GEOLOGY OF THE
BIG SANDY QUADRANGLE, MONTANA

by

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INTRODUCTION

The Big Sandy quadrangle includes an area of about 200 square miles in the northeastern part of Chouteau County in north-central Montana. The quadrangle is in the Missouri Plateau section of the northern Great Plains physiographic province. Deposits of Pleistocene drift mantle the region, overlying sedimentary rocks of Cretaceous age. Many igneous dikes and sills crop out, and several faults are exposed. Known economic resources include sand and gravel and minor amounts of coal and bentonite.

The Missouri River flows through the southwestern corner of the quadrangle. Tributary streams have dissected areas along their lower courses into badland topography. A broad shallow valley, the partly filled pre-glacial course of the Missouri River, trends northeasterly across the area, separating the gently rolling upland plains of the northwestern and southeastern parts of the quadrangle.

Big and Little Sandy Creeks are the major tributary streams in the area. Big Sandy Creek with headwaters in the Bearpaw Mountains east of the quadrangle, enters the area from the east and flows in a northerly course to join the Milk River. Little Sandy Creek rises in the southwestern foothills of the Mountains and joins the Missouri River in the southern part of the quadrangle.

Local relief is from 50 to 200 feet, maximum relief is about 500 feet. The surface ranges in altitude from about 2,500 feet along the Missouri River, to about 3,000 feet on the upland areas.

The climate is characterized by low rainfall, dry atmosphere, hot summers, cold winters, and a large proportion of sunny days. Annual precipitation at Big Sandy averages 12.15 inches. The heaviest rainfall is in late spring and early summer; occasional heavy snows are recorded during the winter. Maximum and minimum recorded temperatures are 105° and -48°. During the summer months the daily range is great and the nights are usually cool. The frost-free period dates from late May to early September, averaging about 100 days. The area is subject to strong winds which are more prevalent in the early spring. Hail storms occur locally during the summer.

Wheat farming and cattle raising are the chief industries in the area. Big Sandy, a town of 800 population, is the local marketing center. The area is served by the Great Northern Railway and by U. S. Highway No. 87. State Highway No. 116 is paved for a distance of six miles south of Big Sandy. A well-developed network of improved roads covers most parts of the quadrangle.

Bedrock Formations

Bedrock formations, all of Cretaceous age, which crop out in the quadrangle include the Colorado shale, Telegraph Creek formation. Eagle sandstone, Claggett shale, Judith River formation, Bearpaw shale, Fox Hills sandstone, and Hell Creek formation. The Colorado shale, Claggett shale, and Bearpaw shale are gray to brown marine shales, and the Telegraph Creek formation, Eagle sandstone, Judith River formation, Fox Hills sandstone, and Hell Creek formation consist of interbedded sandstone, shale, carbonaceous shale, and clay. The formations, locally interrupted by folding and faulting, dip northeast a few feet per mile.

Colorado shale

The Colorado shale (Kc) underlies the entire quadrangle and consists of about 1,800 feet of dark grayish-blue marine shale, of which only the upper 400 to 500 feet crop out. The formation is predominantly shale but contains thin beds of bentonite, sandstone, and sandy shale, as well as numerous calcareous concretions. The concretionary layers and bentonite beds are more prevalent in the upper two-thirds of the formation; the sandstone beds in the lower one-third. Most of the concretions are spheroidal masses of rusty-brown clay-ironstone or dark-gray limestone one to three feet in diameter that are generally arranged along bedding planes. Many of the concretions contain invertebrate fossils including *Scaphites*, *Baculites*, *Inoceramus*, and *Ostrea*. Calcite filled shrinkage cracks are common. Cracks and fissures in the shale contain veins of selenite (gypsum).

The formation is generally exposed in steep weathered slopes that are subject to landsliding and slumping, particularly along bentonite beds. It is conformably underlain by the Kootenai formation which is not exposed in the quadrangle.

The Colorado shale was named by Hayden (1876, p. 45) from outcrops east of the Front Range in Colorado.

Telegraph Creek formation

The Telegraph Creek formation (Kt), a transition zone between the Colorado shale and the Eagle sandstone, consists of alternating beds of white to buff sandstone and dark grayish-blue shale. In places the beds reach a thickness of 150 feet or more, and in other areas are locally absent. The formation is generally exposed in gentle to steep weathered slopes.

The Telegraph Creek formation was named by Thom (1922, p. 38) from exposures on the Crow Indian Reservation southeast of Billings, Montana.

Eagle sandstone

The Eagle sandstone underlies most of the quadrangle and is exposed along the Missouri River and in several faulted areas. The upper and middle members (Ke) together consist of 125 to 150 feet of alternating beds of gray to buff sand, sandstone, shale, carbonaceous shale, and coal. The upper member is locally a thick massive sandstone, the middle member is predominantly shale. Two thin beds of coal are present near the base of the middle member.

A conglomerate six inches to two feet thick of polished chert and quartzite pebbles in a matrix of fine sand and clay occurs at or near the top of the upper member. The pebbles are black, dark brown, dark blue, and dark green, round to oval, and range from one-eighth to two inches in diameter. In some localities the pebbles occur along bedding planes in the upper sandstone member, and also in the basal part of the overlying Claggett shale.

The Virgelle sandstone member (Kev) comprises the lower 80 to 100 feet of the formation and is a hard, massive, white to buff, medium-grained cross-bedded sandstone containing sandy limonitic concretions.

The upper and middle members generally form a subdued type of badland topography. The Virgelle sandstone member forms steep cliffs.

The formation was named by Weed (1899, p. 2) from exposures at the mouth of Eagle Creek six miles south of the quadrangle. Bowen (1915, p. 7) applied the name Virgelle sandstone member to the lower massive sandstone at exposures near the town of Virgelle in the southwestern corner of the quadrangle.

The Eagle sandstone is conformably overlain by the Claggett shale.

Claggett shale

The Claggett shale (Kcl) underlies the northern and central parts of the quadrangle. The formation consists chiefly of brownish-gray marine shale ranging in thickness from 450 to 500 feet. The upper 150 feet is a sandy yellowish-gray shale. The lower 100 feet contains several beds of bentonite as much as 18 inches thick. Rusty-yellow to dark-gray spheroidal calcareous concretions are common in the middle part of the formation. These concretions are generally one to four feet in diameter: calcite-filled shrinkage cracks are common: cone-in-cone structure occurs along upper and lower surfaces; many contain specimens of *Baculites*. Selenite (gypsum) crystals occur in creeks and fissures in the shale.

Badland topography is formed on both steep and gentle slopes of the Claggett shale. On steep slopes slumping and landsliding are common.

The formation was named by Stanton and Hatcher (1905, p. 13) from exposures near old Fort Claggett, at the mouth of the Judith River, 30 miles southeast of the Big Sandy quadrangle.

The Claggett shale is conformably overlain by the Judith River formation. The contact was originally placed at the top of a massive, light-brown ferruginous marine sandstone, which overlies sandy yellowish-gray marine shale. In this report, however, the contact is placed at the base of this massive sandstone because the latter is lithologically more similar to the Judith River formation than it is to the typical shale of the Claggett.

Judith River formation

The Judith River formation (Kjr), which underlies the eastern and northwestern parts of the quadrangle, consists of about 500 feet of alternating beds of light-gray to buff sandstone, and gray to buff shale. The sandstone is generally fine-grained and thin-bedded to massive; the shale is in many places carbonaceous and contains a few thin beds of coal. The lower 200 feet includes more coal, carbonaceous shale, and dark-colored deposits than the upper 300 feet, which consists predominantly of light-colored sandstone and shale. Light-brown ferruginous sandstone beds are a marked feature of the basal 100 feet.

