

# AREAL GEOLOGY OF THE GOPHER QUADRANGLE

EXPLANATION

SEDIMENTARY ROCKS

**Qal**  
Alluvium  
(Valley-bottom deposits of clay, silt, sand, and gravel in present streams.)

**Qol**  
Older Alluvium  
(Older valley-bottom deposits above present streams.)

**Qfg**  
Terrace Gravel  
(Terrace deposits of sand and gravel 1-6' thick. Generally less covered.)

**Qgr**  
Terrace Gravel Remnants  
(High sand and gravel outliers about 2300' in altitude. 1-16' thick.)

**Khu**  
Upper Hell Creek  
(“Somber beds” of lens-like bentonitic clays, silts, part loess, sands, and peat-clays. Mn-Fe concretions. Local badlands. Few burr-top sandstones. Collium or slope wash in barren-slope areas. Residual, brown Tongue River ortho-quartzite boulders and silicified wood of Tertiary age scattered on surface. Upper part missing. About 250' thick.)

**Khf**  
Isabel-Firesteel Coal Member  
(Black subbituminous coal 0-7' thick, some lignite, often carries “blackjack”, a black carbonaceous clay as partings in coal or super- and/or sub-sequent positions. Thin brown clay-peat beds generally with coal. Pseudoscoria, a buff to red burned claystone, is hill-forming. Coal ashes often found below pseudoscoria.)

**Khl**  
Lower Hell Creek  
(Medium to dark gray lens-like bentonitic clays, silts (part loess), sands, thin peat-clay beds. Mn-Fe concretions. Few *Quereas* bivalves, occasional dinosaur (*Trochodon* or *Triceratops*?) bones. About 32-63' thick.)

**Kfb**  
Colgate Sandstone Member  
(“Pepper-and-salt” high-rank graywacke, calcareous cement, cross-laminated, spheroidal-concretionary shaped. 5-15' thick.)

**Kf**  
“Banded” Member  
(Alternating light and medium gray clayey sand and silt with small brown limonite concretionary layers, some thin streaks of plant matter. About 100' exposed.)

**DRAINAGE**

Intermittent Streams

Intermittent Lakes

**CULTURE**

Buildings  
(House, church, and school)

Roads and Trails

Altitudes  
(In feet above sea level.)

Bench Marks  
(Monuments marking points of known altitude.)

Triangulation Stations  
(U.S. Coast & Geodetic and/or U.S. Geological Survey monuments marking points of exact geographic location.)

Coal mines and Gravel pits

Coal Thickness  
(Exposed)

Drill Holes

Dams  
(Large, small earthen or cement.)

PLEISTOCENE

Wisconsin(?)

