

# AREAL GEOLOGY

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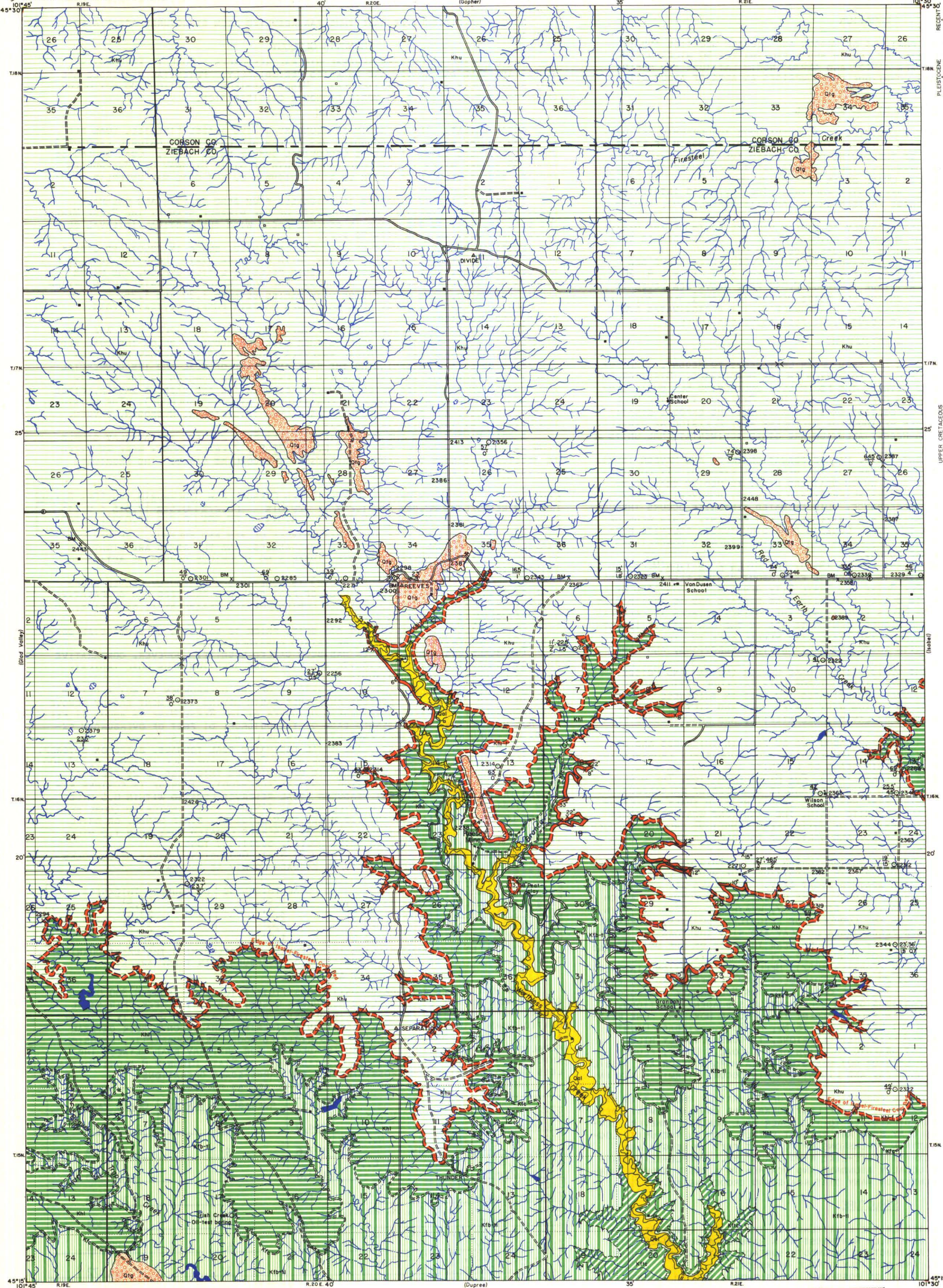
### WORTHLESS CREEK QUADRANGLE