Vertebrate fossils, mainly dinosaur remains, are most common in the upper beds; invertebrate fossils, chiefly oyster shells, are found in the carbonaceous zones in the lower beds, and at the top of the formation. The bivalve *Tancredia americana* occurs in the massive ferruginous sandstone at the base of the formation. Large quantities of silicified wood and plant fragments are also found in the formation.

The sandstone, shale, and clay of the formation generally weather into hard barren surfaces and erode to badland topography.

The Judith River formation was named by Hayden (1871, p. 97) from exposures near the mouth of the Judith River.

The formation is conformably overlain by the Bearpaw shale.

Bearpaw shale

The Bearpaw shale (Kbs) which outcrops in a downfaulted area five miles southeast of the town of Big Sandy, consists of about 700 feet of brownish-gray to bluish-gray marine shale, of which only about the upper 300 to 400 feet is exposed. Bentonite beds, ranging in thickness from a fraction of an inch to 10 inches, occur throughout the formation. Selenite (gypsum) crystals occur in cracks and fissures in the shale. Gray and dark-red calcareous concretions are numerous, particularly in the middle part of the Bearpaw shale. Many of the concretions are fossiliferous and contain specimens of *Baculites*, *Acanthoscaphites*, and *Placenticeras*. Fossils of marine reptiles are also reported.

In the Big Sandy quadrangle the Bearpaw shale crops out in steep slopes, many of which are covered by slumps and landslides.

The formation was named by Stanton and Hatcher (1905, p. 14) from exposures south of the Bearpaw Mountains.

The Bearpaw shale grades into the Fox Hills sandstone through a transition zone of alternating thin-bedded gray to buff shale and sandstone beds.

Fox Hills sandstone

The Fox Hills sandstone (Kfh) also crops out in the faulted area five miles southeast of Big Sandy. The formation consists of 100 to 200 feet of light-brown to light-gray sand and sandstone interbedded with tan and gray shale and carbonaceous shale. The sandstone in the lower 50 to 100 feet is thin-bedded to massive and locally cross-bedded. Limonite concretions are common throughout the sandstone beds. Invertebrate brackish water fossils including *Anomia* and *Corbula* were found in carbonaceous shale beds near the top of the formation.

The Fox Hills sandstone crops out as steep slopes and numerous sandstone ledges. The formation was named by Meek and Hayden (1862, p. 419) from exposures in Fox Ridge in north-central South Dakota. The Fox Hills sandstone is overlain by the Hell Creek formation.

Hell Creek formation

The Hell Creek formation (Khc), also exposed in the downfaulted area southeast of Big Sandy, is composed of thin-bedded, gray, green, pink, and buff clay, shale, and sandstone. Small, nodular claystone concretions are abundant in the middle part. A black bentonitic clay bed, 10 to 15 feet thick, is a distinctive marker bed in the lower 100 feet. The formation ranges from 400 to 500 feet in thickness, but only the lower 150 to 200 feet are exposed in the Big Sandy quadrangle. Fragments of dinosaur bones are found in the lower part of the formation.

In the Big Sandy quadrangle the formation has been eroded into badland topography.

The Hell Creek formation was named by Barnum Brown (1907, p. 829-835) from exposures along Hell Creek south of the Fort Peck reservoir in northeastern Montana.

SURFICIAL FORMATIONS

Most of the quadrangle is covered by unconsolidated surficial deposits resulting from glaciation and stream action during the Pleistocene and Recent periods. These deposits are separated into three groups: (1) ground moraine deposited directly from glacial ice masses, (2) outwash deposits laid down by meltwater derived from the ice masses, and (3) deposits of material reworked by stream action, slopewash, or wind action.

Ground moraine

Ground moraine (Qgm) forms the surface of over half the quadrangle and underlies younger deposits in other large areas. Much of the ground moraine is composed of till, and unstratified mixture of buff clay, silt, and sand interspersed with gravel, cobbles, and boulders. The deposits are generally 5 to 30 feet thick, but in filled pre-glacial valleys are as much as 150 feet thick. Small areas in the south and south-central parts of the quadrangle have a swell and swale topography of low rounded hills and shallow undrained depressions. Long ridges of till, 10 to 30 feet high, from one-fourth to 1 mile in length in the southeastern part of the quadrangle has been classified as drumlinoidal ridges, formed by filling of long tunnels on the underside of the glacial ice.

Outwash deposits

Silt, sand, and gravel classified as terraces (Qt), kames (Qk), eskers (Qe), silt deposits (Qst) and sand deposits (Qs), rest on the ground moraine in many parts of the quadrangle. The kames and eskers were deposited by glacial meltwater at or near the ice margin. The terraces were deposited along the Missouri River. The sand deposits are an outwash plain deposited by running water immediately in front of the ice margin, and the silt deposits represent sediments laid down in temporary lakes formed in front of the ice margin.

These deposits are chiefly light-brown or buff, exhibit crude to well-developed stratification, and with the exception of the silt deposits, are generally less than 20 feet thick. The silt deposits are locally more than 100 feet thick.

Reworked deposits

Alluvium (Qal), colluvium (Qco), and alluvium-colluvium (Qac) consists of interbedded light-brown to gray clay, silt, sand, and gravel. Alluvium is generally confined to valley bottoms adjacent to streams, and colluvium mantles the sides of most major stream valleys and areas downslope from large bedrock outcrops. Alluvium-colluvium fills the pre-glacial valley of the Missouri, south, east, and northeast of Big Sandy.

Kettle deposits (Qkd), consisting of dark gray clay, silt, and sand, floor the bottoms of undrained depressions on the ground moraine.

Sand dunes (Qsd) consist of sand deposits (Qs) reworked by wind action.

IGNEOUS ROCKS

Igneous dikes and sills of Tertiary age crop out in the eastern and northern parts of the quadrangle. They are shonkinite, a dark igneous rock composed of hornblende, olivine, pyroxene, biotite, and orthoclase. Most of the dikes and sills are more resistant to weathering than the confining sedimentary rocks and protrude a few feet above the surrounding land surface. Other than a slight baking effect at the contact, the igneous rocks have caused little alteration of the rocks into which they were intruded. The dikes and sills are believed to have been intruded after the faulting of the sedimentary strata, as indicated by the fact that in adjacent areas, many dikes cut across fault planes without displacement.

STRUCTURE

The Cretaceous sedimentary rocks of the region are essentially flat-lying with a slight tilt to the northeast locally interrupted by faulting and folding. The faults are part of the thrust-faulted belt encircling the Bearpaw Mountains and have been the subject of a special study by Reeves (1924).

All of the faults mapped in the quadrangle, with the exception of those in the downfaulted area five miles southeast of Big Sandy, are of the reverse type. Vertical displacement along the faults ranges from about 100 to 500 feet. The strike and dip of the fault plane generally parallels the strike and dip of the beds on the upthrown side of the fault. Within a quarter of a mile from a fault, steeply dipping strata on the upthrown side generally flatten to the regional dip.

Reeves (1929, pp. 172-185) believes that the thrust faults are shallow and do not extend below the upper part of the Colorado shale. His reasons are summarized as follows: (1) none of the faults expose strata below the middle of the Colorado shale; (2) thrust faults of this type are absent where strata below the Colorado shale are at the surface; (3) the lowest beds exposed along faults have about the same inclination as the fault plane, suggesting that the faulting began as a movement along a bedding plane and passed upward along a curving surface; (4) subsurface data indicate that below the thrust faults the underlying Kootenai formation is in a normal position and not at a higher level on the upthrust side of the hypothetically extended fault; (5) mathematical calculation of the depth of faulting gives an average of 900 feet below the Eagle sandstone. During the present investigations no evidence was found that did not agree with Reeves' conclusions concerning the depth of the faulting.

