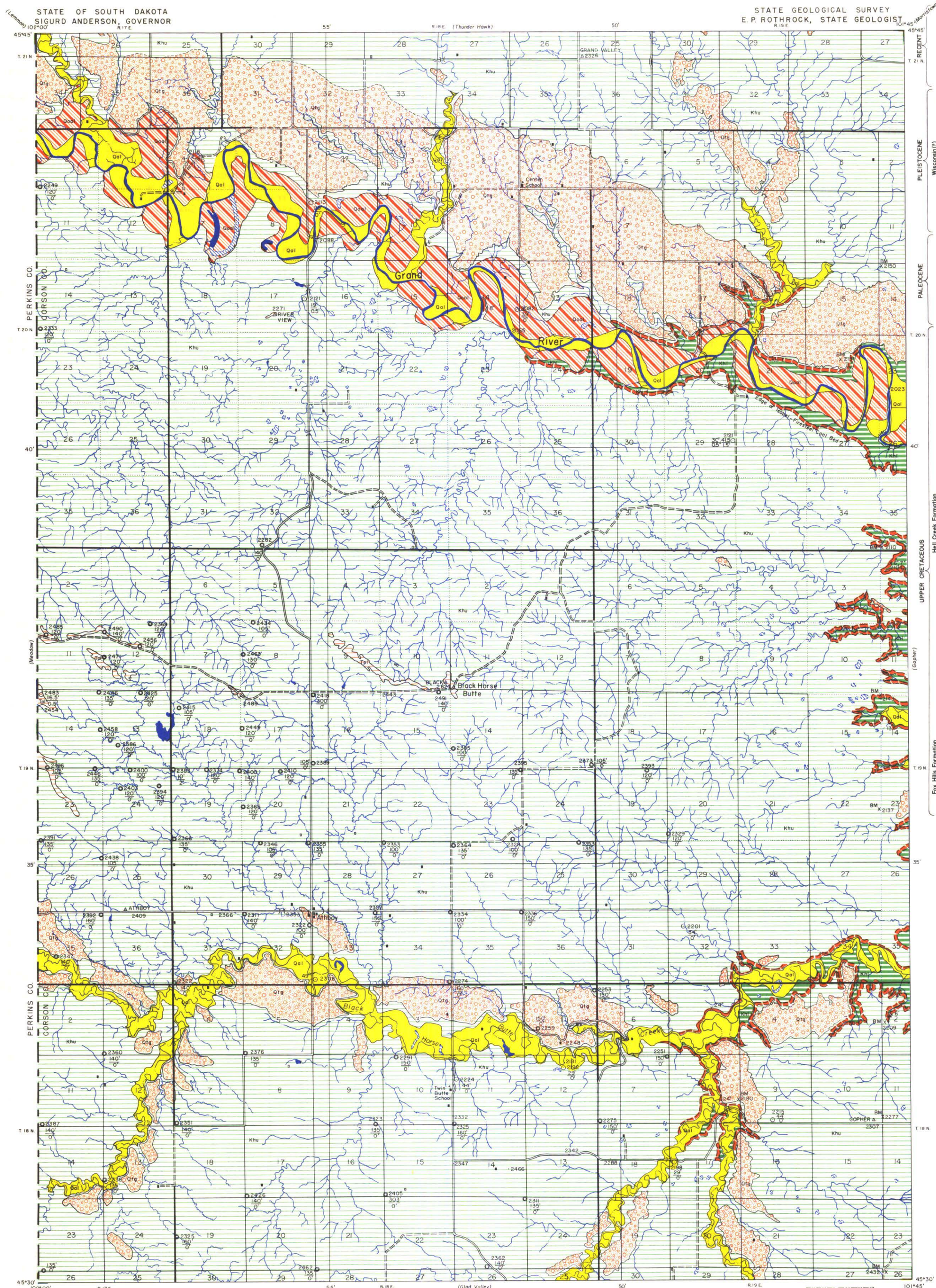
AREAL GEOLOGY
OF THE
BLACK HORSE BUTTE QUADRANGLE

STATE OF SOUTH DAKOTA
SIGURD ANDERSON, GOVERNOR

STATE GEOLOGICAL SURVEY
E. P. ROTHROCK, STATE GEOLOGIST



Geology by R. E. Curtiss.
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Surveyed in 1953. Drafted by P. Rist.
Coal-Test Holes Drilled in 1954.