STATE OF SOUTH DAKOTA  
SIGURD ANDERSON, GOVERNOR

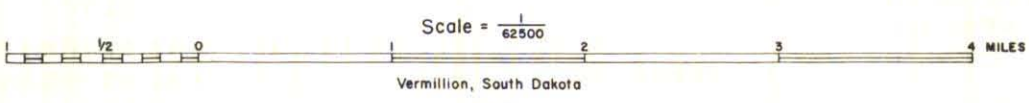
STATE GEOLOGICAL SURVEY  
E. P. ROTHROCK, STATE GEOLOGIST

#### EXPLANATION

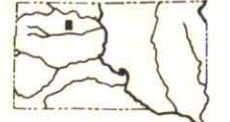
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|---|--|--|--|--|
| <p><b>QUATERNARY</b></p> <p><b>Qal</b><br/>Alluvium<br/>(Recent valley-bottom deposits of clay, silt, sand, and gravel in present streams.)</p> <p><b>Q1g</b><br/>Terrace Gravel<br/>(Terrace deposits of sand and gravel 1-6' thick.)</p>  | <p><b>PLEISTOCENE</b></p> <p><b>Upper Hell Creek</b><br/>[Somber beds of lens-like bentonitic clays, silts (partly loess), sands, and peat-clays. Mn-Fe concretions. Local boulders. Few butte-top sandstones. Collosum slope west in barren slope areas. Residual, brown Tongue River orthoquartzite boulders and splintered wood of Tertiary age scattered on surface. Upper part missing 300-350' exposed.]</p> | <p><b>HELL CREEK FORMATION</b></p> <p><b>Khu-f</b><br/>Isabel-Firesteel Coal Member<br/>(Black subbituminous coal 0'-4.5' thick, some lignite, often carries blackrock, a black carbonaceous clay as partings in coal or super- and/or sub-sequent positions. Three brown clay-peat beds generally with coal. Pseudoscorpia, a buff to red-burned claystone, in hill-forming. Coal coals often found beneath pseudoscorpia.)</p> <p><b>Khu</b><br/>Lower Hell Creek<br/>(Medium to dark gray lens-like bentonitic clays, silts (partly loess), sands, thin peat-clay beds. Mn-Fe concretions. Few <i>Clatagia</i> bivalves, occasional <i>Trachodon</i> (Trachodon or Trachogona?) bones. About 50-80' thick.)</p> | <p><b>UPPER CRETACEOUS</b></p> <p><b>Kp</b><br/>Colgate Sandstone Member<br/>(Pepper and salt high-rank graywacke, calcareous cement, cross-laminated, "spiraloid-concretionary" shaped 3'-15' thick.)</p> <p><b>Kp-II</b><br/>Banded and Timber Lake Members, Undifferentiated<br/>(Insufficient outcrop data preclude subdivision. Banded member: Alternating light and medium gray clayey sand and silt with small brown laminar concretionary layers, some thin streaks of plant matter. About 100' thick. Timber Lake Sand Member: Buff-yellow sand. About 25-50' thick.)</p> | <p><b>PIERRE FORMATION</b></p> <p><b>Kp</b><br/>Trail City Member<br/>(Medium to dark gray, very silty bentonitic clay, few thin beds of sand, limonite streaks and concretions, weathers medium gray, slightly "popcorn" surface. About 85-100' thick.)</p> <p><b>Kpe</b><br/>Elk Butte Member<br/>(Dark gray silty bentonitic clay, weathers light fuffy black gray, golden calcite concretions, melterite, selenite, thin bentonitic, cone-in-cone structure, weathers "popcorn" surface. About 50' exposed.)</p> |
| <p><b>DRAINAGE</b></p> <p>Intermittent Streams</p> <p>Intermittent Lakes</p>  |  |  |  |  |
| <p><b>CULTURE</b></p> <p>Buildings<br/>(House, church, and school)</p> <p>Roads and Trails</p>  |  |  |  |  |
| <p>Altitudes<br/>(In feet above sea level)</p> <p>Bench Marks<br/>(Monuments marking points of known altitude)</p> <p>Triangulation Stations<br/>(U.S. Coast &amp; Geodetic and/or U.S. Geological Survey monuments marking points of exact geographic location)</p> <p>Operating<br/>Abandoned</p> |  |  |  |  |
| <p>Coal mines and Gravel pits</p> <p>Coal Thickness<br/>(Exposed)</p> <p>Drill Holes<br/>Shell Oil Co.<br/>Winter No. 1</p> <p>Oil-test Borings</p> <p>Dams<br/>(Large, small earthen or cement)</p>  |  |  |  |  |



