

AREAL GEOLOGY OF THE STROOL QUADRANGLE

EXPLANATION

SEDIMENTARY ROCKS



Dune Sand
(Chiefly fine sand, with fractions ranging from silt to medium sand, exhibiting deflation topography.)



Alluvium
(Floodplain deposits of sand, silt, and clay in valleys of South Fork of Grand and major tributaries.)



Older Alluvium
(Alluvial terrace deposits somewhat above present floodplain.)



Chadron Formation
(Chiefly grayish green and greenish yellow bentonitic, shaly clay, with pale green sandy, bentonitic clay at base, and very light gray to white shaly limestone at top.)



Tongue River Boulders
(Residual deposits of gray to brown, wind polished ortho-quartzite boulders derived from Tongue River Fm.)



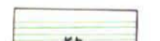
Tongue River Formation
(Yellow, micaceous, calcareous, very fine to fine-grained, friable sandstone and loose sand.)



Cannonball Formation
(Medium gray, highly calcareous, micaceous, chloritic, glauconitic, very fine to fine-grained sandstone with marine invertebrate fossils, and gray clay, clayey sand, and sand with numerous dark gray, hard limestone concretions.)



Ludlow Formation
(Gray to buff, fine to medium-grained arkosic sand, and gray clay, with ledges and lenses of calcareous sandstone. Tpi-Hillen Coal Facies - one or more coal beds with a maximum thickness of 5" and associated blackpack, peat clay, and clay. There appears to be a discontinuous coal zone in the interval between the Hillen and Shadwell facies of places. Tpi-Shadwell Coal Facies - one to four thin coal beds, with associated blackpack, peat clay, and clay at base of Ludlow formation.)



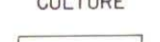
Hell Creek Formation
(Light to dark gray bentonitic clay which weathers to "popcorn" surface on exposure, contains lenticular beds of fine buff sand, ironstone concretions abundant, includes several thin discontinuous coals in upper part.)



Intermittent Streams



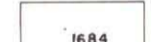
Intermittent Lakes



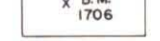
Buildings
(House, church, and school)



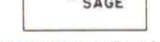
Roads and Trails



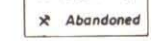
Altitudes
(In feet above sea level)



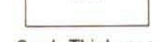
Bench Marks
(Monuments marking points of known altitude)



