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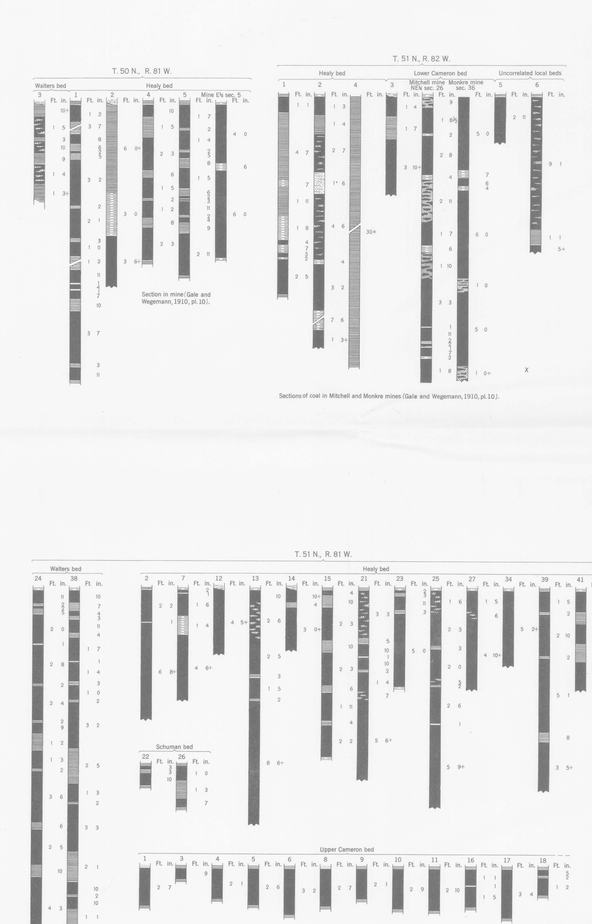
COAL INVESTIGATIONS
MAP C 23 (SHEET 2 OF 2)

GEOLOGY AND COAL RESOURCES OF THE LAKE DE SMET AREA, JOHNSON COUNTY, WYOMING

By
William J. Mapel
1954



THE GEOLOGY AND COAL RESOURCES OF THE LAKE DE SMET AREA, JOHNSON COUNTY, WYOMING

By William J. Mapel

INTRODUCTION

The Lake De Smet area comprises about 340 square miles in northern Johnson County, Wyo. Investigation of this area was undertaken as part of the program of the Department of the Interior for the development of the Missouri River Basin with the purposes of determining its coal reserves and of evaluating its oil and gas possibilities. Field work was done during the summers of 1949 and 1950. The author was assisted in 1949 by R. H. Dott, Jr.

In the late fall of 1950 the writer supervised the drilling of four core holes near the north end of Lake De Smet from which information was obtained on the coal deposits in that area. The U. S. Bureau of Reclamation supplied logs of 25 shallow borings drilled from 1944 through 1950 near Lake De Smet as part of their investigation of the lake as a possible reservoir site; and that bureau furnished topographic maps of the area made in 1946–47 by Fairchild Aerial Surveys, Inc., J. E. Rice of Sheridan, Wyo., supplied the logs of four holes drilled near the north end of the lake in August and September 1950, and Carl Hepp contributed the log of a well drilled in 1944 on his island.

GEOGRAPHY

The Lake De Smet area lies on the eastern flank of the Big Horn Mountains and the western margin of the Powder River Basin. The east flank of the mountain is a steep, pine-covered slope that rises abruptly 2,000 to 3,000 feet above the adjacent foothills and plains. Smoothly rounded grassy hills and broad gravel-capped terraces characterize the foothills in a belt 3 to 5 miles wide at the base of this mountain slope. Farther eastward the country is characterized by steep ridges and divides the sides of which are trenched by narrow ravines. Altitudes are as high as 8,000 feet along the mountainous western edge of the area, and they range from 5,500 to about 4,200 feet in the foothills and plains.

Lake De Smet is about 3 miles long, a mile wide, and 60 feet deep and lies in the northern part of the area in a natural undrained basin on the divide between Piney and Boxelder Creeks.

Buffalo, at the junction of U. S. Highways 87 and 16, is the only town in the area. The nearest railroad shipping points are at Clearmont and Sheridan, about 29 miles northeast and 34 miles north respectively of Buffalo. Both of these towns are on the Chicago, Burlington, & Quincy Railroad.

STRATIGRAPHY

The combined thickness of sedimentary rocks exposed in the Lake De Smet area is about 17,500 feet. All geologic periods from the Cambrian to the Quaternary are represented, with the exception of the Silurian and Devonian. Pre-Cambrian igneous and metamorphic rocks, which underlie the sedimentary sequence unconformably, crop out in the core of the Big Horn Mountains. The accompanying composite stratigraphic section shows the lithology of the formations of Paleozoic and Mesozoic ages exposed in the mapped area. Tertiary and Quaternary rocks in the area are described below.

