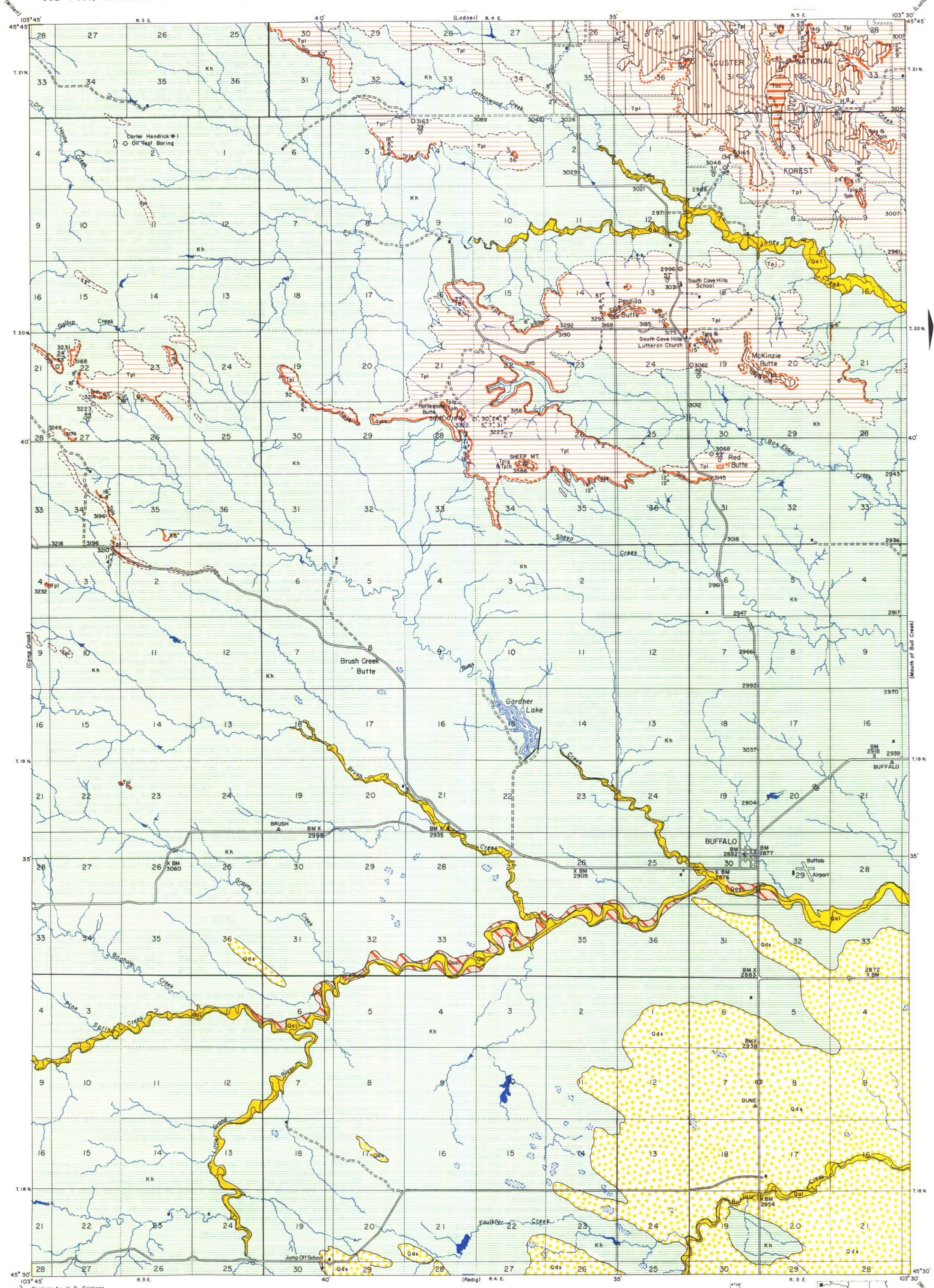


AREAL GEOLOGY OF THE BUFFALO QUADRANGLE

STATE OF SOUTH DAKOTA
JOE FOSS, GOVERNOR

STATE GEOLOGICAL SURVEY
E. P. ROTHROCK, STATE GEOLOGIST



EXPLANATION

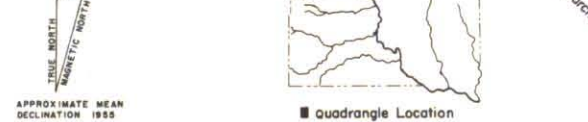
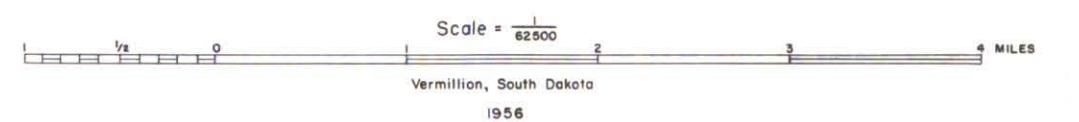
SEDIMENTARY ROCKS