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



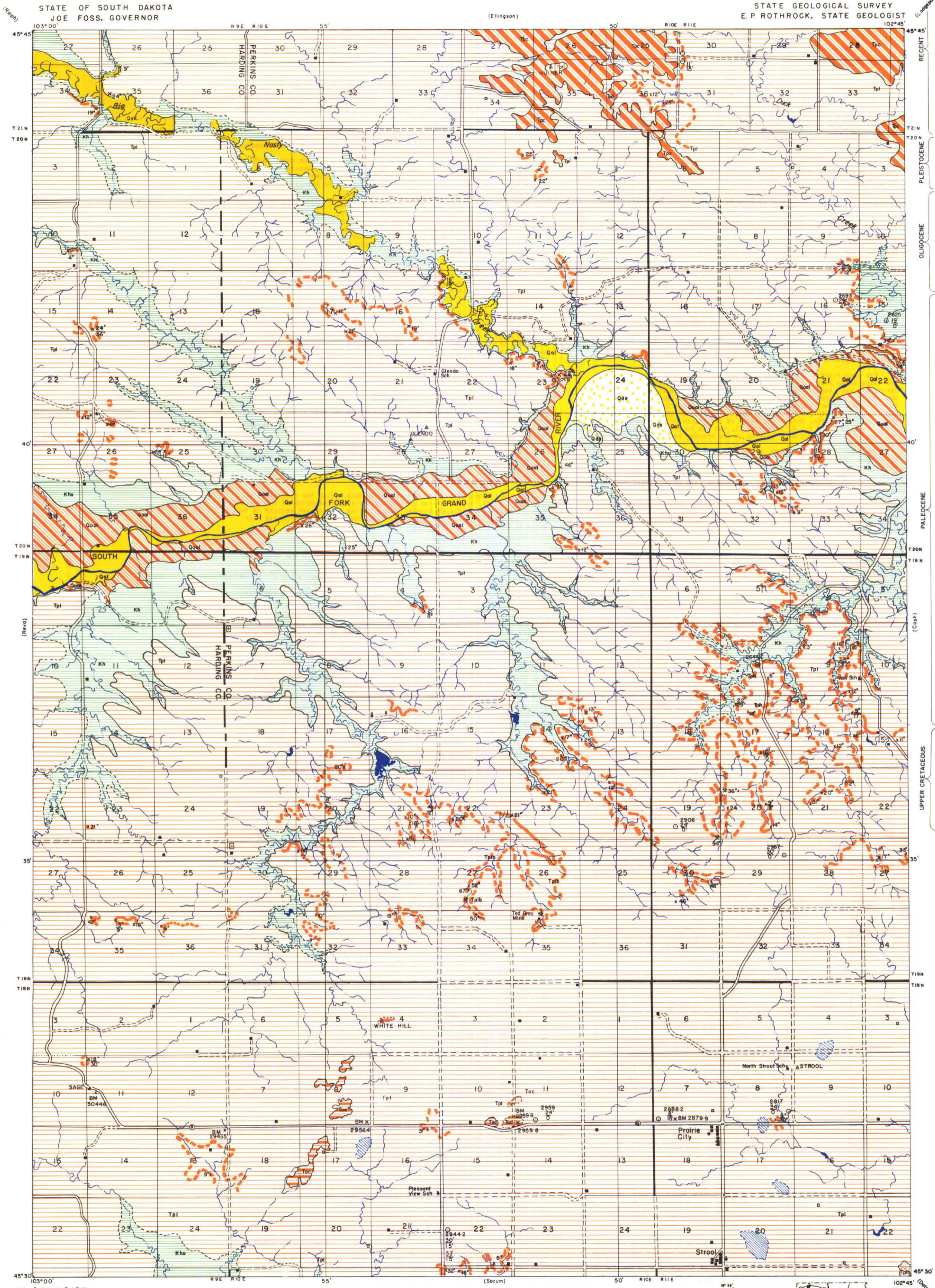
Coal mines and Gravel pits



Coal Thickness
(Exposed)



Drill Holes



Geology by E. J. Bain
Assisted by F. J. Buckmeier, E. Glazier, R. Wilson.
Surveyed in 1954
Coal-Test Holes Drilled in 1956
Base Map by South Dakota State Geological Survey

Scale = 82500
Vermillion, South Dakota
1956

APPROXIMATE
MAGNETIC
DECLINATION
MEAN YEAR

Quadrangle Location

QUATERNARY

PLEISTOCENE

OLIGOCENE

PALEOCENE

UPPER CRETACEOUS

CRETACEOUS

CULTURE

Bench Marks

Coal Thickness

Drill Holes

AREAL GEOLOGY OF THE STROOL QUADRANGLE

By
Edward J. Bolin

INTRODUCTION

THE QUADRANGLE WAS MAPPED DURING THE SUMMER OF 1954 AS PART OF THE STATE GEOLOGICAL SURVEY'S COAL RESOURCES PROGRAM. THE COAL TEST HOLES WERE DRILLED IN THE SUMMER OF 1955.

LOCATION

THE QUADRANGLE LIES PRINCIPALLY IN WEST-CENTRAL PERKINS COUNTY, BUT INCLUDES A STRIP ABOUT TWO AND ONE-HALF MILES WIDE IN EAST-CENTRAL HARDING COUNTY. IT IS LOCATED ABOUT 14 MILES WEST OF BISON AND 26 MILES EAST OF BUFFALO BETWEEN PARALLELS 45° 30' AND 45° 45' NORTH LATITUDE AND MERIDIANS 102° 45' AND 103° 00' EAST LONGITUDE. IT EMBRACES AN AREA OF ABOUT 210 SQUARE MILES.

GEOGRAPHY

THE QUADRANGLE LIES IN AN AREA IN WHICH GENTLY ROLLING MEADOW LANDS TO THE SOUTH RAPIDLY GIVE WAY TO RUGGED TOPOGRAPHIC FEATURES DEVELOPED BY EROSION ALONG THE SOUTH FORK OF GRAND RIVER AND ITS TRIBUTARIES. THE SURFACE OF THE MEADOW LANDS IS BROKEN BY A FEW SMALL, STEEP-SIDED WHITE RIVER BUTTES WHICH FORM WELL KNOWN LANDMARKS IN T. 18 N., R. 10 E. THE HIGHEST AND MOST PROMINENT OF THESE IS WHITEHILL IN SEC. 4. THESE BUTTES ARE FLAT-TOPPED AND ARE CAPPED WITH A THIN, RESISTENT, SLABBY LIMESTONE.

