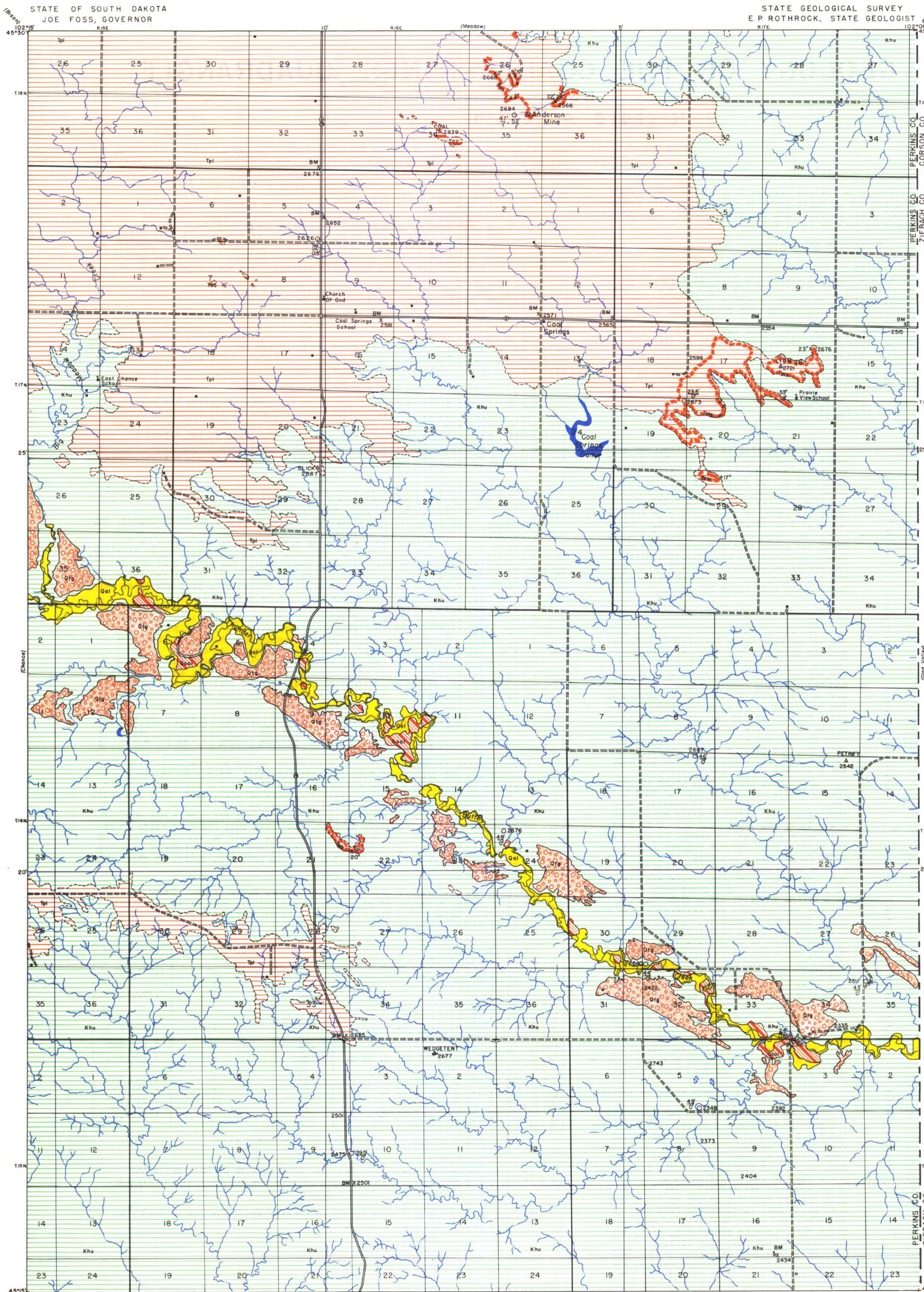


AREAL GEOLOGY OF THE COAL SPRINGS QUADRANGLE

EXPLANATION

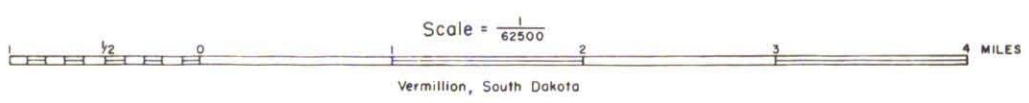
SEDIMENTARY ROCKS



STATE OF SOUTH DAKOTA
JOE FOSS, GOVERNOR

STATE GEOLOGICAL SURVEY
E. P. ROTHROCK, STATE GEOLOGIST

Geology by R.A. Hoppin and R.E. Curtiss.
Assisted by E.E. Lutzen, E.J. Bolin, W.L. Foley, D.L. Fairbanks, R.L. Hale.
Surveyed in 1953.
Coal-Test Holes Drilled in 1954.
Base Map by South Dakota State Geological Survey.



