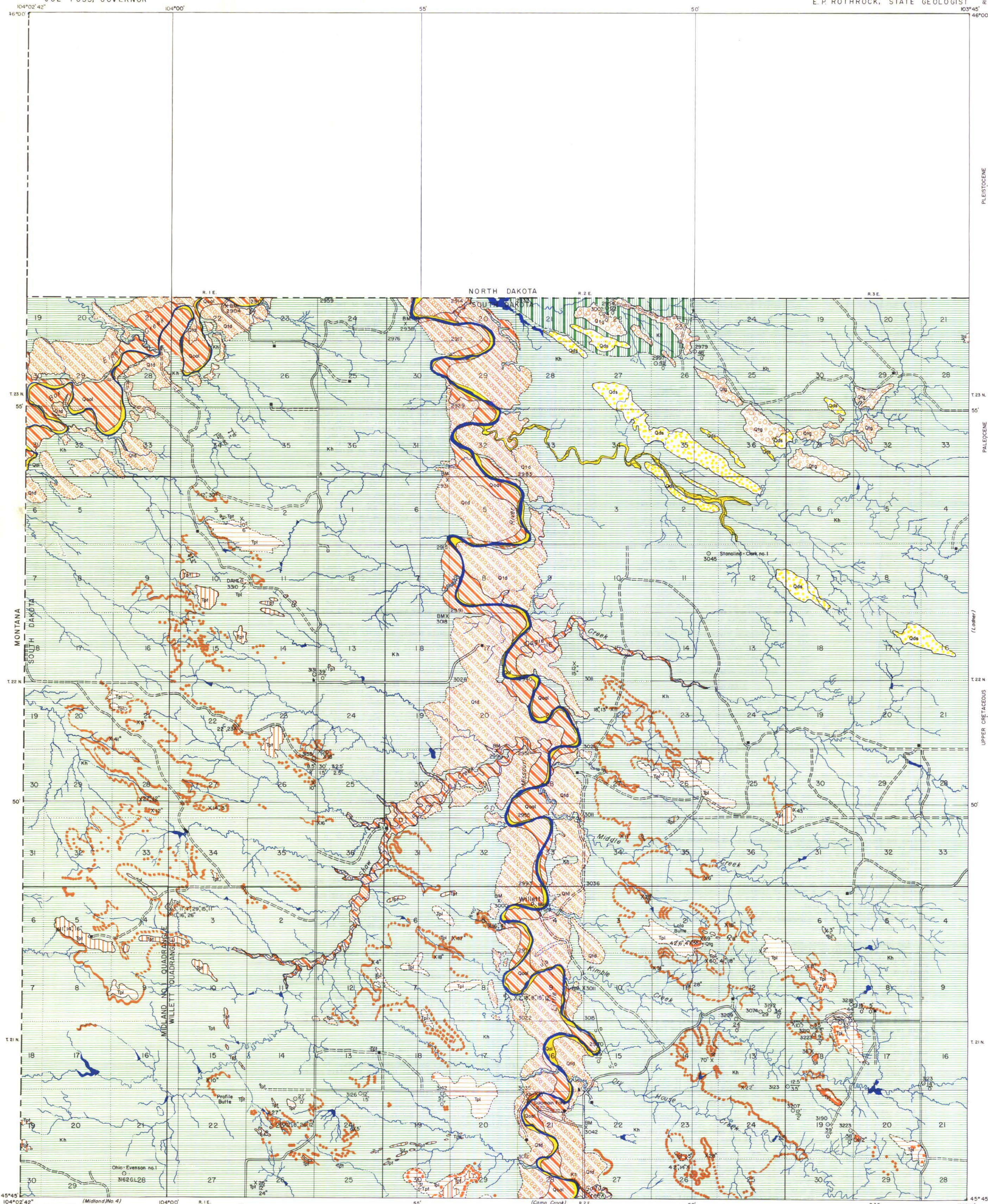


AREAL GEOLOGY OF THE WILLETT AND MIDLAND NO.1 QUADRANGLES

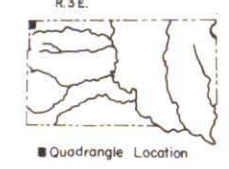
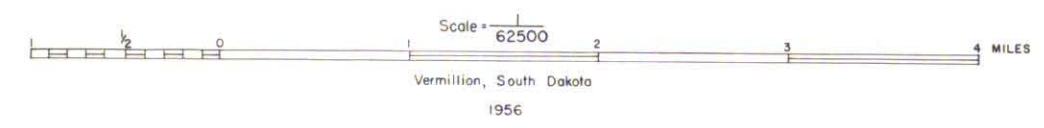
STATE OF SOUTH DAKOTA
JOE FOSS, GOVERNOR