- Qal**
Alluvium
(Silt, sand, clay, and gravel floodplain deposits occupying silt bottoms along present stream courses.)
- Qds**
Dune Sand
(Sand, quartz, clear, with some darker mineral grains, forms grassed dunes with local "blowouts" 10'-40' wide.)
- Qol**
Older Alluvium
(Silt, sand, clay, and gravel occupying flats and terraces above present stream courses.)
- Tol**
Chadron Formation
(Clay, gray to grayish white highly bentonitic with some fine calcite beds in the upper portion with micules filled with bentonitic clay 0-35' in thickness.)
- Tpl**
Tongue River Formation
(Sandstone, light yellowish brown to brown, occasional purple and greenish hues are common. Massive, cross-bedded, locally consolidated to indurated, carbonaceous fragments, petrifed wood, occasional silty sands and quartzitic sands. 0-150' in thickness.)
- Tplg**
Ludlow Formation
(Clay and shales, all silty clay and sand, buff to soft pasty yellowish gray, bentonitic in part. Contains chert and banded clay, fossil plants, brownish-black iron concretions, soft sandy concretions, lignite carbonaceous sandstone ledges, and lignite. Tplg, Tpl, and Tplg-Gannaworth (Blair?) Helen (Morrow Clark), and Shale all coal bedrock respectively with associated carbonaceous clays and shales. Coal thickness vary from less than 1' to more than 10'. Approximate thickness 250'.)
- Kh**
Hell Creek Formation
Undifferentiated
(Clay and silt, dark to light gray to yellowish gray, "somer" colored, highly bentonitic, with numerous bright yellow locally consolidated orbic sands. Contains varying amounts of carbonaceous clay with local lenses of poor grade lignite. Carries black manganese-iron saprotion concretions, poorly developed cone-in-cone concretions, fossil wood, carbonaceous to sandstone concretions in yellow sand, and dinosaur bones and bone fragments. Approximately 300' exposed.)

DRAINAGE

- Intermittent Streams
- Intermittent Lakes
- CULTURE**
- 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.)
- Operating
 Abandoned
- Coal mines and Gravel pits**
- Coal Thickness
(Exposed)
- Drill Holes
- Dams
(Large, small earthen or cement.)

Geology by H. D. Erickson
Assisted by M. J. Tipton, J. T. Kalkman, W. J. Matousek
Surveyed in 1955. Drafted by H. D. Erickson
Coal-Test Holes Drilled in 1955



Base Map by South Dakota State Geological Survey

Vermillion, South Dakota
1956

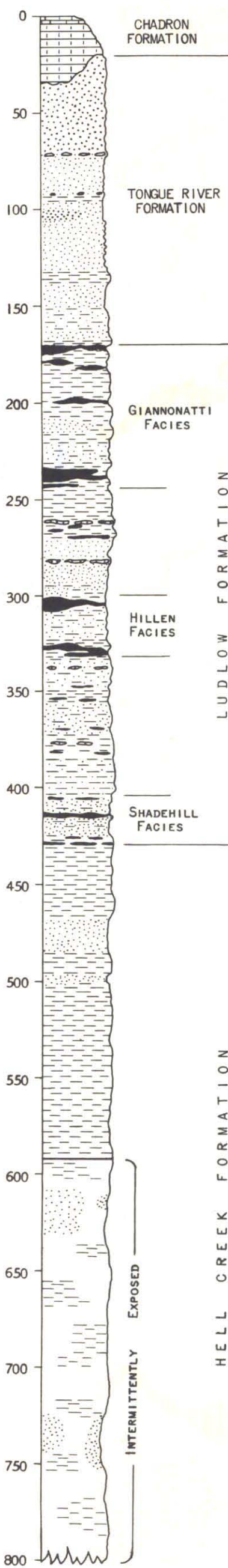
APPROXIMATE MEAN DECLINATION 1955

quadrangle location

AREAL GEOLOGY OF THE BUFFALO QUADRANGLE

By
Harold D. Erickson

GENERALIZED COLUMNAR SECTION



EXPLANATION



INTRODUCTION

THIS QUADRANGLE WAS MAPPED DURING JULY AND AUGUST, 1955, AS PART OF THE STATE GEOLOGICAL SURVEY'S COAL RESOURCES PROGRAM. A VERY LIMITED AMOUNT OF EXPLORATORY DRILLING FOR STRATIGRAPHIC INFORMATION WAS ALSO CARRIED ON DURING THESE MONTHS.