Upper Hell Creek

Isabel-Firesteel

Coal Member

Lower Hell Creek

Colgate Sandstone

Member

“Banded” Member

UPPER CRETACEOUS

Hell Creek Formation

Fox Hills Formation

QUATERNARY

QUATERNARY

QUATERNARY

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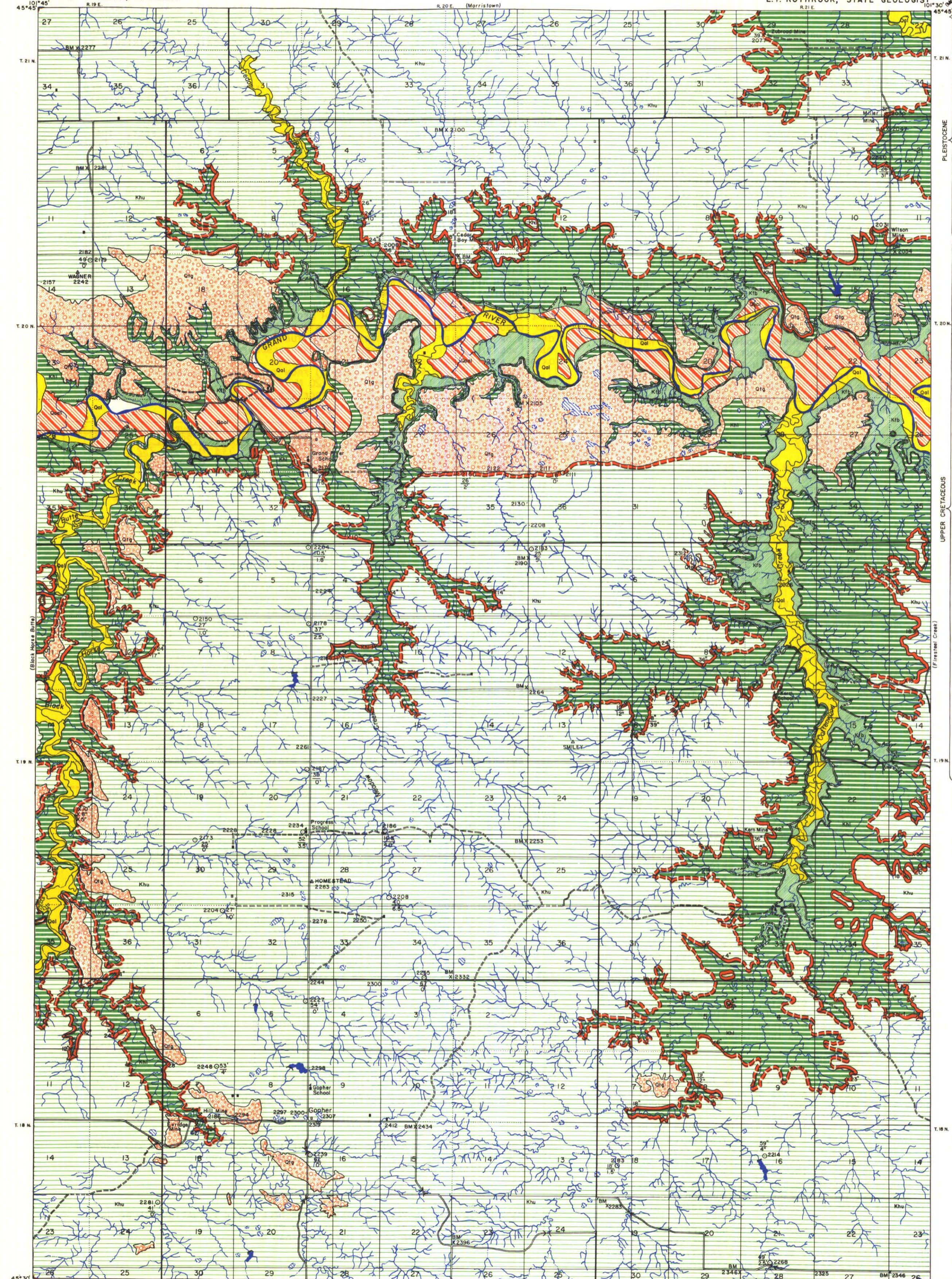
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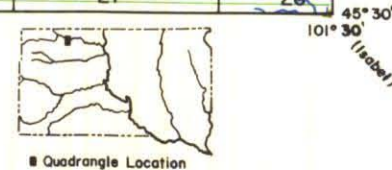
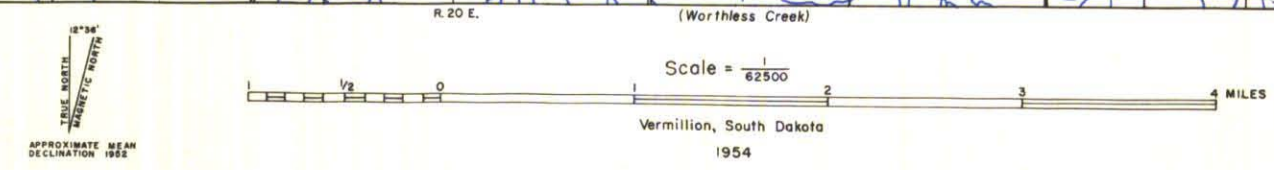
QUATERNARY

STATE OF SOUTH DAKOTA  
SIGURD ANDERSON, GOVERNOR

STATE GEOLOGICAL SURVEY  
E. P. ROTHROCK, STATE GEOLOGIST



Geology by R.E. Curtiss  
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Surveyed in 1952.  
Coal-Test Holes Drilled in 1953.