Vermillion, South Dakota
1955



- QUATERNARY**
- Qal** Alluvium (Valley-bottom deposits of clay, silt, sand, and gravel in present streams.)
 - Qol** Older Alluvium (Alluvial terrace deposits above present floodplain.)
 - Qtg** Terrace Gravel (Terrace deposits of sand and gravel, 5'-15' thick.)
 - Tpc** Chadron Formation (Pale greenish gray siliceous conglomerate and grit caps 10 buffes.)
- TERTIARY**
- Tpl** Ludlow Formation (Buff-yellow, white, and gray silty clay, silt, cross-bedded sand, and pink clay with ledges of calcareous sandstone, scattered thin beds of limestone conglomerate, some plant remains, pink-gray botryoidal-like limestone pillars, and log-like cementations. Residual brown Tongue River orthoquartzite boulders scattered on surface. Tpl-Hill coal: 2'-12" thick, some "blackjack" and peat-clay beds and melanterite. Tpl-Shadell coal: 1-3 coals in basal biofacies. 0-33" thick. Coal sometimes grades into "blackjack" and/or peat-clay beds. Interbeds of gray and brown clay and silt. Upper part of formation missing. About 250' thick.)
 - Khu** Upper Hell Creek ("Somber beds" of lens-like laminated clay, silt, sand and peat-clays. Sands up to 60' thick. Irregular calcareous cementation yields log-like concretions. Mn-Fe, clay ironstone, and marcsite concretions. Dinosaur bones occur sporadically. Some discontinuous beds of "blackjack" present in uppermost part of unit. Parts of member erode to badlands. About 250' exposed.)
- CRETACEOUS**
- HELL CREEK FORMATION**
- DRAINAGE**
- Intermittent Streams
 - Intermittent Lakes
- CULTURE**
- Buildings (House, church, and school)
 - Roads and Trails
- ALTITUDES** (in feet above sea level)
- BM 1706
- BENCH MARKS** (Monuments marking points of known altitude)
- RENA
- TRIANGULATION STATIONS** (U.S. Coast & Geodetic and/or U.S. Geological Survey monuments marking points of exact geographic location)
- Operating
 - Abandoned
- COAL MINES AND GRAVEL PITS**
- x 36"
- COAL THICKNESS** (Exposed)
- 2323 Top Hole
 - 35 Altitude
 - 2 Overburden
 - 2 Thickness
- DRILL HOLES**
- Dams (Large, small earthen or cement.)

AREAL GEOLOGY OF THE COAL SPRINGS QUADRANGLE

By
Richard A. Hoppin

LOCATION

THE QUADRANGLE IS SITUATED IN EASTERN PERKINS COUNTY APPROXIMATELY 10 MILES EAST-SOUTHEAST OF BISON AND 30 MILES SOUTH OF LEMMON. IT LIES BETWEEN PARALLELS 45°15' AND 45°30' NORTH LATITUDE AND MERIDIANS 102°00' AND 102°15' WEST LONGITUDE AND INCLUDES AN AREA OF ABOUT 210 SQUARE MILES.

TOPOGRAPHY AND DRAINAGE

MOST OF THE AREA IS DRAINED BY THE SOUTHEASTERLY FLOWING THUNDER BUTTE CREEK. THIS STREAM FOLLOWS A MEANDERING COURSE AND OCCUPIES A VALLEY UP TO A HALF MILE WIDE. IN PLACES, ESPECIALLY ON THE OUTER SIDES OF MEANDER CURVES, THE STREAM IS ACTIVELY UNDERCUTTING ITS BANKS. LOCALLY, THE VALLEY WALLS ARE 100 FEET HIGH. THE VALLEY BECOMES NARROWER AND LESS CONSPICUOUS TO THE NORTHWEST.