THE SOUTH FORK OF GRAND RIVER IS THE LARGEST STREAM IN THE AREA, AND IT RECEIVES THE RUNOFF FROM THE ENTIRE QUADRANGLE WITH THE EXCEPTION OF THE SOUTHERN AND SOUTHEASTERN PORTIONS WHICH ARE DRAINED BY SOUTH FLOWING TRIBUTARIES TO RABBIT CREEK. THE SOUTH FORK OF GRAND RIVER TRENDS SLIGHTLY NORTH OF EAST ACROSS THE SOUTHERN PART OF T. 20 N. IT FOLLOWS A MEANDERING COURSE IN A BROAD VALLEY UP TO NEARLY TWO MILES IN WIDTH. THE SLOPES ON THE SOUTH SIDE OF THE RIVER ARE MUCH SHARPER AND ABRUPT THAN THOSE ON THE NORTH SIDE. THE TRIBUTARIES FROM THE NORTH FOLLOW THE GENERAL STRIKE OF THE BEDROCK IN A SOUTHEASTERLY DIRECTION. THE VALLEYS OF THE LARGER CREEKS ARE BROAD AND OPEN, BUT THE UPLANDS IN THE AREA ARE EXTREMELY ROUGH AND BROKEN. THE TRIBUTARIES FROM THE SOUTH FLOW NORTHWARD IN NARROW, STEEP-SIDED VALLEYS MORE THAN 100 FEET DEEP WHICH HAVE DISSECTED THE SURFACE INTO A RUGGED "BREAKS" TOPOGRAPHY. NUMEROUS FLAT-TOPPED HILLS CAPPED WITH THIN RESISTANT SANDSTONES FORM AN INTERESTING FEATURE IN THIS "BREAKS" AREA.

THE TOTAL RELIEF IN THE QUADRANGLE APPROXIMATES 700 FEET. THE MAXIMUM ALTITUDE IS 3141 FEET ABOVE SEA LEVEL ON WHITEHILL IN SEC. 4, T. 18 N., R. 10 E., AND THE MINIMUM IS 2439 FEET ABOVE SEA LEVEL ALONG THE SOUTH FORK OF GRAND RIVER FIVE MILES EAST OF THE QUADRANGLE.

FEW UNCULTIVATED TRACTS REMAIN ON THE ROLLING MEADOW LANDS WHICH FORM THE INTERSTREAM DIVIDE BETWEEN THE SOUTH FORK OF GRAND RIVER AND RABBIT CREEK, AND DRY LAND FARMING HAS MET WITH CONSIDERABLE SUCCESS IN THIS AREA. NORTH OF THE MEADOWS THE LAND IS TOO ROUGH FOR FARMING AND IT IS USED CHIEFLY FOR GRAZING PURPOSES. THE VALLEYS OF THE SOUTH FORK OF GRAND RIVER AND ITS LARGER TRIBUTARIES FROM THE NORTH AFFORD SOME AREAS SUITABLE FOR CULTIVATION. HOWEVER, SAND DUNES OCCUR IN THE VALLEY OF THE SOUTH FORK OF GRAND RIVER IN T. 20 N., R. 10 AND 11 E., AND THE SOIL IN THIS VALLEY IS TOO SANDY FOR SUCCESSFUL CROP RAISING IN THE WESTERN PART OF THE AREA.

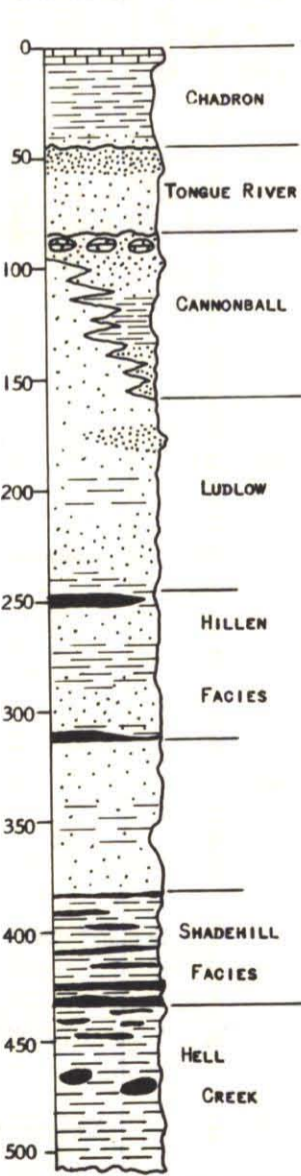
THE SMALL VILLAGE OF STROOL WHICH LIES ALONG THE SOUTH BOUNDARY OF THE QUADRANGLE IN SEC. 19, T. 18 N., R. 11 E., IS THE OLDEST SETTLEMENT IN THE AREA. TWO MILES TO THE NORTH ALONG STATE HIGHWAY 8 THE LITTLE COMMUNITY OF PRAIRIE CITY HAS SPRUNG UP IN THE LAST 10 OR 15 YEARS. THE NEAREST RAILROAD IS THE CHICAGO, MILWAUKEE, ST. PAUL AND PACIFIC LINE BETWEEN HETTINGER AND BOWMAN, NORTH DAKOTA, SOME 20 MILES TO THE NORTH. STATE HIGHWAY 8 BETWEEN BUFFALO AND BISON CROSSES THE QUADRANGLE ABOUT TWO MILES NORTH OF THE SOUTH BOUNDARY. SECTION LINE ROADS AND TRAILS ARE FAIRLY NUMEROUS IN THE MEADOW LANDS, BUT THE LARGER PORTION OF THE AREA IS ACCESSIBLE ONLY BY THREE NORTH-SOUTH GOOD WEATHER ROADS AND AN EAST-WEST TRAIL NEAR THE NORTH BOUNDARY OF THE QUADRANGLE.