Fort Union formation.—The Fort Union formation, which is Paleocene in age, conformably overlies the Lance formation of Cretaceous age and is unconformably overlapped by the Wasatch formation of Eocene age. The Fort Union is approximately 5,900 feet thick about 10 miles south of the Lake De Smet area, where a complete sequence of beds crops out (R. K. Hose, oral communication). At this locality the formation consists of interbedded lightgray sandstone, pale olive-green claystone, gray siltstone, and brown carbonaceous shale. Dark-red ferruginous sandstone concretions occur in sandstone beds throughout the formation but are particularly numerous near the base. Beds of carbonaceous shale are thicker and more numerous in the upper two-thirds of the formation than in the lower one-third. Thin lenses of poorly consolidated limestone- and chert-pebble conglomerate crop out locally in the upper 500 feet.

The contact of the Fort Union with the underlying Lance formation is gradational through an interval of 100 to 200 feet. Beds below the contact are characterized by massive lenticular sandstone, whereas those above it consist mainly of thin-bedded sandstone containing thin stringers of carbonaceous shale and numerous ferruginous concretions.

Less complete sections of the Fort Union formation are exposed within the mapped area at Mowry Basin and south of Bald Ridge. At Mowry Basin an angular unconformity divides the Fort Union formation into two members. The lower member has a maximum exposed thickness of about 1,000 feet. Its thickness is variable, however, and at places the member is absent, owing to overlap of the upper member. The lower member is similar in lithology to the lower part of the Fort Union formation to the south. The upper member, with a maximum exposed thickness of about 1,200 feet, contains in the basal 200 to 300 feet lenticular beds of conglomerate 1 to 20 feet thick. Rock fragments comprising the conglomerates are subrounded to angular pebbles and cobbles of limestone, dolomite, and chert. They are embedded in a matrix of coarse-grained light-gray sandstone and pink and green sandy shale. This conglomeratic sequence grades upward into a very poorly exposed sequence of sandstone and shale that constitutes the remainder of the formation.

On the basis of lithologic similarity, the upper member of the Fort Union formation at Mowry Basin may represent the upper 900 feet of conglomeratic strata in the Fort Union formation noted 25 miles to the south, and the angular unconformity at Mowry Basin may represent as much as 2,600 feet of strata in the lower and middle parts of the formation that locally have been removed by erosion prior to deposition of the upper member. No fossils other than fragmentary and indiagnostic plant remains were found in the Fort Union formation.

Wasatch formation.—The Wasatch formation, of Eocene age, forms the surface of most of the Lake De Smet area. Near the mountains an angular unconformity divides the formation into two lithologically distinct members. The lower of these is the Kingsbury conglomerate member, and the upper is the Moncrief member. Eastward from the mountains the two members grade laterally into a single nonconglomeratic sequence of sandstone, shale, and coal that could not be subdivided. This fine-grained sequence makes up the Wasatch formation east of Buffalo and Lake De Smet.

The Kingsbury conglomerate member of the Wasatch formation in 200 to about 800 feet thick and consists of lenticular beds of conglomerate 20 or more feet thick interstratified with beds of light-gray and light greenish-gray shale and sandy shale. Subrounded pebbles, cobbles, and boulders of limestone and dolomite, derived from formations of Paleozoic and Mesozoic ages exposed in the Big Horn Mountains, make up the larger rock fragments in the conglomerate. Black and gray chert pebbles are a common minor constituent, and a few pebbles of pre-Cambrian crystalline rocks occur locally in the upper beds. These rock fragments are embedded in a coarse-grained sandstone matrix.

The Kingsbury conglomerate member rests unconformably on underlying formations with an angular discordance of as much as 45° near Sand Draw, in the southwestern part of the area. This discordance decreases markedly eastward from the mountains; and about 10 miles southeast of the mapped area, where the Kingsbury grades into finer-grained sediments, beds at the base of the Wasatch formation are conformable with those in the underlying Fort Union formation. Similarly, in the W½ sec. 33, T. 52 N., R. 83 W., massive beds of conglomerate at the base of the Kingsbury overlie conglomerates in the Fort Union formation with a discordance of about 25°, whereas a mile to the northeast along Rock Creek the basal beds of the Kingsbury, which here contain only a few stringers of conglomerate, rest on the Fort Union formation with little if any discordance in dip.

The Kingsbury grades upward by decrease in the number of conglomeratic beds into lightgray sandstone and lightbrown and green sandy shale. The upper contact of the Kingsbury is placed at the top of the main conglomeratic mass; however, thin lenticular beds of conglomerate occur locally in the basal part of the next younger sequence of rocks throughout a thickness of several hundred feet.