Geology by R.E. Curtiss  
Assisted by L.G. Stillwell, F.V. Steece, C. Dodson, R. Hanson  
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 WORTHLESS CREEK QUADRANGLE

By

ROBERT E. CURTISS

## LOCATION

THE QUADRANGLE OCCUPIES PORTIONS OF CORSON AND ZIEBACH COUNTIES AND IS LOCATED ABOUT 31 MILES SOUTHEAST OF LEMMON AND APPROXIMATELY 90 MILES NORTHWEST OF PIERRE BETWEEN PARALLELS 45°15' AND 45°30' NORTH LATITUDE AND MERIDIANS 101°30' AND 101°45' WEST LONGITUDE AND COMPRISES AN AREA OF ABOUT 211 SQUARE MILES.

## TOPOGRAPHY AND DRAINAGE

THE MOREAU-GRAND INTERSTREAM DIVIDE IS A CONSPICUOUS TOPOGRAPHIC FEATURE. THE DIVIDE TRENDS ROUGHLY EAST-WEST, FROM THREE TO FIVE MILES NORTH OF STATE HIGHWAY 8. THE NORTH SLOPES OF THE DIVIDE DRAIN TOWARD THE GRAND RIVER WHICH IS 12 MILES NORTH OF THE QUADRANGLE. THESE SLOPES ARE RATHER SHARP AND PRECIPITOUS, WHEREAS THE SOUTH SLOPES WHICH DRAIN TOWARD THE MOREAU RIVER, ABOUT TWO MILES SOUTH OF THE QUADRANGLE, ARE GENTLY ROLLING. THE DIVIDE IS INTRICATELY DISSECTED BY A DENDRITIC DRAINAGE PATTERN WHICH EXHIBITS SHARPLY-CUT, YOUTHFUL STREAM VALLEYS.

COAL EXPOSURES ARE CONFINED LARGELY TO STREAM VALLEYS SOUTH OF THE DIVIDE, AND SMALL-SCALE MINING IS DONE ALONG THE OUTCROP WHERE THE OVERBURDEN IS THIN. SPRINGS ARE GENERALLY EVIDENT WHERE THE COAL BEDS CROP OUT.

THE MAXIMUM ALTITUDE IN THE QUADRANGLE IS ABOUT 2,610 FEET ABOVE SEA LEVEL ON THE CREST OF THE INTERSTREAM DIVIDE IN SE $\frac{1}{4}$  SEC. 5, T. 17 N., R. 20 E., ZIEBACH COUNTY. THE MINIMUM ALTITUDE IS ABOUT 2,040 FEET ABOVE SEA LEVEL IN THE CHANNEL OF WORTHLESS CREEK ON THE ELK BUTTE MEMBER IN SE $\frac{1}{4}$  SEC. 20, T. 15 N., R. 21 E., ZIEBACH COUNTY. THE QUADRANGLE RELIEF APPROXIMATES 570 FEET, AND THE AVERAGE ALTITUDE IS ABOUT 2,325 FEET ABOVE SEA LEVEL.