The faults mapped at the downfaulted area five miles southeast of Big Sandy are of the normal type. Displacement along the fault planes ranges from about 100 to 300 feet.

Additional faults may exist under cover of glacial drift in the quadrangle.

ECONOMIC GEOLOGY

Extensive resources of sand and gravel are located in the glacial outwash deposits. Minor amounts of coal, bentonite, and riprap have been found. Five shallow wells have been drilled in an unsuccessful search for gas and oil.

Sand and gravel

Kame, esker, and terrace deposits are sources of large quantities of sand and gravel suitable for road material. Material near the surface of the deposits generally is carbonate coated, but at greater depths clean material suitable for concrete aggregate is available. The outwash sand deposits covering about six square miles in the southwest part of the quadrangle are a source of large quantities of fine to medium, well-graded sand.

Riprap

Scattered glacial boulders, consisting chiefly of quartzite, granite, and basic igneous rocks ranging from three inches to two feet in diameter, are a limited source of riprap. The more resistant parts of the shonkinite dikes and sills are another possible source of material.

Coal

Exploitation of the sub-bituminous coal beds in the Judith River formation and the Eagle sandstone has been limited to small scale mining operations. The coal beds range from a few inches to about two and one-half feet in thickness. Small mines were operated in sec. 16, T. 26 N., R. 12 E. and in sec. 22, T. 28 N., R. 13 E., but are now abandoned.

The thinness and variable extent of the coal beds, plus thick overburden limit the possibilities for profitable commercial mining in the area. Measured sections of the beds are shown on the Coal Sections Chart and the locations are recorded on the map.

A brief account of the coal outcrops in the eastern part of the quadrangle is included in a report by Bowen (1914, pp. 77-80). Coal outcrops in the western part of the quadrangle are described by Pierce and Hunt (1937, pp. 261-263).

Bentonite

Commercial development of bentonite beds in the Colorado and Claggett shales is governed by the thickness of the beds and the amount of overburden. Because these beds are less than 18 inches thick and generally covered by 50 to 100 feet of overburden they are not believed to be of commercial importance at present. Small quantities of bentonite for lining stock reservoirs can probably be obtained from outcrops in sec. 23, T. 26 N., R. 12 E., where beds in the Claggett shale are near the surface.

Oil and Gas

The oil and gas possibilities of this region have been discussed by Reeves (1924, pp. 103-112) and by Pierce and Hunt (1937, pp. 258-261).

Six wells have been drilled in the quadrangle in search of oil and gas, but all have been abandoned as dry holes. A water well drilled in the NW¼SE¼ sec. 23, T. 27 N., R. 13 E., in 1952 obtained a moderate flow of dry gas at a depth of 400 feet. This is believed to flow from the upper part of the Eagle sandstone. The gas is utilized for heating and cooking purposes.

GEOLOGIC HISTORY

The fine-grained sediments which compose the Colorado shale were deposited in a broad shallow sea which occupied the continental interior of the United States during much of the Cretaceous period. Intermittent volcanic eruptions in adjacent areas spread thin layers of volcanic ash--later altered to bentonite--over the region.

Near the end of the deposition of the Colorado shale, local variations in source of supply produced the alternating sand and silt beds of the Telegraph Creek formation.

The sands comprising the Virgelle sandstone member were deposited in a shallow marine sea, followed by the deposition of the alternating beds of sand, silt, clay, and coal of the upper and middle members of the Eagle sandstone, which were laid down in a continental environment of swamps, lagoons, and shallow lakes.

The Claggett shale, including the beds of volcanic ash, was laid down in a broad shallow sea under conditions similar to the deposition of the Colorado shale.

The alternating beds of clay, sand, shale, and coal of the Judith River formation accumulated in a continental environment.

Another broad shallow sea served as a depository for sediments of the Bearpaw shale.

Overlying the Bearpaw shale the lower sands of the Fox Hills sandstone were deposited under marine conditions. The upper part of the Fox Hills sandstone, and the overlying Hell Creek formation were deposited in a continental environment.

Still younger formations were probably deposited above the Hell Creek formation within the quadrangle during the early part of the Tertiary period, but they have since been removed by erosion. Down-faulted blocks near the Bearpaw Mountain preserve parts of these formations.

During the middle part of the Tertiary period, forces accompanying the formation of the Bearpaw Mountains are thought to have caused the faulting of the strata in the Big Sandy quadrangle. The intrusion of the igneous dikes and sills also occurred at this time.

This deformation probably initiated the erosion which removed most of the younger sedimentary rocks down to the Judith River formation. The resulting badland topography was highly modified by the Pleistocene continental glaciers which covered the area, depositing a blanket of drift. Streams were diverted into new courses when their valleys were blocked by ice, and on retreat of the glaciers failed to reoccupy their old valleys which were filled with drift. The present course of the Missouri River originated in this manner, and the old pre-glacial, drift-filled valley can yet be traced northeastward across the quadrangle. Several ice sheets may have covered the region during the Pleistocene epoch, but efforts to differentiate their deposits have not been successful.

The present ground surface of the quadrangle was formed during the advance and subsequent retreat of the last glacier to pass over the region. The ground moraine consists chiefly of material deposited under the ice during the advance of the glacier. When the ice margin began to recede, meltwater flowing over the ice and through cracks and crevasses deposited sand and gravel as kames, eskers, terraces, and outwash sand plains.

Since the disappearance of the ice sheet the ground surface has been somewhat modified in several areas. Erosion has formed badland topography near the Missouri River and its tributaries, and widespread deposits of alluvium and colluvium have accumulated.