THE AREA WAS MAPPED WITH AREAL PHOTOGRAPHS (1938 FLIGHTS). HORIZONTAL CONTROL WAS BASED ON TRIANGULATION FROM KNOWN COAST AND GEODETIC SURVEY STATIONS.

THANKS IS GIVEN TO M. J. TIPTON, ASSISTANT, AND J. T. KALKMAN AND W. J. MATOUSEK, DRILLERS.

LOCATION

THE QUADRANGLE LIES APPROXIMATELY IN THE CENTRAL PART OF HARDING COUNTY, IN NORTHWESTERN SOUTH DAKOTA. IT COMPRISES AN AREA OF APPROXIMATELY 210 SQUARE MILES. THE QUADRANGLE IS NAMED FOR THE TOWN OF BUFFALO, THE COUNTY SEAT, WHICH HAS A POPULATION OF 350 (1950). BUFFALO IS IN THE SOUTHEASTERN PART OF THE MAPPED AREA, AND IS 105 AIR MILES NORTH-NORTHWEST OF RAPID CITY AND 178 AIR MILES NORTHWEST OF PIERRE. NO RAILROADS SERVE THE AREA, BUT ARTERIAL HIGHWAYS AND COUNTY ROADS ARE GOOD.

GEOGRAPHY

THE TOPOGRAPHY OF THE AREA IS GENTLE ROLLING PRAIRIE LAND INTERRUPTED BY "BAD LANDS" ALONG THE MAJOR STREAM TRIBUTARIES. THE SOUTH CAVE HILLS, WHERE CUSTER NATIONAL FOREST IS LOCATED, IS REPRESENTED BY HIGH MESAS AND OUTLYING BUTTES, IN THE NORTHEAST PART OF THE QUADRANGLE. THE SOUTHEASTERN PART OF THE QUADRANGLE IS COVERED ALMOST ENTIRELY BY DUNE SAND WITH NUMEROUS AREAS WHERE HELL CREEK "SOMBER" BEDS ARE EXPOSED. THESE DUNES ARE MOSTLY COVERED WITH A MODERATE AMOUNT OF VEGETATION, BUT SOME SHIFTING OF THE SAND Owing TO THE PREVAILING WINDS THAT BLOW ACROSS THIS STEPPE-LIKE COUNTRY IS COMMON. THE SOUTHWESTERN PART OF THE QUADRANGLE IS PREDOMINANTLY "BAD LANDS" LOCALLY KNOWN AS THE "JUMP OFF." THE RUGGEDNESS OF THIS AREA IS DUE TO THE DEEP DISSECTION OF THE HELL CREEK SEDIMENTS BY THE HEADWATERS OF THE SOUTH FORK OF THE GRAND RIVER. THROUGHOUT THIS "BAD LANDS" AREA ROCK EXPOSURES ARE PRESENT, BUT ON THE FLAT, GENTLY ROLLING PRAIRIE THEY ARE FEW AND WIDELY SCATTERED. THE NORTHWESTERN CORNER OF THE QUADRANGLE EXHIBITS ROLLING PRAIRIE LAND AND LOCAL "BAD LANDS" ALONG THE INTERSTREAM DIVIDE BETWEEN THE SOUTH FORK OF THE GRAND RIVER AND ITS TRIBUTARIES, AND THE TRIBUTARIES OF THE LITTLE MISSOURI RIVER.

THE RELIEF IS GENERALLY MODERATE EXCEPT IN THE SOUTH CAVE HILLS WHERE THE BUTTES RISE 350 FEET ABOVE THE SURROUNDING COUNTRYSIDE. THE GENERAL ALTITUDE OF THE QUADRANGLE, HOWEVER, INCREASES WESTWARD TOWARD THE INTER-STREAM DIVIDE MENTIONED ABOVE. THE MAXIMUM ELEVATION FOUND IN THE QUADRANGLE IS 3586 FEET ABOVE SEA LEVEL ON SHEEP MOUNTAIN, A LARGE ISOLATED BUTTE IN SECTION 27, T. 20 N., R. 4 E., WHEREAS THE MINIMUM ELEVATION, APPROXIMATELY 2860 FEET, IS FOUND IN THE VALLEY OF THE SOUTH FORK OF THE GRAND RIVER AT THE EASTERN EDGE OF THE QUADRANGLE. THE TOTAL MAXIMUM RELIEF IN THE AREA THUS APPROACHES 730 FEET.