STATE GEOLOGICAL SURVEY
E. P. ROTHROCK, STATE GEOLOGIST



- EXPLANATION**
- SEDIMENTARY ROCKS**
- Qal**
Alluvium
(Silt, clay, sand and gravel occupying present flood-plains along major rivers and streams)
 - Qds**
Dune Sand
(Sand, fine to medium grained quartz, mica, and some darker ferro-magnesian minerals. Derived from Fox Hills and Hell Creek sands. Partially grassed with local "blowouts". 0-30 feet in relief)
 - Qol**
Older Alluvium
(Silt, sand, clay and occasionally gravel occupying lower flats and slip-off slopes above present stream floodplains)
 - Qta**
Terrace Deposits
(Gravels, silts, clays and sands occupying successive terraces above present river and stream levels. Some of higher terraces have eroded back to Hell Creek)
 - Qtg**
Terrace Gravels
(Gravel, coarse to fine, well sorted to poorly sorted. Contains petrified wood, Hell Creek manganese-iron concretions material, quartz, and some igneous and metamorphic rocks derived from weathering of Tertiary intrusives to the south and west. 0-15 feet in thickness)
 - Tpl**
Tongue River Formation
(Sandstone channel deposits, light yellowish brown to light gray, massive, cross-bedded, loosely consolidated to indurated, carbonaceous in part, with some coarse conglomerate composed of clay pebbles, sandstone pebbles (up to 4" in diameter), and stream rounded Hell Creek manganese-iron concretions. 0-45 feet in thickness)
 - Lud**
Ludlow Formation
(Clay and shale, silt, silty clay, and sand, light gray to tan (locally shales) in color, loosely cemented, bentonitic in part. Contains clinker and baked clay derived from burning lignite beds (usually highest burn in area), fossil leaves, rusty brown limonite concretions, fluggy, thin bedded, ripple marked, calcareous sandstone concretions, and thin lignite seams associated with carbonaceous clay and shale. 0-110 feet in thickness)
 - Kh**
Hell Creek Formation
Undifferentiated
(Clay, silt, highly bentonitic, tough light gray to dark gray ("samber") in color, with some massive loosely consolidated, cross-bedded, sub-arkose sandstone up to 75 feet (?) in thickness and carrying lenticular calcareous sandstone concretions. Upper part carries several thick but highly reticular lignite beds associated with carbonaceous clay and shale, many of which have burned leaving clinker and baked clay throughout the area. Contains fossil leaves, petrified wood, manganese-iron "sampler" concretions, cone-in-cone concretions, and dinosaur bones. 550 to 600 feet in thickness)
 - FH**
Fox Hills Formation
(Sandstone, fine grained, cross-bedded, argillaceous in part, pepper and salt texture. Upper part a light buff color grading into a light gray to bluish-gray sandstone. Lower part is 20 to 30 feet of sandstone grading into shale which are the "Transition" beds overlying the Pierre formation. *Halimnites* *sp.* is found in upper portion. No marine fossils are found. Approximately 80 feet in thickness)
- DRAINAGE**
- Intermittent Streams
- CULTURE**
- Buildings (house, church, and school)
 - Roads and Trails
 - Altitudes (in feet above sea level)
 - Bench Marks (Monuments marking points of known altitudes)
 - Triangulation Stations (U.S. Coast & Geodetic and U.S. Geological Survey monuments marking points of exact geographic location)
 - Operating
 - Abandoned
 - Gravel pits
 - Coal Thickness (Exposed)
 - 2790 Top Hole Altitude
 - 36 Overburden Thickness
 - Drill Holes
 - Hunt State No. 1
 - Oil-test Borings
- QUATERNARY**
- PLEISTOCENE**
- PALEOCENE**
- UPPER CRETACEOUS**
- CRETACEOUS**
- TERTIARY**

Geology by H.D. Erickson
Assisted by F.V. Steece, E. Glazier, R. Wilson
Surveyed in 1956. Drafted by F.V. Steece
Coal-Test Holes Drilled in 1956
Base Map by South Dakota State Geological Survey