STRATIGRAPHY

EXPOSED SEDIMENTS IN THE AREA RANGE IN AGE FROM UPPER CRETACEOUS TO RECENT. THE UPPER HELL CREEK (UPPER CRETACEOUS AGE) AND LUDLOW FORMATION (PALEOCENE AGE) FORM THE BEDROCK OF MOST OF THE QUADRANGLE. DEPOSITS OF THE CHADRON FORMATION (OLIGOCENE AGE) ARE CONFINED TO SMALL BUTTES AND HUMMOCKS IN T. 18 N., R. 10 E. THE CANNONBALL FORMATION, THE MARINE EQUIVALENT OF THE UPPER PART OF THE LUDLOW, IS FOUND ON THE HIGH UPLANDS IN THE NORTH-EASTERN QUARTER OF THE AREA, AND THE TONGUE RIVER FORMATION (PALEOCENE AGE) IS RESTRICTED TO TWO HIGH HILLS ALONG THE NORTH-CENTRAL EDGE OF THE QUADRANGLE. DEPOSITS OF PLEISTOCENE-RECENT LOESS AND ALLUVIUM OCCUR IN THE VALLEYS OF THE SOUTH FORK OF GRAND RIVER AND BIG NASTY CREEK, AND DUNE SANDS ARE FOUND ON THE SOUTH SIDE OF A LARGE MEANDER IN THE SOUTH FORK OF GRAND RIVER IN T. 20 N., R. 10 AND 11 E.

UPPER HELL CREEK, HELL CREEK FORMATION (BROWN, 1907). THE UPPER HELL CREEK IS EXPOSED ALONG THE VALLEYS OF THE SOUTH FORK OF GRAND RIVER AND ITS TRIBUTARIES, AND ALONG A SOUTH FLOWING TRIBUTARY TO RABBIT CREEK IN T. 18 N., R. 9 E. ONLY 20 TO 30 FEET OF THE UNIT IS EXPOSED IN THE BLUFF OF THE SOUTH FORK OF GRAND RIVER IN THE EASTERN PART OF THE QUADRANGLE, BUT THE EXPOSED SECTION THICKENS WESTWARD IN THE AREA TO ABOUT 50 TO 75 FEET. IT CONSISTS PRINCIPALLY OF DULL GRAY AND BROWN CLAY, SILTY CLAY, AND SILT, BUT LOCALLY LENTICULAR COAL FACIES OCCUR IN THE UPPER PART OF THE UNIT. AS MANY AS FIVE COALS OCCUR AT PLACES, ASSOCIATED WITH MUCH PEAT CLAY AND BLACKJACK. THE SEDIMENTS IN THE UNIT ARE EXTREMELY BENTONITIC, AND UPON EXPOSURE AND DRYING DEVELOPE A HARD AND PUSTULAR SURFACE. LIMONITE CONCRETIONS ARE ABUNDANT AT PLACES, AND THEIR FRAGMENTS SOMETIMES FORM A REDDISH BROWN RUBBLE ON THE SURFACE.

GENERALIZED COLUMNAR SECTION



LUDLOW FORMATION (LLOYD AND HARES, 1915). THE HELL CREEK-LUDLOW CONTACT WAS PLACED AT THE BASE OF THE LOWEST COAL OR ASSOCIATED LITHOLOGY IN THE SHADEHILL FACIES. WHERE THIS BASAL FACIES OF THE LUDLOW IS ABSENT OR COVERED, THE CONTACT WAS MAPPED AT A COLOR CHANGE FROM THE DULL GRAY OR BROWN OF THE HELL CREEK TO THE BUFF OR YELLOW OF THE LUDLOW, OR WAS EXTENDED ON THE BASIS OF TOPOGRAPHY.

THE LUDLOW FORMATION ATTAINS A MAXIMUM THICKNESS OF APPROXIMATELY 340 FEET IN THE AREA. IT CONSISTS PRINCIPALLY OF BUFF TO YELLOW SILT AND SAND, CLAYEY IN PART, WITH MUCH LIGHT GRAY CLAY IN PLACES. LEDGE FORMING, CALCAREOUS SANDSTONES ARE PROMINENT AT SOME HORIZONS.

