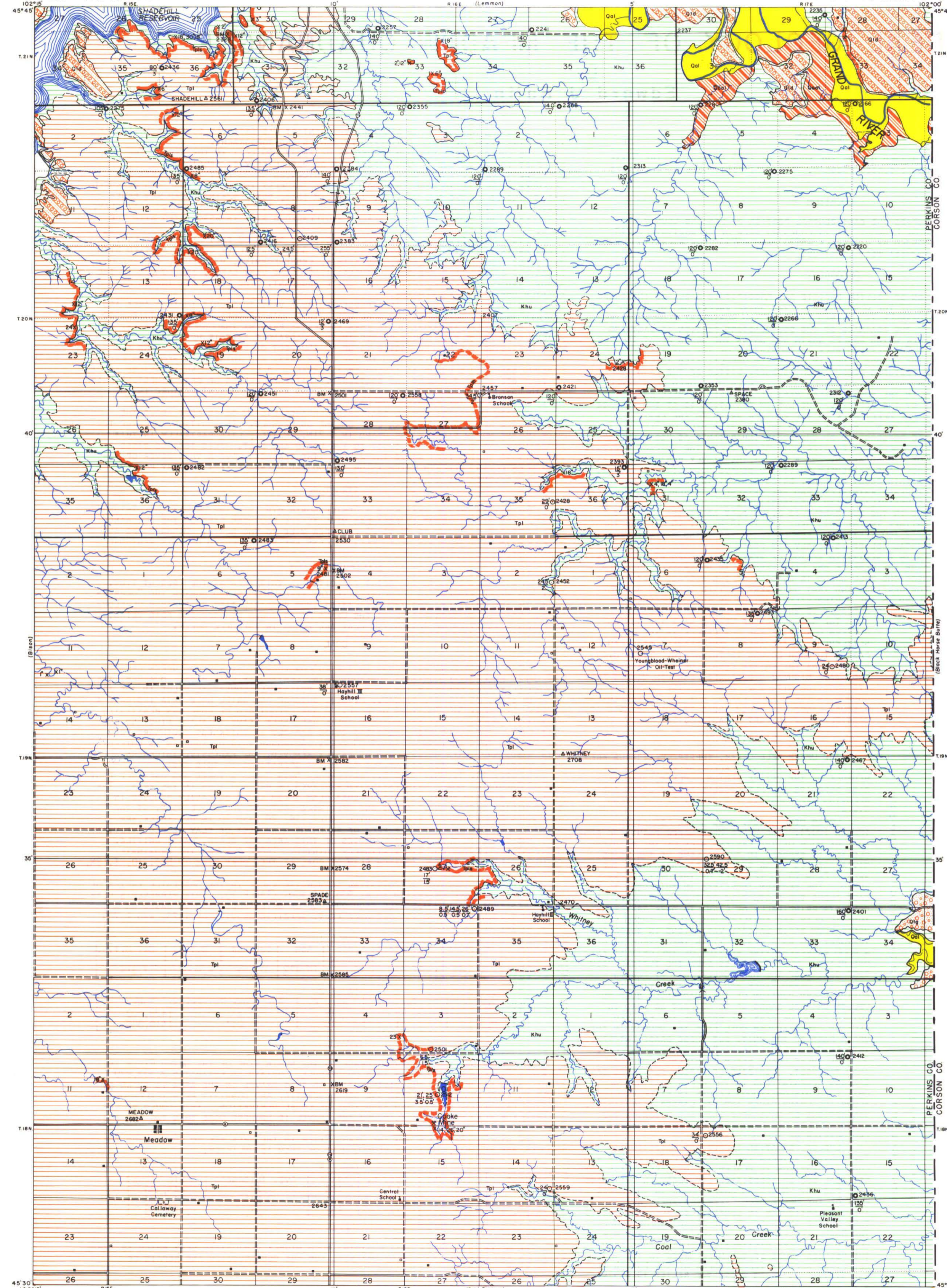


# AREAL GEOLOGY OF THE MEADOW QUADRANGLE

## EXPLANATION

STATE OF SOUTH DAKOTA  
JOE FOSS, GOVERNOR

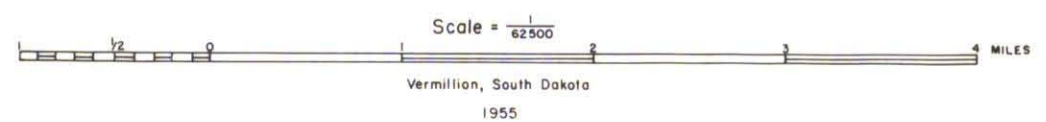
STATE GEOLOGICAL SURVEY  
E. P. ROTHROCK, STATE GEOLOGIST



- |   |  |  |
|---|--|--|
| <p>RECENT</p> <p>QUATERNARY</p> <p>PLEISTOCENE</p> <p>PALEOCENE</p> <p>UPPER CRETACEOUS</p> <p>CRETACEOUS</p> | <p><b>Qal</b><br/>Alluvium<br/>(Floodplain deposits of clay, silt, and sand in valleys of present streams)</p> <p><b>Qal</b><br/>Older Alluvium<br/>(Old valley bottom deposits of present streams, from 1-5' above present floodplain)</p> <p><b>Q1g</b><br/>Terrace Gravel<br/>(Terrace deposits of sand and gravel)</p> <p><b>Q1d</b><br/>Terrace Deposits<br/>(Poorly sorted deposits of clay to conglomeratic gravel on terraces along major streams)</p> <p><b>Tpl</b><br/>Ludlow Formation<br/>(White, gray, and yellow sandstone, sand, silt, and silty clay, numerous ledges of hard, calcareous sandstone lenses, maximum exposed thickness about 250'. Tpl1-Hillen coal, thin bed of coal (8"-10") and associated clay-peat and "blackjack", poorly exposed Tpl3-Shadehill facies, 1 to 4 coal beds with maximum thickness of 2'2", with much "blackjack", clay-peat, gray gumbo clay, and sand.)