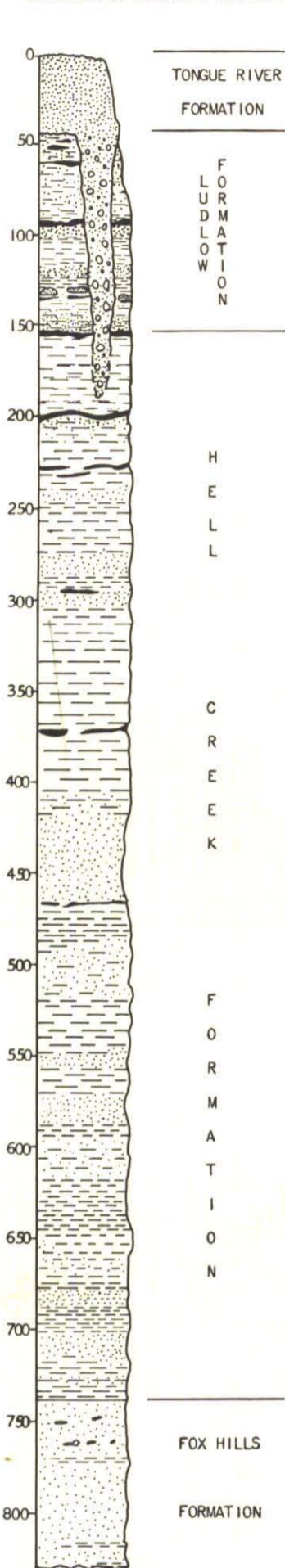


AREAL GEOLOGY OF THE WILLETTS AND MIDLAND NO. 1 QUADRANGLES

By

Harold D. Erickson

GENERALIZED COLUMNAR SECTION



INTRODUCTION

THESE QUADRANGLES WERE MAPPED AS PART OF THE SOUTH DAKOTA GEOLOGICAL SURVEY'S COAL RESOURCES PROGRAM. PRELIMINARY WORK ON HORIZONTAL CONTROL WAS DONE DURING THE SUMMER OF 1955 AND COMPLETED IN THE SUMMER OF 1956. GEOLOGICAL MAPPING AND A LIMITED AMOUNT OF EXPLORATORY DRILLING FOR COAL AND STRATIGRAPHIC INFORMATION WAS CARRIED ON IN THE SUMMER OF 1956.

THE AREA WAS MAPPED WITH AERIAL PHOTOGRAPHS (1938 FLIGHT). HORIZONTAL CONTROL WAS BASED ON TRIANGULATION FROM KNOWN COAST AND GEODETIC SURVEY TRIANGULATION STATIONS AS WELL AS FROM UNITED STATES GEOLOGICAL SURVEY TOPOGRAPHIC MAPS OF THE LITTLE MISSOURI RIVER FROM MARATH, NORTH DAKOTA TO THE NORTH FORK IN WYOMING, WHICH WERE SURVEYED IN COOPERATION WITH THE BUREAU OF RECLAMATION WITH HORIZONTAL CONTROL BASED ON BUREAU OF LAND MANAGEMENT (1946) RESURVEYS.

LOCATION AND SIZE

THESE QUADRANGLES LIE IN THE NORTHWEST CORNER OF HARDING COUNTY, SOUTH DAKOTA, BORDERED BY MONTANA ON THE WEST AND NORTH DAKOTA ON THE NORTH. THE WILLETTS QUADRANGLE COMPRISES AN AREA OF APPROXIMATELY 175 SQUARE MILES, WHILE THE MIDLAND NUMBER 1 QUADRANGLE LYING ADJACENT ON THE WEST COMPRISES AN AREA OF APPROXIMATELY 29 SQUARE MILES AND OCCUPIES A NARROW STRIP ALONG THE MONTANA-SOUTH DAKOTA BORDER. THE CENTER OF THE MAPPED AREA IS 23 AIR MILES NORTHWEST OF BUFFALO, THE COUNTY SEAT OF HARDING COUNTY. THE WILLETTS QUADRANGLE IS NAMED FOR THE OLD STAGE COACH STOP AND POST OFFICE AT WILLETTS IN SECTION 4, T21N., R2E., WHICH IS NOW ABANDONED.

GEOGRAPHY

THE TOPOGRAPHY OF THE AREA IS PREDOMINANTLY ROLLING PRAIRIE LAND INTERRUPTED BY "BAD LANDS" ALONG MAJOR STREAMS, AND BY CUESTA FACES WHERE A PRONOUNCED DIP IN BEDS IS ENCOUNTERED.