THE SHADEHILL COAL FACIES IS PERSISTENT THROUGHOUT MOST OF THE AREA BUT ITS LENTICULAR NATURE IS SHOWN BY WIDE VARIATIONS IN THICKNESS. IT HAS A MAXIMUM THICKNESS OF MORE THAN 50 FEET IN THE NW $\frac{1}{4}$, SEC. 9, T. 19 N., R. 11 E. IT CONSISTS OF UP TO SEVEN THIN COAL BEDS ASSOCIATED WITH MUCH PEAT CLAY, BLACKJACK, GRAY TO BROWN CLAY, AND BUFF TO BROWN SILT. THE THICKEST COAL BED MEASURED IN THE FACIES WAS 30 INCHES THICK.

AN INTERVAL OF ABOUT 70 FEET OF SAND AND SILT LIES BETWEEN THE TOP OF THE SHADEHILL AND THE NEXT HIGHER COAL FACIES IN THE LUDLOW. THIS IS CORRELATED WITH THE HILLEN FACIES TO THE EAST, AND IN THIS AREA APPEARS TO BE SPLIT INTO TWO COAL BEARING HORIZONS SEPARATED BY 50 TO 60 FEET OF SILT, SAND AND CLAY. THE LOWER OF THESE HORIZONS CONSISTS OF ONE OR TWO THIN COALS IN THE EASTERN PART OF THE AREA, BUT IN T. 19 N., R. 10 E., A SINGLE BED OF COAL WITH A MAXIMUM REPORTED THICKNESS OF SIX FEET ONE INCH OCCURS AT THE HORIZON. THE UPPER COAL HORIZON HERE INCLUDED IN THE HILLEN FACIES IS ABSENT TO THE WEST, AND WAS FOUND ONLY AT THREE ABANDONED MINES WHERE NO COAL IS NOW VISIBLE IN SECS. 19 AND 30, T. 19 N., R. 11 E., AND AT TWO SMALL OUTCROPS IN SEC. 27 OF THE ABOVE TOWNSHIP WHERE THE COAL REACHES A MAXIMUM THICKNESS OF 33 INCHES.

IN THE EASTERN PART OF THE AREA A RESISTANT, LEDGE FORMING, CALCAREOUS SANDSTONE ABOUT 70 FEET ABOVE THE HIGHEST HILLEN COAL PROBABLY REPRESENTS THE SCOTCH CAP SANDSTONE. THIS HORIZON MAY BE CONTINUOUS THROUGHOUT THE AREA BUT IT IS DIFFICULT TO CORRELATE BECAUSE OF THE PRESENCE OF DISCONTINUOUS LEDGES AT IRREGULAR INTERVALS THROUGHOUT THE LUDLOW.

A HIGHER COAL HORIZON OCCURS IN THE LUDLOW NEAR THE TOPS OF SEVERAL HILLS IN SECS. 14 AND 26, T. 20 N., R. 9 E. THIS HORIZON LIES MORE THAN 200 FEET ABOVE THE HELL CREEK-LUDLOW CONTACT AND INCLUDES TWO COAL BEDS WITH A TOTAL THICKNESS OF FIVE FEET IN SEC. 14. THIS HORIZON CORRELATES WITH THE WIDOW CLARK COAL TO THE WEST.

CANNONBALL FORMATION (LLOYD, 1914). DEPOSITS OF THE MARINE CANNONBALL FORMATION OCCUPY THE UPLAND AREAS IN THE NORTHEASTERN PART OF THE QUADRANGLE. THESE UPLANDS ARE CHARACTERIZED BY EXTREMELY FLAT TOPS AND STEEP SLOPES DUE TO THE PRESENCE OF A VERY RESISTANT, HARD BED OF SANDSTONE NEAR THE TOP OF THE FORMATION. THIS SANDSTONE IS MEDIUM GRAY, FINE GRAINED MICACEOUS AND CALCAREOUS, AND CONTAINS NUMEROUS SMALL MOLLUSKS. THE TOP FEW FEET OF THE FORMATION HAS BEEN REMOVED FROM THE FLAT-TOPPED UPLANDS, BUT WHERE PRESERVED BENEATH THE OVERLYING TONGUE RIVER FORMATION, IT CONSISTS OF SOFT BUFF SAND WITH A ROW OF DARK GRAY LIMESTONE CONCRETIONS AT THE TOP. SOFT SANDS AND CLAYS LIE BENEATH THE HARD SANDSTONE CAPPING THE UPLANDS. THE FORMATION IS APPROXIMATELY 50 TO 75 FEET THICK IN THE AREA.

THE CANNONBALL IS EQUIVALENT TO THE UPPER PART OF THE NON-MARINE LUDLOW FORMATION TO THE SOUTH, AND THE CONTACT BETWEEN THE TWO IS OF AN INTERFINGERING NATURE. IT WAS MAPPED PRINCIPALLY ON THE BASIS OF TOPOGRAPHY, AND WAS PLACED ABOVE A COAL HORIZON FOUND ALONG A SMALL CREEK IN SEC. 36, T. 21 N., R. 10 E.