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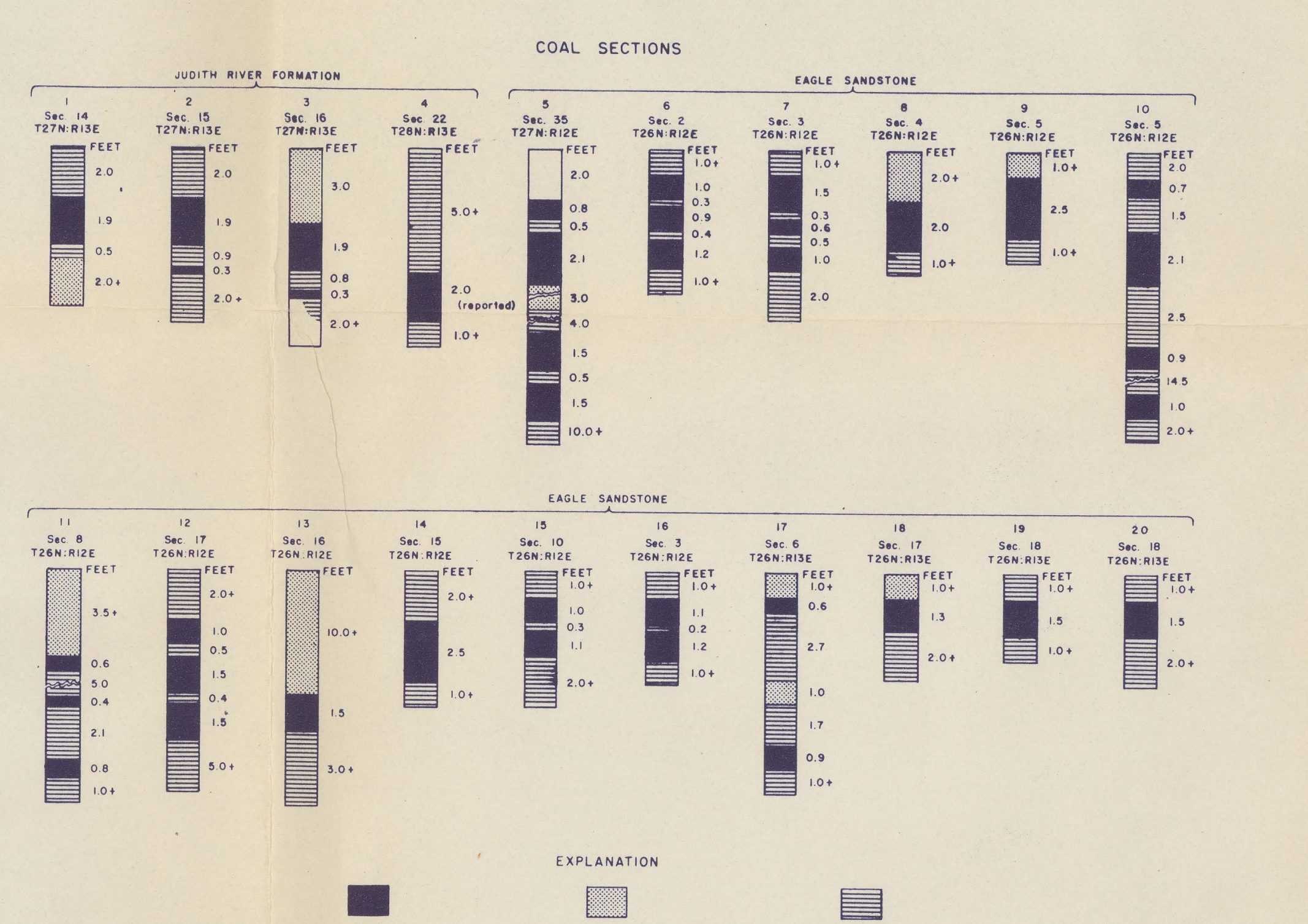
COAL SECTIONS