## STRATIGRAPHY

SURFACE FORMATIONS RANGE IN AGE FROM UPPER CRETACEOUS TO RECENT. THE FOX HILLS IS THE ONLY COMPLETELY EXPOSED FORMATION IN THE QUADRANGLE. STRATIGRAPHIC BOUNDARIES ARE CONFORMABLE BETWEEN THE FOX HILLS, UNDERLYING ELK BUTTE MEMBER OF THE PIERRE FORMATION, AND OVERLYING LOWER HELL CREEK UNIT OF THE HELL CREEK FORMATION. CONTINUOUS DEPOSITION EXISTS THROUGHOUT THE EXPOSED STRATIGRAPHIC SEQUENCE. TONGUE RIVER RESIDUUM OF PALEOCENE AGE, PLEISTOCENE GRAVELS, PLEISTOCENE-RECENT LOESS, AND RECENT ALLUVIUM ARE OTHER SEDIMENTATIONAL UNITS EXPOSED IN THE AREA.

**ELK BUTTE MEMBER** (SEARIGHT 1937), **PIERRE FORMATION** (MEEK AND HAYDEN 1862). APPROXIMATELY 50 FEET OF THE UPPER PART OF THE MEMBER IS EXPOSED. IT CONSISTS OF DARK GRAY SILTY BENTONITIC CLAY WHICH WEATHERS LIGHT TO MEDIUM GRAY POLYGONAL CHIPS. WET BENTONITIC CLAY IS SLIPPERY AND PLASTIC; HOWEVER, THE DRY SURFACE DISPLAYS A "POPCORN" APPEARANCE. DISSEMINATED BENTONITE OCCURS THROUGHOUT THE MEMBER, AND SEVERAL  $\frac{1}{4}$ - $\frac{1}{8}$ " BENTONITE SEAMS ARE PRESENT. THIN BEDS OF SILT AND SAND ARE FOUND NEAR THE TOP. CONE-IN-CONE STRUCTURES, SELENITE GYPSUM CRYSTALS, LIMONITE, MELANTERITE, LIMONITIC AND LIME-CEMENTED CONCRETIONS WITH GOLDEN CALCITE GEODES ARE FOUND.

**TRAIL CITY MEMBER** (MORGAN AND PETSCH 1945), **FOX HILLS FORMATION** (MEEK AND HAYDEN 1861). THE MEMBER VARIES IN THICKNESS FROM ABOUT 85-100 FEET. A TRANSITION INTERVAL, BETWEEN THE ELK BUTTE AND TRAIL CITY MEMBERS, IS COMPOSED OF MEDIUM TO DARK GRAY BENTONITIC CLAYEY SILT WITH SAND STREAKS AND IS ARBITRARILY PLACED AT THE BASE OF THE FOX HILLS FORMATION. THE CONTACT BETWEEN THE MEMBERS WAS CHOSEN ON THE BASIS OF THE HIGHEST BENTONITE BED IN THE ELK BUTTE. ISOLATED PATCHES ON THE UPPER PORTION OF THE TRAIL CITY REVEAL BUFF TO LIGHT GRAY SILT, SAND, AND CLAYEY SILT WITH RUSTY BROWN LIMONITIC CONCRETIONS, AND SOME MARINE INVERTEBRATE FOSSILS.

**"BANDED" MEMBER** (SEARIGHT 1931)- **TIMBER LAKE MEMBER** (MORGAN AND PETSCH 1945) **FOX HILLS FORMATION**. INSUFFICIENT OUTCROP DATA PRECLUDE CARTOGRAPHIC SUBDIVISIONS. THE "BANDED" MEMBER APPROXIMATES 100 FEET IN THICKNESS AND IS COMPOSED OF ALTERNATING LIGHT TO MEDIUM GRAY CLAYEY SAND AND SILT WITH SMALL RUSTY BROWN LIMONITIC CONCRETIONARY LAYERS, MELANTERITE, AND SHALY-BEDDED PLANT MATTER.