NUMEROUS SMALL BUTTES CAPPED WITH RED TO TAN BAKED CLAY (LOCALLY CALLED SCORIA) DERIVED FROM THE BURNING OF COALS ARE FOUND THROUGHOUT THE SOUTHERN AND WEST-CENTRAL PORTION OF THE QUADRANGLE, AND FORM A CONSPICUOUS LANDMARK IN THE AREA. THE NORTHEASTERN CORNER OF THE QUADRANGLE IS ALMOST ENTIRELY "BAD LANDS" DERIVED FROM THE "BREACHING" OF THE FOX HILLS DOME. NUMEROUS AREAS INSIDE THE CUESTA'S OF THE DOME ARE COVERED WITH DUNE SAND DERIVED MOSTLY FROM THE BASAL SANDS OF THE HELL CREEK FORMATION AND IN PART FROM THE FOX HILLS FORMATION.

THE LITTLE MISSOURI RIVER AND ITS TRIBUTARIES DRAIN THE ENTIRE AREA.

THE MAXIMUM ELEVATION (3310 FEET) FOUND IN THE QUADRANGLE IS ON TRIANGULATION STATION DAHL, WHILE THE LOWEST IS FOUND AT THE POINT WHERE THE LITTLE MISSOURI RIVER ENTERS NORTH DAKOTA, AND IS 2876 FEET. THE TOTAL MAXIMUM RELIEF IN THE AREA THUS APPROACHES 434 FEET.

THE CLIMATE IS SEMI-ARID WITH AN ANNUAL PRECIPITATION OF 8 TO 11 INCHES. CATTLE AND SHEEP RANCHING ARE THE PREDOMINANT OCCUPATION, ALTHOUGH SOME WHEAT AND CORN DRY-LAND FARMING IS CARRIED ON. IN RECENT YEARS EXTENSIVE IRRIGATION PROJECTS HAVE BEEN DEVELOPED ON ALLUVIAL TERRACES ALONG THE LITTLE MISSOURI RIVER AND BOX ELDER CREEK.

THE SURFACE WATER SUPPLIES OF THE AREA ARE MEAGER. NEARLY ALL CREEKS AND STREAMS EXCEPT THE LITTLE MISSOURI RIVER AND BOX ELDER CREEK ARE INTERMITTENT. STOCK DAMS AND SHALLOW WELLS PROVIDE THE MAIN SOURCE OF WATER SUPPLY, BUT IN TIMES OF CONTINUED DROUGHT THESE BECOME INADEQUATE. A FEW SPRINGS ARE FOUND IN THE AREA, USUALLY ASSOCIATED WITH COAL SEAMS.

STRATIGRAPHY

THE SURFACE FORMATIONS OF THE AREA ARE REPRESENTED BY CLASTIC SEDIMENTS RANGING IN AGE FROM LATE CRETACEOUS THROUGH PALEOGENE AND QUATERNARY. THE BEDROCK (LATE CRETACEOUS THROUGH PALEOGENE) INCLUDES THE FOX HILLS, HELL CREEK, LUDLOW, AND TONGUE RIVER FORMATIONS, WHILE THE QUATERNARY UNCONSOLIDATED SEDIMENTS ARE REPRESENTED BY YOUNGER AND OLDER ALLUVIAL DEPOSITS, TERRACE GRAVEL, OTHER TERRACE DEPOSITS, AND DUNE SAND.

THE CONTACT BETWEEN THE FOX HILLS AND HELL CREEK APPEARS TO BE CONFORMABLE, BUT AT CERTAIN PLACES OUTSIDE THE AREA (AND POSSIBLY WITHIN THE AREA) LOWER HELL CREEK CHANNELS APPEAR TO HAVE BEEN ERODED DOWN INTO THE FOX HILLS. IN THE FOX HILLS DOME AREA MUCH OF THE HELL CREEK CONTACT IS COVERED BY PLEISTOCENE (?) GRAVEL TERRACES AND MORE RECENT DUNE SAND.

THE CONTACT BETWEEN THE HELL CREEK AND LUDLOW IS CONFORMABLE AND TRANSITIONAL. THE BASAL COAL OF THE LUDLOW-SHADEHILL COAL FACIES THAT WAS USED AS A CONTACT IN MAPPING THE QUADRANGLES FARTHER EAST, COULD NOT BE USED IN MAPPING THE WILLETTS AND MIDLAND NO. 1 QUADRANGLES, AS NUMEROUS COALS ARE FOUND IN UPPER HELL CREEK "SOMBER" BEDS.

THE CONTACT BETWEEN THE LUDLOW AND TONGUE RIVER IS UNCONFORMABLE, FOR IN CERTAIN AREAS TONGUE RIVER CHANNEL DEPOSITS LIE DIRECTLY ON HELL CREEK BEDS AND AT A LOWER ELEVATION THAN SURROUNDING LUDLOW OUTCROPS.