Base Map by South Dakota State Geological Survey.

Vermillion, South Dakota  
1954

## AREAL GEOLOGY OF THE GOPHER QUADRANGLE

By

ROBERT E. CURTISS

## LOCATION

THE QUADRANGLE, WHICH OCCUPIES PART OF CORSON COUNTY, IS SITUATED ABOUT 20 MILES SOUTHEAST OF LEMMON AND APPROXIMATELY 100 MILES NORTHWEST OF PIERRE BETWEEN PARALLELS 45°30' AND 45°45' NORTH LATITUDE AND MERIDIANS 101°30' AND 101°45' WEST LONGITUDE AND CONSTITUTES AN AREA OF ABOUT 210 SQUARE MILES.

## TOPOGRAPHY AND DRAINAGE

THE GRAND RIVER VALLEY IS A CONSPICUOUS TOPOGRAPHIC FEATURE WHICH TRAVERSES THE NORTHERN PORTION OF THE QUADRANGLE FROM WEST TO EAST. THE VALLEY MEANDERS VARY FROM ONE-HALF TO ONE AND ONE-HALF MILES IN WIDTH, AND MANY PRECIPITIOUS VALLEY BLUFFS RANGE BETWEEN 50 AND 150 FEET IN RELIEF.

MANY FLAT-TOPPED GRAVEL TERRACES ARE FOUND ALONG THE GRAND RIVER AND BLACK HORSE BUTTE CREEK.

DRAINAGE FLOWS SOUTH TO THE GRAND RIVER ALONG THE SOUTH SLOPES OF THE GRAND-CANNONBALL DIVIDE. STREAM COURSES TREND NORTH TO THE GRAND RIVER FROM THE NORTH SLOPES OF THE MOREAU-GRAND INTERSTREAM DIVIDE. THE GRAND RIVER IS THE MASTER STREAM WHICH RECEIVES SURFACE RUNOFF FROM THE QUADRANGLE. YOUTHFUL, SHARPLY-DISSECTED, INTERMITTENT STREAM CHANNELS INTRICATELY FRINGE THE INTERSTREAM DIVIDES. THE DRAINAGE PATTERN IS DENDRITIC. SPRINGS ARE GENERALLY ASSOCIATED WITH COAL OUTCROPS.

COAL CROPS OUT IN STREAM VALLEYS, BOTH NORTH AND SOUTH OF THE GRAND RIVER, AND MINING IS GENERALLY CONFINED TO THE OUTCROP WHERE THE OVERBURDEN IS OF MINIMUM THICKNESS. OVERBURDEN IS THICKEST IN THE SOUTH PART OF THE QUADRANGLE WHERE THE INTERSTREAM DIVIDE FORMS A PROMINENT TOPOGRAPHIC HIGH.

THE MAXIMUM ALTITUDE IN THE QUADRANGLE IS ABOUT 2,452 FEET ABOVE SEA LEVEL ON A RIDGE OF UPPER HELL CREEK SILTY CLAY IN THE NE $\frac{1}{4}$ , SE $\frac{1}{4}$ , SEC. 10, T. 18 N., R. 20 E. THE MINIMUM ALTITUDE IS ABOUT 1,952 FEET ABOVE SEA LEVEL IN THE GRAND RIVER CHANNEL ON THE "BANDED" MEMBER OF THE FOX HILLS FORMATION IN THE NE $\frac{1}{4}$ , SW $\frac{1}{4}$ , SEC. 23, T. 20 N., R. 21 E. THE RELIEF IS APPROXIMATELY 498 FEET, AND THE AVERAGE ALTITUDE OF THE QUADRANGLE IS ABOUT 2,202 FEET ABOVE SEA LEVEL.