TONGUE RIVER FORMATION (TAFF, 1909). THE TONGUE RIVER FORMATION OCCUPIES TWO SMALL HILLS IN SECS. 35 AND 26, T. 21 N., R. 10 E., WHERE IT RESTS WITH APPARENT CONFORMABILITY ON THE CANNONBALL FORMATION. AT THE TOPS OF THESE HILLS IS A SOMEWHAT LEDGE FORMING, FRIABLE, YELLOW, VERY FINE TO FINE GRAINED, MICACEOUS, SLIGHTLY CALCAREOUS SANDSTONE. BELOW THIS SANDSTONE THE FORMATION, WHICH IS 40 FEET THICK IN THE AREA, CONSISTS OF YELLOW, FINE GRAINED, LOOSE SAND.

THE CANNONBALL-TONGUE RIVER CONTACT IS VERY DISTINCT, AND LIES IMMEDIATELY ABOVE A ROW OF HARD LIMESTONE CONCRETIONS AT THE TOP OF THE CANNONBALL.

TONGUE RIVER BOULDERS AND TONGUE RIVER FORMATION. THICK CONCENTRATIONS OF RESIDUAL ORTHOQUARTZITE BOULDERS BLANKET THE LUDLOW FORMATION IN THE NORTHEAST CORNER OF THE QUADRANGLE. THE BOULDERS ARE LIGHT GRAY AND POSSESS A HIGH DEGREE OF WIND POLISH (VENTIFACTS) AND VESICULAR IMPRESSIONS OF ROOTS AND BRANCHES.

CHADRON FORMATION (DARTON, 1899). THE CHADRON FORMATION IS RESTRICTED TO SEVERAL BUTTES AND SMALL HUMMOCKS IN T. 18 N., R. 10 E., AND THE FORMATION ATTAINS A MAXIMUM THICKNESS OF 45 FEET ON WHITEHILL BUTTE IN SEC. 4. THE BUTTES ARE CAPPED WITH A VERY LIGHT GRAY TO WHITE, SLABBY LIMESTONE WITH NUMEROUS CHERT NODULES. THIS LIMESTONE IS ABOUT SEVEN FEET THICK ON WHITEHILL. THE MAJOR PART OF THE FORMATION CONSISTS OF GREENISH-YELLOW AND GRAY-ISH-GREEN, HIGHLY BENTONITIC, SHALY CLAY, AND AT THE BASE IS ABOUT FIVE FEET OF PALE GREEN, VERY SANDY, BENTONITIC CLAY.

THE CHADRON RESTS UNCONFORMABLY ON THE LUDLOW FORMATION IN THIS AREA. THE EROSION SURFACE DEVELOPED ON THE LUDLOW PRIOR TO THE DEPOSITION OF THE CHADRON WAS APPARENTLY QUITE UNEVEN AS SMALL DEPOSITS OF THE CHADRON LIE AT ALTITUDES CONSIDERABLY BELOW THE CONTACT IN THE BUTTES.

DUNE SANDS: AN AREA OF MORE THAN ONE SQUARE MILE ON THE SOUTH SIDE OF A LARGE MEANDER IN THE SOUTH FORK OF GRAND RIVER IS OCCUPIED BY SAND DUNES. THESE DUNES ARE STATIONARY AND MOST OF THEM ARE COVERED WITH A THIN GROWTH OF VEGETATION. HOWEVER, SOME ARE COMPLETELY BARREN AND THE SANDS COMPOSING THESE ARE BEING CONSTANTLY SHIFTED AND SORTED. A STUDY OF THESE SANDS SHOWS THE REMARKABLE TRANSPORTING CAPACITY OF THE WINDS OF THE AREA. THEY CONSIST PRINCIPALLY OF FINE AND MEDIUM GRAINED FRAGMENTS, WITH FRACTIONS RANGING FROM VERY FINE TO COARSE GRAINED. QUARTZ IS THE PRINCIPAL CONSTITUENT, BUT BLACK CONCRETION FRAGMENTS ARE ABUNDANT, AND THERE ARE SOME LIGHT GRAY, BUFF, AND BROWN SILTSTONE AND SANDSTONE FRAGMENTS.

STRUCTURE

THE AREA INCLUDED IN THIS QUADRANGLE LIES ON THE WEST FLANK OF THE DAKOTA (WILLISTON) BASIN. THE REGIONAL DIP OF THE SURFACE ROCKS IS ABOUT 15 TO 30 FEET PER MILE NORTHEASTWARD INTO THE BASIN. MINOR FAULTS AND FOLDS ARE SUPERIMPOSED ON THIS REGIONAL STRUCTURE.

THE SANDSTONE CAPPING AN EAST-WEST RIDGE THROUGH SECS. 35 AND 36, T. 19 N., R. 9 E., AND EXTENDING INTO SEC. 31, T. 19 N., R. 10 E., SHOWS SOUTHEAST DIPS UP TO 12°.