QUATERNARY TERRACE DEPOSITS WERE DIVIDED INTO TERRACE GRAVELS (QTg) WHERE THE EXACT AREAL EXTENT OF ONE TERRACE LEVEL COULD BE DETERMINED, AND TERRACE DEPOSITS (Qtd) WHERE A NUMBER OF TERRACES ARE INCLUDED. THE HIGHER TERRACE ALONG THE LITTLE MISSOURI RIVER AND BOX ELDER CREEK HAS BEEN ERODED BACK TO HELL CREEK "SOMBER" BEDS.

THE GENERALIZED GEOLOGIC COLUMN TO THE LEFT IS CONSTRUCTED FROM PARTIAL SECTIONS TAKEN THROUGHOUT THE QUADRANGLE. PARTS OF THE SECTION ARE INFERRED WHERE EXPOSURES WERE OBTAINED.

FOX HILLS FORMATION (MEEK AND HAYDEN, 1861) LATE CRETACEOUS AGE

THE FOX HILLS FORMATION REPRESENTS THE ONLY MARINE DEPOSIT EXPOSED IN THE AREA. IT IS COMPOSED OF A LOWER SAND, SILTSTONE, AND SHALE TRANSITION ZONE 20-30 FEET IN THICKNESS AND LYING IMMEDIATELY ABOVE THE PIERRE SHALE FORMATION. ABOVE THIS TRANSITION ZONE IS A LIGHT BLuish GRAY, (WHEN WET) CLEAN TO SLIGHTLY ARGILLACEOUS SANDSTONE GRADING UPWARD INTO A BROWNISH, CLEAN, MEDIUM TO FINE GRAINED SANDSTONE CARRYING HALYMNITES MAJOR. LOCAL CEMENTATIONS OF THIS UPPER SANDSTONE CAUSE IT TO OCCUR AS A RIDGE ON THE APPROXIMATE AXIS OF THE FOX HILLS DOME.

HELL CREEK FORMATION (BROWN, 1907) LATE CRETACEOUS AGE

THIS FORMATION FORMS THE BEDROCK OF ALMOST THE ENTIRE AREA, AND IS EXPOSED IN ITS ENTIRETY FROM THE HELL CREEK-FOX HILLS CONTACT ON THE FOX HILLS DOME TO TRIANGULATION STATION DAHL FIVE MILES TO THE SOUTHWEST.

IT IS COMPOSED OF DARK TO LIGHT GRAY TO YELLOWISH GRAY BENTONITIC CLAYS AND SILTS, WEATHERING TO A "POPCORN" SURFACE. MANY CLAYS AND SHALES WITH VARYING AMOUNTS OF CARBONACEOUS MATERIAL ARE FOUND THROUGHOUT THE FORMATION. THESE CARBONACEOUS BEDS SHOW AS DARK-BROWN BANDS ON MOST OF THE "MUD BUTTES" IN THE AREA, AND GIVE A "SOMBER" APPEARANCE TO THE BEDS.

THE UPPER PORTION OF THE FORMATION EXHIBITS NUMEROUS LIGNITE COAL SEAMS WHICH ARE HIGHLY LENTICULAR. IT ALSO IS MUCH LIGHTER IN COLOR IN THE WESTERN PART OF THE AREA OWING TO THE LARGE AMOUNT OF ALKALI CRUSTS DUE TO WEATHERING.

THE LOWER HELL CREEK IN THIS AREA IS MUCH HIGHER IN SAND CONTENT THAN IN AREAS FARTHER EAST INTO THE WILLISTON BASIN. THIS SAND IS FINE TO MEDIUM GRAINED, SUB-ARKOSIC, CLEAN, WELL SORTED, CROSS-BEDDED, WITH LENTICULAR CALCAREOUS SANDSTONE CONCRETIONS, AND SEEMS TO HAVE BEEN DEPOSITED IN FLUVIAL CHANNELS. THE HELL CREEK IS 550'-600' THICK IN THE SOUTHWESTERN PORTION OF THE AREA, BUT MAY THIN TOWARDS THE CREST OF THE CEDAR CREEK ANTICLINAL TEND.