## STRATIGRAPHY

THE EXPOSED FORMATIONS RANGE IN AGE FROM UPPER CRETACEOUS TO RECENT. A MAJOR PORTION OF THE HELL CREEK FORMATION IS EXPOSED; HOWEVER, THE UPPER PART OF THE UPPER HELL CREEK UNIT HAS BEEN ERODED. THE FOX HILLS-HELL CREEK BOUNDARY IS CONFORMABLE AS THE EXPOSED STRATIGRAPHIC SEQUENCE DENOTES CONTINUOUS DEPOSITION. TERTIARY RESIDUUM, COMPOSED OF ORTHOQUARTZITE BOULDERS AND SILICIFIED WOOD FROM THE PALEOCENE TONGUE RIVER FORMATION, PLEISTOCENE GRAVELS, PLEISTOCENE-RECENT LOESS AND ALLUVIAL TERRACES, AND RECENT ALLUVIUM COMPLETE THE SURFACE SEDIMENTS IN THE QUADRANGLE.

"BANDED" MEMBER (SEARIGHT 1931), FOX HILLS FORMATION (MEEK AND HAYDEN, 1861). ABOUT 100 FEET OF THE MEMBER CROPS OUT. IT CONSISTS OF A BANDED SERIES OF ALTERNATING LIGHT AND MEDIUM GRAY CLAYEY SAND AND SILT WITH RUSTY BROWN LIMONITIC CONCRETIONARY LAYERS. THIN INTERCALATED STREAKS OF PLANT MATTER AND MINOR QUANTITIES OF DISSEMINATED BENTONITE ARE PRESENT. NO INVERTEBRATE FOSSILS WERE FOUND.

COLGATE SANDSTONE MEMBER (CALVERT 1912), FOX HILLS FORMATION. THIS UNIT VARIES IN THICKNESS FROM FIVE TO 15 FEET IN THICKNESS, SILICA- AND CALCAREOUS-CEMENTED HIGH-RANK GRAYWACKE SANDSTONES ARE MEDIUM GRAY "PEPPER-AND-SALT" IN COLOR, SHALY TO FLAGGY BEDDING, SLIGHTLY CROSS-LAMINATED, WITH RUSTY BROWN LIMONITE STAIN AND DIMINUTIVE FRAGMENTS OF SILICIFIED WOOD. NO INVERTEBRATE FOSSILS WERE NOTED.

LOWER HELL CREEK, HELL CREEK FORMATION (BROWN 1907). THIS UNIT VARIES IN THICKNESS FROM ABOUT 32-63 FEET. IT IS COMPOSED OF MEDIUM GRAY LENTICULAR, SLIGHTLY CROSS-LAMINATED LOESSIAL SILTS, FINE-GRAINED SANDS, SILTSTONE, SANDSTONE, DISSEMINATED BENTONITE, CLAYS, AND CHANNEL-FLOODPLAIN DEPOSITS OF HETEROGENEOUS SIZES, THIN BROWN CLAY-PEAT BEDS OR FLORASTROMES FREQUENTLY CONTAIN SMALL FRAGMENTS OF FUSAIN COAL AND RESIN PELLETS. ALSO FOUND ARE PURPLE-BLACK TO RUSTY BROWN MANGANESE-IRON CONCRETIONS, YELLOW MELANITERITE NODULES, DISCONTINUOUS OSTREA BIOSTROMES, AND OCCASIONAL UNARTICULATED DINOSAUR (TRACHODON OR TRICERATOPS (?) BONES.