ECONOMICS

COAL WAS MINED AT SEVERAL PLACES IN THE AREA DURING THE EARLY 1900'S AND THE THIRTIES, BUT NO MINING OPERATIONS ARE BEING CONDUCTED AT THE PRESENT TIME. HOWEVER, POTENTIALLY COMMERCIAL QUANTITIES OF COAL ARE PRESENT IN THE AREA. IN ADDITION THE UPPER HELL CREEK UNIT CONTAINS MUCH BENTONITIC CLAY WHICH IS UTILIZED TO A LIMITED EXTENT.

COAL

THE LOWEST COAL STRATIGRAPHICALLY IN THE AREA OCCURS IN THE UPPER PART OF THE UPPER HELL CREEK. THE COALS IN THIS UNIT ARE EXTREMELY LENTICULAR. IT IS REPORTED THAT A 3 FOOT 10 INCH BED WAS MINED FROM THIS HORIZON IN THE BLUFF OF THE SOUTH FORK OF GRAND RIVER IN THE SE $\frac{1}{4}$, SEC. 26, T. 20 N., R. 10 E., BUT NO COAL IS VISIBLE AT THIS LOCALITY NOW. AS MANY AS FIVE THIN COALS WERE FOUND IN THE UPPER HELL CREEK, BUT NOWHERE WERE SUFFICIENT QUANTITIES PRESENT TO HAVE ANY POTENTIAL COMMERCIAL VALUE.

THE SHADEHILL FACIES OF THE LUDLOW IS QUITE PERSISTENT THROUGHOUT THE AREA, BUT IT WAS NOT MINED TO ANY GREAT EXTENT IN THE PAST AND THE ONLY POTENTIALLY COMMERCIAL COAL IN THE FACIES IS FOUND IN THE EAST-CENTRAL PORTION OF THE QUADRANGLE. IN THE NE $\frac{1}{4}$, SEC. 28, T. 20 N., R. 11 E., THE SHADEHILL FACIES INCLUDES SEVEN COAL BEDS. THE TOP FIVE ARE THIN, BUT THE LOWER TWO ARE 27 AND 25 INCHES THICK AND ARE SEPARATED BY LESS THAN 3 $\frac{1}{2}$ FEET OF CLAY AND PEAT CLAY. THE 27 INCH BED WAS MINED TO A LIMITED EXTENT FOR LOCAL USE IN THE EARLY 1900'S. THE AREA CONTAINS RESERVES OF POTENTIALLY COMMERCIAL COAL ESTIMATED TO BE 850,000 TONS. THE OVERBURDEN IS ABOUT 20 FEET THICK, AND CONSISTS OF THE OVERLYING SOFT SEDIMENTS IN THE SHADEHILL FACIES WHICH COULD BE READILY AND CHEAPLY REMOVED IN STRIP MINING OPERATIONS.

IN THE NORTHERN PART OF SEC. 17 AND THE SOUTHERN PART OF SEC. 8, T. 19 N., R. 11 E., THE FACIES CONTAINS TWO COAL BEDS ABOUT TWO FEET THICK SEPARATED BY FOUR FEET OF SILTY CLAY. RESERVES IN THIS AREA ARE ESTIMATED TO BE 272,000 TONS. THE OVERBURDEN THICKENS RAPIDLY AWAY FROM THE OUTCROPS AND WOULD PROVE DETRIMENTAL TO LARGE SCALE MINING OPERATIONS IN THE AREA.

THE SHADEHILL COALS ARE BLACK, QUITE BRITTLE, THINLY BEDDED, VERTICALLY JOINTED, AND CONTAIN THIN STREAKS OF MELANITERITE AND GYPSUM IN PLACES. A PROXIMATE CHEMICAL ANALYSIS OF THE LOWER COAL FROM THE EXPOSURE IN SEC. 28, T. 20 N., R. 11 E., IS SHOWN IN TABLE 1 AND TABLE 2.

THE SHADEHILL FACIES CONTAINS POTENTIALLY COMMERCIAL COAL RESERVES ESTIMATED TO BE 850,000 TONS. THIS ESTIMATION IS BASED ON A SPECIFIC GRAVITY OF 1.25 AND 1,700 TONS TO THE ACRE-FOOT, AND INCLUDES ONLY THOSE AREAS WHERE ONE OR MORE COALS HAVE AN AGGREGATE THICKNESS OF MORE THAN 2 $\frac{1}{2}$ FEET.