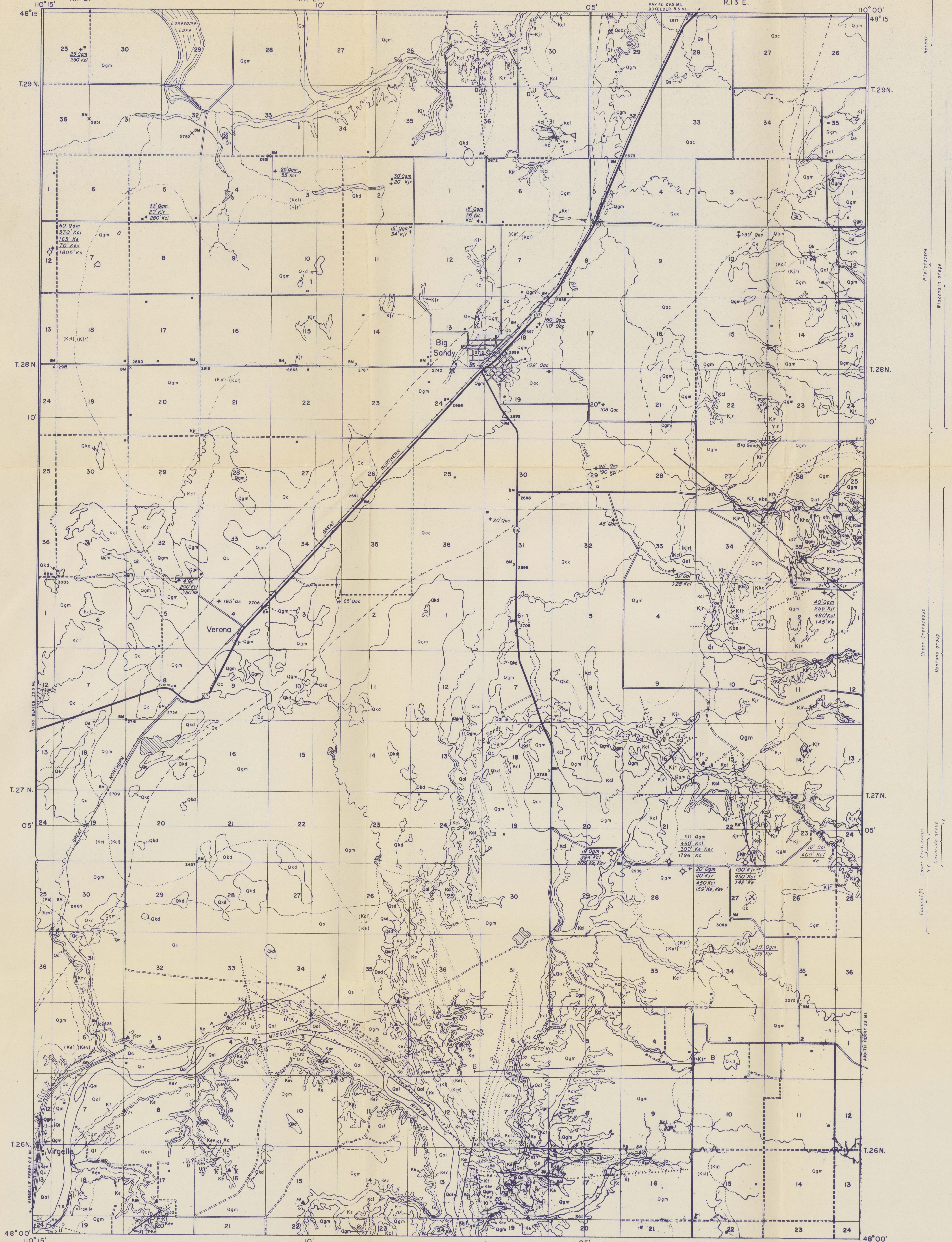
GENERALIZED DESCRIPTION OF ENGINEERING PROPERTIES OF MAP UNITS

MAP UNIT	GENERAL DESCRIPTION	DISTRIBUTION AND THICKNESS	TERRAIN AND NATURAL SLOPES	DRAINAGE AND PERMEABILITY	SLOPE STABILITY, FROST HEAVE, EASE OF EROSION	EASE OF COMPACTION AND EXCAVATION	ECONOMIC CONSIDERATIONS
ALLUVIUM Qal	Interbedded light-brown to gray clay, silt, sand, and sandy gravel. Unconsolidated. Crude to well-developed stratification. Derived from reworking of surficial and bedrock materials by stream action.	Distribution: Floodplain of Missouri River and major tributaries; not mapped in smaller stream valleys. Thickness: 1 to more than 20 feet. Locally as much as 50 feet.	Terrain: Gently sloping to flat surfaces. Local relief rarely exceeds 5 feet. Slopes: Gentle to flat: steep where banks undercut.	Drainage: Poor to good. Surface muddy as much as 24 hours after rains. Permeability: Very low in clays, somewhat higher in silt, sand, and gravel.	Stability: High strength when dry, low strength when wet or moist. Shallow cuts (2 to 4 feet) generally stable at angles up to 90°. Frost heave: Low in clay, moderate to high in silt and fine sand, low in gravel. Erosion: Erodes readily along stream courses.	Compaction: Difficult to compact where clay is predominant. Excavation: Easily excavated with light power machinery when dry, difficult when wet.	Generally unsatisfactory sub-base for hard-surfaced roads, where clay and silt content is high. Fair source of fill material depending on proportions of clay, silt, and sand. Unsurfaced roads generally impassable when wet. Small tracts irrigated along Missouri River.
COLLUVIUM Qc	Interbedded light-brown to gray clay, silt, and sand. Unconsolidated. Generally well-stratified. Derived from reworking of surficial and bedrock materials by slopewash, creep, and slumping. Colluvium in quadrangle is chiefly silt, derived from Claggett shale.	Distribution: Flanks the walls of major stream valleys and downslope from large bedrock outcrops. Extensive exposures in west-central part of quadrangle. Thickness: 1 to more than 30 feet.	Terrain: Long sloping surfaces, grading from steep to nearly flat. Relief as much as 100 feet along Missouri River. Slopes: Steep to flat.	Drainage: Generally good, but surface remains muddy as much as 24 hours after heavy rainfall. Permeability: Very low.	Stability: High strength when dry, low strength when wet. Shallow cuts (2 to 4 feet) generally stable at angles up to 90°. Frost heave: Generally high due to predominance of silt. Erosion: Erodes rapidly in small ravines and gullys.	Compaction: Generally difficult to compact. Excavation: Easily excavated with light power machinery when dry, difficult when wet.	Unsatisfactory sub-base for hard-surfaced roads: Generally poor source of fill material. Unsurfaced roads impassable when wet.
ALLUVIUM-COLLUVIUM (UNDIFFERENTIATED) Qac	Interbedded light-brown to gray clay, silt, sand, and gravel. Unconsolidated. Crude to well-developed stratification. Derived from reworking of surficial and bedrock materials by stream action, slopewash, creep, and slump. On east side of valley of Big Sandy Creek consists mainly of broad, gently sloping alluvial fans of streams originating in Bearpaw Mountains.	Distribution: Northeastern part of quadrangle, in broad valley believed to be pre-glacial course of Missouri River. Thickness: 1 to more than 100 feet.	Terrain: Gently sloping to flat surfaces. Broad alluvial fans. Local relief generally less than 10 feet. Slopes: Gentle to flat. In places steep undercut banks along Big Sandy Creek.	Drainage: Poor to good. In places marshland, and areas of alkali salt deposits. Permeability: Poor to excellent. Big Sandy town water supply obtained from 100-120 foot wells in alluvium-colluvium.	Stability: Moderately high strength when dry, low strength when wet. Cut banks along streams stand at 90°. Frost heave: Low to high. Erosion: Erodes rapidly along stream courses.	Compaction: Generally difficult to compact, requires close moisture control. Excavation: Easily excavated with light power machinery when dry.	Unsatisfactory sub-base for hard-surfaced roads. Generally poor source of fill material. Small tracts irrigated for alfalfa crops.
KETTLE DEPOSITS Qkd	Dark gray plastic clay, containing minor amounts of silty clay, silt, and sand. Unconsolidated. Derived from reworking of ground moraine.	Distribution: Shallow closed depressions on ground moraine surface. Thickness: 1 to 10 feet.	Terrain: Gently sloping to flat surfaces: Relief less than 3 feet. Slopes: Gentle to flat.	Drainage: Very poor. Kettles may contain water in Spring and after heavy rains. Permeability: Very low.	Stability: High strength when dry. Frost heave: Generally low. Erosion: Generally present in closed depressions, not subject to erosion.	Compaction: Difficult to compact due to high clay content. Excavation: Easily excavated with light power machinery when dry.	Unsatisfactory sub-base for hard-surfaced roads. Poor source of fill material. Possible limited use for impervious lining of canals and reservoirs.
TERRACE DEPOSITS Qt	Interbedded light-brown silt, sand, and gravel. Unconsolidated. Crude to well-developed stratification. Deposited by glacial meltwater.	Distribution: Along Missouri River in southern part of quadrangle and along west side of broad valley of Big Sandy Creek in northern part of quadrangle. Thickness: 10 to 20 feet.	Terrain: Generally flat surfaces. Relief up to 20 feet where cut by gullies and ravines. Slopes: Up to 35° along stream courses.	Drainage: Good to excellent. Permeability: High.	Stability: High strength, will stand in cuts up to 35° angles. Frost heave: None to slight. Erosion: Generally high resistance to erosion.	Compaction: Good to difficult. Excavation: Easily excavated with hand tools and light power machinery.	Good sub-base material for hard-surfaced roads. Good source of pervious fill material. Sand and gravel source, some carbonate coating. Overburden 1 to 2 feet.
SAND DEPOSITS Qs Qsd	Light-brown to gray, well-sorted, medium- to fine-grained sand. Unconsolidated. Generally well-stratified. Deposited by glacial meltwater. Areas of active dunes mapped as Qsd. Areas of stabilized dunes covered by grass.	Distribution: North of Missouri River in southwestern quarter of quadrangle. Thickness: 10 to 30 feet.	Terrain: Gently rolling surfaces of stabilized sand dunes. Relief up to 30 feet. Slopes: Up to 35°, chiefly in active dune areas.	Drainage: Good to excellent. Permeability: High.	Stability: Poor to fair strength. Cuts stand up to 35°. Frost heave: None to slight. Erosion: Generally low resistance to water and wind erosion.	Compaction: Poor to fair. Excavation: Easily excavated with hand tools and light power machinery.	Fair sub-base material for hard-surfaced roads. Fair source of pervious fill material. Unsurfaced roads subject to wind erosion and drifting.
SILT DEPOSITS Qst	Stratified, light-brown silt and sandy silt. Unconsolidated. Deposited in lakes or ponds of glacial meltwater.	Distribution: South of Missouri River in southern part of quadrangle. Thickness: 5 to more than 100 feet.	Terrain: Rounded hills and steepsided gullies. Relief up to 100 feet. Slopes: Up to 35° in gullies tributary to Missouri River.	Drainage: Good to excellent. Permeability: Low.	Stability: High strength, cuts stand at angles up to 35°. Frost heave: Generally high. Erosion: Erodes rapidly along tributaries to Missouri River especially where subject to undercutting.	Compaction: Generally difficult to compact. Excavation: Easily excavated with light power machinery.	Generally unsatisfactory sub-base for hard-surfaced roads. Fair source of pervious fill material.
KAME DEPOSITS Qk	Stratified or semi-stratified light-brown sand and gravel containing minor amounts of silt, and clay. Unconsolidated. Deposited by glacial meltwater.	Distribution: On ground moraine surface. Thickness: 5 to 20 feet.	Terrain: Gently rounded hills short ridges and irregular-shaped mounds. Relief up to 20 feet. Slopes: Generally less than 20°.	Drainage: Excellent. Permeability: Generally high.	Stability: High strength, cuts stand at angles up to 35°. Frost heave: None to slight. Erosion: Generally high resistance to erosion.	Compaction: Generally difficult to compact. Excavation: Easily excavated with light power machinery.	Good sub-base material for hard-surfaced roads. Good source of pervious fill material, some carbonate coating. Fair source of gravel for concrete work, washing necessary.
ESKER DEPOSITS Qe	Stratified or semi-stratified sinuous ridges of light-brown sand and gravel. Minor amounts of silt, and clay. Unconsolidated. Deposited by glacial meltwater.	Distribution: On ground moraine surface. Thickness: 5 to 25 feet.	Terrain: Segmented, narrow, winding ridges: Uneven tops, steeply sloping sides. Relief up to 25 feet. Slopes: Up to 35°.	Drainage: Excellent. Permeability: Generally high.	Stability: High strength, cuts stand at angles up to 35°. Frost heave: None to slight. Erosion: Generally high resistance to erosion.	Compaction: Generally difficult to compact. Excavation: Easily excavated with light power machinery.	Good sub-base material for hard-surfaced roads. Good source of pervious fill material, some carbonate coating. Fair source of gravel for concrete work, washing necessary.