A LOW DIVIDE SEPARATES THE THUNDER BUTTE CREEK DRAINAGE AND THAT OF RABBIT CREEK AND THE MOREAU RIVER TO THE SOUTH. THE DIVIDE AVERAGES ABOUT 2,500 FEET IN ALTITUDE AND TRENDS EAST-WEST JUST NORTH OF THE SOUTH MARGIN OF THE QUADRANGLE FOR ABOUT NINE MILES BEFORE TURNING NORTHWEST TOWARDS THE WEST EDGE OF THE AREA. THE SOUTH SLOPE OF THE DIVIDE IS DEEPLY CUT BY TRIBUTARY STREAMS OF THE MOREAU RIVER AND IN PLACES HAS CLIFFS OVER A HUNDRED FEET HIGH.

THE DRAINAGE PATTERN IS DENDRITIC AND FAIRLY DENSE. THE STREAMS ARE ALL INTERMITTENT ALTHOUGH THUNDER BUTTE CREEK MAY MAINTAIN A FLOW IN WET YEARS.

THE TOPOGRAPHY IS GENTLY ROLLING AND RISES GRADUALLY TO THE NORTH. THE AVERAGE RELIEF IS 50-100 FEET BUT IS INTERRUPTED BY SCATTERED BUTTES WHICH RISE 150-200 FEET ABOVE THE GENERAL SURFACE.

THE HIGHEST ALTITUDE IS 2,839 FEET ABOVE SEA LEVEL ON COAL BUTTE JUST EAST OF THE CENTER OF SEC. 34, T. 18N., R. 16E. THE LOWEST ALTITUDE IS APPROXIMATELY 2,350 FEET ABOVE SEA LEVEL IN A TRIBUTARY GULLY OF RABBIT CREEK IN NE 1/4 SEC. 23, T. 15N., R. 15E. THE RELIEF IS APPROXIMATELY 489 FEET, AND THE AVERAGE ALTITUDE OF THE QUADRANGLE IS ABOUT 2,590 FEET ABOVE SEA LEVEL.

STRATIGRAPHY

THE EXPOSED STRATIGRAPHIC UNITS, RANGING IN AGE FROM UPPER CRETACEOUS TO RECENT, CONSIST MAINLY OF THE HELL CREEK FORMATION (UPPER CRETACEOUS) AND THE LUDLOW FORMATION (PALEOCENE AGE). MINOR AMOUNTS OF CHERT BOULDER RESIDUUM FROM THE TONGUE RIVER FORMATION (PALEOCENE AGE) CAP A FEW BUTTES IN THE NORTHWEST PART OF THE QUADRANGLE. THE BASAL PORTION OF THE CHADRON (?) FORMATION OF THE WHITE RIVER GROUP (OLIGOCENE AGE) CAPS SEVERAL BUTTES. PLEISTOCENE GRAVEL TERRACES, PLEISTOCENE-RECENT ALLUVIAL TERRACES AND RECENT VALLEY ALLUVIUM COMPRISE THE REMAINDER OF THE UNITS EXPOSED.

UPPER HELL CREEK, HELL CREEK FORMATION (BROWN 1907). ABOUT 250 FEET OF THIS LITHOLOGIC UNIT ARE EXPOSED. IT CONSISTS OF INTERBEDDED AND INTERLAMINATED BENTONITIC CLAY, SILT, AND SAND. THE MEDIUM TO DARK GRAY AND BLACK CLAY, OR GUMBO, IS SLIPPERY AND PLASTIC WHEN WET BUT BECOMES SPONGY AND TOUGH ON DRYING. THIN BEDS AND LAMINAE OF DARK BROWN CLAY-PEAT AND PEAT-CLAY ARE COMMON. SANDS UP TO 60 FEET THICK ARE EXPOSED IN STREAM BANKS. THESE SANDS VARY IN COLOR FROM YELLOW TO GRAY, ARE MEDIUM- TO FINE-GRAINED AND ARE SOFT AND FRIABLE OR VERY HARD WHERE CEMENTED BY CALCITE. CALCAREOUS CEMENTATION FAVORS NO PARTICULAR HORIZON AND IS THUS IRREGULAR IN DISTRIBUTION. IN PLACES, THE CEMENTATION YIELDS RESISTANT LEDGES OR BOULDERS AND LOG-SHAPED "CONCRETIONS."