</p> <p><b>Khu</b><br/>Upper Hell Creek<br/>(Light to dark gray, bentonitic clay and sandy clay, with lenticular beds of buff silt and very fine sand, clays weather to "popcorn" surface, much gypsum and melanterite in clays and sandy clays, dark clay ironstone concretions form ledges in lower part, lenticular coal beds present near base.)</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>1684<br/>Altitudes<br/>(In feet above sea level)</p> <p>x B.M.<br/>1706<br/>Bench Marks<br/>(Monuments marking points of known altitude)</p> <p>▲ RENA<br/>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<br/>Coal mines and Gravel pits</p> <p>x 36"<br/>Coal Thickness<br/>(Exposed)</p> <p>○ 2323 Top Hole<br/>○ 36 Allitude<br/>○ 36 Overburden<br/>○ 36 Thickness<br/>Drill Holes<br/>(○ State Geological Survey<br/>○ Seismograph Shot Holes<br/>○ Courtesy of Geotech Corp. of Del.)</p> <p>○ Youngblood-Whiner<br/>Oil-test Borings</p> <p>▬ Dams<br/>(Large, small earthen or cement)</p> |
|---|--|--|

Geology by E.J. Bolin,  
Assisted by F.J. Buckmeier and W.L. Foley  
Surveyed in 1953.  
Coal-Test Holes Drilled in 1954.  
Base Map by South Dakota State Geological Survey.

APPROXIMATE MEAN DECLINATION 1955



# AREAL GEOLOGY OF THE MEADOW QUADRANGLE

By  
Edward J. Bolin

## INTRODUCTION

THE QUADRANGLE WAS MAPPED DURING THE SUMMER OF 1953 AS PART OF THE STATE GEOLOGICAL SURVEY'S COAL RESOURCES PROGRAM. THE COAT-TEST HOLES WERE DRILLED IN JUNE OF 1954.

