which overlies the Bearpaw shale in the northeastern part of the township, usually yields fairly good supplies of water.

T. 2 N., R. 34 E.

The unpromising Bearpaw shale is at the surface in the southwestern part of T. 2 N., R. 34 E. The depth to the underlying Parkman sandstone, which is usually a favorable water-bearing formation, is everywhere in excess of 500 feet and in some parts of the township much greater. The Lance formation, which overlies the Bearpaw shale, crops out over a considerable part of the township. It contains sandstone beds that yield water. The Lebo shale member of the Fort Union formation, which overlies the Lance formation, is at the surface in the eastern part of the township, and is an unfavorable source of water.

T. 3 N., R. 34 E.

The Lance formation is at the surface over most of T. 3 N., R. 34 E., except where it is overlain by alluvium, and is usually a fairly good source of water. In the SE¼ sec. 18 a 6-inch well 62 feet deep on the property of G. T. Van Cleve yields water reported as good and used for domestic purposes. The water contains 965 parts per million of total solids and has a hardness of 141 parts per million. (See analysis 21, p. 155.) Water encountered at 35 feet and again at 58 to 62 feet below the surface comes from sandstone, and rises within 15 feet of the surface. The Lebo shale member of the Fort Union formation, a less favorable source of water, is at the surface in sec. 24.

The alluvium in the valley of the Big Horn River yields relatively large supplies of poor water to dug wells, most of which do not exceed 20 feet in depth. In the SE¼ sec. 18, on the property of G. T. Van Cleve, a dug well 18 feet deep with 8 feet of water in the bottom yields a large supply that is reported as fair and used only for stock. This water contains 2,965 parts per million of total dissolved solids and 672 parts per million of hardness. (See analysis 22,

p. 155.) This well is less than 100 yards from the drilled well in the Lance formation on the same property, but the analyses show that the waters are vastly different in quality.

T. 1 S., R. 34 E.

The oldest series of formations cropping out in T. 1 S., R. 34 E., are the shales and unproductive formations of the Colorado group. In parts of the township they are overlain by undifferentiated Eagle sandstone and Telegraph Creek formation, and the Claggett shale, which are also unpromising for water supplies. In this township the depth to the Cloverly formation, which generally yields water, is 2,000 feet or considerably more. Alluvium covers the older formations in the valley of the Little Horn River and usually furnishes supplies of highly mineralized water.

T. 2 S., R. 34 E.

The oldest deposit cropping out in T. 2 S., R. 34 E., is the Colorado group, which is overlain by sandy shales belonging to the Telegraph Creek formation, Eagle sandstone, and Claggett formation, all of which are unfavorable for water supplies. The Parkman sandstone, which overlies the Claggett shale, should yield small supplies of fairly good to poor water.

The alluvium, which is at the surface over a considerable area along the valley of the Little Horn River, is the source of considerable quantities of hard water. In the SW¼ sec. 11, on the property of W. A. Peden, a dug well 3 feet square and 35 feet deep supplies a large volume of water. There is normally about 10 feet of water in this well, and pumping at the rate of 8 to 10 gallons a minute does not pump the well dry. The water, however, contains 1,948 parts per million of total dissolved solids and has a hardness of 1,200 parts per million. (See analysis 23, p. 155.) A cistern is used to catch rain water. Many people use river water, which is run from the irrigating ditches into cisterns.

T. 3 S., R. 34 E.

The principal settlement in T. 3 S., R. 34 E., is Crow Agency, which is the headquarters of the Indian Service for the Crow Indian Reservation. The village consists of the headquarters buildings, a few stores and dwellings, and several garages.

The unpromising Colorado group is the oldest deposit cropping out in the township. Overlying the Colorado group are the equally unpromising shaly beds belonging to the Telegraph Creek formation, Eagle sandstone, and Claggett formation. The Parkman sandstone, which overlies the Claggett shale, is normally a fair water-bearing formation, but some of the water yielded may be too highly mineralized for domestic use.

Alluvium rests upon the Parkman sandstone in the northeastern part of the township, where it could furnish fairly large supplies of water if necessary. At Crow Agency, in sec. 1, the Indian Service well is 20 feet in diameter and 12 feet deep and is in the alluvium within a few yards of the river. The water level in the well is usually about 10 feet below the surface, and the pump empties the well several times a day. The water contains 535 parts per million of total dissolved solids and has a hardness of 344 parts per million. (See analysis 24, p. 155.) An older well at the agency, 30 feet in diameter and 18½ feet deep, is also used. (See analysis 25, p. 155.) The water is pumped into a tank on the hill west of the Custer Battlefield Highway and distributed through the Government buildings and grounds by gravity. The dug well of

Logan Morris, in Crow Agency, is 30 feet deep and yields a considerable volume of water used for domestic purposes. The water contains 1,864 parts per million of total dissolved solids and has a hardness of 736 parts per million—a decided increase in total dissolved solids over the water from the Government well. (See analysis 26, p. 155.)

T. 4 S., R. 34 E.

In T. 4 S., R. 34 E., the same formations as in T. 3 S., R. 34 E., except the alluvium, are at the surface.

T. 5 S., R. 34 E.

In T. 5 S., R. 34 E., the outcropping formations are the Eagle sandstone, Telegraph Creek formation, Claggett shale, and Parkman sandstone.

T. 6 S., R. 34 E.

The Colorado group is the oldest deposit cropping out in T. 6 S., R. 34 E., and is successively overlain by the Telegraph Creek formation, Eagle sandstone, and Claggett shale. All these shaly formations are unpromising for water supplies.

T. 7 S., R. 34 E.

The Colorado group, which is the oldest deposit cropping out in T. 7 S., R. 34 E., is very unpromising for water supplies. The Telegraph Creek formation, Eagle sandstone, and Claggett shale overlie the Colorado group in parts of the township. In the SW¼ sec. 1, at St. Ann's Mission, a 3-inch well 70 feet deep yields a small supply of rather highly mineralized but soft water that is considered good and is used for domestic purposes. The well starts in the Claggett shale but probably ends in the sandy shales of the Eagle sandstone or Telegraph Creek formation. This well pumped at the rate of 5 gallons a minute will yield about 50 gallons of water before going dry but recovers after a rest of an hour or two.

T. 8 S., R. 34 E.

Conditions in T. 8 S., R. 34 E., are similar to those in T. 7 S., R. 34 E. There is much terrace gravel on the divide between Lodgegrass Creek and the Little Horn River, but in this township the gravel may be too thoroughly drained to yield much water.

T. 9 S., R. 34 E.

The formations cropping out in T. 9 S., R. 34 E., are the Chugwater, Sundance, Morrison, and Cloverly formations and the Colorado group. The best prospects for finding water are in the Sundance and Cloverly formations. The Black Gulch dome (see p. 77), which centers in sec. 24, was tested by the Producers & Refiners Corporation, which drilled a well in the NE¼SW¼ of the section. According to the log of this well (pl. 6) a considerable volume of water was encountered in a sandstone between the depths of 2,545 and 2,580 feet. The water is reported to have flowed over the casing head.