LUDLOW FORMATION (LLOYD AND HARES, 1915) PALEOGENE IN AGE

THE LUDLOW FORMATION IS EXPOSED ONLY ON SOME OF THE HIGHER BUTTES AND RIDGES IN THE QUADRANGLES. IT IS MUCH LIKE THE HELL CREEK IN CHARACTER, BUT IS LESS BENTONITIC, MORE SANDY THROUGHOUT, AND LIGHTER IN COLOR. IT CONSISTS OF LIGHT BUFF (PASTEL) TO GRAY SILTS, SANDS, BENTONITIC CLAYS AND SHALES, WITH SOME CARBONACEOUS CLAY AND SHALE ASSOCIATED WITH A FEW THIN LIGNITE SEAMS. CALCAREOUS "LOG-LIKE CONCRETIONS" ARE FOUND WHILE JAROSITE SANDSTONE CONCRETIONS ARE LESS COMMON. THIN LIGNITE BEDS ARE PRESENT. A TOTAL SECTION OF 110 FEET WAS MEASURED ON A BUTTE IN SECTIONS 3 AND 4, T21N., R1E.

NO DEFINITE ATTEMPT WAS MADE TO CORRELATE ANY OF THE COALS IN THIS AREA WITH COALS IN PREVIOUSLY MAPPED AREAS TO THE EAST, AS EXPOSURES WERE SPARSE. IT APPEARS, HOWEVER, THAT THE SHADEHILL COAL FACIES OF THE BASAL LUDLOW EAST OF THIS AREA IS HIGHLY TRANSITIONAL IN THE WILLETTS AND MIDLAND NO. 1 QUADRANGLES.

THE CONTACT BETWEEN THE HELL CREEK AND LUDLOW IS PLACED AT A DISTINCT COLOR CHANGE AND A CHANGE FROM SOFT LUDLOW SILTS TO TOUGH HELL CREEK "SOMBER" BEDS; IN MOST CASES THIS CONTACT OCCURS BELOW A FAIRLY PERSISTENT ZONE OF FLAGGY CALCAREOUS SANDSTONE CONCRETIONS.

TONGUE RIVER FORMATION (TAFF, 1909) PALEOGENE IN AGE

ONLY REMNANTS OF THE TONGUE RIVER FORMATION ARE FOUND IN THIS AREA. THEY CONSIST OF A LIGHT BROWN TO LIGHT GRAY, MASSIVE, CROSS-BEDDED, LOOSELY CONSOLIDATED, CHANNEL SANDSTONE, WITH A LITTLE CARBONACEOUS MATERIAL AND SOME COARSE CONGLOMERATES. EXPOSURES ON THE EAST AND WEST CUESTA FACES OF THE CAMP CROOK ANTICLINAL TREND SHOW SOME THICK BEDS OF CONGLOMERATE COMPOSED OF SANDSTONE PEBBLES, CLAY PEBBLES, AND REWORKED ROUNDED HELL CREEK MANGANESE-IRON CONCRETIONS IN A MEDIUM TO FINE GRAINED SAND MATRIX. THE CLAY AND SANDSTONE PEBBLES ARE AS MUCH AS 4 INCHES IN DIAMETER. THE CHANNELS TEND IN ONE DIRECTION WITH NO LATERAL DEVELOPMENT. A SECTION MEASURED ON THE WEST CUESTA ESCARPMENT OF THE CAMP CROOK ANTICLINE (SECTION 19, T21N., R1E.) SHOWED APPROXIMATELY 45 FEET OF TONGUE RIVER.

QUATERNARY DEPOSITS

THE QUATERNARY DEPOSITS OF THE AREA ARE REPRESENTED BY YOUNGER AND OLDER ALLUVIUM ALONG THE MAJOR RIVERS AND CREEKS, BY DUNE SAND AND TERRACE GRAVELS IN THE FOX HILLS DOME AREA, AND THE TERRACE DEPOSITS ALONG THE LITTLE MISSOURI RIVER AND SOME OF ITS LARGER TRIBUTARIES SUCH AS BOX ELDER AND SHAW CREEKS.

STRUCTURE

THESE QUADRANGLES ARE LOCATED ON THE VERY WESTERN FLANK OF THE WILLISTON BASIN, AND HAVE AN AVERAGE REGIONAL DIP OF 20 TO 30 FEET NORTHEASTWARD. THROUGHOUT THE QUADRANGLES NO COMPETENT BED WHICH MAY BE USED AS A DATUM FOR MAPPING STRUCTURE IS EXPOSED AT THE SURFACE. HOWEVER, FROM THE RELATIVE ALTITUDE OF THE CONTACTS OF CERTAIN BEDS OF THE DIFFERENT FORMATIONS EXPOSED, IT IS POSSIBLE TO DETERMINE WITH SOME DEGREE OF ACCURACY THE REGIONAL STRUCTURE OF THE AREA.