## LOCATION

THE QUADRANGLE OCCUPIES THE EAST-CENTRAL PORTION OF PERKINS COUNTY AND IS ABOUT 13 MILES SOUTH OF LEMMON. IT INCLUDES AN AREA OF APPROXIMATELY 210 SQUARE MILES, AND IS BOUNDED BY PARALLELS 45°30' AND 45°45' NORTH LATITUDE AND MERIDIANS 102°00' AND 102°15' WEST LONGITUDE.

## GEOGRAPHY

THE AREA IS A REGION OF ROLLING PRAIRIE AND PRECIPITOUS BADLANDS INTERRUPTED ALONG THE NORTH EDGE OF THE QUADRANGLE BY THE SHARP VALLEY OF THE GRAND RIVER. MOST OF THE QUADRANGLE IS DRAINED BY NORTH AND NORTHEAST FLOWING TRIBUTARIES TO THE GRAND, BUT THE DRAINAGE OF THE SOUTHEASTERN PORTION IS EASTWARD TO BLACK HORSE BUTTE CREEK WHICH ANGLES NORTH AND JOINS THE GRAND ABOUT 15 MILES EAST OF THE QUADRANGLE. THE WESTERN HALF TO TWO-THIRDS OF THE QUADRANGLE IS LARGELY AN AREA OF ROLLING MEADOW LANDS IN WHICH FEW UNCULTIVATED TRACTS REMAIN. TO THE EAST THE SURFACE FEATURES BECOME MUCH ROUGHER, LITTLE OF THE LAND IS SUITABLE FOR CULTIVATION, AND TYPICAL BADLANDS HAVE BEEN DEVELOPED ON A SMALL SCALE BY RECENT EROSION IN THE NORTHEASTERN PART OF THE AREA. THESE SURFACE FEATURES ARE CONTROLLED BY THE BEDROCK. THE LUDLOW FORMATION IS AT THE SURFACE IN THE MEADOW LANDS AND THE HELL CREEK IN THE ROUGHER AREAS TO THE EAST.

IN THE SE $\frac{1}{4}$  SEC. 34, T.20 N., R.17 E., AND THE NORTHERN HALF OF SEC. 4, T.19N. R. 17 E., ARE SMALL AREAS REFERRED TO BY THE LOCAL INHABITANTS AS "SOAP HOLES". THESE ARE PLACES WHERE AN IMPERMEABLE LAYER SOME DEPTH BELOW THE SURFACE PREVENTS THE DOWNWARD MIGRATION OF GROUND WATER. AS A RESULT THE HIGHLY BENTONITIC CLAYS AND SILTS OF THE HELL CREEK ARE EXTREMELY MOIST AND BEHAVE MUCH LIKE QUICKSAND. THESE SMALL AREAS HAVE A THIN CRUST OF HARD, DRIED BENTONITIC CLAY OVER THEM, EXCEPT IMMEDIATELY AFTER HEAVY RAINFALLS, AND ARE EXTREMELY TREACHEROUS TO LIVESTOCK AND EVEN TO PEOPLE UNFAMILIAR WITH THE TERRITORY.

THE HIGHEST ALTITUDE IN THE QUADRANGLE IS 2,708 FEET ABOVE SEA LEVEL AT TRIANGULATION STATION WHITNEY IN THE SW $\frac{1}{4}$ , SEC. 13, T. 19 N., R. 16 E., AND THE LOWEST ALTITUDE IS ABOUT 2,150 FEET ABOVE SEA LEVEL AT THE GRAND RIVER IN THE NORTHEAST CORNER. THE TOTAL RELIEF IS NEARLY 550 FEET.