THE CLIMATE IS SEMI-ARID WITH AN ANNUAL PRECIPITATION OF FROM 8-11 INCHES. RANCHING, BOTH CATTLE AND SHEEP, IS THE PREDOMINANT OCCUPATION. SOME DRY LAND FARMING IS CARRIED ON, WITH WHEAT BEING THE MOST IMPORTANT SMALL GRAIN CROP, WHEREAS CORN IS THE MOST IMPORTANT ROW CROP.

THE SURFACE WATER SUPPLIES IN THIS AREA ARE MEAGER. NEARLY ALL THE STREAMS AND CREEKS EXCEPT THE SOUTH FORK OF THE GRAND RIVER ARE INTERMITTENT, AND DURING PARTS OF THE YEAR IT TOO IS DRY. A NUMBER OF SPRINGS, FOUND IN THE SOUTH CAVE HILLS, SERVE AS WATER SUPPLIES FOR STOCK GRAZING. OTHER THAN THIS, STOCK DAMS AND SHALLOW WELLS ARE THE MAIN SOURCE. SHALLOW WELLS USUALLY PROVIDE ENOUGH WATER FOR DOMESTIC AND A SMALL NUMBER OF LIVESTOCK NEEDS, BUT IN TIMES OF DROUGHT THEY ARE INADEQUATE. ONE ARTIFICIAL LAKE, GARDNER LAKE, IS FOUND IN THE AREA IN SECTIONS 10 AND 15, T. 19 N., R. 4 E.

THE VEGETATION IS PREDOMINANTLY PRAIRIE GRASSES. A FEW DECIDUOUS TREES ARE FOUND ALONG THE MAJOR CREEKS, WHEREAS PINE TREES ARE VERY COMMON IN THE SOUTH CAVE HILLS AREA. CACTUS ABOUNDS WHERE THE SOIL HAS A SANDY CALCAREOUS NATURE, WHEREAS SAGE BRUSH IS USUALLY FOUND WHERE THE SOIL COVER IS THIN AS IT IS ON THE HELL CREEK FORMATION. BUFFALO BERRY BUSHES ARE USUALLY CONFINED TO THE GRASSY FLATS ALONG STREAMS.

STRATIGRAPHY

THE SURFACE FORMATIONS IN THIS QUADRANGLE ARE REPRESENTED BY CLASTIC SEDIMENTS RANGING IN AGE FROM LATE CRETACEOUS THROUGH OLIGOCENE, AND QUATERNARY. THE BEDROCK (LATE CRETACEOUS TO OLIGOCENE) OF THE AREA INCLUDES THE HELL CREEK, LUDLOW, TONGUE RIVER, AND CHADRON FORMATIONS, WHEREAS THE QUATERNARY UNCONSOLIDATED SEDIMENTS ARE REPRESENTED BY OLDER AND YOUNGER ALLUVIAL DEPOSITS, DUNE SAND, AND AN OCCASIONAL THIN, CLAYEY, IMPURE TERRACE GRAVEL.

THE CONTACTS BETWEEN THE HELL CREEK AND LUDLOW, AND THE LUDLOW AND TONGUE RIVER ARE CONFORMABLE. THE CONTACT BETWEEN THE TONGUE RIVER AND CHADRON FORMATIONS, HOWEVER, IS AN EROSIONAL UNCONFORMITY.

THE GENERALIZED GEOLOGIC COLUMN TO THE RIGHT IS CONSTRUCTED FROM PARTIAL SECTIONS IN THE SOUTH CAVE HILLS AND A DETAILED SECTION TAKEN ON A BUTTE IN THE NE $\frac{1}{4}$ SEC. 28, T. 20 N., R. 4 E. THE UPPER 40 FEET OF THE TONGUE RIVER SHOWN ON THE COLUMN AS WELL AS THE LOWER 130 FEET OF THE HELL CREEK IS INFERRED.

HELL CREEK FORMATION, (BROWN, 1907) LATE CRETACEOUS AGE

THIS FORMATION FORMS THE BEDROCK OF MUCH OF THE QUADRANGLE. ONLY 170 FEET OF THE UPPER PART OF THE FORMATION WAS MEASURED IN SEC. 28, T. 20 N., R. 4 E., BUT PARTIAL SECTIONS TAKEN THROUGHOUT THE AREA INDICATE IT TO BE WELL OVER 300 FEET IN THICKNESS.