ISABEL-FIRESTEEL COAL MEMBER (CURTISS 1952), HELL CREEK FORMATION. THIS MEMBER, ABOUT 25 FEET THICK, INCLUDES SEVERAL DIFFERENT, INTERRELATED LITHOLOGIES. COAL, BOTH SUBBITUMINOUS C RANK AND LIGNITE, VARIES FROM ZERO TO SEVEN FEET IN THICKNESS AND OFTEN CONTAINS "BLACKJACK" OR BONE COAL, A TOUGH BLACK CARBONACEOUS CLAY, AS PARTINGS IN THE COAL OR IN SUPER- AND/OR SUBJACENT POSITIONS, LOCALLY ABUNDANT FOSSIL RESIN PELLETS, AND RARELY OBSERVED PYRITE AND MARCASITE NODULES. PSEUDOSCORIA, BUFF TO BRICK RED CLINKERED CLAYSTONE, REPRESENTS BURNED PEAT-CLAY BEDS OVERLYING A BURNED OUT COAL BED. GRAY-WHITE ASHES DIRECTLY UNDERLIE PSEUDOSCORIA.

IN SOME AREAS, THE COAL BED SPLITS INTO THREE DISTINCT COAL BEDS, WHICH CONSTITUTE AN INTERVAL UP TO 25 FEET IN THICKNESS. GENERALLY, THE THREE BEDS CONSIST OF PEAT-CLAY WITH VARIABLE THICKNESSES AND PERCENTAGES OF COAL. THEREFORE, THE BEDS RETAIN NO LATERAL HOMOGENEITY.

UPPER HELL CREEK, HELL CREEK FORMATION. THIS UNIT, WHICH IS ABOUT 250 FEET THICK, IS ALMOST LITHOLOGICALLY IDENTICAL TO THE LOWER HELL CREEK. HOWEVER, PEAT-CLAY BEDS ARE THINNER, AND SEVERAL "BLACKJACK" BELTS WERE NOTED. SAND BEDS AND SLIGHTLY INDURATED SANDSTONES AND SILTSTONES ARE FAIRLY NUMEROUS. PURPLISH BLACK MANGANESE-IRON CONCRETIONS ARE LOCALLY ABUNDANT IN ERODED AREAS, AND SEVERAL EXCEED TWO FEET IN DIAMETER. THE CONCRETIONS WEATHER A CHARACTERISTIC RUSTY LIMONITE BROWN. RESIDUAL TONGUE RIVER ORTHOQUARTZITE BOULDERS AND SILICIFIED WOOD ARE SCATTERED INTERMITTENTLY ON THE SURFACE. THE UPPER PORTION OF THE UNIT IS ERODED. NO INVERTEBRATE FOSSILS WERE NOTED.

## STRUCTURE

THE QUADRANGLE IS LOCATED ON THE EAST FLANK OF THE DAKOTA (WILLISTON) BASIN. THE REGIONAL DIP IS NORTHWEST AT A RATE OF ABOUT 15 TO 25 FEET PER MILE. THE FLANK IS NOT A STRUCTURALLY SMOOTH SURFACE, BUT INTERRUPTED BY SMALL FAULTS AND SLUMPS AND POSSIBLY GENTLE FLEXURES.

COAL-TEST BORINGS WERE MADE BY THE STATE GEOLOGICAL SURVEY TO DETERMINE THICKNESSES OF COAL AND OVERBURDEN AND THE STRUCTURAL TENDENCIES INDICATED BY SEA LEVEL ALTITUDES ESTABLISHED ON THE COAL, THE MOST RELIABLE "KEY" BED. STRUCTURE CONTOURS INDICATE AN ASYMMETRIC ANTICLINE WITH POSSIBLY 50 FEET OF CLOSURE IN SECS. 3, 4, 5, 32, 33, 34, T. 19-20 N., R. 20 E.

SMALL-SCALE NORMAL FAULTS AND SLUMPS OCCUR IN THE UPPER HELL CREEK. ONE TYPICAL NORMAL FAULT EXISTS ALONG THE EAST BANK OF COTTONWOOD CREEK, SEC. 7, T. 18 N., R. 21 E. A ONE-FOOT THICK PEAT-CLAY BED IS VERTICALLY DISPLACED SIX FEET.