T. 1 N., R. 35 E.

The Lance formation is exposed in T. 1 N., R. 35 E., except in the southeastern part of sec. 31, where the underlying Bearpaw shale crops out. Water supplies can generally be obtained from wells dug or drilled into the Lance formation. In the SE¼ sec. 2 a 6-inch drilled well 77 feet deep, on the property of L. S. Perkins, yields several gallons of water a minute, which is used for domestic purposes. The water enters the well near the bottom and is under sufficient pressure to rise within about 27 feet of the surface. It contains 1,566 parts per million of total dissolved solids. (See analysis 27, p. 155.) Several other wells in adjacent sections have about the same depth and yield adequate supplies of water that is used for domestic purposes.

A small amount of alluvium in Tullock Creek covers the Lance formation to an unknown depth. Shallow wells sunk in these unconsolidated materials should yield small supplies of rather hard and highly mineralized water. A dug well 14 feet deep in sec. 2 yields an adequate supply of water that is now used for stock but is considered by the users as also suitable for domestic purposes.

T. 2 N., R. 35 E.

The Lance formation is at the surface over most of T. 2 N., R. 35 E., except in the valley of Tullock Creek, where it is covered with Quaternary alluvium. Though drilled wells are usually successful at depths of less than 200 feet, except along the divide between the Big Horn River and Tullock Creek, they may be small producers, yielding but a few hundred gallons a day. Dug wells carefully located in coulees usually yield somewhat larger quantities of water at depths not exceeding 30 feet.

The exact thickness of the Quaternary alluvium resting upon the Lance formation in Tullock Creek Valley is not known, but it is probably not great. Though the alluvium will yield relatively large supplies, much of the water is too highly mineralized for domestic use, although very valuable for stock.

T. 1 S., R. 35 E.

The oldest formation cropping out in T. 1 S., R. 35 E., is the Claggett shale. Wells in this formation are usually failures or yield meager supplies of water that can be used only for stock.

The Parkman sandstone, which overlies the Claggett, consists chiefly of sandstone and sandy shale. In this township it crops out in a narrow belt of sandy hills between open rolling lowlands underlain by the Claggett and Bearpaw shales. In the NW¼SW¼ sec. 8 a drilled well 110 feet deep known as the "Community well" yields from 7 to 10 gallons a minute of water that is used for domestic purposes. Sandstone between 70 and 110 feet supplies the water, which rises within 40 feet of the surface, showing the existence of considerable pressure, as the well is high on a hill. The water contains 322 parts per million of total dissolved solids and 222 parts per million of hardness, chiefly carbonate hardness. (See analysis 28, p. 155.) This well, which was drilled for the convenience of the people along Sarpy Creek, shows the possibilities of developing water supplies from the Parkman sandstone in this area.

The Bearpaw shale, which overlies the Parkman sandstone, is an extremely poor source of water. Where the depth to the underlying Parkman sandstone is less than 250 feet, it is recommended that attempts be made to drill through the Bearpaw into the somewhat more favorable Parkman.

The Hell Creek member of the Lance formation, which overlies the Bearpaw shale, has a strikingly different topographic expression and forms steep pine-covered rim rocks, which separate the uplands of the Lance formation from the lowlands of the Bearpaw shale.

The Lance formation is usually a good water-bearing formation, and the sandstone yields small to medium supplies that can be used for domestic purposes, although some wells and springs yield water that is too highly mineralized for domestic use.

T. 2 S., R. 35 E.

The formations cropping out in T. 2 S., R. 35 E., are the same as in T. 1 S., R. 35 E., under which their water-bearing properties are noted.

T. 3 S., R. 35 E.

The most interesting landmark in T. 3 S., R. 35 E., is the Custer Battlefield National Cemetery, where General Custer and his command were annihilated by the Indians June 25, 1876.

The Parkman sandstone is the oldest formation cropping out in the township and is at the surface over most of its western half. The Bearpaw shale, which overlies the Parkman, normally consists of dark blue-gray to black marine shales, but the sandy upper beds, which appear in the township to the north, become thicker in this area and greatly resemble the overlying Lance formation. The Hell Creek member of the Lance formation overlies the Bearpaw shale and is usually a fairly good source of water, yielding small supplies that can generally be used for domestic purposes, but the formation is at the surface only in part of sec. 1 and consequently has slight value as a source of ground water in this township. The water-bearing properties of these formations are noted under T. 1. S., R. 35 E.

T. 4 S., R. 35 E.

The Claggett shale is the oldest formation cropping out in T. 4 S., R. 35 E., and is an extremely poor source of water. The Parkman sandstone, which overlies the Claggett formation, is at the surface over a considerable area in this township; it is usually a fairly good water bearer and yields small supplies that can be used for domestic purposes, as shown by the "Community well" in T. 1 S., R. 35 E. (See analysis 28, p. 155.) The Bearpaw shale, overlying the Parkman sandstone, is always a poor water bearer, and successful wells ending in this shale are rare; however, the upper part is sandy, closely resembling the overlying Lance, and may yield some water that can be used for domestic purposes. The Hell Creek member of the Lance formation overlies the Bearpaw shale and is a fairly good water-bearing formation from which small supplies are usually obtainable, but it is at the surface over so small an area that it is of little value in this township.

Quaternary alluvium occurs in the valley of the Little Horn River, where it rests chiefly upon the Claggett shale. Though wells in the alluvium are not numerous, they usually supply considerable quantities of water, much of which is too highly mineralized for domestic use but is very valuable for stock. The depth to water should rarely exceed 25 feet. Dug wells are recommended instead of drilled wells because of their larger storage capacity and lower cost.

T. 5 S., R. 35 E.

The formations cropping out in T. 5 S., R. 35 E., are the same as those described under T. 4 S., R. 35 E.

T. 6 S., R. 35 E.

The town of Lodge Grass, in sec. 19, T. 6 S., R. 35 E., is one of the larger settlements of the Little Horn River Valley. It has no public waterworks, and the residents obtain their supplies from wells, chiefly shallow dug wells in the alluvium. Many of these wells yield water that is so highly mineralized that it has a decided "alkali" or "soda" taste.

The oldest formation cropping out in this township is the Claggett shale. In sec. 28 a drilled well 120 feet deep on the Cadwell ranch flows several gallons of highly mineralized water a minute. This well, which is near Lodgegrass Creek, probably obtains its water from a shaly sandstone in the Claggett or the top of the underlying Eagle sandstone. The water is reported as containing so much "soda" that it cannot be used for domestic purposes.

The Parkman sandstone, which overlies the Claggett shale and crops out in a narrow belt of hills west of Lodge Grass, should yield small supplies for domestic use. The area of outcrop in this township is much less than in the township to the north. In Lodge Grass the 3-inch drilled well of J. Stevens is 60 feet deep. The major portion of the water supply comes from "hardpan" in the alluvium 10 feet below the surface, but some water was encountered in the Parkman sandstone at the bottom of the well. The water rises within 4 feet of the surface. The users report that the water is suitable for domestic purposes. In the same village the 3-inch drilled well of E. Baldwin is 68 feet deep and yields a small but adequate supply of water that is reported to be soft and used for domestic purposes. The larger part of the supply comes from carbonaceous material about 12 feet below the surface. The Parkman sandstone should have small supplies of water that can be used for domestic purposes.