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

FROM SECTIONS TAKEN WEST AND NORTHWEST OF THE BUFFALO QUADRANGLE, IT APPEARS THAT THE HELL CREEK FORMATION EXHIBITS THREE DISTINCT ZONES OR FACIES WHICH ARE PREDOMINANTLY SANDSTONE, WHICH OCCUR STRATIGRAPHICALLY AT THE BASE, APPROXIMATELY THE MIDDLE, AND THE TOP OF THE FORMATION. THE SANDSTONE IS USUALLY LOOSELY CONSOLIDATED, ARKOSIC, CROSSBEDDED, WITH LIMY CONCRETIONS. ORIGIN OF THIS SANDSTONE SEEMS TO BE DEPOSITION IN FLUVIAL CHANNELS; AS A RESULT THESE SANDSTONES EXHIBIT NO CONTINUITY IN EXTENT OR THICKNESS. IN THIS QUADRANGLE THE MIDDLE AND UPPER FACIES ARE DEFINITELY EXPOSED, AND THE LOWER FACIES AT THE BASE MAY BE EXPOSED ALONG THE LITTLE GRAND RIVER IN THE SOUTHEASTERN PART OF THE QUADRANGLE.

FOSSIL EVIDENCE IS NOT ABUNDANT IN THE HELL CREEK BUT DINOSAUR BONES ARE FOUND IN THE LOWER AND MIDDLE PARTS. MANGANESE-IRON SEPTARIAN CONCRETIONS ARE COMMON. CONE-IN-CONE INTERNAL SEDIMENTARY STRUCTURES ARE PRESENT, BUT LESS COMMON. FOSSIL LEAVES ARE FOUND ASSOCIATED WITH THE CARBONACEOUS BEDS AND SOME OF THE SANDSTONES. NO COALS OF COMMERCIAL THICKNESS ARE FOUND IN THE AREA, BUT LOCAL STRAY COALS 1 TO 2 FEET THICK ARE FOUND.

LUDLOW FORMATION, (LLOYD AND HARES, 1915) PALEOCENE

NEARLY ALL THE LUDLOW FORMATION HAS BEEN ERODED FROM THIS AREA EXCEPT WHERE IT HAS BEEN PROTECTED BY THE RESISTANT SANDSTONES OF THE OVERLYING TONGUE RIVER FORMATION. OUTCROPS ARE RESTRICTED TO THE WESTERN EDGE AND NORTHERN ONE THIRD OF THE QUADRANGLE.

THIS FORMATION IS MUCH LIKE THE HELL CREEK IN CHARACTER AND COMPOSITION, BUT IS LESS BENTONITIC AND LIGHTER IN COLOR. IT CONSISTS OF LIGHT BUFF (PASTEL) TO GRAY SILTS, BENTONITIC CLAYS AND SHALES, AND SANDS, WITH NUMEROUS THICK COALS AND CARBONACEOUS CLAY AND SHALE ZONES. THROUGHOUT THE OUTCROPPING REGION TWO CONCRETIONARY ZONES ARE PREVALENT, APPROXIMATELY 100 FEET BELOW THE TOP OF THE LUDLOW. THEY ARE REPRESENTED BY CALCAREOUS "LOG-LIKE" STRUCTURES. AT SOME LOCALITIES AND THROUGHOUT THE ENTIRE SECTION OF THE LUDLOW, SMALL TO MEDIUM PINKISH CALCAREOUS NODULES ARE FOUND. THEY ARE MOSTLY SOFT AND ARE EASILY CRUMBLING. A CERTAIN AMOUNT OF MANGANESE-IRON CONCRETIONS ARE FOUND IN THE SECTION, BUT THEY ARE NOT AS DARK BLACK OR DO THEY EXHIBIT THE SEPTARIAN STRUCTURE FOUND IN THE HELL CREEK FORMATION BELOW. THE TOTAL SECTION OF LUDLOW MEASURES 265 FEET IN THIS QUADRANGLE.

IN THIS AREA THE LUDLOW FORMATION CONTAINS NUMEROUS COAL BEDS WHICH SEEM TO FIT NAMES APPLIED IN QUADRANGLES TO THE EAST. HOWEVER, IN THE BUFFALO QUADRANGLE MANY COAL BEDS ARE BETWEEN THE AFORE MENTIONED ONES. THUS, THE LATTER ARE INCLUDED IN THE REGULAR FACIES INTERVALS, THEREBY GIVING THE FACIES A GREATER THICKNESS THAN NORMAL, FARTHER EAST. ACTUALLY IT APPEARS FROM STRATIGRAPHIC SECTIONS OF THE LUDLOW IN THIS AREA THAT THERE ARE NO DISTINCT SEPARATE COAL FACIES; RATHER, ALL OF THE LUDLOW COULD BE CLASSIFIED AS A COAL FACIES, AS IT WAS ORIGINALLY NAMED (LUDLOW LIGNITIC MEMBER OF THE LANCE) BY LLOYD AND HARES (1915), AS THE TYPE SECTION OF THE LUDLOW, IN SECS. 32 AND 36, T. 22 N., R. 5 E., DOES NOT EXHIBIT DEFINITE COAL FACIES. THE FACT THAT THE COAL BEDS ARE DISCONTINUOUS OVER THE ENTIRE AREA ALSO MAKES IT DIFFICULT TO ESTABLISH REGULAR FACIES INTERVALS.