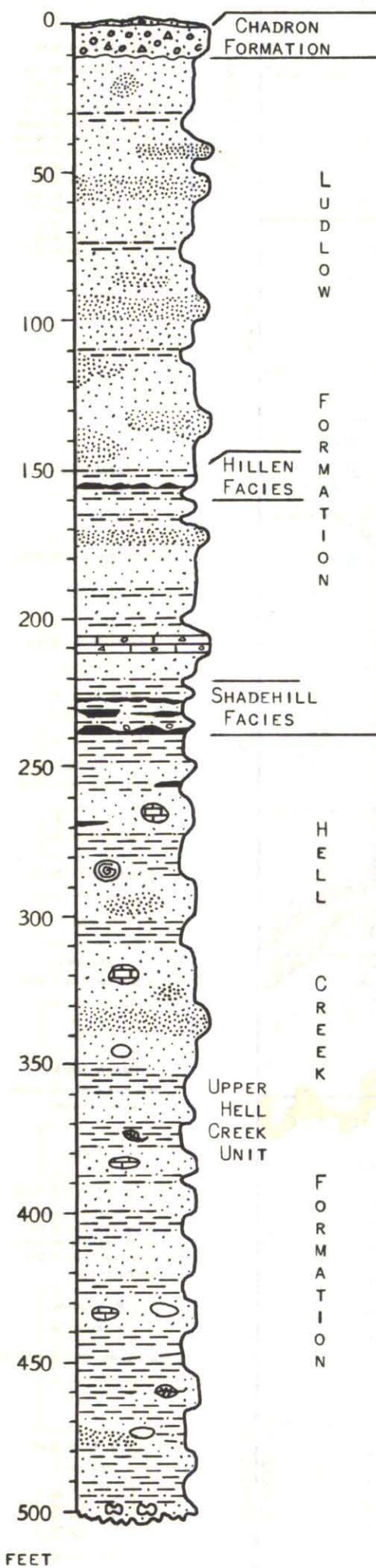
CLAY IRONSTONE, MANGANESE-IRON, AND MARCASITE CONCRETIONS ARE SCATTERED THROUGHOUT. DINOSAUR BONES OCCUR SPORADICALLY. IRREGULAR, DISCONTINUOUS BEDS OF "BLACKJACK" ARE PRESENT IN THE UPPERMOST PART OF THE UNIT.

RAPID VERTICAL AND LATERAL VARIATION IS CHARACTERISTIC. THIS, ALONG WITH THE LACK OF ANY CONSISTENT COAL HORIZON, MAKES CORRELATION DIFFICULT. PORTIONS OF THE MEMBER ERODE TO TYPICAL BADLANDS TOPOGRAPHY.

LUDLOW FORMATION (LLOYD AND HARES 1915). THE CONTACT BETWEEN THE UPPER HELL CREEK AND LUDLOW IS DRAWN AT THE BASE OF THE LOWEST COAL IN THE SHADEHILL COAL FACIES OR ASSOCIATED LITHOLOGY, CONSISTING OF VARIATED RED, BROWN, AND PURPLE CLAY SHALE BEDS. THE UPPER PART OF THE FORMATION IS MISSING. ABOUT 250 FEET ARE EXPOSED. THE SHADEHILL COAL HORIZON CONSISTS OF ONE TO THREE COAL BEDS WHICH VARY IN THICKNESS FROM ZERO TO 33 INCHES AND FROM 15-30 FEET OF GRAY AND BROWN CLAY, LOCALLY BENTONITIC, SILT, SAND, "BLACKJACK", AND PEAT-CLAY BEDS.

UP TO 100 FEET OF PREDOMINANTLY SAND AND CALCAREOUS-CEMENTED SANDSTONE OVERLAY THE SHADEHILL AND CONSIST OF YELLOW TO LIGHT GRAY

GENERALIZED COLUMNAR SECTION



MEDIUM- TO FINE-GRAINED SAND WHICH EXHIBITS PLANT REMAINS, GOOD STRATIFICATION, AND MARKED CROSS-BEDDING. WHERE HIGHLY CALCAREOUS, THE SANDSTONE FORMS RESISTANT CAPS ON BUTTES AND MESAS.

UNUSUAL "PILLAR" STRUCTURES AND ROUND AND LOG-SHAPED LENSES ARE COMMON. THIN BEDS OF LIMESTONE CONGLOMERATE ARE PRESENT.

THE HILLEN COAL FACIES IS PRESENT IN THE EXTREME NORTH-CENTRAL PORTION OF THE AREA. THE ASSOCIATED LITHOLOGY CONSISTS OF INTERBEDDED YELLOW, BROWN, AND GRAY CLAY, SILT, AND SAND WITH PLANT DEBRIS. THE COAL IS FROM 2-12 INCHES THICK.