THE TIMBER LAKE MEMBER RANGES FROM ABOUT 25-50 FEET IN THICKNESS AND CONSISTS OF BUFF-YELLOW AND GRAY, PARTLY LIMONITE-STAINED, MODERATELY CROSS-LAMINATED GLAUCONITE-QUARTZ SAND WITH THIN SEAMS OF LIMONITE AND PLANT MATTER.

**COLGATE SANDSTONE MEMBER** (CALVERT 1912), **FOX HILLS FORMATION**. THE MEMBER VARIES BETWEEN THREE AND 15 FEET IN THICKNESS AND IS COMPOSED OF CALCAREOUS-CEMENTED, "PEPPER-AND-SALT" HIGH-RANK GRAYWACKE SANDSTONE WITH SHALY TO FLAGGY BEDDING, CROSS-LAMINATIONS, AND LIMONITE STAIN. THE SANDSTONE WEATHERS "SPHEROIDAL-CONCRETIONARY", REVEALING PATCHES OF WHITE FRESH SANDSTONE SHOWING THROUGH THE BUFF-BROWN SURFACE WHICH IS SPONGY AND WARTY DUE TO SOLUTION REMOVAL OF A PORTION OF THE CALCAREOUS CEMENT.

**LOWER HELL CREEK, HELL CREEK FORMATION** (BROWN 1907). THIS UNIT RANGES FROM ABOUT 50-80 FEET IN THICKNESS AND CONSISTS OF ADMIXTURES OF MEDIUM GRAY SANDS, SILTS, AND BENTONITIC CLAYS WHICH WEATHER LIGHT GRAY. THE CLAYS ARE PREDOMINANTLY DISSEMINATED BENTONITE, AND RESEMBLE CLAYS OF THE PIERRE FORMATION WHICH ARE SOFT, UNCTUOUS, STICKY, AND SLIPPERY BEHIND DRY, WEATHERED OUTCROPS. THIN PEAT-CLAY BEDS ARE BROWN IN COLOR AND COMPOSED OF SLIGHTLY-INDURATED, COMPRESSED PLANT MATTER, CONTAINING LARGER PERCENTAGES OF CLAY AND SILT THAN ORGANIC MATTER. SEVERAL THIN BUTTE-CAPPING SANDSTONES ARE FOUND NEAR THE BASE OF THE UNIT. **OSTREA** BIOSTROMES AND UNARTICULATED DINOSAUR BONES CROP OUT UNCOMMONLY.

**ISABEL-FIRESTEEL COAL MEMBER** (CURTISS 1952), **HELL CREEK FORMATION**. THE MEMBER ATTAINS A THICKNESS OF ABOUT 20 FEET. COAL BEDS VARY BETWEEN ZERO AND FOUR AND ONE-HALF FEET IN THICKNESS. THE COAL OFTEN CONTAINS "BLACKJACK", A TOUGH, BLACK CARBONACEOUS CLAY, AS PARTINGS OR IN SUPER-AND/OR SUBJACENT POSITIONS. THREE BROWN CLAY-PEAT BEDS ARE GENERALLY PRESENT IN THE COAL HORIZON. ONE PEAT-CLAY BED IS 11 $\frac{1}{2}$  FEET THICK IN NE $\frac{1}{4}$  SEC. 25, T. 16 N., R. 20 E., ZIEBACH COUNTY. **PSEUDOSCORIA**, BUFF TO BRICK RED CLINKERED CLAYSTONE, IS CONSPICUOUSLY HILL-FORMING AND INDICATES THE STRATIGRAPHIC POSITION OF THE COAL. LIGHT, FLUFFY GRAY-WHITE COAL ASHES FREQUENTLY CROP OUT DIRECTLY BENEATH **PSEUDOSCORIA**. FOSSIL RESIN, PYRITE AND MARCASITE NODULES, AND LIMONITE STAIN OCCUR INTERMITTENTLY IN THE COAL.