PERHAPS THE MOST CONTINUOUS FACIES OF THE LUDLOW FORMATION IS THE SHADEHILL OR BASAL FACIES. THIS FACIES VARIES IN THICKNESS AND IS TRANSITIONAL BETWEEN THE HELL CREEK AND LUDLOW FORMATIONS. THE SHADEHILL FACIES IN THIS AREA IS APPROXIMATELY 25-30 (?) FEET THICK AND IS ALMOST ENTIRELY

BARREN OF ANY THICK LIGNITE BEDS. COAL BEDS MEASURED IN THIS FACIES RANGE FROM 0 TO 23 INCHES IN THICKNESS AND ARE REPRESENTED BY BLACK TO BROWN FISSILE LIGNITE. NUMEROUS ZONES OF CARBONACEOUS SHALE ARE COMMON. JAROSITE AND/OR MELANITERITE AS WELL AS GYPSUM LAYERS ARE COMMON IN THE COALS. THE CONTACT BETWEEN THE LUDLOW AND HELL CREEK WAS PLACED AT THE LOWERMOST COAL OF THIS FACIES.

THE HILLEN FACIES IS LOCALLY CALLED THE WIDOW CLARK, WHICH IS ACTUALLY THE THICKEST COAL IN THE HILLEN FACIES. THIS FACIES LIES APPROXIMATELY 70 TO 75 FEET ABOVE THE SHADEHILL FACIES, AND IS APPROXIMATELY 30 FEET THICK. SOME THIN COALS ARE FOUND BETWEEN THESE TWO FACIES AS WELL AS BETWEEN THE HILLEN AND GIANNONATTI FACIES. THE COALS OF HILLEN FACIES ARE USUALLY BLACK, BLOCKY AND FISSILE, READILY SLACKED, AND ATTAIN MORE THAN 11 FEET IN THICKNESS IN THE NW-SE SEC. 6, T. 20 N., R. 5 E., AT THE ABANDONED HILTON MINE. THE GIANNONATTI FACIES IS THE UPPERMOST FACIES OF THE LUDLOW, AND MAY CORRELATE WITH THE BISON COAL FACIES 50 MILES TO THE EAST. THE CONTACT BETWEEN THE LUDLOW AND THE TONGUE RIVER SANDSTONE WAS PLACED AT THE UPPERMOST COAL HORIZON IN THIS FACIES. THE COAL BEDS OF THE GIANNONATTI FACIES ARE LITHOLOGICALLY THE SAME AS THOSE OF THE HILLEN, AND ATTAIN A THICKNESS OF FROM 0 TO 5 FEET. THE ENTIRE THICKNESS OF THE FACIES APPROACHES 75 FEET AND ITS BASE LIES APPROXIMATELY 60 FEET ABOVE THE HILLEN FACIES.

OCCASIONALLY ASSOCIATED WITH THE THICKER COALS OF THESE FACIES IS CLINKER, BAKED CLAY, AND ASH RESULTING FROM THE BURNING OF THE LIGNITE BEDS.

TONGUE RIVER FORMATION, (TAFF, 1909) PALEOCENE AGE

THE SANDSTONE OF THIS FORMATION FORMS THE RESISTANT RIMROCK OF THE SOUTH CAVE HILLS AND MOST OF THE ADJOINING BUTTES TO THE SOUTH AND WEST. LITHOLOGICALLY IT CONSISTS OF A MASSIVE CLIFF-FORMING LIGHT-TAN TO BROWN (GREEN TO PURPLE HUES ARE ALSO COMMON) UNCONSOLIDATED TO INDURATED FINE- TO MEDIUM-GRAINED, CROSSBEDDED ARKOSIC SANDSTONE. OCCASIONALLY INTERBEDDED WITH THESE SANDS ARE LIGHT-GRAY CLAYS AND SILTY CLAYS WITH SOME BLACK CARBONACEOUS ZONES WHICH LOCALLY DEVELOP INTO LOCAL COAL BEDS. "BED E" OF DENSON, BACHMAN, AND ZELLER (1954), A COAL BED ABOUT 45 TO 55 FEET ABOVE THE BASE OF THE TONGUE RIVER FORMATION, IS LOCALLY PRESENT, AND IN MOST CASES RADIOACTIVE.

THE THICKNESS MEASURED ON A BUTTE IN NW-NE SEC. 28, T. 20 N., R. 4 E., IS 101 FEET, BUT A COMPLETE SECTION WOULD MEASURE APPROXIMATELY 150 FEET.