The Bearpaw shale overlies the Parkman sandstone. A drilled well 57 feet deep in sec. 12, on the property of E. D. Baldwin, yields an adequate supply of water used for domestic purposes. The water comes from a sandstone 55 feet below the surface. This sandstone is probably part of the sandy phase of the Bearpaw shale. In general, the shale will yield almost no water, but the sandy phase at the top, which resembles the Lance formation, should yield water that can be used for domestic purposes, as in sec. 12. Dug wells in the coulees should yield water at depths of less than 30 feet, but where the water obtained comes from shale it may be unfit for either stock or domestic use.

The Quaternary alluvium is confined to the valleys of the Little Horn River and Lodgegrass Creek and rests on the Parkman sandstone and the Bearpaw shale. The alluvium yields fairly large supplies of water that is usually somewhat highly mineralized for domestic use but can always be used for stock. There is little use in digging through the alluvium in search of better water in areas where it is underlain by the Bearpaw shale because the water encountered in the shale may be worse than that in the alluvium. Where the alluvium is underlain by the Parkman sandstone wells drilled through the alluvium into the sandstone may be successful and yield small supplies of fairly good water.

T. 7 S., R. 35 E.

The Claggett shale crops out along the west edge of T. 7 S., R. 35 E. This formation is overlain by the Parkman sandstone, which in turn is overlain by the Bearpaw shale with its sandy upper part. In the valley of the Little Horn River the Bearpaw shale is covered by a variable thickness of Quaternary alluvium. The water-bearing properties of these formations are described under T. 6 S., R. 35 E.

T. 8 S., R. 35 E.

The town of Wyola, an important point on the Chicago, Burlington & Quincy Railroad, is in secs. 22 and 23, T. 8 S., R. 35 E. This town has no waterworks, and the inhabitants obtain their water from wells.

The oldest formation cropping out in this area is shale belonging to the Colorado group, which is at the surface in the southwest corner of sec. 31. The undifferentiated Telegraph Creek formation and Eagle sandstone overlie the Colorado group and consist chiefly of yellow sandy shale. In the southern part of the reservation these shales become much sandier and may yield some water which, although somewhat highly mineralized, can be used for domestic purposes, but no well data were available. The Eagle sandstone is overlain by the Claggett shale, the Parkman sandstone, and the Bearpaw shale. The water-bearing properties of these formations are described under T. 6 S., R. 35 E.

The Little Horn River issues from the mountains and flows in a general northeasterly direction until it reaches Wyola, where it swings north. The river valley contains a deposit of Quaternary alluvium, which increases in width and probably in thickness north of Wyola. The 4-inch drilled well on the property of W. H. Spear, in the NW¼ sec. 27, is 79 feet deep and yields an adequate supply of water reported by the users to be soft and suitable for domestic purposes. The major part of the supply comes from gravel in the alluvium at a depth of 30 feet. A very small amount of water is obtained in the Claggett shale, which lies below the Quaternary alluvium. In the NE¼ sec. 32, on the property of Harry Throssel, a dug well 21 feet deep obtains an adequate supply from gravel, the water usually standing 5 feet above the bottom of the well. This water, which is considered by the users as good though hard, contains 756 parts per million of total dissolved solids and 553 parts per million of hardness. (See analysis 29, p. 155.) There seems little difficulty in obtaining water supplies from the alluvium, and the dug wells rarely exceed 25 feet in depth; but many ranchers prefer water from the river and fill cisterns from irrigation ditches.

T. 9 S., R. 35 E.

The oldest beds cropping out in T. 9 S., R. 35 E., are those of the Colorado group, an extremely poor water bearer in which there are very few successful wells. However, in sec. 7 a drilled well 60 feet deep on the property of E. C. Woodly is reported to yield an adequate and satisfactory supply, although the well has never been equipped with a pump. A nearby drilled well is 200 feet deep and yields gas and water. The water enters the well 60 feet below the surface, and the gas at 200 feet.

The Telegraph Creek formation and Eagle sandstone, which overlie the Colorado group, are much sandier and in this township contain a thick sandstone that may yield domestic supplies.

The Claggett formation, which consists mostly of marine shales, is an exceedingly poor water bearer. Wells in this formation are usually failures, although some produce meager supplies of water that can be used by stock. However, should the heavy sandstone in the underlying formation prove to be water-bearing, the problem of water supply can be solved by drilling into the sandstone.

The Parkman sandstone, which overlies the Claggett shale, is normally a fairly good source of water. A 2½-inch drilled well on the property of Ida B. Flowers, in the NW¼ sec. 12, is 200 feet deep and flows 1½ gallons a minute. The water is soft and has a rather high mineral content. This well indicates that small supplies of highly mineralized water may be obtained from the Parkman sandstone. It is possible that this sandstone may yield still more highly mineralized water where covered by the marine shales of the Bearpaw shale.

The Bearpaw shale is usually a very poor water bearer, but the upper sandy phase, which closely resembles the overlying Lance formation, may yield water similar to that from the Lance.

The floor of the Little Horn River Valley is covered with Quaternary alluvium. The river has been diverted, and the area is irrigated. A dug well 18 feet deep in sec. 5, on the property of Vera T. Throssell, yields an adequate supply of very hard water. Springs in secs. 7, 8, and 18 flow several gallons of water a minute. All the springs issuing from the alluvium are reported to yield hard water. Most inhabitants prefer ditch water, which is stored in cisterns during the irrigating season for use during the period when the ditches are dry. The water from the irrigation ditches comes from the Little Horn River and is much softer than the ground water.

T. 1 N., R. 36 E.

The oldest formation cropping out in T. 1 N., R. 36 E., is the Lance formation, which is at the surface over most of the western part of the township. This formation consists of sandstones and shales, with a few thin coal beds, but most of the ground water occurs in the sandstones. The shales yield some water, but, on the whole, it is more highly mineralized than water from the sandstones. In the S½ sec. 10, on the property of D. Ives, a drilled well 70 feet deep yields an adequate supply of water for domestic use which is reported to be good by the users. This well also yields a little gas. In sec. 17 a small spring on the property of H. S. Allen flows about a gallon a minute. This spring is boxed, and the water is piped half a mile to the owner's residence and used for domestic purposes. In the SW¼ sec. 30, on the property of James O'Leary, a drilled well 131 feet deep yields an adequate supply of water for domestic use. This water comes from blue shale at 125 feet and rises 85 feet in the well. In the NE¼ sec. 31 a drilled well 100 feet deep on the property of H. Hobson is reported to yield an adequate supply that is used for domestic purposes. The Lance formation yields small but generally adequate supplies from drilled wells at depths which rarely exceed 150 feet in this township, and dug wells are usually successful where properly located in the coulees at depths not exceeding 25 or 30 feet.

The Fort Union formation overlies the Lance formation and is composed of the Lebo shale member below and the Tongue River member above. The Lebo shale is usually a poor water bearer. Where difficulty is encountered in obtaining water from this shale the best plan is to drill through it into the underlying Lance formation, from which supplies should be obtainable. The upper or Tongue River member, consisting of sandstones, shales, and coal beds, usually yields water suitable for domestic supplies. In the NW¼ sec. 13 a drilled well 254 feet deep on the property of J. R. Conway yields a supply of hard water used for domestic purposes. In the NE¼ sec. 24, on the property of A. E. Hubbard, a drilled well 300 feet deep obtains a small supply of water from shale and coal at 157 to 159 feet. This well will yield about 75 gallons, after which it takes about 10 hours to recover. A shallow dug well in this same section usually goes dry in summer. The water contains 2,014 parts per million of total dissolved solids and 1,380 parts per million of hardness. (See analysis 30, p. 155.) The Tongue River member is a good water bearer from which small supplies are obtainable in drilled wells at depths not exceeding 250 feet, except on high narrow divides, where it may be necessary to drill deeper. Dug wells properly located in the coulees and 25 to 30 feet deep should not fail except in unusually dry years.