STRUCTURES ASSOCIATED WITH THE COAL HAVE IMPOSED NO DIFFICULTIES TO COAL MINING. STRUCTURAL DETERMINATION IS COMPLICATED BY THE GENERAL ABSENCE OF MARKER BED EXPOSURES, VEGETATION COVER, SLUMPS, AND ERRATIC LENTICULARITY OF BEDS EXHIBIT SEDIMENTATIONAL DIPS RATHER THAN TRUE STRUCTURAL DIPS.

## ECONOMIC GEOLOGY

THE QUADRANGLE CONTAINS A VARIETY OF MINERAL RESOURCES, BOTH OF CURRENTLY-EXPLOITED AND POTENTIAL VALUE. CURRENTLY, COAL IS THE MOST IMPORTANT ECONOMIC PRODUCT. SAND AND GRAVEL ARE QUARRIED SPASMODICALLY. COAL BY-PRODUCTS, MANGANESE-IRON CONCRETIONS, BENTONITIC CLAYS, AND PSEUDOSCORIA MAY CONTRIBUTE TO THE AREA'S FUTURE ECONOMY.

## COAL

**AREAL EXTENT.** THE APPROXIMATE BOUNDARY OF THE ISABEL-FIRESTEEL COAL BED IS SHOWN ON THE MAP. THIS BOUNDARY WAS DETERMINED LARGELY BY NATURAL EXPOSURES, COAL MINES, ROAD CUTS, AND STATE GEOLOGICAL SURVEY DRILL HOLES. COAL UNDERLIES ABOUT 150 SQUARE MILES IN THE QUADRANGLE.

**THICKNESS.** THE COAL VARIES IN THICKNESS FROM ZERO TO SEVEN FEET. THE ISABEL-FIRESTEEL COAL CONSISTS OF ONE MINABLE SEAM AT THE HILL, ZUBROAD, CEDAR BOY, MILLER AND EVRIDGE MINES. THE COAL SPLITS INTO TWO AND THREE COALS IN SEVERAL AREAS WITH THE VERTICAL INTERVAL BETWEEN COAL BEDS VARYING BETWEEN TWO TO 20 FEET.

**PHYSICAL CHARACTER.** MOST OF THE COAL IS BANDED, BLACK IN COLOR AND STREAK, HARD, BRITTLE, SMOOTH SURFACED, BLOCKY, WITH LIMONITE STAIN ALONG THE BEDDING AND JOINTS, DISSEMINATED SUBROUNDED AMBER-COLORED RESIN PELLETS, SOME GYPSUM, AND MINOR AMOUNTS OF PYRITE AND MARCASITE NODULES. THE COAL SLACKS MODERATELY UPON DRYING AND IS NONCOKING. THE SPECIFIC GRAVITY VARIES BETWEEN 1.20 AND 1.25. PEAT-CLAY BEDS SOMETIMES CONTAIN FUSAIN, VITRAIN, FOSSIL RESIN, AND MEL-ANTERITE AND LIMONITE NODULES.

THIN PARTINGS OF "BLACKJACK" AND/OR PEAT-CLAY BEDS ARE OCCASIONALLY ASSOCIATED WITH THE COAL, EITHER DIRECTLY ABOVE OR BELOW THE COAL BED.

**CHEMICAL CHARACTER.** CHEMICAL ANALYSES PROVIDE A SATISFACTORY BASIS FOR COMPARING COALS AND DETERMINING THE RANK AND GRADE OF COAL AND ITS COMMERCIAL QUALITIES. PROXIMATE ANALYSES FURNISH NECESSARY DATA CONCERNING THE QUALITY AND COMBUSTION PROPERTIES OF COAL (MOISTURE, VOLATILE AND GASEOUS MATTER, FIXED CARBON OR THE CHIEF HEAT-PRODUCING CONSTITUENT, ASH, AND SULPHUR). THE MOISTURE, VOLATILE MATTER, AND FIXED CARBON ARE RESOLVED INTO CARBON, HYDROGEN, OXYGEN, AND NITROGEN BY THE ULTIMATE ANALYSES.