CHADRON FORMATION, (DARTON, 1909) OLIGOCENE AGE

EXPOSURES OF THE CHADRON FORMATION ARE RESTRICTED TO A SMALL AREA IN SEC. 5, T. 20 N., R. 5 E., AND IN SECTIONS 31 AND 32, T. 21 N., R. 5 E., IN THE SOUTH CAVE HILLS, WHERE IT LIES UNCONFORMABLY UPON THE TONGUE RIVER SANDSTONE AND IS APPROXIMATELY 35 FEET IN THICKNESS.

THE CHADRON CONSISTS ESSENTIALLY OF LIGHT GRAY BENTONITIC CLAY THAT WEATHERS WHITE, WITH A FEW SILTY CLAYS. THE UPPER 3 TO 4 FEET EXPOSED IN THIS AREA IS A CALICHE BED OR FRESH WATER LIMESTONE. THE LIMESTONE OR CALICHE CONTAINS SMALL VESICLES OF BENTONITIC CLAY WHICH WEATHER, LEAVING THE LIMESTONE WITH A RAGGED VESICULAR SURFACE.

FEW FOSSILS WERE FOUND. ONE WAS IDENTIFIED BY J. R. MACDONALD OF THE SOUTH DAKOTA SCHOOL OF MINES AS *HYRACODON*, A RHINOCEROS.

QUATERNARY DEPOSITS

THE QUATERNARY DEPOSITS IN THIS AREA ARE REPRESENTED BY OLDER AND YOUNGER ALLUVIUM ALONG THE MAJOR RIVERS AND CREEKS, AND BY DUNE SAND IN THE SOUTHEASTERN PART OF THE QUADRANGLE. THE ALLUVIUM IS COMPOSED OF CLAY, SILT, SAND, AND GRAVEL WHICH OCCUPY THE PRESENT FLOODPLAIN AND THE TERRACES ABOVE. THE DUNE SAND IS COMPOSED OF QUARTZ GRAINS, WITH SOME DARKER GRAINS DERIVED FROM THE FERROMAGNETIC MINERAL SUITE, AS WELL AS SMALL DARK CONCRETION FRAGMENTS. IT IS THE AUTHOR'S BELIEF THAT THE SAND DUNES COVERING THE SOUTH EASTERN PART OF THE QUADRANGLE WERE PARTIALLY DERIVED FROM THE MIDDLE SANDSTONE FACIES OF THE HELL CREEK FORMATION.

STRUCTURE

THE QUADRANGLE IS ON THE WESTERN FLANK OF THE WILLISTON BASIN, AND HAS A GENTLE REGIONAL DIP OF 15 TO 25 FEET PER MILE TO THE NORTHEAST. THE FLANK OF THE BASIN IS NOT UNIFORM, BUT IS BROKEN BY GENTLE TO SHARP ANTI-CLINES AND SYNCLINES. THROUGHOUT THE QUADRANGLE NO COMPETENT BED IS EXPOSED AT THE SURFACE WHICH MAY BE USED AS A DATUM FOR MAPPING STRUCTURE. HOWEVER, BY THE RELATIVE ALTITUDE OF THE BEDS, IN THIS QUADRANGLE AS COMPARED WITH SURROUNDING AREAS, IT IS POSSIBLE TO DETERMINE REGIONAL STRUCTURE. THE MOST PROMINENT STRUCTURAL FEATURE IN THIS QUADRANGLE IS A BROAD SYNCLINE, WHICH ENTERS THE WESTERN EDGE OF THE QUADRANGLE FROM A NORTHWESTERLY DIRECTION AND PLUNGES TO THE NORTHWEST. SOUTHWESTWARD FROM THE CENTER OF T. 20 N., R. 3 E., THE BEDS RISE SLIGHTLY MORE THAN THE REGIONAL DIP, WHEREAS NORTHEASTERLY THE BEDS RISE ON THE FOX HILLS DOME OF THE BAKER-GLENDELY ANTI-CLINEAL TRENDS, GIVING A REVERSAL OF DIP. A REFLECTION OF SURFACE STRUCTURE IN THE SUBSURFACE IS POSSIBLE. BECAUSE COMPETENCE OF THE UPPER CRETACEOUS AND LOWER PALEOCENE FORMATIONS ARE VERY POOR, SLUMPING HAS BEEN COMMON; AS A RESULT MANY OF THE LOCAL STRIKES AND DIPS THAT MIGHT BE READ AT THE SURFACE DO NOT REPRESENT A TRUE STRUCTURAL PICTURE.

ECONOMIC GEOLOGY

COAL

AT THE PRESENT TIME NO MINERAL RESOURCES ARE BEING EXPLOITED, ALTHOUGH POTENTIALLY COMMERCIAL QUANTITIES OF COAL AND URANIUM ARE PRESENT. TERRACE GRAVEL DEPOSITS OF POOR QUALITY OCCUR, BUT ARE NOT CONSIDERED COMMERCIAL.