A few fragile mollusk shells collected by R. K. Hose in 1950 from conglomeratic beds on the east side of Kingsbury Ridge in T. 50 N., R. 83 W., have been identified by T. C. Yen as *Pisidium* sp. under., *Viviparus* sp. under., *Hydobia? eulimoides* Meek, *Goniobasis* cf. *G. tenera* (Hall), *Physa* cf. *P. longiscala* Meek and Hayden, *Macrocyclus* sp. under., *Viviparus* cf. *V. retusus* Meek and Hayden, and *Discus* cf. *D. ralstonensis* (Cockerell). Yen states (written communication of 12/15/50 to W. J. Mapel) that this collection contains a mixed fauna, some of the fossils being related to species of Paleocene age and some to species of early Eocene age, but that *Discus ralstonensis* (Cockerell) has been reported so far only from lower Eocene rocks.

The Moncrief member of the Wasatch formation was named originally the Moncrief gravel by Sharp (1948) from exposures on Moncrief Ridge, about 6 miles north of the mapped area. It is best exposed and is thickest in the Lake De Smet area at North and Bald Ridges, where it consists of about 1,400 feet of poorly stratified conglomerate, composed of boulders, cobbles, and pebbles of pre-Cambrian igneous and metamorphic rocks interbedded with lenses of light-gray coarse-grained arkosic sandstone. Granite and gneiss make up most of the larger rock fragments. Boulders 5 to 10 feet in maximum dimension are common in the upper beds of the deposit; a few are much larger. The conglomeratic sequence grades downward and interfingers eastward with a sequence of lightgray poorly sorted coarse-grained sandstone, grayish-green siltstone, and green shale.

Sharp (1948, p. 1) defines the boundaries of the member as follows: "The present topographic surface determines the top of the unit...the lowermost and uppermost gravel bed containing primarily of pre-Cambrian rock debris" determines the base. For convenience in mapping, the base of the Moncrief member as used in this report includes above it only the main conglomeratic mass, disregarding laterally equivalent strata that may contain thin beds of conglomerate but that are predominantly fine-grained.

Where the Moncrief member is closest to the mountain flank, an angular unconformity separates the Moncrief from the underlying Kingsbury conglomerate member. North of Johnson Creek, in the NE¼ sec. 29, T. 51 N., R. 83 W., the Kingsbury dips about 60° E., whereas higher on the same slope the overlying Moncrief is nearly horizontal. Likewise, in the vicinity of Sand Draw, in the southwestern corner of T. 50 N., R. 82 W., the Kingsbury dips from 25° to 42° E., whereas a few hundred yards to the north, on Bald Ridge, the Moncrief member and associated fine-grained sandstone and sandy shale dip less than 5° E.

Brown (1948, p. 1170) recognized plant remains of Eocene age from the lower slopes of Bald Ridge near the level of Clear Creek (sec. 6, T. 50 N., R. 83 W.). Beds at this stratigraphic horizon grade laterally into the lower part of the Moncrief member. He also has found vertebrates of Eocene age at about the same horizon nearby in the NE¼ sec. 27, T. 50 N., R. 82 W. (Brown, 1948, p. 1169).

Strata that crop out east of Buffalo and Lake De Smet belong to the upper and middle parts of the Wasatch formation and consist of about 800 feet of interbedded lightgray and lightyellowish-gray sandstone, gray shale, brown carbonaceous shale, and low-rank subbituminous coal. Individual lithologic units other than some of the coal beds have little continuity or extent. Beds of fine-grained fairly well sorted sandstone make up about 50 percent of the formation a few miles east of the lake. These beds thicken, become more numerous, and are coarser grained westward toward the mountains.

Tertiary rocks, undifferentiated.—Deposits of possible Oligocene or Miocene age cover small areas on the valley sides of Clear Creek and one of its tributaries in the upland region of the Big Horn Mountains. The rocks consist of boulders and cobbles of pre-Cambrian crystalline rocks in a poorly stratified matrix of coarse-grained arkosic sandstone and brown sandy clay. Their distribution suggests that they are remnants of more extensive deposits that filled valleys and canyons of an old land surface.

Stream terrace deposits.—Deposits of stream-worn gravel, sand, and silt cap terraces along Piney, Shell, Rock, French, Clear, Bull, and Dry Creeks. The gravels consist of cobbles and pebbles of pre-Cambrian rocks and to a lesser extent of limestone and dolomite of Paleozoic age. They lie at no great main levels, which are designated Qt 1 for the youngest and lowest, Qt 2 and Qt 3 for those of intermediate age and height, and Qt 4 for the oldest and highest. Terraces adjacent to the mountains have a pronounced basinward gradient that is greatest on the lower levels; thus upslope the levels tend to merge.

Pediment deposits.—Deposits of gravel 5 to 10 feet thick made up largely of angular to subrounded fragments of limestone and sandstone as much as 18 inches in longest dimension rest on flat interstream divides near Mowry Basin and Bald Ridge. These gravels lie on pediment surfaces that rise toward the mountains with an increasing gradient and at many places merge into steep slip slopes on Tensleep sandstone. Downslope the gravels merge into terrace deposits at the level of Qt 2.