GROUND MORAINE Qgm	Unstratified mixture of buff to light-gray clay, silt, and sand, containing minor amounts of pebbles, cobbles, and boulders. Compact but unconsolidated. Upper 20 to 30 feet oxidized to buff or yellowish-brown; underlying unoxidized till light-gray to bluish gray. A caliche (carbonate enriched) zone 2 to 4 feet thick a few inches below surface. Deposited by glacial ice sheet.	Distribution: Covers most of quadrangle except where removed by erosion. In places hidden by alluvium or other glacial deposits. Thickness: Generally 5 to 30 feet, but in filled pre-glacial valleys may be more than 150 feet.	Terrain: Gently rolling surface characterized in places by shallow, irregular-shaped, undrained, or poorly drained depressions. Local relief generally less than 30 feet. Slopes: Generally less than 20°.	Drainage: Fair to good. Surface may remain muddy up to 24 hours after heavy rainfall. Permeability: Low. Lenses of sand and gravel in till may be local sources of groundwater.	Stability: High strength, cuts stand at angles up to 45° or more. Frost heave: Slight to moderate. Erosion: Erodes readily where grass cover has been removed.	Compaction: Generally easy to compact. Excavation: Easily excavated with light power machinery. Large boulders may require special handling.	Fair sub-base material for hard-surfaced roads. Good source of impervious fill material for earth dams, reservoir and canal linings. Boulders may be limited source of rip-rap material. Unsurfaced roads very muddy when wet.
HELL CREEK FORMATION Khc	Gray, green, pink, and buff clay, shale, and sandstone. Small nodular claystone concretions abundant in upper part. Prominent black bentonitic clay bed 10 to 15 feet thick in lower 100 feet.	Distribution: Downfaulted area 5 miles southeast of Big Sandy. Thickness: 400 to 500 feet, but only 150 to 200 feet exposed in quadrangle.	Terrain: Eroded to badland topography. Local relief up to 100 feet, where exposed in quadrangle. Slopes: Generally less than 30°.	Drainage: Good. Surface generally muddy up to 24 hours after heavy rainfall. Permeability: Very low in clay and shale, somewhat higher in sandstone.	Stability: Generally high strength, cuts stand at angles up to 30°. Frost heave: Slight to moderate. Erosion: Erodes easily with exception of resistant sandstones.	Compaction: Generally difficult to compact. Excavation: Easily excavated with light power machinery with exception of resistant sandstones.	Generally poor sub-base for hard-surfaced roads. Fair source of fill material. Unsurfaced roads impassable after heavy rainfall.
FOX HILLS SANDSTONE Kfh	Light-brown to light-gray sand and sandstone, interbedded with tan and gray shale and carbonaceous shale. Sandstone thin-bedded to massive, some cross bedding.	Distribution: Same as Hell Creek formation. Thickness: 100 to 200 feet.	Terrain: Eroded to badland topography. Local relief up to 100 feet. Slopes: Generally less than 30°.	Drainage: Good. Permeability: Low in shale, somewhat higher in sandstone.	Stability: High strength. Cuts in sandstone will stand at 90°. Frost heave: None to slight. Erosion: Shales erode easily, sandstone resistant.	Compaction: Difficult to compact. Excavation: Resistant sandstones difficult to excavate with light power machinery.	Poor to fair sub-base for hard-surfaced roads. Fair source of fill material.
BEARPAW SHALE Kbs	Brownish-gray to dark blue gray marine shale. Upper 100 feet contains brownish sandy beds. Thin bentonite beds throughout formation. Numerous gray and dark red calcareous concretions. Selenite (gypsum) fillings in cracks and fissures.	Distribution: Same as Hell Creek formation. Thickness: About 700 feet thick, only upper 300 to 400 feet exposed in quadrangle.	Terrain: Eroded to badland topography. Local relief up to 50 feet. Slopes: Gentle to steep.	Drainage: Generally good. Surface may remain muddy up to 24 hours after heavy rainfall. Permeability: Very low.	Stability: Moderate, shallow cuts stand at angles up to 45°. Subject to slumping and landsliding, especially along bentonite beds. Frost heave: Low to moderate. Erosion: Erodes easily.	Compaction: Generally difficult to compact. Excavation: Easily excavated with light power machinery.	Poor sub-base for hard-surfaced roads. Fair source of fill material for earth dams, reservoir and canal linings. Small amounts of bentonite. Unsurfaced roads impassable when wet.
JUDITH RIVER FORMATION Kjr	Interbedded light gray to buff, thin-bedded to massive sandstone, and gray to buff clay and shale. Thin coal beds in upper part of formation and in lower 200 feet.	Distribution: Underlies northern and eastern parts of quadrangle. Thickness: About 500 feet.	Terrain: Sandstone forms steep cliffs; shales weather to long slopes. Badland topography. Local relief up to 100 feet. Slopes: Gentle to steep.	Drainage: Generally good. Permeability: Low in clay and shale, somewhat higher in sandstone.	Stability: Moderate to high, cuts in sandstone stand at 90°. Subject to slumping in shales. Frost heave: Moderate to high. Erosion: Sandstone moderately resistant to erosion; shale and clay erode easily.	Compaction: Generally difficult to compact. Excavation: Easily excavated with light power machinery. Massive sandstone may require explosives.	Poor to fair sub-base for hard-surfaced roads. Fair source of fill material. Source of small amounts of sub-bituminous coal.
CLAGGETT SHALE Kcl	Brownish-gray marine shale. Upper 150 feet is sandy, yellowish gray, lower 100 feet contains bentonite beds as much as 18 inches thick. Numerous calcareous concretions throughout formation. Cracks and fissures contain veins of selenite (gypsum).	Distribution: Underlies northern and central parts of quadrangle. Thickness: 450 to 500 feet.	Terrain: Eroded to badland topography. Local relief up to 100 feet. Slopes: Gentle to steep, generally less than 25°.	Drainage: Good. Surface may remain muddy up to 24 hours after heavy rainfall. Permeability: Very low.	Stability: Moderate: Shallow cuts stand at angles up to 45°. Subject to slumping and landsliding, especially along bentonite beds. Frost heave: Low to moderate. Erosion: Erodes easily.	Compaction: Generally difficult to compact. Excavation: Easily excavated with light power machinery.	Poor sub-base for hard-surfaced roads. Fair source of fill material for earth dams, reservoir and canal linings. Small amounts of bentonite. Unsurfaced roads impassable when wet.
EAGLE SANDSTONE Ke Kev	Upper and middle members (Ke) are alternating beds of gray to buff thin-bedded sand, sandstone, shale, and carbonaceous shale. Bed of highly polished, dark-colored chert pebbles at top of upper member. Two thin coal beds locally present near base of middle member. Virgelle sandstone member (Kev) a massive, white to buff sandstone, locally cross-bedded, numerous sandy limonitic concretions.	Distribution: Underlies most of area. Crops out along Missouri River and in fault zones. Thickness: Upper and middle member 125 to 150 feet: Virgelle sandstone member 80 to 100 feet.	Terrain: Upper and middle members form gentle to steep slopes, Virgelle sandstone member forms cliffs. Local relief up to 200 feet. Slopes: Up to 45° in upper and middle members. Up to 90° in Virgelle sandstone member.	Drainage: Good to excellent. Permeability: Low to medium in upper and middle members, high in Virgelle sandstone member, which is water bearing in some areas.	Stability: Moderate in upper and middle members, shallow cuts stand at angles up to 60°. High in Virgelle sandstone member, stands in vertical cliffs. Frost heave: Low to moderate. Erosion: Upper and middle members erode easily. Virgelle sandstone member moderately resistant.	Compaction: Generally difficult to compact. Excavation: Upper and middle members generally easy to excavate with light power machinery. Virgelle sandstone member may require use of explosives.	Poor to fair sub-base for hard-surfaced roads. Fair source of fill material. Source of small amounts of sub-bituminous coal. Virgelle sandstone member water bearing in some areas.
TELEGRAPH CREEK FORMATION Kt	Alternating thin-bedded buff sandstone and grayish-blue shale. Transition zone between Virgelle sandstone member and Colorado shale. Varies in composition and thickness. Locally absent.	Distribution: Underlies most of area, locally absent or thin. Crops out along Missouri River and in fault zones. Thickness: Varies from less than 10 feet to more than 150 feet. Locally absent.	Terrain: Generally eroded to badland topography. Local relief up to 100 feet. Slopes: Gentle to steep, generally less than 35°.	Drainage: Generally good. Permeability: Very low.	Stability: Moderate. Frost heave: Moderate to high. Erosion: Erodes easily in shales, sandstone breaks in chunks where undercut.	Compaction: Generally difficult to compact. Excavation: Moderately difficult with light power machinery.	Poor sub-base for hard-surfaced roads. Fair source of fill material.
COLORADO SHALE Kc	Dark grayish-blue marine shale containing numerous calcareous concretions. Cracks and fissures contain veins of selenite (gypsum), scattered thin beds of bentonite.	Distribution: Underlies entire area. Crops out along Missouri River and in fault zones. Thickness: About 1,800 feet, but only upper 400 to 500 feet exposed in quadrangle.	Terrain: Generally eroded to badland topography. Local relief up to 200 feet. Slopes: Generally less than 35°.	Drainage: Generally good. Permeability: Very low.	Stability: Moderate: Shallow cuts stand at angles up 45°. Subject to slumping and landsliding, especially along bentonite beds. Frost heave: Low to moderate. Erosion: Erodes easily.	Compaction: Generally difficult to compact. Excavation: Easily excavated with light power machinery.	Poor sub-base for hard-surfaced roads. Fair source of fill material for earth dams, reservoir and canal linings.
SHONKINITE DIKES AND SILLS	Dark intrusive rock, composed of hornblende, olivine, pyroxene, biotite, and orthoclase. Dikes and sills formed when molten rock was forced upward from the earth's interior into cracks and fissures near the surface.	Distribution: Northern and eastern part of quadrangle. Thickness: Dikes average 4 feet in width. Sills range from 2 to more than 20 feet thick.	Terrain: Generally more resistant than surrounding materials and stand a few feet above the surrounding land surface.	Permeability: Generally impermeable.	Stability: Generally high. Many dikes and sills are hard and dense. Others disintegrate easily, owing to lack of binding materials. Frost heave: None. Erosion: Generally resistant.	Excavation: Explosives generally required.	Possible source of small quantities of rip-rap material from more resistant parts of dikes.