THE QUADRANGLE LIES IN A SEMI-ARID REGION OF VERY SPARSE POPULATION. WHERE THE LUDLOW FORMATION FORMS THE BEDROCK DRY LAND FARMING IS MODERATELY SUCCESSFUL, BUT TO THE EAST WHERE THE HELL CREEK IS EXPOSED AT THE SURFACE MOST OF THE LAND IS SUITABLE ONLY FOR GRAZING, AND THAT ON A VERY LIMITED SCALE IN MUCH OF THE AREA. MUCH OF THE LAND IN THE NORTHWESTERN PORTION OF THE QUADRANGLE IS GOVERNMENT PASTURE LAND, AND AS A RESULT IS UNPOPULATED AND LIGHTLY GRAZED.

THE SMALL TOWN OF MEADOW NEAR THE WESTERN CORNER OF THE QUADRANGLE IS THE ONLY SETTLEMENT IN THE AREA. THE NEAREST RAILROAD PASSES THROUGH LEMMON TO THE NORTH. STATE HIGHWAY 73 RUNS THE ENTIRE LENGTH OF THE QUADRANGLE, AND STATE HIGHWAY 8 GOES WEST THROUGH MEADOW FROM ITS JUNCTION WITH 73. SECTION LINE ROADS ARE COMMON IN THE MEADOW LANDS, BUT THE GOVERNMENT PASTURE LANDS AND ROUGH AREAS TO THE EAST ARE ACCESSIBLE ONLY IN PART BY AUTOMOBILE.

## STRATIGRAPHY

THE UPPER HELL CREEK, (UPPER CRETACEOUS AGE), AND LUDLOW FORMATION, (PALEOCENE AGE), FORM THE BEDROCK OF THE ENTIRE REGION. PLEISTOCENE TERRACE DEPOSITS AND PLEISTOCENE-RECENT LOESS AND ALLUVIUM ARE FOUND IN THE VALLEY OF THE GRAND RIVER.

**UPPER HELL CREEK, HELL CREEK FORMATION** (BROWN 1907). THE UPPER HELL CREEK FORMS THE BEDROCK OF MUCH OF THE EASTERN HALF OF THE QUADRANGLE AND IS EXPOSED IN THE VALLEYS OF THE GRAND RIVER AND ITS MAJOR TRIBUTARIES THROUGHOUT THE AREA. FROM 70 TO 125 FEET OF THE UNIT IS EXPOSED. THE SECTION INCREASES IN THICKNESS TO THE EAST ALONG THE NORTH EDGE OF THE QUADRANGLE. IT CONSISTS PRINCIPALLY OF LIGHT TO DARK GRAY BENTONITIC CLAY AND ARGILLACEOUS SILT. THESE SEDIMENTS SHOW RAPID LATERAL VARIATIONS IN COLOR AND TEXTURE, AND AS A RESULT IT IS IMPOSSIBLE TO GET A GOOD REPRESENTATIVE SECTION OF THE UNIT AT ANY ONE PLACE. MOST EXPOSURES SHOW THE TYPICAL "SOMBER" COLORS OF THE HELL CREEK, BUT AT PLACES ALONG THE GRAND RIVER AND ITS TRIBUTARIES IN THE NORTHEASTERN PORTION OF THE QUADRANGLE BUFF TO YELLOW CHANNEL SANDS UP TO 50 FEET OR MORE IN THICKNESS OCCUR NEAR THE BASE OF THE EXPOSED SECTION. LENTICULAR COAL BEDS ARE COMMON IN THE UPPER PART OF THE UNIT, BUT THESE GRADE LATERALLY INTO PEAT-CLAY, "BLACKJACK," AND DARK GRAY CLAY. SOME OF THESE COALS REACH A THICKNESS OF MORE THAN TWO FEET. HORIZONS OF LARGE, FLATTENED CALCAREOUS CEMENTATIONS IN THE UPPER PART OF THE UNIT FORM DISCONTINUOUS LEDGES IN STEEP EXPOSURES ALONG THE GRAND RIVER AND ITS LARGER TRIBUTARIES. CONCRETIONS OF MANGANESE-IRON AND LIMONITE ARE ABUNDANT LOCALLY, PARTICULARLY IN THE NORTHEASTERN QUARTER OF THE QUADRANGLE.