THERE ARE TWO PRONOUNCED ANTICLINES AND ONE SYNCLINE IN THE AREA, ALONG WITH SOME MINOR STRUCTURES THAT MAY PROVE TO BE IMPORTANT ECONOMICALLY. THE NORTHEASTERN-MOST ANTICLINE IS DESIGNATED THE FOX HILLS DOME (SEE INDEX MAP) AND IS THE SOUTHERN EXTENSION OF THE BAKER-GLENNDIVE OR CEDAR CREEK ANTICLINE EXTENDING NORTHWESTERLY INTO NORTH DAKOTA AND TERMINATING NEAR GLENDDIVE, MONTANA. THE SOUTHWESTERLY ANTICLINE IS CALLED THE CAMP CROOK ANTICLINE. THE AREA BETWEEN IS A BROAD LOW SYNCLINE THAT CONTAINS A STRUCTURAL HIGH IN THE SOUTHERN AND NORTHWESTERN PORTION OF THIS AREA.

ALL THE COALS IN THIS AREA ARE WITHIN THE LIMITS OF THIS SYNCLINE. FROM THE OUTCROP PATTERN OF THESE COALS, STREAM PATTERNS, AND LOCAL RIDGES, IT APPEARS THAT THE AXIAL TRENDS OF THESE FOLDS ARE MORE NORTHWESTERLY THAN PREVIOUSLY HAD BEEN SUPPOSED (Moulton and Bass, 1922). SINCE THE HELL CREEK EXHIBITS MORE COALS IN ITS UPPER PORTION IN THIS AREA THAN IN AREAS TO THE EAST, IT IS HIGHLY PROBABLE THAT THIS SYNCLINE WAS PRESENT OR BEING DOWN-WARPED DURING DEPOSITION OF HELL CREEK SEDIMENTS.

NEAR THE CENTER OF THE SYNCLINE THE BEDS APPEAR TO RISE, EITHER OWING TO FAULTING OR BECAUSE OF AN ANTICLINAL TREND EXTENDING NORTHWESTERLY FROM THE GALLUP CREEK DOME. EVIDENCE OF THE NORTHERN EXTENSION OF THE GALLUP CREEK DOME IS FOUND IN SECTIONS 13, 14, 15, 22, 23, 24, 25, 26, AND 27, T21N., R2E., WHERE THE DIPS ARE STEEPER THAN THE REGIONAL DIPS AND THE PLUNGE IS NORTHWESTWARD. NO EVIDENCE OF REVERSAL IS FOUND, HOWEVER, EXCEPT FOR SOME STEEP DIPS OCCURRING WEST OF SECTION 15, T21N., R2E., WHERE A RATHER MINOR FAULT IS VISIBLE. WEST OF THIS FAULT AND EXTENDING SOUTHEASTWARD AND NORTHWESTWARD TOWARD TRIANGULATION STATION DAHL, DIPS FROM 3 TO 6 DEGREES CAN BE MEASURED IN A STRIP ABOUT 1 1/2 TO 2 MILES WIDE. WEST OF THIS STRIP THE DIP OF THE BEDS IS THE REGIONAL DIP.

THE CONTACT OF THE HELL CREEK AND LUDLOW ON LOLA BUTTE EAST OF THE FAULT ZONE IS MUCH HIGHER THAN WEST OF THE LITTLE MISSOURI RIVER WHERE THE DIP IS AGAIN REGIONAL.

A TEST BORING 90 FEET DEEP, ON AN ALLUVIAL FLAT WEST OF THE FAULT (SEC. 15, T21N., R2E.) ENCOUNTERED A BLUISH GRAY SAND AND INTERBEDDED BLUISH TO DARK GRAY SHALE, WHICH IS THOUGHT TO BE FOX HILLS (LOWER). THE SAME SEQUENCE WAS ENCOUNTERED IN 4 TEST HOLES ON THE FOX HILLS DOME, WHERE FOX HILLS STRATA CROP OUT.

ANOTHER STRUCTURAL HIGH APPEARS TO BE PRESENT IN THE VICINITY OF TRIANGULATION STATION DAHL, BUT, ALTHOUGH STEEP SOUTHWESTERLY DIPS ARE PRESENT, GRADED SLOPES DO NOT PERMIT ACCURATE MAPPING.

THE WRITER BELIEVES THAT MOST OF THE FOLDING IN THE AREA OF THE CAMP CROOK AND CEDAR BUTTE ANTICLINES (FOX HILLS DOME), AND OTHER MINOR STRUCTURES TOOK PLACE DURING POST-PALEOGENE TIME. ALTHOUGH SOME MOVEMENT PROBABLY OCCURRED AT THE END OF THE CRETACEOUS PERIOD, ITS EFFECTS APPEAR TO HAVE BEEN OBTUSCURED BY THE LATER FOLDING.