The Quaternary alluvium, which rests upon the Lance formation, is confined to a small area in the southwestern part of the township. Normally the alluvium yields fairly large supplies of water, but in this area it is probably thin and may yield only small supplies that may be too highly mineralized for domestic use.

T. 2 N., R. 36 E.

The Lance formation is the oldest formation cropping out in T. 2 N., R. 36 E., and is at the surface over a considerable area in the western part of the township. The water-bearing properties of the Lance are described under T. 1 N., R. 36 E.

The Fort Union formation overlies the Lance. The lower or Lebo shale member has a large outcrop area and forms open rolling treeless country, in striking contrast to the rugged upland areas underlain by the sandier Lance formation and the overlying Tongue River member. The Lebo shale is a poor water bearer, and few if any wells in it yield large supplies of water that can be used for domestic purposes. In many places it may be necessary to drill through this shale into the underlying Lance formation, where water-bearing sandstones will usually be encountered. As the Lebo shale rarely exceeds 300 feet in thickness and generally is more or less eroded, one of these water-bearing sandstones can usually be encountered at a depth of less than 300 feet. The Tongue River member is composed of sandstone, shale, clinker, and coal beds. In the NW¼ sec. 10, on the property of T. Martin, a dug well 5 feet in diameter and 15 feet deep yields an adequate supply of water for domestic purposes, including washing. The water comes from sandstone at the bottom of the well and rises 2 feet in the well. Several small springs in the same section yield small supplies of water reported as satisfactory for domestic purposes. This upper member is usually a fairly good water bearer, yielding small supplies of water to drilled wells at depths not exceeding 300 feet, except on high, narrow divides, where successful wells may be somewhat deeper. Dug wells in the coulees are usually successful at shallow depths, rarely exceeding 30 feet.

There is a small patch of alluvium of unknown thickness resting upon the Lance formation in sec. 7.

T. 1 S., R. 36 E.

The Lance formation, composed of sandstone and shale with a few thin coal seams, is the oldest one cropping out in T. 1 S., R. 36 E. The Lebo shale or lower member of the Fort Union formation, overlying the Lance formation, consists chiefly of dark-colored shales that form rolling treeless country. Alluvium is well developed in the valley of Tullock Creek, a perennial stream, and covers the Lance formation with a variable thickness of unconsolidated sand and gravel. The water-bearing properties of the Lance formation, the Lebo member of the Fort Union formation, and the alluvium have been described under T. 1 N., R. 36 E.

T. 2 S., R. 36 E.

The Lance formation is the oldest one cropping out in T. 2 S., R. 36 E., and except in a tract of less than a quarter of a mile square in sec. 7, where the Lebo shale member of the Fort Union is exposed, it is the only one at the surface anywhere in the township. The water-bearing properties of the Lance and Lebo have been described under T. 1 N., R. 36 E.

T. 3 S., R. 36 E.

The oldest formation cropping out in T. 3 S., R. 36 E., is the Bearpaw shale, a very poor water-bearing formation. Most wells drilled in this shale are failures, as they are either dry or yield water unfit for any use. No wells should be drilled or dug in this shale with the expectation of obtaining water, except possibly in the upper sandy phase. This sandy phase closely resembles in lithology the overlying Lance formation and will doubtless yield small supplies of water similar to that obtained from the Lance. However, few attempts have been made to obtain supplies from these sandy beds.

The Lance formation consists of the Hell Creek and Tullock members and is usually a good source of water. The water-bearing properties of this formation have been described under T. 1 N., R. 36 E.

T. 4 S., R. 36 E.

The Bearpaw shale is the oldest formation cropping out in T. 4 S., R. 36 E.; its water-bearing possibilities have been described under T. 3 S., R. 36 E. The Bearpaw is overlain by the Lance formation, which has been described under T. 1 N., R. 36 E.

T. 5 S., R. 36 E.

The Lance formation, which consists of the Hell Creek and Tullock members, is the oldest formation cropping out in T. 5 S., R. 36 E. Its water-bearing possibilities are described under T. 1 N., R. 36 E.

The Fort Union formation, overlying the Lance formation, consists of the Lebo shale member below and the Tongue River member above. The Lebo shale member consists chiefly of dark-colored shale; it crops out in a narrow belt of rolling treeless country between the more rugged uplands underlain by the Lance formation and the Tongue River member. The Tongue River member is made up of light-colored sandstones, light to dark shales, and coal and clinker beds; it is usually a fairly good source of ground water, although drilled wells must in some places be more than 300 feet deep to obtain supplies adequate for domestic use.

T. 6 S., R. 36 E.

The Little Horn River flows northward along the west edge of T. 6 S., R. 36 E., in a deep valley about a mile wide, between high hills. The Bearpaw shale is the oldest formation cropping out in this township. The Lance formation, which consists of the Hell Creek and Tullock members, overlies the Bearpaw, and although it is at the surface over a considerable part of the township but few wells have been sunk in it. The Fort Union formation, which overlies the Lance, is at the surface in the eastern part of the township, where the Lebo and Tongue River members are exposed. The water-bearing properties of the Bearpaw are described under T. 3 S., R. 36 E.; those of the Lance and Fort Union under T. 1 N., R. 36 E.

The alluvium, the youngest formation in the township, is found in the valley of the Little Horn River, where it covers the Bearpaw shale with a variable thickness of unconsolidated silt and gravel. The alluvium is a fairly good water bearer; the amount of water yielded is considerable, but much of it is too highly mineralized for domestic consumption.

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T. 7 S., R. 36 E.

The oldest formation cropping out in T. 7 S., R. 36 E., is the Bearpaw shale, and the sandy phase at its top is well exposed. The Bearpaw shale is overlain by the Lance formation. The Fort Union formation, which is at the surface in the eastern part of the township, is represented by the lower or Lebo shale member. The water-bearing possibilities of the Bearpaw shale have been described under T. 3 S., R. 36 E.; those of the other formations under T. 1 N., R. 36 E.

T. 8 S., R. 36 E.

The Bearpaw shale is the oldest formation that crops out in T. 8 S., R. 36 E. Its water-bearing properties are discussed under T. 3 N., R. 36 E. The Lance formation overlies the Bearpaw shale and is at the surface over most of the township. The possibility of obtaining water supplies from these rocks has been described under T. 1 N., R. 36 E.

T. 9 S., R. 36 E.

The Montana-Wyoming State line forms the south boundary of T. 9 S., R. 36 E. The Parkman sandstone is the oldest formation that crops out in this township; it should yield small supplies of potable water. The Bearpaw shale, which overlies the Parkman sandstone, consists of a lower shaly phase that is an extremely poor water bearer and an upper sandy phase that may yield small supplies of fairly good water usable for domestic purposes. The Lance formation overlies the Bearpaw shale and is normally a fairly good water bearer. The Fort Union formation, which overlies the Lance, is at the surface in the extreme southeast corner of the township. The Lebo shale, or lower member of the Fort Union, forms an open treeless country. The water-bearing possibilities of the Lance formation and of the Lebo shale member of the Fort Union are described under T. 1 N., Rs. 36 and 37 E.