**LUDLOW FORMATION** (LLOYD AND HARES 1915). THE CONTACT BETWEEN THE UPPER HELL CREEK UNIT AND LUDLOW FORMATION IS PLACED AT THE BASE OF THE LOWEST COAL BED OR ASSOCIATED LITHOLOGY IN THE SHADEHILL FACIES. NUMEROUS COALS OCCUR IN THE UPPER PART OF THE UPPER HELL CREEK BUT THESE ARE EXTREMELY LENTICULAR IN CONTRAST TO THE MORE PERSISTENT NATURE OF THOSE IN THE BASAL LUDLOW. WHERE THE SHADEHILL FACIES IS ABSENT THE CONTACT WAS PLACED AT A VERY DISTINCTIVE COLOR CHANGE FROM THE "SOMBER" HUES OF THE HELL CREEK TO THE MORE BRILLIANT BUFF TO YELLOW COLOR OF THE LUDLOW SANDS AND SILTS. IN AREAS WHERE THE RELIEF IS GENTLE

AND VEGETATION OBSCURES THE BEDROCK, THE CONTACT WAS EXTENDED SOMEWHAT ARBITRARILY ON THE BASIS OF SMALL SCATTERED EXPOSURES AND TOPOGRAPHY.

THE LUDLOW HAS A MAXIMUM THICKNESS OF ABOUT 250 FEET IN THE AREA. THE UPPER PART IS ABSENT DUE TO NON-DEPOSITION OR MORE LIKELY TO EROSION.

THE SHADEHILL COAL FACIES ATTAINS A THICKNESS OF 35 FEET IN THE AREA AND INCLUDES FROM ZERO TO FIVE THIN COALS. THE THICKEST INDIVIDUAL COAL BED MEASURED WAS 30 INCHES IN THE NW $\frac{1}{4}$  SEC. 36, T. 21N., R. 15E., BUT A 42-INCH SEAM WAS PENETRATED IN A TEST HOLE NEAR THE CENTER OF SEC. 10, T.18N., R.16E. MUCH GRAY CLAY, PEAT CLAY, "BLACKJACK", AND IN PLACES ARGILLACEOUS SILT IS ASSOCIATED WITH THE COAL.

BETWEEN THE SHADEHILL AND HILLEN FACIES IS 50 TO 60 FEET OF BUFF-YELLOW, LIGHT BROWN, AND LIGHT GRAY SAND AND SILT. SOME GRAY FLAKY CLAY IS ADMIXED WITH THE SANDS AND SILTS AT PLACES, AND A THIN, LEDGE-FORMING, MICACEOUS, CALCAREOUS, SANDSTONE OCCURS NEAR THE TOP. CEMENTATIONS, SOME VERY LARGE, ARE COMMON IN THE SANDS, AND LIMONITE CONCRETIONS ARE QUITE ABUNDANT. THE UPPER FEW INCHES FREQUENTLY CONTAIN PLANT REMAINS.

THE HILLEN COAL FACIES IS REPRESENTED BY A VERY THIN UNIT IN THIS AREA AND NOWHERE INCLUDES MORE THAN ONE COAL BED. THIS COAL REACHES A MAXIMUM THICKNESS OF 17 INCHES. IT IS DOUBTFUL IF THIS FACIES IS PRESENT THROUGHOUT THE AREA, AS COAL WAS FOUND AT ONLY THREE PLACES IN THE QUADRANGLE AT THIS HORIZON.