Colluvium.—The deposits shown as colluvium on the accompanying geologic map are heterogeneous aggregates of rock detritus such as talus and slope wash resulting from the transporting action of gravity. Colluvium is shown on the geologic map only where it is so thick or extensive that the bedrock could not be mapped with reasonable accuracy. One such deposit covers an area of about half a square mile mostly in sec. 13, T. 52 N., R. 84 W., and another covers an area of about three-fourths of a square mile in sec. 17, T. 51 N., R. 83 W., and parts of adjoining sections to the north and west. Both deposits include a large proportion of granitic debris ranging in size from sand to boulders as much as 4 feet across that were shed from cliffs of granite a short distance away.

Alluvium.—Narrow bands of Recent alluvium lie along most of the permanent and many of the intermittent streams in the Lake De Smet area. The deposits consist of silt and sand interspersed with lenses of gravel. Along Piney, Shell, and Clear Creeks alluvium and deposits of gravel on low terraces 10 to 25 feet above the present streams were mapped as alluvium and terrace deposits undifferentiated.

Landslide material.—Areas covered by landslides occur at several places in the Lake De Smet area, the displaced material generally consisting of either the Gros Ventre and Gallatin formations undifferentiated and overlying formations of Paleozoic age or poorly consolidated beds of the Moncrief gravel and Kingsbury conglomerate members of the Wasatch formation. Two elliptical masses in sec. 17 and in the N½ sec. 20, T. 51 N., R. 83 W., are composed of large jumbled blocks of Bighorn dolomite and Madison limestone surrounded by limestone and shale of the Gros Ventre and Gallatin formations undifferentiated. These materials crop out near the crest of a high ridge formed by the Kingsbury conglomerate member of the Wasatch formation. Darton (1906, p. 92-95) described these masses as fault blocks, but no evidence could be found to show that rocks of Mesozoic age exposed in place between them and formations of Paleozoic age that form the east flank of the mountains are divided by faulting complex enough to account for the present position of the displaced material. These masses are believed to be remnants of a landslide largely removed by erosion except for the most resistant constituents, which now are perched on the Kingsbury conglomerate member.

Other areas of landslide material shown on the geologic map are near steep slopes, and the slides probably occurred during the present cycle of erosion.

STRUCTURE

Rocks of Paleozoic age flank the igneous and metamorphic core of the Big Horn Mountains, with dips as low as 20° E. on the high slopes of the range. The dips steepen along a flexure at the base of the mountains, and at many places, strata of Mesozoic age exposed in the foothills stand vertically or are overturned. The very steep dips flatten to 45° or less within 2 miles of the mountain front. Tertiary strata, which unconformably overlap older formations, dip as much as 45° in the high ridges underlain by the Kingsbury conglomerate member of the Wasatch formation but become nearly horizontal east of Buffalo and Lake De Smet.

The steep folding in pre-Tertiary rocks along the east flank of the mountains is shown on the accompanying geologic map by structure contours drawn with an interval of 500 feet on the top of the Madison limestone. Shallow, undulating folds in the Wasatch formation in the eastern part of the area are shown by structure contours drawn with an interval of 50 feet on the base of the Healy coal bed.

The Piney Creek fault, named by Dessonese (1942, p. 167-168), bounds the mountain flank for about 2 miles in the northwestern part of the Lake De Smet area and can be traced from the edge of the area northward for an additional 7 miles. Rocks of Paleozoic age west of this fault are displaced eastward an apparent horizontal distance of 1½ to 2 miles and brought against conglomerates of the Wasatch formation. Tabs everywhere conceals the fault surface, but the configuration of its trace as mapped across ridges and valleys indicates that the fault is nearly vertical. At depth the fault surface probably dips eastward beneath the displaced block.

A few fault that strikes about N. 45° E. terminates the Piney Creek fault at its south end. The trace of this tear takes a sharp bend southward at the point where it crosses the North Fork Rock Creek, and the peculiar alignment of the drainage suggests that the fault splits and a branch fault continues southwestward into the core of the range.

As Sayles Creek, south of Mowry Basin, a large block of pre-Cambrian granite is bounded on the north, east, and south by an arcuate fault that brings the granite against all formations from the Flathead sandstone to the Tensleep formation. A high-angle reverse fault nearby extends for about 2 miles from the South Fork Sayles Creek southward to Johnson Creek, bringing rocks of Paleozoic and Mesozoic ages on the west against the Kingsbury conglomerate and Moncrief members of the Wasatch formation on the east. The fault trace disappears to the north under deposits of slope wash and talus, but the fault may continue for a mile or more in nearly vertical beds of the Cody shale in secs. 5 and 8, T. 51 N., R. 83 W. To the south, a branching fault extends for about 3 miles from Johnson Creek to Clear Creek, bringing steeply dipping beds of Madison limestone against nearly flat lying beds of the Moncrief member. The fault is well exposed in a road cut along U. S. Highway 16, where it dips about 25° W.