**UPPER HELL CREEK, HELL CREEK FORMATION**. THE UPPER PART OF THE UNIT IS MISSING, BUT ABOUT 250 FEET IS EXPOSED. THESE LENTICULAR BEDS CONTAIN ALMOST IDENTICAL GROSS LITHOLOGICAL CHARACTERISTICS TO THE LOWER HELL CREEK. HOWEVER, SEVERAL THIN BLACK CARBONACEOUS CLAY BEDS ARE PRESENT FAIRLY HIGH IN THE UNIT. LOG-LIKE SANDSTONE CONCRETIONS ATTAIN DIMENSIONS UP TO EIGHT FEET IN LENGTH AND THREE FEET IN DIAMETER AND EXHIBIT TREE-LIKE RING STRUCTURE. PURPLE-BLACK MANGANESE-IRON CONCRETIONS ARE LOCALLY ABUNDANT AND WEATHER TO A RUSTY BROWN LIMONITIC RUBBLE WHICH FORMS A VENEER ON MANY DIRT ROADS AND ERODED AREAS.

## STRUCTURE

THE QUADRANGLE IS SITUATED ON THE EAST FLANK OF THE DAKOTA (WILLISTON) BASIN. THE REGIONAL DIP IS GENERALLY NORTHWEST AT A RATE OF ABOUT 10-25 FEET PER MILE. THE FLANK IS NOT A STRUCTURALLY SMOOTH SURFACE, BUT INTERRUPTED BY SMALL NORMAL FAULTS, SLUMPS, AND POSSIBLY GENTLE FLEXURES.

MUCH OF THE HELL CREEK FORMATION POSSESSES DEPOSITIONAL IRREGULARITIES. LENTICULARITY AND CROSS-LAMINATIONS COUPLED WITH CONTEMPORANEOUS EROSION AND REDEPOSITION WITH SUBSEQUENT SLUMPING GIVE RISE TO SEDIMENTATIONAL STRUCTURES

WHICH RESEMBLE ANGULAR UNCONFORMITIES AND STRUCTURAL DIPS. THEREFORE, COMPLICATIONS ARISE IN THE DETERMINATION OF SURFACE STRUCTURES.

COAL-TEST BORINGS WERE MADE BY THE STATE GEOLOGICAL SURVEY TO DETERMINE THICKNESSES AND CHARACTER OF COAL AND OVERBURDEN AND THE STRUCTURAL TENDENCIES INDICATED BY SEA LEVEL ALTITUDES ESTABLISHED ON THE COAL. THE COAL APPEARS "HIGH" IN SEC. 36, T. 17 N., R. 20 E., AND SEC. 31, T. 17 N., R. 21 E., ZIEBACH COUNTY.

NO MINING DIFFICULTIES HAVE THUS FAR RESULTED FROM STRUCTURES ASSOCIATED WITH THE COAL.

## ECONOMIC GEOLOGY

THE QUADRANGLE CONTAINS SEVERAL MINERAL RESOURCES. COAL IS FREQUENTLY MINED, AND SAND AND GRAVEL ARE QUARRIED PERIODICALLY. POTENTIAL RESOURCES ARE COAL BY-PRODUCTS AND BENTONITIC CLAY. MANGANESE-IRON CONCRETIONS DO NOT OCCUR IN SUFFICIENT QUANTITIES TO MERIT ECONOMIC CONSIDERATION.

## 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 56 SQUARE MILES IN THE QUADRANGLE SOUTH OF STATE HIGHWAY 8. OVERBURDEN APPEARS EXCESSIVELY THICK NORTH OF STATE HIGHWAY 8, BUT COAL MAY UNDERLIE ABOUT 96 SQUARE MILES OF THIS AREA.