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

PREPARED AS A PART OF THE DEPARTMENT OF THE INTERIOR'S PROGRAM
FOR THE DEVELOPMENT OF THE MISSOURI RIVER BASIN

MISSOURI RIVER BASIN
MAPPING AND MINERAL RESOURCE INVESTIGATIONS
BIG SANDY QUADRANGLE, MONTANA



Base compiled from Bureau of Land Management township plats.

APPROXIMATE MEAN DECLINATION 1950

Geology mapped in 1950 by R.M. Lindvall and J.H. Dolloff

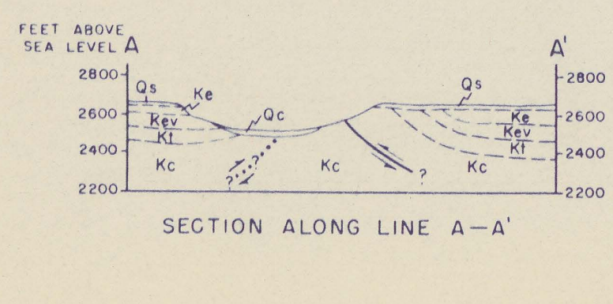
PRELIMINARY MAP OF THE

GEOLOGY OF THE BIG SANDY QUADRANGLE, MONTANA

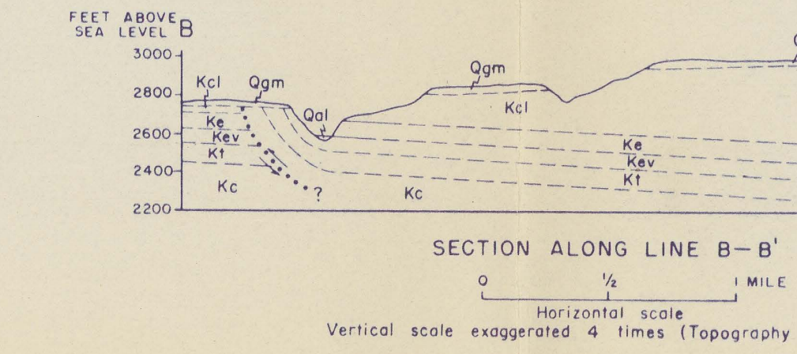
Scale 1:48,000

1 0 1 2 Miles

1953

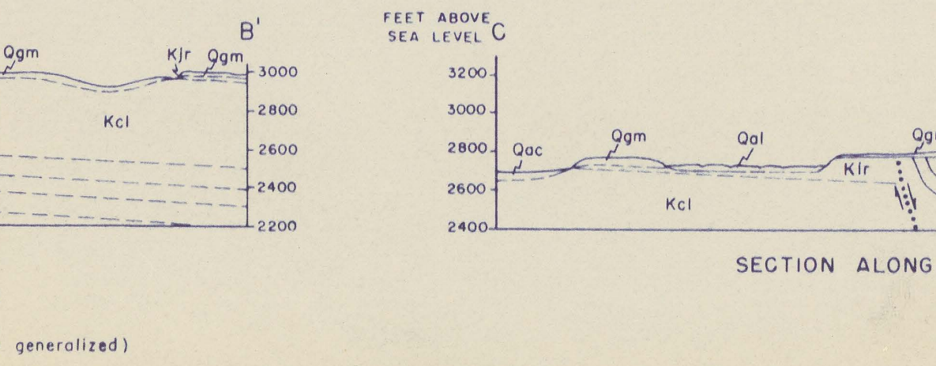


SECTION ALONG LINE A-A'



SECTION ALONG LINE B-B'

0 ½ 1 MILE
Horizontal scale
Vertical scale exaggerated 4 times (Topography generalized)