South of Clear Creek a block including rocks of Paleozoic age and pre-Cambrian rocks is offset several hundred feet to the east along a high-angle thrust fault the trace of which curves around the northern and eastern edges of the block and extends southwestward into pre-Cambrian granite in secs. 15 and 16, T. 50 N., R. 83 W.

Pre-Tertiary rocks exposed at Mowry Basin are cut by high-angle faults at several places. The largest, with a maximum horizontal displacement of about 1,000 feet, trends northeastward for about a mile in secs. 23, 24, and 26, T. 52 N., R. 84 W., cutting all formations in turn from the Bighorn dolomite to the Mowry shale. The fault trace bends sharply northwestward in sec. 24, and the fault dies out along the bedding planes of the Mowry shale. Near the center of sec. 25 of the same township the Sundance formation is in contact with the Mowry shale along a reverse fault about three-fourths of a mile long that trends northwestward parallel to the strike of the beds.

A northeastward-trending reverse fault at least a mile long in secs. 29 and 32, T. 52 N., R. 83 W., cuts the Parkman sandstone and Beaver shale, displacing their outcrops about 800 feet northeastward on the west side of the fault. The fault trace was lost northward in the Lance formation and southward in the Cody shale.

The nearly flat lying Wasatch formation east of the mountains is relatively undisturbed by faulting; however, two faults were noted. A high-angle fault underlies Lake De Smet and extends an unknown distance northwestward from the lake beneath terrace gravels of Piney Creek. The fault surface is nowhere exposed; but tentative correlation of coal beds in closely spaced drill holes at the north end of the lake indicate that the strata east of the fault are raised about 150 feet relative to those west of it. A normal fault with vertical displacement of about 50 feet in the opposite direction extends southeastward from the lake for about a mile on the same strike.

COAL

Several persistent coal beds occur in the Wasatch formation east of Buffalo and Lake De Smet. From oldest to youngest these are: the Ucross, Murray, lower and upper Cameron, Schuman, Healy, Walters, and Monument Peak(?) beds. Ucross, Murray, Cameron, Schuman, and Monument Peak(?) are names applied in this report to hitherto unmapped coal beds. The Healy and Walters beds were named and described by Gale and Wegemann (1910, p. 153) in an early report covering the Lake De Smet and adjoining areas. In addition to these persistent coal beds, other beds of local extent crop out at various horizons in the Wasatch formation, but generally these are less than 3 feet thick and reserves of coal contained in them comprise less than 0.5 percent of the total reserves in the area. Thicknesses of beds as measured at outcrops or as reported in water wells are shown graphically by township and range in an accompanying chart. Table 1 shows the thicknesses of coal beds found in shallow holes drilled near Lake De Smet.

Stone and Lupton (1910, p. 127) correlate the Healy bed with the Lower Ulm bed of the Sheridan coal field. According to Taft (1909, p. 130) the Lower Ulm bed of the Sheridan field is about 1,100 feet stratigraphically above the top of the Tongue River coal group, or as it is now known, the Tongue River member of the Fort Union formation.

Ucross coal bed.—The Ucross bed, which is named from its occurrence near the town of Ucross, Wyo., in T. 53 N., R. 80 W., crops out along the east bank of Clear Creek in the northeastern corner of T. 52 N., R. 81 W. Its maximum observed thickness is 17 feet 3 inches, including 3 feet 3 inches of shale partings, at locality 35 in sec. 15. The coal splits about 1½ miles north of this locality, and at locality 1 in sec. 1 it occurs in a zone about 30 feet thick in four benches ranging in thickness from 6 inches to 3 feet.

Murray coal bed.—The Murray coal bed crops out along tributaries of Clear Creek in T. 52 N., R. 81 W. It is thickest at the mouth of Murray Draw (locality 88), where the coal, free of partings, is 7 feet 2 inches thick. The bed thins northeastward, and at locality 30 in sec. 7 it contains only 9 inches of coal.

Upper and lower Cameron coal beds.—These beds crop out in the northeastern part of the Lake De Smet area along tributaries of Clear Creek and along Boxelder Creek. The beds are named from exposures near Cameron Gulch 5 miles north of the mapped area in T. 53 N., R. 82 W. The maximum observed thickness of coal in the upper Cameron bed is 4 feet 3 inches in a partial exposure at locality 16, sec. 6, T. 52 N., R. 81 W. Seismographic shot hole 64, drilled in sec. 23 of the next township to the west reportedly found 10 feet of coal at the approximate horizon of the upper Cameron bed, but elsewhere, where examined at the surface, it contains less than 2 feet of coal.