COAL SAMPLES ("TRENCH" OR CHANNEL) FROM THE HILL MINE, SEC. 7, T. 18 N., R. 20 E., CEDAR BOY MINE, SEC. 11, T. 20 N., R. 20 E., ZUBROAD MINE, SEC. 29, T. 21 N., R. 21 E., WERE ANALYZED AS RECEIVED, MEANING THE SAMPLES REPRESENT THE COAL AS MINED. THE PROXIMATE ANALYSES ARE AS FOLLOWS:

LOCATION	MOISTURE	VOLATILE MATTER	FIXED CARBON	ASH	SULPHUR	B.T.U.	DRY B.T.U.
HILL MINE	34.94%	33.08%	27.69%	4.29%	0.29%	7,363	11,317
CEDAR BOY MINE	41.07%	30.26%	22.74%	5.93%	0.33%	5,732	9,727
ZUBROAD MINE	41.07%	32.20%	20.78%	5.95%	0.39%	5,586	9,479

THE COAL CONTAINS VERY SMALL QUANTITIES OF SULPHUR AND ASH, TYPICAL OF THE ISABEL-FIRESTEEL COAL ANALYZED FROM OTHER QUADRANGLES, AND THE ASHES ARE LIGHT AND USUALLY DEVOID OF CLINKERS. BURNING IMPARTS NO DELETERIOUS CORROSIVE ACTION TO BOILER PIPES.

ECONOMICALLY, AN AIR-DRIED COAL, PRIOR TO DOMESTIC OR COMMERCIAL CONSUMPTION, WILL INCREASE THE HEATING VALUE CONSIDERABLY. (SEE DRY B.T.U. IN ABOVE TABLE.)

THE BLACK COAL IN THIS QUADRANGLE HAS BEEN CALLED LIGNITE. HOWEVER, COMPARATIVE PHYSICAL CHARACTERISTICS OF LIGNITE AND SUBBITUMINOUS COAL INDICATE THIS COAL APPROXIMATES SUBBITUMINOUS C RANK.

**CHARACTER OF OVERBURDEN.** THE LITHOLOGIC NATURE OF THE OVERBURDEN IS NOT A DETRIMENT TO STRIP MINING. BULLDOZERS AND OTHER EARTH-MOVING EQUIPMENT EASILY REMOVE THE COVER. OVERBURDEN THICKNESSES AT VARIOUS MINES IN THE QUADRANGLE ARE AS FOLLOWS: HILL MINE, 10-28 FEET; CEDAR BOY MINES, ABOUT 20 FEET; KERN MINE, UP TO 40 FEET; EVRIDGE MINE, FIVE-20 FEET; MILLER MINE, 13 FEET; WILSON MINE, ABOUT 30 FEET; AND, ZUBROAD MINE, 10-15 FEET.

**ESTIMATED COAL RESERVES.** THE TOTAL ESTIMATED COAL TONNAGE, BASED ON OUTCROPS, MINE DATA, AND DRILL HOLES, FOR THE GOPHER QUADRANGLE IS ABOUT 33,277,500 TONS. TONNAGE IS COMPUTED ON THE BASIS OF A MINIMUM THICKNESS OF 2½ FEET, A SPECIFIC GRAVITY OF 1.25, AND 1,700 TONS PER ACRE-FOOT. TONNAGE IS FURTHER RESOLVED INTO THREE CATEGORIES: MEASURED (COAL RESERVES LOCATED WITHIN 0.5 MILES FROM OUTCROPS, STRIP MINES, OR DRILL HOLES), 623,900 TONS; INDICATED (COAL RESERVES LOCATED BETWEEN 0.5 AND 1.5 MILES FROM OUTCROPS, STRIP MINES, OR DRILL HOLES), 18,387,200 TONS; AND, INFERRED (COAL RESERVES LOCATED MORE THAN 1.5 MILES FROM OUTCROPS, STRIP MINES, OR DRILL HOLES), 14,266,400 TONS.