OVERLYING THE HILLEN FACIES IS UP TO 150 FEET OF BUFF TO YELLOW SAND AND SILT. SOME SILTY CLAY IS FOUND IN THE LOWER PART, AND THIN, LEDGE-FORMING CALCAREOUS SANDSTONES OCCUR AT IRREGULAR INTERVALS. A LEDGE-FORMING SANDSTONE ABOUT 50 FEET BELOW THE TOP CONTAINS SCATTERED, FLATTENED LENSES OF GRAY LIMESTONE. LIMONITE CONCRETIONS AND CALCAREOUS CEMENTATIONS ARE A PROMINENT FEATURE IN THE UPPER 25 FEET OF THE EXPOSED LUDLOW.

**TERRACE DEPOSITS:** SMALL SCATTERED TERRACES LIE 30 TO 45 FEET ABOVE THE GRAND RIVER ALONG THE NORTHERN EDGE OF THE QUADRANGLE. IN ADDITION, A LARGE TERRACE ON THE NORTH SIDE OF THE GRAND IN T.21N., R.17E., LIES PARTIALLY IN THIS QUADRANGLE AND EXTENDS INTO THOSE TO THE NORTH AND EAST. THIS TERRACE RISES ABRUPTLY 75 TO 100 FEET ABOVE THE RIVER. THE TERRACES HAVE A THIN COVER OF ALLUVIUM OR LOESS, BENEATH WHICH IS UP TO TWO AND ONE-HALF FEET OF VERY POORLY SORTED CONGLOMERATIC GRAVEL.

## STRUCTURE

THE STRATA OF THE AREA SHOW A GENTLE NORTH DIP INTO THE DAKOTA (WILLISTON) BASIN. THE DIP IS ABOUT 15 FEET PER MILE IN THE SOUTHERN PART OF THE QUADRANGLE AND INCREASES SLIGHTLY TO 20 TO 25 FEET PER MILE TO THE NORTH. MINOR FOLDS AND FAULTS WITH DISPLACEMENTS OF 20 FEET OR LESS ARE SUPERIMPOSED ON THIS REGIONAL STRUCTURE.

## ECONOMIC GEOLOGY

NO MINERAL PRODUCTS ARE BEING EXPLOITED IN THIS AREA AT THE PRESENT TIME. COAL WAS MINED AT SEVERAL LOCALITIES IN THE EARLY 1900'S AND DURING THE "DEPRESSION" OF THE THIRTIES, AND TWO LOCALITIES SHOW POSSIBILITIES OF FURTHER DEVELOPMENT. GRAVELS ON TERRACES ALONG THE GRAND RIVER COULD BE USED FOR ROAD METAL, AND VAST QUANTITIES OF BENTONITIC CLAY ARE FOUND IN THE HELL CREEK.

## COAL

TWO COAL HORIZONS ARE FOUND IN THE LUDLOW FORMATION, AND THE UPPER PART OF THE UPPER HELL CREEK CONTAINS NUMEROUS THIN, LENTICULAR COAL BEDS. HOWEVER, THE SHADEHILL FACIES CONTAINS THE ONLY COAL OF POTENTIAL COMMERCIAL VALUE IN THE AREA.

IN SECS. 35 AND 36, T. 21N., R.15E., OUTCROP AND DRILL HOLE DATA INDICATE A RESERVE OF ABOUT 510,000 TONS OF COAL. A THREE-FOOT BED OF COAL WAS PENETRATED IN A DRILL HOLE, AND AT THE OUTCROP THERE ARE THREE SEAMS TOTALING FIVE AND ONE-HALF FEET. THE OVERBURDEN INCREASES QUITE RAPIDLY IN THICKNESS SOUTHWARD FROM THE OUTCROP TO A MAXIMUM OF ABOUT 80 FEET. ALTHOUGH THIS OVERBURDEN IS CHIEFLY SOFT SANDS AND CLAYS WHICH COULD BE EASILY REMOVED, THE EXCESSIVE THICKNESS WOULD BE A DETRIMENTAL FACTOR TO ANY FUTURE MINING OPERATIONS IN THIS AREA.