T. 1 N., R. 37 E.

The Fort Union formation is at the surface over all of T. 1 N., R. 37 E., except along Sarpy Creek, where it is overlain by Quaternary alluvium. The Fort Union formation comprises the Lebo shale member below and the Tongue River member above; the Lebo is composed chiefly of shale and weathers to a subdued topography; the Tongue River is composed of lighter-colored sandstone and shale with beds of coal and clinker and weathers to a bold relief.

The Lebo shale member usually yields meager supplies of poor water, although a few wells yield water that can be used for domestic purposes. In the NE¼ sec. 4 a drilled well 64 feet deep on the property of R. Shepperd obtains a small domestic supply reported as good. This water is probably from the shale, but it may come from the base of the alluvium. The water rises 35 feet in the casing, indicating an artesian pressure not usually found in the alluvium. In the S½ sec. 4 a drilled well about 120 feet deep yields water somewhat more highly mineralized. The Tongue River member is usually a fairly good source of supply, but some drilled wells more than 300 feet deep may obtain only rather meager supplies.

The Quaternary alluvium rests chiefly upon the Lebo shale member of the Fort Union, although in places it encroaches on the Tongue River member, producing discontinuous outcrops of Lebo shale along Sarpy Creek. The exact thickness of the alluvium is not known, but it probably does not exceed 50 feet. In the S½ sec. 4 a dug well about 25 feet deep yields an adequate domestic supply, but in the NE¼ of the same section water encountered in the alluvium at 24 feet was so poor that it was cased out. These two wells show the variable character of the waters from the alluvium.

T. 2 N., R. 37 E.

The south half of T. 2 N., R. 37 E., is in Big Horn County; the north half forms part of Treasure County. The formations exposed in this township are the same as in T. 1 N., R. 37 E., to which reference should be made for information concerning their water-bearing properties. A drilled well in the NE¼ sec. 34 is 75 feet deep and yields an adequate supply of water used for domestic purposes. The water is reported to come from sand in the alluvium along Sarpy Creek at a depth of 14 feet.

T. 1 S., R. 37 E.

The Lance and Fort Union formations and the alluvium are at the surface in T. 1 S., R. 37 E. The water-bearing properties of these formations have been discussed under T. 1 N., Rs. 36 and 37 E.

T. 2 S., R. 37 E.

The Lance formation, the oldest formation cropping out in T. 2 S., R. 37 E., occupies a considerable area, especially in the southeastern part. It is overlain by the Fort Union formation, of which both members are well developed. The alluvium, which covers a considerable area in T. 1 S., R. 37 E., is absent in this township or so scanty that it was not mapped. The water-bearing properties of these formations have been described under T. 1 N., Rs. 36 and 37 E.

T. 3 S., R. 37 E.

The oldest formation at the surface in T. 3 S., R. 37 E., is the Lance formation, which is exposed over the western part of the township, forming rugged, rough country with pine-covered slopes. Both the Hell Creek and Tullock members crop out in this area. The Fort Union formation is at the surface over some of the eastern part of the township, where the lower or Lebo shale member forms the surface over a considerable area. The Lebo shale, as usual, forms a belt of rolling treeless country. The Tongue River member is at the surface over a smaller area than the Lebo member. The water-bearing properties of these formations are discussed under T. 1 N., Rs. 36 and 37 E.

T. 4 S., R. 37 E.

The oldest formation cropping out in T. 4 S., R. 37 E., is the Lance formation, which consists of the Hell Creek and Tullock members and is at the surface in the eastern part of the township. The Lance is overlain by the Fort Union formation, which is composed of the Lebo shale member below and the Tongue River member above. The areas underlain by Lebo shale are easily distinguished by their open rolling topography from those underlain by the Tullock and Tongue River members. The water-bearing properties of these formations are described under T. 1 N., Rs. 36 and 37 E.

T. 5 S., R. 37 E.

The only formation cropping out in T. 5 S., R. 37 E., is the Fort Union, which consists of the Lebo shale member below and the Tongue River member above. The water-bearing properties of this formation are described under T. 1 N., R. 37 E.

T. 6 S., R. 37 E.

The Fort Union formation is the oldest formation that crops out in T. 6 S., R. 37 E. The lower or Lebo shale member crops out along the mountains, forming an open treeless strike valley in front of the Rosebud Mountains. The upper or Tongue River member is well exposed in the mountains. The water-bearing properties of the Fort Union are described under T. 1 N., R. 37 E.

T. 7 S., R. 37 E.

The Lance formation, which consists of the Hell Creek and Tullock members, is the oldest one cropping out in T. 7 S., R. 37 E., and is at the surface over a large part of the western third of the township. The water-bearing properties of the Lance formation are described under T. 1 N., R. 36 E.

The Fort Union formation, which overlies the Lance, consists of the Lebo shale member below and the Tongue River member above. The Lebo shale crops out in a narrow depression usually less than a mile wide. The water-bearing possibilities of the Fort Union formation are described under T. 1 N., R. 37 E.

The Wasatch formation overlies the Fort Union formation. It consists of gray clay, yellow sandstone, and some coal. The beds should yield some supplies of water resembling in quality those obtained from the underlying Tongue River member, but as they are found only in the higher, more rugged, and thinly inhabited parts of the Rosebud Mountains, few attempts have yet been made to develop water supplies from them. Small springs are adequate for existing needs.

T. 8 S., R. 37 E.

The Lance formation is at the surface in the western part of T. 8 S., R. 37 E. It is overlain by the Fort Union formation and the Wasatch formation. The water-bearing properties of these formations are described under T. 1 N., Rs. 36 and 37 E., and T. 7 S., R. 37 E.

T. 9 S., R. 37 E.

The Fort Union formation is the oldest one that crops out in T. 9 S., R. 37 E.; its water-bearing properties are described under T. 1 N., R. 37 E. The Wasatch formation overlies the Fort Union formation in the high and rugged parts of the Rosebud Mountains; its water-bearing properties are described under T. 7 S., R. 37 E.

T. 1 N., R. 38 E.

The upper or Tongue River member of the Fort Union formation is exposed in T. 1 N., R. 38 E., the Lebo shale member not appearing at the surface. The Tongue River member consists chiefly of sandstones, shales, and coal beds, and is usually a fairly good water bearer, from which adequate domestic supplies are obtainable in this township at depths of less than 200 feet.