**THICKNESS:** THE COAL VARIES IN THICKNESS FROM ZERO TO FOUR AND ONE-HALF FEET. THE ISABEL-FIRESTEEL COAL CONSISTS OF ONE MINABLE SEAM AT THE REESE MINE. THE COAL SPLITS INTO TWO COALS IN SEVERAL AREAS WITH THE VERTICAL INTERVAL BETWEEN COALS VARYING FROM 11 $\frac{1}{2}$ -19 $\frac{1}{2}$  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, SUBROUNDED AMBER-COLORED RESIN PELLETS, LITTLE 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.

CLAY-PEAT AND PEAT-CLAY BEDS SOMETIMES CONTAIN FUSAIN, VITRAIN, FOSSIL RESIN, AND MELANTERITE.

THIN PARTINGS OF "BLACKJACK" SOMETIMES OCCUR, AND CLAY-PEAT 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 ANALYSIS.

A COAL SAMPLE FROM THE REESE MINE, SE $\frac{1}{4}$  SEC. 23, AND A PEAT-CLAY SAMPLE FROM AN OUTCROP, NE $\frac{1}{4}$  SEC. 25, T. 16 N., R. 20 E., ZIEBACH COUNTY WERE ANALYZED AS RECEIVED, MEANING THE SAMPLES REPRESENT THE COAL AS MINED. THE PROXIMATE ANALYSES ARE AS FOLLOWS:

LOCATION	MOISTURE	VOL. MATTER	FIXED CARBON	ASH	SULPHUR	B.T.U.	DRY B.T.U.
REESE MINE (COAL)	22.88%	41.24%	29.61%	6.27%	0.51%	7,515	9,745
OUTCROP (PEAT-CLAY)	9.88%	19.03%	3.51%	57.58%	0.21%	2,039*	2,263*

THE COAL CONTAINS VERY SMALL PERCENTAGES OF ASH AND SULPHUR, TYPICAL OF ISABEL-FIRESTEEL COAL FOUND IN OTHER QUADRANGLES, AND THE ASHES ARE LIGHT AND GENERALLY FREE OF CLINKERS. BURNING IMPARTS NO INJURIOUS CORROSIVE ACTION TO BOILER PIPES.

LOCALLY, A PEAT-CLAY (FLORASTROME) IS SOMETIMES ERRONEOUSLY TERMED BROWN COAL OR LIGNITE. THEREFORE, A SAMPLE OF PEAT-CLAY WAS ANALYZED FOR COMPARATIVE ANALYSIS WITH A COAL SAMPLE. THE ASH CONTENT OF THE PEAT-CLAY IS EXCESSIVE, SO THE PEAT-CLAY IS USELESS AS A FUEL.

ECONOMICALLY, IF THE COAL IS AIR DRIED PRIOR TO DOMESTIC OR COMMERCIAL CONSUMPTION, THE HEATING VALUE WILL BE RAISED CONSIDERABLY.

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

**CHARACTER OF OVERBURDEN.** THE CHARACTER OF THE OVERBURDEN IS NOT A DETRIMENT TO STRIP MINING. BULLDOZERS AND OTHER EARTH-MOVING EQUIPMENT EASILY REMOVE THE OVERBURDEN. THE AVERAGE THICKNESS OF COVER AT THE REESE MINE IS ABOUT 11 FEET. IF, HOWEVER, MINING WAS EXTENDED BACK OF THE OUTCROP, 61 FEET OF OVERBURDEN EXISTS. OVERBURDEN THICKNESSES ENCOUNTERED IN DRILL HOLES ARE SHOWN ON THE MAP.