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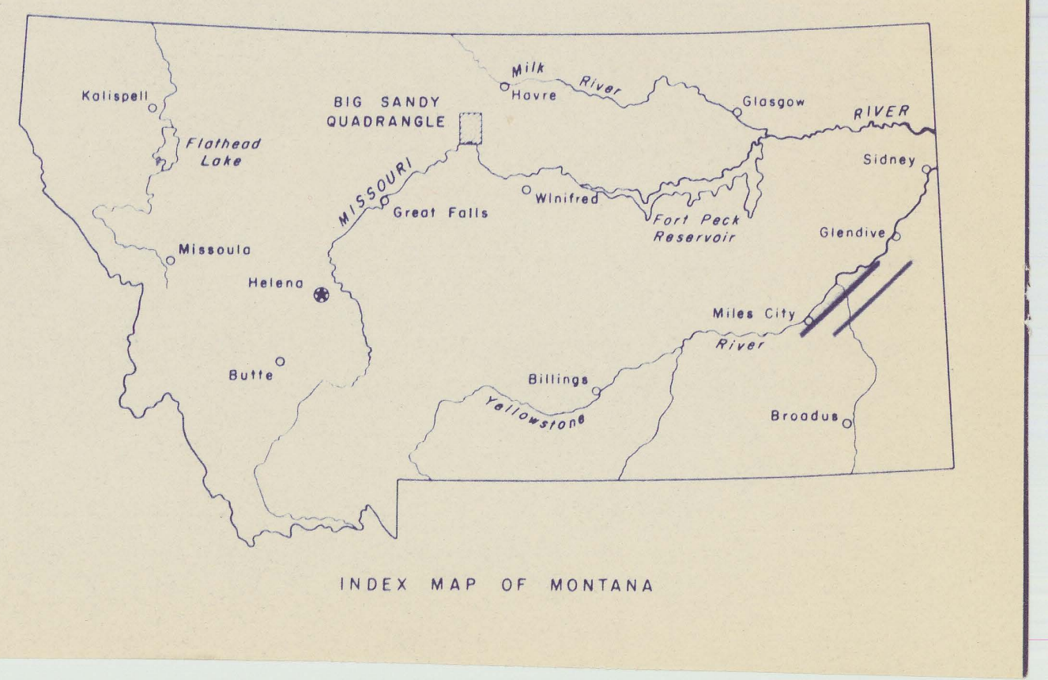

INDEX MAP OF MONTANA

EXPLANATION

SEDIMENTARY ROCKS

QUARTERNARY

Recent

Qal **Qc**

Alluvium and Colluvium

Alluvium (Qal). Interbedded light-brown to gray clay, silt, sand, and fine gravel. Unconsolidated, moderately permeable; 1 to more than 20 feet thick. Not mapped along minor streams.
Colluvium (Qc). Interbedded light-brown to gray clay, silt, and sand. Unconsolidated, slightly permeable; 1 to 10 feet thick.

Qac

Alluvium-colluvium (undifferentiated)

Interbedded light-brown to gray clay, silt, sand, and gravel. Unconsolidated, slightly to moderately permeable; 1 to more than 100 feet thick.

Pleistocene

Wisconsin stage

Qkd

Kettle deposits

Dark gray plastic clay containing minor amounts of silty clay, silt, and sand. Unconsolidated, slightly permeable; 1 to 10 feet thick.

Qt

Terrace deposits

Interbedded light-brown silt, sand, and gravel. Unconsolidated, permeable; 10 to 20 feet thick.

Qs **Qsd**

Sand deposits

Light-brown to gray, well-sorted, medium to fine-grained sand. Unconsolidated, highly permeable; 10 to 30 feet thick. Areas of active sand dunes mapped as Qsd.

Qst

Silt deposits

Stratified, light-brown silt and sandy silt. Unconsolidated, slightly permeable; 5 to more than 100 feet thick.

Qk

Kame deposits

Stratified or semi-stratified light-brown sand and gravel containing minor amounts of silt and clay. Unconsolidated, permeable; 5 to 20 feet thick.

Qe

Esker deposits

Stratified or semi-stratified sinuous ridges of light-brown sand and gravel. Minor amounts of silt and clay. Unconsolidated, permeable; 5 to 25 feet thick.

Qgm

Ground moraine

Unstratified mixture of buff to light-gray clay, silt, and sand, containing minor amounts of pebbles, cobbles, and boulders. Compact but unconsolidated, slightly permeable; 5 to 30 feet thick: in filled pre-glacial valleys as much as 150 feet thick. Hachures indicate drumlinoidal ridges in ground moraine.

CRETACEOUS

Upper Cretaceous

Khc

Hell Creek formation

Gray, green, pink, and buff clay, shale, and sandstone. Small nodular claystone concretions abundant in upper part. Prominent black bentonitic clay bed 10 to 15 feet thick in lower 100 feet; 400 to 500 feet thick, only 150 to 200 feet exposed in quadrangle.

Montana group

Kfh

Fox Hills sandstone

Light-brown to light-gray sand and sandstone, interbedded with tan and and gray shale and carbonaceous shale. Sandstone thin-bedded to massive, some cross-bedding; 100 to 200 feet thick.

Kbs

Bearpaw shale

Brownish-gray to dark blue-gray marine shale. Upper 100 feet contains brownish sandy beds. Thin bentonite beds throughout formation. Numerous gray and dark red calcareous concretions. About 700 feet thick, only upper 300 to 400 feet exposed in quadrangle.

Kjr

Judith River formation

Interbedded light-gray to buff, thin-bedded to massive sandstone, and gray to buff clay and shale. Thin coal beds in upper part of formation and in lower 200 feet. About 500 feet thick.

Kcl

Claggett shale

Brownish-gray marine shale. Upper 150 feet is sandy, yellowish-gray; lower 100 feet contains bentonite beds as much as 18 inches thick. Calcareous concretions abundant throughout formation; 450 to 500 feet thick.

Ke
Kev

Eagle sandstone

Upper and middle members (Ke) are alternating beds of gray to buff thin-bedded sand, sandstone, shale, carbonaceous shale and coal. Total thickness of upper and middle members ranges from 125 to 150 feet. Lower (Virgelle) sandstone member (Kev) is a massive, white to buff, cross-bedded sandstone containing numerous sandy limonitic concretions; 80 to 100 feet thick.

Kt

Telegraph Creek formation

Alternating thin-bedded buff sandstone and grayish-blue shale. Transition zone between Colorado shale and Eagle sandstone; 10 to 150 feet thick, locally absent.

Lower Cretaceous

Colorado group

Kc

Colorado shale

Dark grayish-blue marine shale containing numerous calcareous concretions. Total thicknesses about 1,800 feet, only upper 400 to 500 feet exposed.

IGNEOUS ROCKS

TERTIARY

Eocene(?)

Shonkinite dikes and sills

Dark intrusive rock, composed of hornblende, olivine, pyroxene, biotite and orthoclase. More resistant than surrounding materials and stand a few feet above the surrounding land surface. Dikes average 4 feet in width, and up to one quarter mile in length. Sills range from 2 to more than 20 feet thick.

Contact
(Dashed where approximately located)

(Kjr) (Kcl)
Concealed bedrock contact
(Symbols in parenthesis indicate the concealed bedrock)

U D
Fault

Concealed fault
(Direction of dip shown by arrows; U-upthrown side; D-downthrown side.)

30
Strike and dip of beds

BM X 2710
Bench mark
(elevation in feet)

T. S. BIG SANDY
Triangulation station
(with name of station)

Gravel pit

Coal mine
(abandoned)

5
Measured coal section
(figure indicates number of measured section)

Channel of preglacial Missouri River

Segment of glacial meltwater channel

Drumlinoidal ridge

28' Qgm
85' Kjr
>90' Kcl
Abbreviated columnar section
(with location symbol)

Abandoned oil or gas well

Stratigraphic sequence and approximate thickness, in feet, of geologic units. Data based on natural and artificial exposures and on test drilling. Symbol > means: more than.

Intermittent stream

Spring

Dam and reservoir

Intermittent lake

Building
(occupied)

Building
(unoccupied)

School

87
Hard surfaced road
(U.S. Highway)

Improved road

Unimproved road