IN SEC. 10, T.18N., R.16 E., DRILL-HOLE DATA SHOWS A THREE AND ONE-HALF FOOT BED OF SHADEHILL COAL, WITH ESTIMATED RESERVES OF 428,400 TONS IN THE AREA. THE COAL LIES BENEATH ABOUT 20 FEET OF SOFT CLAY WHICH COULD BE EASILY REMOVED IN STRIP-MINING OPERATIONS. ABOUT ONE-HALF MILE SOUTH OF THE DRILL HOLE, AT THE ABANDONES COOKE MINE, THREE SHADEHILL COALS, 14, 26, AND 20 INCHES THICK, ARE SEPARATED BY ONE AND ONE-HALF FEET OF SAND AND NINE FEET OF CLAY RESPECTIVELY.

THE COALS IN THE SHADEHILL FACIES OF THIS AREA ARE BLACK, HARD, BRITTLE, HORIZONTALLY LAMINATED, AND VERTICALLY JOINTED. TABLE 1 SHOWS THE PROXIMATE CHEMICAL ANALYSIS OF THE 26-INCH SEAM OF COAL AT THE COOKE MINE IN SEC. 10, T.18N., R.16E.

TOTAL COAL RESERVES OF POTENTIAL COMMERCIAL VALUE IN THE SHADEHILL FACIES OF THIS QUADRANGLE ARE ESTIMATED TO BE 938,400 TONS (TABLE 2). THIS REPRESENTS MEASURED RESERVES, WITHIN 0.5 MILE FROM OUTCROP OR DRILL HOLE, AND IS BASED ON A MINIMUM THICKNESS OF TWO AND ONE-HALF FEET, SPECIFIC GRAVITY OF 1.25, AND 1,700 TONS TO THE ACRE-FOOT.

TABLE 1

LOCATION	MOISTURE	VOL.MATTER	FIXED CARBON	ASH	SULPHUR	B.T.U.	DRY B.T.U.
COOKE MINE	39.84%	27.65%	16.09%	16.42%	0.39%	4,400	7,314

TABLE 2

SECTIONS	TWP. N.	RGE. E.	AVE. COAL THICKNESS	TONS
10	18	16	3'	428,400
35, 36	21	15	2 $\frac{1}{2}$ '	510,000

## GRAVEL

THE PORTIONS OF THE LARGE TERRACE ON THE NORTH SIDE OF THE GRAND RIVER IN T. 21N., R.17E., WHICH LIE IN THIS QUADRANGLE, CONTAIN AN ESTIMATED 2,303,839 CUBIC YARDS OF GRAVEL. THE DISTRIBUTION OF THIS GRAVEL IN THE AREA IS SHOWN ON TABLE 3. THE GRAVEL IS COARSE AND CONGLOMERATIC, AND CONSISTS PRINCIPALLY OF CONCRETION FRAGMENTS, CHERT, AND SANDSTONE OF LOCAL DERIVATION. THIS COULD BE DEVELOPED FOR ROAD SURFACING ALTHOUGH THE GRAVEL IS NOWHERE MORE THAN TWO AND ONE-HALF FEET THICK IN THIS AREA.

THE OTHER TERRACES ALONG THE GRAND RIVER IN THE AREA ARE SO SMALL, AND THE GRAVELS ARE SO THIN, THAT ANY DEVELOPMENT OF THEM IS UNLIKELY.

TABLE 3

SECTIONS	TWP. N.	RGE. E.	ACRES	AVE. THICKNESS	CUBIC YARDS
29, 30, 31	21	17	138	2'	445,280
28, 29	21	17	40	2'	129,066
27, 28, 33, 34	21	17	536	2'	1,729,493

## CLAY

THE UPPER HELL CREEK UNIT CONTAINS MUCH HIGHLY BENTONITIC CLAY WHICH IS IMPERVIOUS AND PROVIDES EXCELLENT MATERIAL FOR THE CONSTRUCTION AND REPAIR OF STOCK DAMS.

## GENERALIZED COLUMNAR SECTION