The lower Cameron bed occurs 15 to 35 feet stratigraphically below the upper Cameron bed. Coal at this horizon ranges in thickness from 2 to 3 feet in most of T. 52 N., R. 81 W., but the bed thickens southwestward in T. 51 N., R. 81 W., and where exposed at locality 32, in sec. 17 of this township, it contains 8 feet 2 inches of coal, including partings of shale. It is 13 feet 7 inches thick, including thin partings, in the Grace Creek Coal Co. mine in sec. 20 (locality 37). Drillers' logs of four seismograph shot holes in secs. 7 and 18 of the same township show 7 to 10 feet of coal at the horizon of the lower Cameron bed.

Coal formerly was mined from the lower Cameron bed at the Mitchell and Monkre mines near Buffalo. According to Gale and Wegemann (1910, p. 162) the coal bed is about 125 feet and 85 feet below the surface, respectively, at these mines.

Schuman coal bed.—The Schuman coal bed is named from exposures near a cattle camp run by the Schuman ranch 5 miles east of the Lake De Smet area in secs. 27, 28, and 29, T. 52 N., R. 80 W. It crops out in the eastern part of T. 52 N., R. 81 W., with a maximum observed thickness of 3 feet 6 inches at locality 73, in sec. 24, but it thins southwestward and could not be found in adjoining townships to the west and south.

Healy coal bed.—The Healy bed, which is exposed east of Buffalo and Lake De Smet in the valleys of Piney, Boxelder, Clear, and Dry Creeks, contains half of the coal estimated for reserves of the area. At most places the Healy bed is 15 to 25 feet thick, but it thickens abruptly in the vicinity of Lake De Smet. On the eastern side of the lake, in sec. 8, T. 52 N., R. 82 W., core hole GS-26 found 52 feet of coal in the Healy bed, including thin partings of shale; and drill hole 305, 2 miles to the southeast in sec. 22 of the same township reportedly found 112 feet of coal in the Healy bed, including partings.

A bed of coal that in core holes ranges in thickness from 115 to 131 feet (holes 7, 200, A–6, A–8, GS–1, and GS–6) and in 2 holes is reported to be more than 200 feet thick (hole C and the Hepp water well) underlies an area of about 25½ square miles west of the fault at the north end of Lake De Smet. This thick bed is correlated tentatively with the Healy bed. Its extent to the north and west of the area explored by drilling is unknown. Hole D, drilled at the edge of the area in sec. 7, T. 52 N., R. 83 W., covers an area of about half a square mile mostly in sec. 13, T. 52 N., R. 84 W., and another covers an area of about three-fourths of a square mile in sec. 17, T. 51 N., R. 83 W., and parts of adjoining sections to the north and west. Both deposits include a large proportion of granitic debris ranging in size from sand to boulders as much as 4 feet across that were shed from cliffs of granite a short distance away.

Walters coal bed.—The Walters coal bed is extensively burned and has produced the clinker that caps high divides and buttes in much of the eastern part of the Lake De Smet area. The coal ranges in thickness from 25 to 35 feet; it commonly contains many thin partings of shale in isolated exposures where it remains unburned.

Monument Peak(?) bed.—The Monument Peak(?) bed is tentatively correlated with a thick bed that crops out near the summit of Monument Peak in T. 53 N., R. 82 W., about 3 miles north of the Lake De Smet area. Except for a partial exposure of a coal bed 5 feet thick in sec. 5, T. 52 N., R. 82 W. (locality 5), and the outcrop of the Monument Peak(?) bed is masked by clinker on the highest parts of the divide between Piney and Boxelder Creeks and between Boxelder and Clear Creeks.

Quality of the coal.—Coal in the Lake De Smet area varies in rank within narrow limits between lignite and subbituminous C as defined by the American Society for Testing Materials (1939). Proximate and ultimate analyses of coal from the Healy and lower Cameron beds are given in table 2.

Burning of the coal.—Some of the coal beds in the Lake De Smet area, particularly the Healy and Walters beds, have burned along most reticular constituents, which now are perched on the Kingsbury conglomerate member.

Other areas of landslide material shown on the geologic map are near steep slopes, and the slides probably occurred during the present cycle of erosion.

STRUCTURE

Rocks of Paleozoic age flank the igneous and metamorphic core of the Big Horn Mountains, with dips as low as 20° E. on the high slopes of the range. The dips steepen along a flexure at the base of the mountains, and at many places, strata of Mesozoic age exposed in the foothills stand vertically or are overturned. The very steep dips flatten to 45° or less within 2 miles of the mountain front. Tertiary strata, which unconformably overlap older formations, dip as much as 45° in the high ridges underlain by the Kingsbury conglomerate member of the Wasatch formation but become nearly horizontal east of Buffalo and Lake De Smet.

The steep folding in pre-Tertiary rocks along the east flank of the mountains is shown on the accompanying geologic map by structure contours drawn with an interval of 500 feet on the top of the Madison limestone. Shallow, undulating folds in the Wasatch formation in the eastern part of the area are shown by structure contours drawn with an interval of 50 feet on the base of the Healy coal bed.