ABOUT 170 FEET OF UPPER LUDLOW OVERLIES THE HILLEN COAL FACIES. APPROXIMATELY 85 FEET OF NONCALCAREOUS SANDSTONE, GRADING UPWARDS INTO GRIT AND CONGLOMERATE, ARE EXPOSED IN COAL BUTTE AND NEARBY BUTTES. THE SANDS IN THIS INTERVAL ARE GENERALLY LIGHT GRAY, MEDIUM-GRAINED, SOFT, AND CROSS-BEDDED. THEY MAKE LEDGES WHERE CEMENTED BY SILICA AND IRON OXIDE.

CHADRON FORMATION (?) (DARTON 1899). THIN, PALE GREENISH GRAY SILICA-CEMENTED CONGLOMERATE AND GRIT FORM RESISTANT CAPS ON 10 BUTTES.

STRUCTURE

THE QUADRANGLE IS ON THE EAST FLANK OF THE DAKOTA (WILLISTON) BASIN. THE REGIONAL DIP IS NORTHWEST ABOUT 10 FEET PER MILE. MINOR SMALL FAULTS AND VERY GENTLE FOLDS ARE PRESENT. THE LACK OF A GOOD MAPPABLE HORIZON, ALONG WITH SLUMPING, MAKE STRUCTURAL DETAILS DIFFICULT TO DETERMINE.

ECONOMIC GEOLOGY

THE QUADRANGLE CONTAINS SEVERAL ACTUAL OR CURRENTLY-EXPLOITED AND POTENTIALLY-IMPORTANT MINERAL RESOURCES. GRAVEL TERRACES ARE QUARRIED PERIODICALLY. LUDLOW COAL WAS FORMERLY MINED EAST OF COAL SPRINGS, BUT NO COAL IS MINED TODAY. COAL BY-PRODUCTS, BENTONITIC CLAYS, AND SANDSTONE MAY CONTRIBUTE TO THE AREA'S FUTURE ECONOMY. FEW SCATTERED SURFICIAL DEPOSITS OF MANGANESE-IRON CONCRETIONS, CONTAINING ABOUT 51% METALLIC IRON, ARE NOT ECONOMICALLY IMPORTANT AT THE PRESENT TIME.

COAL

AREAL EXTENT. THE APPROXIMATE BOUNDARIES OF THE SHADEHILL AND HILLEN COALS ARE SHOWN ON THE MAP. THE BOUNDARIES WERE DETERMINED BY NATURAL EXPOSURES, COAL MINES, 11 STATE GEOLOGICAL SURVEY COAL-TEST HOLES, AND TOPOGRAPHY.

THICKNESS. THE SHADEHILL COALS VARY IN THICKNESS FROM ZERO TO 33 INCHES, AND THE HILLEN COAL RANGES BETWEEN 2-12 INCHES.

PHYSICAL CHARACTER. MUCH OF THE COAL IS BLACK IN COLOR AND STREAK, BLOCKY, BRITTLE, SLACKS MODERATELY ON DRYING OR EXPOSURE, AND IS NONCOKING. CLAY PARTINGS, GYPSUM, MARCASITE, AND PYRITE ARE SCATTERED THROUGHOUT. ONE BROWN CLAY BED OF 10 INCHES SPLITS THE UPPER SHADEHILL COAL INTO TWO BEDS OF 22 INCHES AND 24 INCHES IN SECTIONS 25, 36, T. 18N., R. 16E. THE SHADEHILL AND HILLEN COAL BEDS MAY GRADE Laterally, A HUNDRED FEET OR SO, INTO "BLACKJACK" AND/OR PEAT-CLAY.

CHEMICAL CHARACTER. CHEMICAL ANALYSES PROVIDE A SATISFACTORY BASIS FOR COMPARING COALS AND DETERMINING THE RANK AND GRADE OF COAL AND ITS COMMERCIAL QUALITIES. PROXIMATE ANALYSIS FURNISHES REQUISITE DATA RELATIVE TO THE QUALITY AND COMBUSTION PROPERTIES (MOISTURE, VOLATILE AND GASEOUS MATTER, FIXED CARBON, OR THE CHIEF HEAT-PRODUCING CONSTITUENT, ASH, AND SULPHUR) OF COAL.