In the SW¼ sec. 22, on the property of J. Dyckman, a small perennial spring flows a few gallons a minute, and the water is used for domestic purposes and considered good by the users. In the SE¼ sec. 30 a drilled well 181 feet deep on the property of J. L. Wolf yields a small supply that is reported as soft by the users. The water comes from a sandstone 167 feet below the surface and rises 17 feet in the well. In the SW¼ of the same section, at the school house, a drilled well yields a fair supply of water reported as good but hard. In the NW¼ sec. 34, on the property of J. Dyckman, a drilled well 88 feet deep yields an adequate supply of water used for domestic purposes but reported as having a "soda taste." This water, which was encountered just below a coal seam near the bottom, rises nearly 60 feet in the well. In the SW¼ sec. 34, the Tennessee-Montana Oil & Gas Co.'s well 1 encountered small amounts of poor water, reported as bitter, at 75 and 115 feet, with good water at 335 feet and 615 to 620 feet. A drilled well 180 feet deep on the property of W. G. Cooley, in the NE¼ sec. 36, yields a large supply of water used for domestic purposes and irrigation. The water, which contains 2,026 parts per million of total dissolved solids and 1,130 parts per million of hardness, rises within 30 feet of the surface. (See analysis 31, p. 155.) This well encountered water at seven horizons, but the bulk of the water comes from shale near the bottom. This well when pumped for 72 consecutive hours at the rate of about 10 gallons a minute did not go dry. The small garden irrigated with this water was in excellent shape. There are several more drilled wells in this section, ranging from 80 to 125 feet in depth, and all are reported as yielding adequate supplies of good water. Dug wells in the coulees should yield small amounts of water. In this township most wells report coal seams, usually thin ones, which yield some water.

The alluvium is confined to the valley of the East Fork of Sarpy Creek and is probably rather thin. It should yield water, some of which might be usable for domestic purposes. Few wells have been dug in these unconsolidated beds, most ranches having drilled wells that obtain adequate supplies from the Tongue River member of the Fort Union formation.

T. 1 S., R. 38 E.

T. 1 S., R. 38 E., is a small township; the northern tier of sections is less than half a mile in width north and south, and the entire western tier is missing. The boundary line of the Crow Indian Reservation runs east across the middle of secs. 8, 9, and 10 and turns south along the line between secs. 10 and 11 to the south boundary of the township.

The Fort Union formation is at the surface over all of this township, except for a small area in the valley of Sarpy Creek, where it is overlain by Quaternary alluvium. Drilled wells should yield small to medium supplies of water at depths not exceeding 200 feet, as in T. 1 N., R. 38 E. Dug wells properly located in the coulees should yield adequate though hard water for domestic use at depths not exceeding 25 feet.

The Quaternary alluvium in the Sarpy Creek Valley is of small areal extent and probably thin. It may yield small supplies of water and should be tested, preferably by dug wells, on account of their low cost and ease of construction.

T. 2 S., R. 38 E.

The western tier of sections is missing in T. 2 S., R. 38 E. The Fort Union formation is the only one cropping out in the township. Its water-bearing properties are described under T. 1 N., R. 38 E.

T. 3 S., R. 38 E.

T. 3 S., R. 38 E., like the townships to the north, lacks the western tier of sections. The Fort Union formation is the oldest one that crops out in this township. Its water-bearing properties are discussed under T. 1 N., R. 38 E.

T. 4 S., R. 38 E.

T. 4 S., R. 38 E., also lacks the western tier of sections. The only formation cropping out in this township is the Fort Union formation, of which the upper or Tongue River member alone is exposed. The water-bearing possibilities of the Fort Union formation are described under T. 1 N., R. 38 E.

T. 5 S., R. 38 E.

T. 5 S., R. 38 E., lacks the western tier of sections. The Fort Union formation is at the surface and is represented by the upper or Tongue River member. The lower or Lebo shale member is everywhere concealed. The water-bearing possibilities of this formation are described under T. 1 N., R. 38 E.

T. 6 S., R. 38 E.

T. 6 S., R. 38 E., lacks parts of secs. 4 and 5 as well as the western tier of sections. The only formation cropping out is the Fort Union formation. Its water-bearing properties are described under T. 1 N., R. 38 E.

T. 7 S., R. 38 E.

T. 7 S., R. 38 E., lacks the western tier of sections. The oldest formation cropping out is the Fort Union, of which the upper or Tongue River member is at the surface. Its water-bearing possibilities are described under T. 1 N., R. 38 E. The Wasatch formation, which overlies the Fort Union, is at the surface in part of this township. Its water-bearing properties are described under T. 7 S., R. 37 E.

T. 8 S., R. 38 E.

The Crow Indian Reservation boundary line cuts irregularly through the next to easternmost tier of sections in T. 8 S., R. 38 E., which, unlike the other townships to the north in this range, has 36 sections. The Tongue River or upper member of the Fort Union formation is the oldest rock that crops out in the township; its water-bearing properties are described under T. 1 N., R. 38 E. The Wasatch formation, which overlies the Fort Union, is at the surface over the larger part of the western half of the township; its water-bearing properties are described under T. 7 S., R. 37 E.

T. 9 S., R. 38 E.

The Crow Indian Reservation boundary line follows approximately the section line between the two eastern tiers of sections in T. 9 S., R. 38 E. The oldest formation cropping out in this township is the Fort Union, the Tongue River member of which is at the surface. The ground-water conditions in the Fort Union formation in this township are similar to those described under T. 1 N., R. 38 E. The Wasatch formation overlies the Fort Union. Its water-bearing properties are described under T. 7 S., R. 37 E.

T. 10 S., R. 38 E.

The southern boundary of Montana forms the southern boundary of T. 10 S., R. 38 E., which consists of only six short sections, nos. 1 to 6. The Fort Union and Wasatch formations are the only ones at the surface in this area. The water-bearing properties of these formations are described under T. 1 N., R. 38 E., and T. 7 S., R. 37 E.

T. 1 N., R. 39 E.

Only the southwest quarter of T. 1 N., R. 39 E., is in Big Horn County, the remainder being part of Rosebud County. The only formation cropping out in this township is the Fort Union formation, the water-bearing properties of which are described under T. 1 N., R. 38 E.

T. 1 S., R. 39 E.

Only the west half of T. 1 S., R. 39 E., is in Big Horn County, the other half being in Rosebud County. The Fort Union formation is the only one cropping out in the township; the lower or Lebo shale member is concealed, and the upper or Tongue River member is at the surface. A small spring in sec. 6, on the property of W. G. Cooley, flows several gallons a minute; the water is reported as good and used for domestic purposes. Small springs now afford a sufficient supply for most of the inhabitants, but wells may be needed in the future. Drilled wells should be successful at depths not exceeding 300 feet. except in the roughest part of the mountains; dug wells in coulees should not be more than 30 or 40 feet deep but may yield rather highly mineralized water that can be used only for stock.

T. 2 S., R. 39 E.

Of the part of T. 2 S., R. 39 E., that lies in Big Horn County, part is in the Crow Indian Reservation and part in the Tongue River Indian Reservation. The upper or Tongue River member of the Fort Union formation is at the surface over the entire township. Its water-bearing properties are described under T. 1 N., R. 38 E.

T. 3 S., R. 39 E.

The town of Busby, in sec. 31, T. 3 S., R. 39 E., is the seat of an Indian school and a subagency for the Tongue River Indian Reservation. The Fort Union formation is at the surface everywhere except along Rosebud Creek, where it is covered with a thin layer of Quaternary alluvium. The lower or Lebo shale member of the Fort Union is everywhere concealed, and the upper or Tongue River member is at the surface. The well at the United States Indian school in the SE¼NE¼ sec. 31 is 295 feet deep, and the water rises within 25 feet of the surface. This well is a strong one, as pumping at the rate of about 225 gallons a minute for 24 hours did not make it go dry. The water is used for domestic purposes and contains 1,182 parts per million of total dissolved solids and 569 parts per million of hardness. (See analysis 32, p. 155.) This water is reported as causing a heavy scale but without corrosive effect on boiler tubes. The Tongue River member is a good source of ground water. Wells yielding as large quantities as the one described are uncommon, but drilled wells should strike adequate domestic supplies at depths not exceeding 300 feet. Dug wells in favorable places in the coulees should yield a fair amount of water, but most of it will be hard.