The Piney Creek fault, named by Dessonese (1942, p. 167-168), bounds the mountain flank for about 2 miles in the northwestern part of the Lake De Smet area and can be traced from the edge of the area northward for an additional 7 miles. Rocks of Paleozoic age west of this fault are displaced eastward an apparent horizontal distance of 1½ to 2 miles and brought against conglomerates of the Wasatch formation. Talus everywhere conceals the fault surface, but the configuration of its trace as mapped across ridges and valleys indicates that the fault is nearly vertical. At depth the fault surface probably dips eastward beneath the displaced block.

A few fault that strikes about N. 45° E. terminates the Piney Creek fault at its south end. The trace of this tear takes a sharp bend southward at the point where it crosses the North Fork Rock Creek, and the peculiar alignment of the drainage suggests that the fault splits and a branch fault continues southwestward into the core of the range.

As Sayles Creek, south of Mowry Basin, a large block of pre-Cambrian granite is bounded on the north, east, and south by an arcuate fault that brings the granite against all formations from the Flathead sandstone to the Tensleep formation. A high-angle reverse fault nearby extends for about 2 miles from the South Fork Sayles Creek southward to Johnson Creek, bringing rocks of Paleozoic and Mesozoic ages on the west against the Kingsbury conglomerate and Moncrief members of the Wasatch formation on the east. The fault trace disappears to the north under deposits of slope wash and talus, but the fault may continue for a mile or more in nearly vertical beds of the Cody shale in secs. 5 and 8, T. 51 N., R. 83 W. To the south, a branching fault extends for about 3 miles from Johnson Creek to Clear Creek, bringing steeply dipping beds of Madison limestone against nearly flat lying beds of the Moncrief member. The fault is well exposed in a road cut along U. S. Highway 16, where it dips about 25° W.

South of Clear Creek a block including rocks of Paleozoic age and pre-Cambrian rocks is offset several hundred feet to the east along a high-angle thrust fault the trace of which curves around the northern and eastern edges of the block and extends southwestward into pre-Cambrian granite in secs. 15 and 16, T. 50 N., R. 83 W.

Pre-Tertiary rocks exposed at Mowry Basin are cut by high-angle faults at several places. The largest, with a maximum horizontal displacement of about 1,000 feet, trends northeastward for about a mile in secs. 23, 24, and 26, T. 52 N., R. 84 W., cutting all formations in turn from the Bighorn dolomite to the Mowry shale. The fault trace bends sharply northwestward in sec. 24, and the fault dies out along the bedding planes of the Mowry shale. Near the center of sec. 25 of the same township the Sundance formation is in contact with the Mowry shale along a reverse fault about three-fourths of a mile long that trends northwestward parallel to the strike of the beds.

A northeastward-trending reverse fault at least a mile long in secs. 29 and 32, T. 52 N., R. 83 W., cuts the Parkman sandstone and Beaver shale, displacing their outcrops about 800 feet northeastward on the west side of the fault. The fault trace was lost northward in the Lance formation and southward in the Cody shale.

The nearly flat lying Wasatch formation east of the mountains is relatively undisturbed by faulting; however, two faults were noted. A high-angle fault underlies Lake De Smet and extends an unknown distance northwestward from the lake beneath terrace gravels of Piney Creek. The fault surface is nowhere exposed; but tentative correlation of coal beds in closely spaced drill holes at the north end of the lake indicate that the strata east of the fault are raised about 150 feet relative to those west of it. A normal fault with vertical displacement of about 50 feet in the opposite direction extends southeastward from the lake for about a mile on the same strike.

COAL

Several persistent coal beds occur in the Wasatch formation east of Buffalo and Lake De Smet. From oldest to youngest these are: the Ucross, Murray, lower and upper Cameron, Schuman, Healy, Walters, and Monument Peak(?) beds. Ucross, Murray, Cameron, Schuman, and Monument Peak(?) are names applied in this report to hitherto unmapped coal beds. The Healy and Walters beds were named and described by Gale and Wegemann (1910, p. 153) in an early report covering the Lake De Smet and adjoining areas. In addition to these persistent coal beds, other beds of local extent crop out at various horizons in the Wasatch formation, but generally these are less than 3 feet thick and reserves of coal contained in them comprise less than 0.5 percent of the total reserves in the area. Thicknesses of beds as measured at outcrops or as reported in water wells are shown graphically by township and range in an accompanying chart. Table 1 shows the thicknesses of coal beds found in shallow holes drilled near Lake De Smet.

Stone and Lupton (1910, p. 127) correlate the Healy bed with the Lower Ulm bed of the Sheridan coal field. According to Taft (1909, p. 130) the Lower Ulm bed of the Sheridan field is about 1,100 feet stratigraphically above the top of the Tongue River coal group, or as it is now known, the Tongue River member of the Fort Union formation.