THE AREA EXTENT, THICKNESS, AND PHYSICAL CHARACTER OF THE COAL HAS BEEN DISCUSSED UNDER STRATIGRAPHY AND THIS DISCUSSION WILL NOT BE REPEATED HERE. IN COMPUTING COAL TONNAGES A SPECIFIC GRAVITY OF 1.25 WAS USED.

TABLE 1 SHOWS THE PROXIMATE ANALYSIS OF THESE COALS (ANALYSIS BY THE SOUTH DAKOTA STATE CHEMICAL LABORATORY). ACCORDING TO A.S.T.M. STANDARDS, THESE COALS RANK ABOUT A MEDIUM GRADE LIGNITE.

THE TOTAL AVAILABLE LIGNITE RESERVE OF THIS QUADRANGLE, AS COMPUTED FROM OUTCROPS, MINES, AND DRILL HOLES IS CONSERVATIVELY ESTIMATED AT 9,162,000 TONS.

UNDERGROUND MINING METHODS WOULD HAVE TO BE EMPLOYED, FOR THE OVERBURDEN IS TOO GREAT FOR STRIPPING, EXCEPT IN SOME OF THE AREA OUTSIDE OF THE SOUTH CAVE HILLS.

IN THE TABLE BELOW, SAMPLES 1 AND 2 (UPPER AND LOWER GIANNONATTI RESPECTIVELY) ARE FROM THE NW $\frac{1}{4}$ NE $\frac{1}{4}$ SEC. 28, T. 20 N., R. 4 E.; SAMPLE 3 (BASAL HILLEN) IS FROM THE SW $\frac{1}{4}$ SE $\frac{1}{4}$ SEC. 22, T. 20 N., R. 3 E.

TABLE 1

SAMPLE	MOISTURE	VOLATILE MATTER	FIXED CARBON	ASH	SULPHUR	B. T. U.
1.	26.60%	34.34%	25.55%	13.51%	0.37%	5,984
2.	34.11%	31.63%	15.92%	18.34%	0.38%	4,537
3.	41.38%	33.60%	8.15%	16.87%	2.02%	3,778

URANIUM

URANIUM HAS BEEN RECENTLY DISCOVERED IN MANY OF THE UPPER COALS AND ASSOCIATED CARBONACEOUS CLAYS AND SHALES OF THE LUDLOW FORMATION AS WELL AS IN THE CLINKER AND BAKED CLAY (THE RESULT OF BURNING LIGNITE). AS OF YET, NO URANIUM MINES HAVE BEEN WORKED IN THIS AREA, ALTHOUGH MANY CLAIMS APPEAR TO BE OF COMMERCIAL QUALITY. LACK OF A SUITABLE PROCESS FOR EXTRACTION OF URANIUM FROM COAL AND CARBONACEOUS MATERIAL HAS HELD BACK MUCH OF THE DEVELOPMENT. THE URANIUM MINERALS MOST COMMONLY FOUND ARE CARNOTITE AND AUTUNITE.

OIL AND GAS

COMMERCIAL OIL AND GAS MAY EXIST IN THE SUBSURFACE ROCKS OF THE AREA, BUT ONLY EXPLORATORY DRILLING WILL GIVE THE ANSWER.

CLAYS AND SHALES

THE SURFACE FORMATIONS OF THIS AREA ARE COMPOSED PREDOMINANTLY OF CLAYS AND SHALES. THESE CLAYS MAY HAVE "BLOATING" OR EXPANDING PROPERTIES WHICH WOULD CLASSIFY THEM FOR POSSIBLE USE AS LIGHT AGGREGATE MATERIAL.

BAKED CLAY

THROUGHOUT MUCH OF THE SOUTH CAVE HILLS AREA IN THIS QUADRANGLE, MANY THICK LIGNITE BEDS HAVE BEEN IGNITED BY PRAIRIE FIRES OR LIGHTNING, AND HAVE BURNED. WHILE THE BURNING OF THE LIGNITE TOOK PLACE THE CLAYS AND SANDS IMMEDIATELY ABOVE AND BELOW THE COAL WERE FIRED OR BAKED GIVING THEM A BRICK-LIKE TEXTURE, USUALLY BRIGHT RED TO LIGHT TAN IN COLOR. MUCH OF THIS BAKED CLAY (CALLED SCORIA BY LOCAL RANCHERS) IS QUARRIED FOR USE AS ROAD METAL. MUCH POTENTIAL BAKED CLAY REMAINS TO BE EXPLOITED.

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