The Quaternary alluvium along Rosebud Creek covers the Fort Union formation to a variable depth. In the NE¼NE¼ sec. 31 a dug well 2 feet in diameter and 32 feet deep yields an adequate supply of water for 15 people. The water, which stands 8 feet deep in the well, is used for domestic purposes and is considered good by the users. The alluvium should in general yield medium supplies of water that can be used for domestic purposes, although rather hard and highly mineralized.

T. 4. S., R. 39 E.

All of T. 4 S., R. 39 E., is in the Tongue River Indian Reservation and is relatively rough upland with very few inhabitants. The Tongue River member of the Fort Union formation is at the surface over the entire township, except in the northwest corner, where there is some Quaternary alluvium along Rosebud Creek. Notes on the water-bearing properties of these beds are given under T. 3 S., R. 39 E.

T. 5 S., R. 39 E.

The southern boundary of the Tongue River Indian Reservation coincides with the southern township line of T. 5 S., R. 39 E. The only formation cropping out is the Fort Union formation, the Tongue River member of which is at the surface over the entire area. Notes on the water-bearing probabilities of these rocks are given under T. 3 S., R. 39 E.

T. 6 S., R. 39 E.

Rosebud Creek flows northward through the next to the westernmost tier of sections of T. 6 S., R. 39 E., and drains practically all of it. The Fort Union formation is at the surface over the entire township, except along Rosebud Creek, where there is some Quaternary alluvium. The Lebo shale member of the Fort Union is nowhere exposed, the Tongue River member being at the surface. In the NW¼ sec. 8 a dug well 17 feet deep and 3 feet in diameter, on the property of J. T. Crownover, yields a small supply of water that is used for domestic purposes. The water is obtained from a red shale 1 foot thick at the bottom of the well and rises 4 feet above the top of the shale. A dug well on the property of the Middle Fork Co., in the NW¼ sec. 32, is about 35 feet deep and yields an adequate supply of water which is reported as "hard" by the users. The well passes through the alluvium into the shale at 25 feet, where water was encountered but was cased out. Shale at 30 and 35 feet below the surface supplies the major part of the water. These wells indicate that favorably situated dug wells should yield adequate domestic supplies at relatively shallow depths.

The Quaternary alluvium is confined to a narrow strip along both sides of Rosebud Creek. A dug well 18 feet deep in the SW¼ sec. 32, on the property of W. B. Johnson, is 18 feet deep and yields an adequate supply for household use. In the same section the dug well of Ben Sullivan, 22 feet deep, yields an adequate domestic supply of water containing 1,024 parts per million of total dissolved solids and 799 parts per million of hardness. (See analysis 33, p. 155.)

T. 7 S., R. 39 E.

The rough upland country in T. 7 S., R. 39 E., is very thinly settled. The upper or Tongue River member of the Fort Union formation is at the surface, except in the more mountainous parts, where it is overlain by the Wasatch formation. A 6-inch drilled well 56 feet deep, in sec. 20, on the property of Mrs. F. Kollman, yields a supply of water adequate for domestic purposes, although reported as hard by the users. The water enters the well from a coal bed 54 feet below the surface. The Tongue River member is a fairly good water-bearing formation, in which drilled wells are usually successful at depths of less than 300 feet, and dug wells in coulees yield small supplies at depths of less than 30 feet.

A few small areas of the Wasatch formation have escaped removal by erosion. On account of their elevated position and small extent they are unimportant as sources of ground water.

T. 8 S., R. 39 E.

T. 8 S., R. 39 E., lacks the western tier of sections. The Fort Union formation is the oldest one that crops out in this township. The lower or Lebo shale member is not exposed, and the Tongue River member is at the surface everywhere in the township. In the SW¼ sec. 12 a drilled well 106 feet deep on the property of Frank Robke yields an adequate domestic supply. The water, which comes from blue clay 100 feet below the surface, contains 3,236 parts per million of total dissolved solids and 1,633 parts per million of hardness. (See analysis 34, p. 155.) The Tongue River member of the Fort Union formation is usually a good water bearer, water being obtainable by drilled wells at depths not exceeding 300 feet and commonly less, but the analysis shows that some of the water may be rather highly mineralized. There should be little difficulty in obtaining small supplies from dug wells properly located in coulees at depths not exceeding 35 feet. The water may be hard and rather highly mineralized.

The Wasatch formation, which overlies the Fort Union formation, remains only in the interstream areas. Small supplies of water that can be used for domestic purposes should be obtainable from these beds. Drilled wells should yield small supplies at depths of less than 300 feet, and dug wells carefully located in coulees should be successful at depths of less than 30 or 35 feet.

T. 9 S., R. 39 E.

The south boundary of T. 9 S., R. 39 E., coincides with the Montana-Wyoming boundary. This township, like the one immediately north, lacks the western tier of sections. The Tongue River member of the Fort Union formation is the oldest formation that crops out. The Fort Union is overlain by the Wasatch formation. The water-bearing properties of these formations here are probably the same as in T. 8 S., R. 39 E.

T. 2 S., R. 40 E.

The northern third of T. 2 S., R. 40 E., is in Rosebud County, but the southern two-thirds is in Big Horn County and forms part of the Tongue River Indian Reservation. Rosebud Creek, which drains most of the area, flows across the southeast corner. The Tongue River member of the Fort Union formation is at the surface over the entire township, except along Rosebud Creek, where it is covered by a layer of Quaternary alluvium. The country is rough and chiefly open range, and there has been little need of developing water supplies, as small springs suffice for the stock. Notes on the water-bearing possibilities of the rocks are given under T. 3 S., R. 39 E.

T. 3 S., R. 40 E.

Rosebud Creek flows across the northwest corner of T. 3 S., R. 40 E., which is part of the Tongue River Indian Reservation. Except for a narrow strip in the valley of Rosebud Creek, where it is covered by a layer of Quaternary alluvium, the Tongue River member of the Fort Union formation is at the surface over the entire township. Notes on the water-bearing properties of these formations are given under T. 3 S., R. 39 E.

T. 4 S., R. 40 E.

The only formation cropping out in T. 4 S., R. 40 E., is the Fort Union, of which only the upper or Tongue River member is at the surface, the Lebo shale member being everywhere concealed. Its water-bearing properties are noted under T. 3 S., R. 39 E.

T. 5 S., R. 40 E.

All of T. 5 S., R. 40 E., is in the Tongue River Indian Reservation, and most of it is open range, with few inhabitants. The Tongue River member of the Fort Union formation is at the surface over the entire township. Its water-bearing properties are noted under T. 3 S., R. 39 E.

T. 6 S., R. 40 E.

The Fort Union formation is the only one that crops out in T. 6 S., R. 40 E. The lower or Lebo shale member is everywhere concealed, but the upper or Tongue River member is at the surface. The water-bearing properties of the Tongue River member in this area are described fully under T. 9 S., R. 40 E.

T. 7 S., R. 40 E.

The Tongue River member of the Fort Union formation is at the surface everywhere over T. 7 S., R. 40 E. Its water-bearing properties are described under T. 9 S., R. 40 E.