Ucross coal bed.—The Ucross bed, which is named from its occurrence near the town of Ucross, Wyo., in T. 53 N., R. 80 W., crops out along the east bank of Clear Creek in the northeastern corner of T. 52 N., R. 81 W. Its maximum observed thickness is 17 feet 3 inches, including 3 feet 3 inches of shale partings, at locality 35 in sec. 15. The coal splits about 1½ miles north of this locality, and at locality 1 in sec. 1 it occurs in a zone about 30 feet thick in four benches ranging in thickness from 6 inches to 3 feet.

Murray coal bed.—The Murray coal bed crops out along tributaries of Clear Creek in T. 52 N., R. 81 W. It is thickest at the mouth of Murray Draw (locality 88), where the coal, free of partings, is 7 feet 2 inches thick. The bed thins northeastward, and at locality 30 in sec. 7 it contains only 9 inches of coal.

Upper and lower Cameron coal beds.—These beds crop out in the northeastern part of the Lake De Smet area along tributaries of Clear Creek and along Boxelder Creek. The beds are named from exposures near Cameron Gulch 5 miles north of the mapped area in T. 53 N., R. 82 W. The maximum observed thickness of coal in the upper Cameron bed is 4 feet 3 inches in a partial exposure at locality 16, sec. 6, T. 52 N., R. 81 W. Seismographic shot hole 64, drilled in sec. 23 of the next township to the west reportedly found 10 feet of coal at the approximate horizon of the upper Cameron bed, but elsewhere, where examined at the surface, it contains less than 2 feet of coal.

The lower Cameron bed occurs 15 to 35 feet stratigraphically below the upper Cameron bed. Coal at this horizon ranges in thickness from 2 to 3 feet in most of T. 52 N., R. 81 W., but the bed thickens southwestward in T. 51 N., R. 81 W., and where exposed at locality 32, in sec. 17 of this township, it contains 8 feet 2 inches of coal, including partings of shale. It is 13 feet 7 inches thick, including thin partings, in the Grace Creek Coal Co. mine in sec. 20 (locality 37). Drillers' logs of four seismograph shot holes in secs. 7 and 18 of the same township show 7 to 10 feet of coal at the horizon of the lower Cameron bed.

Coal formerly was mined from the lower Cameron bed at the Mitchell and Monkre mines near Buffalo. According to Gale and Wegemann (1910, p. 162) the coal bed is about 125 feet and 85 feet below the surface, respectively, at these mines.

Schuman coal bed.—The Schuman coal bed is named from exposures near a cattle camp run by the Schuman ranch 5 miles east of the Lake De Smet area in secs. 27, 28, and 29, T. 52 N., R. 80 W. It crops out in the eastern part of T. 52 N., R. 81 W., with a maximum observed thickness of 3 feet 6 inches at locality 73, in sec. 24, but it thins southwestward and could not be found in adjoining townships to the west and south.

Healy coal bed.—The Healy bed, which is exposed east of Buffalo and Lake De Smet in the valleys of Piney, Boxelder, Clear, and Dry Creeks, contains half of the coal estimated for reserves of the area. At most places the Healy bed is 15 to 25 feet thick, but it thickens abruptly in the vicinity of Lake De Smet. On the eastern side of the lake, in sec. 8, T. 52 N., R. 82 W., core hole GS-26 found 52 feet of coal in the Healy bed, including thin partings of shale; and drill hole 305, 2 miles to the southeast in sec. 22 of the same township reportedly found 112 feet of coal in the Healy bed, including partings.

A bed of coal that in core holes ranges in thickness from 115 to 131 feet (holes 7, 200, A–6, A–8, GS–1, and GS–6) and in 2 holes is reported to be more than 200 feet thick (hole C and the Hepp water well) underlies an area of about 25½ square miles west of the fault at the north end of Lake De Smet. This thick bed is correlated tentatively with the Healy bed. Its extent to the north and west of the area explored by drilling is unknown. Hole D, drilled at the edge of the area in sec. 7, T. 52 N., R. 83 W., covers an area of about half a square mile mostly in sec. 13, T. 52 N., R. 84 W., and another covers an area of about three-fourths of a square mile in sec. 17, T. 51 N., R. 83 W., and parts of adjoining sections to the north and west. Both deposits include a large proportion of granitic debris ranging in size from sand to boulders as much as 4 feet across that were shed from cliffs of granite a short distance away.

Alluvium.—Narrow bands of Recent alluvium lie along most of the permanent and many of the intermittent streams in the Lake De Smet area. The deposits consist of silt and sand interspersed with lenses of gravel. Along Piney, Shell, and Clear Creeks alluvium and deposits of gravel on low terraces 10 to 25 feet above the present streams were mapped as alluvium and terrace deposits undifferentiated.

Landslide material.—Areas cov