ECONOMIC GEOLOGY

AT PRESENT NONE OF THE MINERAL RESOURCES ARE BEING EXPLOITED, ALTHOUGH A SIZEABLE AMOUNT OF POTENTIALLY COMMERCIAL COAL AND GRAVEL IS PRESENT. A SMALL AREA OF URANIFEROUS SANDSTONE-IN SECTION 5, T21N., R1E.

COAL

THE COAL IN THIS AREA BELONGS ALMOST ENTIRELY TO THE HELL CREEK FORMATION. ONLY A FEW ACRES ARE UNDERLAIN BY LUDLOW COAL. FOR THE MOST PART NEARLY ALL OF THE COAL OF THE AREA RANGES FROM A DIRTY ARGILLACEOUS LIGNITE TO A HARD WOODY LIGNITE. IT IS USUALLY BLOCKY, EASILY SLACKED AND BLACK TO BROWNISH BLACK IN COLOR. ASSOCIATED WITH THE LIGNITE ARE JAROSITE, SELENITE AND VARYING THICKNESSES OF CARBONACEOUS CLAYS.

NO ATTEMPT WAS MADE TO ESTIMATE THE RESERVES OF THE AREA BECAUSE THE LIGNITE SEAMS ARE HIGHLY LENTICULAR.

UNDERGROUND MINING METHODS WOULD HAVE TO BE EMPLOYED IN EXTRACTING MOST OF THE LIGNITE, BUT IN SOME CASES SMALL AREAS COULD FEASIBLY BE STRIP MINED.

THE TABLE BELOW SHOWS A PROXIMATE ANALYSIS (ANALYSIS BY SOUTH DAKOTA STATE CHEMICAL LABORATORY) OF ONE LUDLOW AND THREE HELL CREEK COALS.

TABLE I

COAL	LOCATION	MOISTURE	VOLATILE	CARBON	ASH	SULFUR	B.T.U.
LUDLOW ¹	Sec 2, T21N R2E	33.80%	41.86%	11.47%	12.87%	1.57%	7571
HELL CREEK ²	Sec 10, T22N R1E	31.83%	39.34%	7.33%	21.50%	1.01%	6165
HELL CREEK ³	Sec 4, T21N R1E	40.82%	41.09%	11.26%	6.83%	0.64%	9060
HELL CREEK ⁴	Sec 14, T21N R2E	25.23%	42.25%	25.73%	6.79%	0.63%	10267

URANIUM

ONLY ONE AREA (SEC. 5, T21N., R1E.) SHOWED ANY COMMERCIAL QUANTITIES OF URANIUM. THIS IS ASSOCIATED WITH CARBONACEOUS MATERIAL IN A FINE TO MEDIUM GRAINED, CROSS-BEDDED CHANNEL SANDSTONE OF TONGUE RIVER LITHOLOGY.

OIL AND GAS

A THICK SECTION OF SEDIMENTARY ROCKS MAY INDICATE THAT COMMERCIAL QUANTITIES OF OIL AND GAS MAY EXIST IN THE AREA, BUT ONLY MORE EXPLORATORY DRILLING WILL GIVE THE ANSWER. UNDOUBTEDLY SUBSURFACE FAULTING WILL PLAY AN IMPORTANT PART IN THE LOCATION OF OIL POOLS.

CLAYS-BAKED CLAY

NUMEROUS CLAYS OF THE HELL CREEK FORMATION MAY HAVE "BLOATING" PROPERTIES WHICH WOULD CLASSIFY THEM FOR USE AS LIGHT AGGREGATE MATERIAL. THE VAST QUANTITY OF BAKED CLAY ("SCORIA") RESULTING FROM THE BURNING OF THE THICKER LIGNITE SEAMS CAN BE USED FOR ROAD METAL WHERE TRAFFIC IS NOT HEAVY.

GRAVELS

THERE IS A LARGE QUANTITY OF GRAVEL OCCUPYING PRESENT FLOODPLAINS, AND HIGHER TERRACES. NO ATTEMPT WAS MADE TO OUTLINE THESE GRAVELS EXCEPT IN THE FOX HILLS DOME AREA WHERE THEY OCCUPY ONLY ONE TERRACE LEVEL. TO OUTLINE THEM IN DETAIL WOULD REQUIRE MANY TEST HOLES IN ORDER TO OBTAIN ACCURATE THICKNESS OF THE DEPOSITS.

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