T. 7½ S., R. 40 E.

T. 7½ S., R. 40 E., consists of one tier of short sections, nos. 31 to 36, and has an area of about 4 square miles. The only rocks cropping out in the township belong to the Tongue River member of the Fort Union formation, the water-bearing properties of which are described under T. 9 S., R. 40 E.

T. 8 S., R. 40 E.

The Tongue River flows northward through the eastern part of T. 8 S., R. 40 E. The Tongue River member of the Fort Union formation is well exposed in this area and is at the surface everywhere except along the river, where it is covered to a variable depth with Quaternary alluvium. In the SW¼ sec. 34 a large spring familiarly known as Big Spring flows several gallons a minute of water that is reported as good. Some wells have been sunk in this section in the Fort Union formation, but definite information concerning them was not available. The water-bearing properties of this member of the Fort Union are described under T. 9 S., R. 40 E.

The Quaternary alluvium is confined to the valley of the Tongue River, where it is used as a source of ground water to a slight extent. Little definite information was available concerning the water-bearing properties of the alluvium except that it yielded considerable water to shallow dug wells and that the water was much harder than either river water or water from wells in the Tongue River member.

T. 9 S., R. 40 E.

The Tongue River flows northward across T. 9 S., R. 40 E., in a broad valley filled with alluvium, between uplands of the Fort Union formation. The Tongue River member of the Fort Union is at the surface everywhere in the township, except where covered by Quaternary alluvium in the river valley. The outcropping beds of sandstone are almost vertical at many places and form rim rocks or steep slopes covered with a thin growth of pines. In sec. 4, on the property of D. Herrington, a 4-inch drilled well 112 feet deep yields a small domestic supply. The water comes from shale near the bottom and is under little head, as it rises but a few feet in the casing. As in most wells that obtain their supply from shale, the yield is small, about 2 gallons a minute. The water is reported by the users as good, though having a "soda taste." In the NE¼ sec. 9, also on the property of D. Herrington, a 4-inch drilled well 150 feet deep yields a small domestic supply, which is reported to have a "soda taste." The water is reported to come from a sandstone near the bottom and rises 50 feet in the casing, which is not a large head. The well yields about 20 gallons of water every 15 minutes, a rather small yield from a well which is supposed to obtain its supply from sandstone. This water contains 2,550 parts per million of total dissolved solids and has a hardness of 660 parts per million. (See analysis 35, p. 155.) A spring on the property of J. W. Thompson, in sec. 16, yields several gallons of water a minute, which is used for domestic purposes. This water contains 464 parts per million of total dissolved solids and 314 parts per million of hardness. (See analysis 36, p. 155.) In the NE¼ sec. 21 the Absaroka Oil Co. drilled a well 3,360 feet deep in which some water was obtained at a depth of 150 to 202 feet and a greater amount at 258 to 273 feet. At 1,300 feet, it is reported, an artesian flow was encountered, which stopped, however, soon after the casing was withdrawn. No information was available concerning the quality of the water. Although the Tongue River member of the Fort Union formation is normally a good water bearer, the showing of these wells is not impressive and indicates that some difficulty may be experienced in obtaining domestic supplies of desirable quality from this formation. The wells described show that small supplies for domestic use are obtainable by drilled wells with depths ranging from 100 to 300 feet. Dug wells favorably located in coulees may yield at depths not exceeding 30 feet fairly large though highly mineralized supplies that can be used for domestic purposes.

The Quaternary alluvium should yield considerable volumes of water, but wells in the alluvium are not used to a large extent because the water is reported as harder and more highly mineralized than that from the river or from the underlying rocks. In spite of its higher mineralization, this water is valuable for stock, especially where wells in the Tongue River member yield only small supplies and also in winter when other sources are frozen.

T. 7½ S., R. 41 E.

The total area of T. 7½ S., R. 41 E., is about 4 square miles, as it consists of one tier of short sections, nos. 31 to 36. The Tongue River flows northeastward through secs. 32 and 33. The Tongue River member of the Fort Union formation forms the uplands above the river valley. These rocks should yield adequate domestic supplies; their water-bearing properties are described under T. 9 S., R. 40 E. The Quaternary alluvium in the river valley should yield considerable amounts of water suitable for stock.

T. 8 S., R. 41 E.

The Tongue River flows across the northwestern part of T. 8 S., R. 41 E. The Tongue River member of the Fort Union formation is at the surface everywhere except in the river valley, where the Quaternary alluvium covers it, and in the southeastern part of the township, where it is overlain by the Wasatch formation. The Tongue River member should be a fairly good source for small domestic supplies of water. The information concerning the Fort Union formation and the Quaternary alluvium given under T. 9 S., R. 40 E., should apply also to this township.

The sandstones in the Wasatch formation should yield some water usable for domestic purposes. Drilled wells should be successful at depths of less than 300 feet; and dug wells should yield small supplies at depths of 35 feet or less if they are properly located in the coulees. Very few wells have been dug or drilled, but it is reported that some efforts to obtain water have been unsuccessful, and local people consider the area between the Tongue River and Hanging Woman Creek one in which it is difficult to develop ground-water supplies.

T. 9 S., R. 41 E.

The only formations that crop out in T. 9 S., R. 41 E., are the Fort Union and Wasatch. The water-bearing possibilities of the Fort Union formation are noted under T. 9 S., R. 40 E., and those of the Wasatch under T. 8 S., R. 41 E.

TPS. 8 AND 9 S., RS. 42, 43, AND 44 E.

The area included in Tps. 8 and 9 S., Rs. 42 to 44 E., is an open rolling to rough upland in which the Tongue River member of the Fort Union formation and the Wasatch formation crop out. In some areas the steep slopes formed by the resistance to erosion of the sandstone and clinker beds of the Tongue River member are covered with a sparse growth of pines. Much of the higher land is almost level and is a remnant of an old erosion surface. The excellent grass on this surface, together with the available shelter of the trees and rim rock, made this region an almost ideal cattle country, and in years past cattle raising was the main industry. The perennial Tongue River and Hanging Woman Creek, with some of their tributaries and some springs, afforded adequate water supply. In recent years access to water has become increasingly difficult, owing to fencing of land taken up as homesteads. The region is still thinly settled, however, and many of the holdings are large tracts which are used for grazing. Wells that would yield large supplies of water suitable for stock are badly needed, but so far as known few wells have been drilled. Although definite information concerning these wells is not available, it is reported that there has been considerable difficulty in obtaining adequate supplies of water. The wells in T. 9 S., R. 40 E., that end in the Tongue River member of the Fort Union formation indicate that the sandstones of this formation can be depended upon to furnish small but adequate supplies of water suitable for domestic purposes. The Absaroka Oil Co.'s well shows that in some places a large supply might be obtained at the base of the Tongue River member by drilling deep wells, but it is improbable that the water would overflow from the wells located on the uplands. The Wasatch formation, which overlies the Fort Union, apparently becomes more shaly and contains fewer beds of sandstone east of the Tongue River. In this area the Wasatch formation is apparently a poor source of ground water, and the meager supplies it yields are said to be rather highly mineralized. Shallow dug wells of large diameter carefully located in coulees may yield considerable quantities of water for stock. The water would have to be pumped from the wells to the watering troughs.

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