**POTENTIAL MINING AREAS.** DATA FROM 22 STATE GEOLOGICAL SURVEY DRILL HOLES INDICATE THE FOLLOWING POTENTIAL STRIPPING AREAS:

LOCATION	COAL THICKNESS	OVERBURDEN THICKNESS
NW $\frac{1}{4}$ NW $\frac{1}{4}$ , SEC. 1, T. 19 N., R. 20 E.	5'	25.0'
SW $\frac{1}{4}$ SW $\frac{1}{4}$ , SEC. 22, T. 19 N., R. 20 E.	4'	16.5'
NW $\frac{1}{4}$ NE $\frac{1}{4}$ , SEC. 7, T. 18 N., R. 19 E.	4'	53.0'
SE $\frac{1}{4}$ NW $\frac{1}{4}$ , SEC. 16, T. 18 N., R. 21 E.	4'	59.0'

SYSTEMATIC DETAILED DRILLING OR AUGERING IS NECESSARY IN DETERMINING THE PRECISE QUANTITIES AND QUALITIES OF COAL AND CHARACTER OF OVERBURDEN IN THESE AREAS.

## SAND AND GRAVEL

SAND AND GRAVEL TERRACE DEPOSITS CONSTITUTE A TOTAL OF ABOUT 42,000,000 CUBIC YARDS AND ARE LOCATED ALONG THE GRAND RIVER AND BLACK HORSE BUTTE CREEK. THESE DEPOSITS CONSIST OF LIMONITE, CHALCEDONY, MILKY AND ROCK CRYSTAL QUARTZ, SANDSTONE PEBBLES, SILICIFIED WOOD, ORTHOQUARTZITE, ARKOSIC PEBBLES, ET CETERA. MUCH OF THIS MATERIAL IS ADEQUATE FOR ORDINARY ROAD METAL.

THE ESTIMATED VOLUMES OF SAND AND GRAVEL WHICH OFFER GOOD POSSIBILITIES FOR LARGE-SCALE OPERATIONS ARE AS FOLLOWS:

LOCATION	ACRES	AVE. THICKNESS	CUBIC YARDS
SECS. 19, 23, 24, 25, 26, 27, 29, 30, T. 20 N., R. 20-21 E.	2,584	3'	12,506,560
SECS. 13, 14, 19, 23, 24, 30, T. 20 N., R. 19-20 E.	944	5'	7,614,933
SECS. 7, 12, 13, 17, 18, 19, 20, 24, T. 20 N., R. 19-20 E.	1,058	3'	5,111,040
SECS. 20, 21, 28, 29, T. 20 N., R. 21 E.	283	10'	4,565,733
SECS. 15, 21, 22, 27, 28, 33, T. 20 N., R. 20 E.	642	3'	3,107,280

OVER 20 OTHER TERRACES CONTAIN LESS THAN ONE MILLION CUBIC YARDS.

## MANGANESE-IRON

LOCALLY-ABUNDANT MANGANESE-IRON CONCRETIONS OCCUR SURFICIALLY AND CONTAIN 51.3% METALLIC IRON, ALMOST IDENTICAL TO SOME OF THE IRON ORE OF THE MESABI IRON RANGE, MINNESOTA.

## CLAY AND PSEUDOSCORIA

MANY BENTONITIC CLAYEY HORIZONS IN THE HELL CREEK FORMATION CAN BE USED TO SEAL LEAKING STOCK DAMS, THUS CONSERVING WATER.

CRUSHED PSEUDOSCORIA CAN BE USED FOR ROAD METAL.