COAL SAMPLES ("TRENCH" OR CHANNEL) FROM THE SHADEHILL COAL OUTCROPS, COAL SAMPLE NUMBER 1, 20-INCHES THICK, SEC. 22, T. 16N., R. 16E., AND COAL SAMPLE NUMBER 2, 33-INCHES THICK, SEC. 21, T. 17N., R. 17E., WERE ANALYZED AS RECEIVED, MEANING THE SAMPLES REPRESENT THE COAL AS MINED. THE PROXIMATE ANALYSES ARE AS FOLLOWS:

TABLE 1

SAMPLE	MOISTURE	VOLATILE MATTER	FIXED CARBON	ASH	SULPHUR	B.T.U.	DRY B.T.U.
1	28.23%	24.15%	13.94%	33.68%	0.57%	3,870	5,392
2	36.18%	27.03%	9.72%	27.07%	0.60%	3,150	4,936

ECONOMICALLY, IF THE COAL IS AIR DRIED PRIOR TO DOMESTIC OR COMMERCIAL CONSUMPTION, THE HEATING VALUE OR B.T.U. IS INCREASED. (SEE DRY B.T.U. IN TABLE ABOVE.)

CHARACTER OF OVERBURDEN. THE LITHOLOGIC CHARACTER OF THE OVERBURDEN, WHICH IS NOT A DETRIMENT TO STRIP MINING, CONSISTS LARGELY OF CLAY, SILT, SAND AND LOCAL SANDSTONES. THE THICKNESS APPROXIMATES 50 FEET EAST OF COAL SPRINGS.

ESTIMATED COAL RESERVES. TONNAGE IS COMPUTED ON THE BASIS OF A MINIMUM THICKNESS OF 2 1/2 FEET, A SPECIFIC GRAVITY OF 1.25, AND 1,700 TONS PER ACRE-FOOT. A RESERVE IN SEC. 16, T. 17N., R. 17E. IS ESTIMATED TO CONTAIN ABOUT 34,000 TONS OF COAL ON THE BASIS OF EIGHT ACRES OF 2 1/2-FOOT COAL. THIS RESERVE IS CLASSIFIED AS MEASURED, MEANING COAL RESERVES LOCATED WITHIN 0.5 MILES FROM OUTCROPS, MINES, OR DRILL HOLES.

GRAVEL

GRAVEL OCCURS AS TERRACE DEPOSITS ALONG THUNDER BUTTE CREEK. THESE DEPOSITS CONSTITUTE A VOLUME IN EXCESS OF 23,500,000 CUBIC YARDS. MUCH OF THIS MATERIAL IS ADEQUATE FOR ROAD METAL. SEVERAL PITS OPERATE SEASONALLY. ESTIMATED VOLUMES FOR THE LARGER TERRACES ARE AS FOLLOWS:

TABLE 2

LOCATION	ACRES	Ave. THICKNESS	CUBIC YARDS
SECS. 4, 5, T. 15N., R. 17E.			
SECS. 31, 32, 33, T. 16N., R. 17E.	319	9'	4,631,880
SECS. 33, 34, T. 16N., R. 17E.	199	12'	
	62	4'	4,260,154
SEC. 1, T. 16N., R. 15 E.			
SECS. 6, 7, T. 16 N., R. 16 E.			
SEC. 36, T. 17 N., R. 15 E.	220	8'	2,839,466
SEC. 24, T. 16 N., R. 16 E.			
SECS. 19, 30, T. 16 N., R. 17 E.	194	9'	2,816,880
SECS. 14, 15, 23, 24, T. 16 N., R. 16 E.	139	8'	1,794,000
SECS. 8, 9, 10, T. 16 N., R. 16 E.			
(OPERATED BY STATE HIGHWAY DEP'T)	192	5'	1,548,800
SECS. 4, 5, 8, T. 16 N., R. 16 E.	165	5'	1,331,000
SECS. 5, 6, T. 16 N., R. 16 E.	75	10'	1,210,000
SECS. 26, 35, T. 17 N., R. 15 E.	144	5'	1,161,600
SECS. 26, 35, T. 17 N., R. 15 E.	128	5'	1,032,533

OTHER TERRACES CONTAIN LESS THAN ONE MILLION CUBIC YARDS.

SANDSTONE

THE SILICA-CEMENTED SANDSTONE, GRIT AND CONGLOMERATE OF COAL BUTTE AND NEIGHBORING HILLS AND BUTTES COULD BE USED LOCALLY FOR FOUNDATIONS AND RIP-RAP.

CLAY

CERTAIN BENTONITIC CLAY BEDS IN THE HELL CREEK FORMATION CAN BE USED FOR SEALING STOCK DAMS, THUS CONSERVING WATER.