THE TWO COAL HORIZONS HERE INCLUDED IN THE HILLEN FACIES WERE MINED TO A CONSIDERABLE EXTENT IN THE PAST, AND CONTAIN THE MOST FAVORABLE COALS FOR FURTHER DEVELOPMENT IN THE AREA. IN SECS. 26, 27, 34, AND 35, T. 19 N., R. 10 E., THE LOWER HILLEN HORIZON CONTAINS ESTIMATED RESERVES OF 9,078,000 TONS. THIS COAL IS REPORTED TO BE 73 INCHES THICK AT AN ABANDONED MINE IN SEC. 27, AND IT IS 67 INCHES THICK AT THE TED GRAY MINE IN SEC. 35. THE OVERBURDEN IN THIS AREA IS QUITE THICK AND FUTURE MINING IF DONE ON A LARGE SCALE, WOULD HAVE TO BE OF THE UNDERGROUND VARIETY.

A 31 INCH BED OF COAL AT THIS HORIZON IS EXPOSED IN SEC. 21, T. 19 N., R. 11 E., BUT ESTIMATED RESERVES OF POTENTIALLY COMMERCIAL COAL ARE ONLY 367,200 TONS IN THIS AREA.

THE UPPER COAL BED IN THE HILLEN FACIES WAS FORMERLY MINED AT THREE PLACES IN SECS. 19 AND 30, T. 19 N., R. 11 E., AND IS REPORTED TO HAVE A MAXIMUM THICKNESS OF 94 INCHES. SLUMPING HAS COMPLETELY OBLISCURED THE COAL IN THE AREA. HOWEVER, ABOUT 300 ACRES UNDERLAIN WITH AN AVERAGE OF 4 FEET OF COAL, HAVE AN ESTIMATED RESERVE OF 2,000,000 TONS. UNDERGROUND MINING WOULD BE NECESSARY FOR FUTURE DEVELOPMENT IN THIS AREA.

THE HILLEN COALS ARE BLACK, BRITTLE, QUITE THICKLY BEDDED AT PLACES, AND VERTICALLY JOINTED. A CHEMICAL ANALYSIS OF THE COAL FROM THE TED GRAY MINE IN THE NE $\frac{1}{4}$, SEC. 35, T. 19 N., R. 10 E., IS SHOWN IN TABLE 1 AND TABLE 2.

THE HILLEN FACIES CONTAINS ESTIMATED RESERVES OF 11,717,000 TONS OF POTENTIALLY COMMERCIAL COAL. THIS INCLUDES ONLY AREAS WHERE THE COAL IS MORE THAN 2 $\frac{1}{2}$ FEET THICK.

THE LUDLOW CONTAINS COALS UP TO 42 INCHES THICK IN THE WESTERN PART OF THE QUADRANGLE, BUT THESE UNDERLIE SMALL AREAS NEAR THE TOPS OF NUMEROUS SMALL HILLS AND DO NOT CONTAIN SUFFICIENT QUANTITIES TO MERIT DEVELOPMENT.

SEVERAL OUTCROPS OF COAL ALONG STATE HIGHWAY 8 MAY REPRESENT THE UPPER BED OF THE HILLEN FACIES. THE COAL HAS A MAXIMUM THICKNESS OF 31 INCHES AND IS BADLY WEATHERED BECAUSE OF THE THIN OVERBURDEN.

TABLE 1 PROXIMATE ANALYSIS

| COAL | SEC | T.P.S. | RGE | MOISTURE | VOLATILE | CARBON | ASH | SULFUR | B.T.U. |
|------------|-----|--------|-----|----------|----------|--------|-------|--------|--------|
| HILLEN | 35 | 19 | 10 | 37.18% | 32.05% | 24.53% | 6.24% | 1.24% | 6250 |
| SHADEHILL | 28 | 20 | 11 | 39.62 | 30.58 | 21.58 | 8.22 | 0.73 | 5598 |
| HELL CREEK | 32 | 20 | 10 | 42.42 | 29.85 | 19.80 | 7.93 | 0.48 | 4996 |

ANALYSIS BY THE STATE CHEMICAL LABORATORY, VERMILION, SOUTH DAKOTA

TABLE 2 ULTIMATE ANALYSIS

| COAL | SEC | T.P.S. | RGE | HYDROGEN | CARBON | NITROGEN | OXYGEN | SULFUR | ASH |
|-----------|-----|--------|-----|----------|--------|----------|--------|--------|-----|
| HILLEN | 35 | 19 | 10 | 6.5 | 42.6 | 0.6 | 44.6 | 0.9 | 4.8 |
| SHADEHILL | 28 | 20 | 11 | 6.7 | 37.4 | 0.7 | 48.4 | 0.7 | 6.1 |

ANALYSIS BY U. S. BUREAU OF MINES

CLAY

THE UPPER HELL CREEK CONTAINS HIGHLY BENTONITIC CLAYS WHICH PROVIDE EXCELLENT IMPERVIOUS MATERIAL FOR THE CONSTRUCTION OF STOCK DAMS.