**ESTIMATED COAL RESERVES.** THE TOTAL ESTIMATED COAL TONNAGE, BASED ON OUTCROP, MINE DATA, AND DRILL HOLES, FOR THE WORTHLESS CREEK QUADRANGLE IS ABOUT 6,377,400 TONS. TONNAGE IS COMPUTED ON THE BASIS OF A MINIMUM THICKNESS OF 2 $\frac{1}{2}$  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), 119,000 TONS; INDICATED (COAL RESERVES LOCATED BETWEEN 0.5 AND 1.5 MILES FROM OUTCROPS, STRIP MINES, OR DRILL HOLES), 946,750 TONS; AND, INFERRED (COAL RESERVES LOCATED MORE THAN 1.5 MILES FROM OUTCROPS, STRIP MINES, OR DRILL HOLES), 5,311,650 TONS.

**POTENTIAL MINING AREAS.** DATA FROM 27 STATE GEOLOGICAL SURVEY DRILL HOLES INDICATE POTENTIAL STRIPPING AREAS IN ZIEBACH COUNTY AS FOLLOWS:

LOCATION	COAL THICKNESS	OVERBURDEN THICKNESS
SE $\frac{1}{4}$ SEC. 14, T. 16 N., R. 21 E.	4.5'	25.5'
SW $\frac{1}{4}$ SEC. 34, T. 17 N., R. 20 E.	3.0'	23.0'
NW $\frac{1}{4}$ SEC. 29, T. 16 N., R. 20 E.	3.0'	23.7'
SW $\frac{1}{4}$ SEC. 35, T. 17 N., R. 21 E.	4.0'	46.0'

SYSTEMATIC DETAILED DRILLING IS NECESSARY IN DETERMINING THE EXACT 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 8,300,000 CUBIC YARDS AND ARE LOCATED ALONG WORTHLESS CREEK, RED EARTH CREEK, FIRESTEEL CREEK, AND BEAVER TRAP CREEK. THESE DEPOSITS CONTAIN A LARGE QUANTITY OF LIMONITIC CONCRETIONS WHICH BREAK EASILY ON WEATHERING, CHALCEDONY, ROCK CRYSTAL AND MILKY QUARTZ, SANDSTONE PEBBLES, SILICIFIED WOOD, ORTHOQUARTZITE, ARKOSIC PEBBLES, ET CETERA. THIS MATERIAL IS ADEQUATE FOR ORDINARY ROAD METAL. THE THICKEST AND LARGEST TERRACES ARE LOCATED NORTH OF STATE HIGHWAY 8 ALONG WORTHLESS CREEK AND OFFER GOOD POSSIBILITIES FOR LARGE-SCALE OPERATIONS.

THE ESTIMATED VOLUMES OF SAND AND GRAVEL ARE AS FOLLOWS:

LOCATION	ACRES	AVERAGE THICKNESS	CUBIC YARDS
SECS. 2, 3, 34, 35, T. 16-17 N., R. 20 E. ZIEBACH COUNTY	254.2	6'	2,460,656
SECS. 17, 20, 21, 28, 29, T. 17 N., R. 20 E., ZIEBACH COUNTY	197.6	5'	1,593,973
SECS. 33, 34, T. 18 N., R. 21 E., CORSON COUNTY	192.0	3'	929,280
SECS. 21, 28, T. 17 N., R. 20 E., ZIEBACH COUNTY	94.4	5'	761,493
SECS. 19, 20, 29, T. 17 N., R. 20 E., ZIEBACH COUNTY	47.7	5'	457,384
SECS. 33, 34, T. 17 N., R. 20 E., ZIEBACH COUNTY	33.3	6'	322,344
SECS. 3, 4, 33, 34, T. 17-18 N., R. 21 E., CORSON COUNTY	58.3	3'	282,172

SEVEN OTHER TERRACES CONTAIN LESSER VOLUMES.

## CLAY

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

\*BECAUSE OF THE HIGH ASH CONTENT OF THIS SAMPLE, IT WAS IMPOSSIBLE TO GET COMPLETE COMBUSTION AND THEREFORE THE FIGURE GIVEN FOR THE B.T.U. IS ONLY AN ESTIMATE.