Base Map By South Dakota State Geological Survey.

12°51' TRUE NORTH / MAGNETIC NORTH
APPROXIMATE MEAN DECLINATION - 1952

Scale = 1/62500
1 0 1 2 3 4 MILES

Vermillion, South Dakota
1954

Quadrangle Location

EXPLANATION

SEDIMENTARY ROCKS

QUATERNARY — RECENT

Qal — Alluvium
(Valley-bottom deposits of clay, silt, sand, and gravel in present streams.)

QUATERNARY — PLEISTOCENE — Wisconsin(?)

Qoal — Older Alluvium
(Older valley-bottom deposits above present streams.)

Qtg — Terrace Gravel
(Terrace deposits of sand, pebble, and cobble sizes consisting of coarse arkosic materials, silicified wood and orthoquartzite (Tongue River derived), quartz, sandstone, and limestone. Four terrace levels along Grand River. 1'-21' thick.)

TERTIARY — PALEOCENE

Tpl — Ludlow Formation
(Buff to gray silty clay, brown to rose shaly clay, weathers light gray, fine-grained lens-like, high-rank graywacke, slighty cross-laminated sandstone; buff-yellow. 100'-150' thick.)

CRETACEOUS — UPPER CRETACEOUS — Hell Creek Formation

Khu — Upper Hell Creek
("Somber beds" of lenticular bentonitic clays, silts (part loess), sands, peat-clays, and few clay-peats. Several "blackjack", a black carbonaceous clay, beds in upper part. Black Mn-Fe concretions spasmodically abundant in badland areas. Few butte-top high-rank graywacke sandstones. Colluvium or slope wash in barren-slope areas. Some residual, brown orthoquartzite and silicified wood (Tongue River derived) scattered on surface. 340'-360' thick.)

Khi-f — Isabel-Firesteel Coal Member
(Black subbituminous C coal 0'-1.5' thick, some lignite, often carries "blackjack" as partings in coal or super- and/or subjacent positions. Three brown clay-peat beds generally found with coal or represent coal beds when coal is absent. Pseudoscoria, a buff to red burned claystone, is conspicuous and hill-forming. Coal ashes often found below pseudoscoria.)

Khi — Lower Hell Creek
(Medium to dark gray lenticular bentonitic clays, silts (part loess), sands, thin peat-clay beds. Some black Mn-Fe concretions. Few Ostrea biostromes, occasional dinosaur (Trachodon or Triceratops (?)) bones. About 40'-80' thick.)

CRETACEOUS — UPPER CRETACEOUS — Fox Hills Formation

Kfc — Colgate Sandstone Member
("Pepper-and-salt" high-rank graywacke sandstone, calcareous cement, cross-laminated, weathers brown, "spheroidal-concretionary" shaped. 4'-15' thick.)

DRAINAGE

Intermittent Streams

Intermittent Lakes

CULTURE

Buildings
(House, church, and school)

Roads and Trails

1684
Altitudes
(In feet above sea level.)

X B.M. 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 Altitude
36' Overburden Thickness
2' Coal (see)
Drill Holes
(○ = State Geological Survey.
● = Seismograph Shot Holes.
Courtesy of Geotech. Corp. of Del.)

AREAL GEOLOGY OF THE BLACK HORSE BUTTE QUADRANGLE

By
Robert E. Curtiss

LOCATION

The quadrangle is located in western Corson County. It is situated 12 miles southeast of Lemmon, about 108 miles northwest of Pierre, and 122 miles northeast of Rapid City between parallels 45°30' and 45°45' north latitude and meridians 101°45' and 102°00' west longitude and constitutes an area of approximately 210 square miles.

TOPOGRAPHY AND DRAINAGE

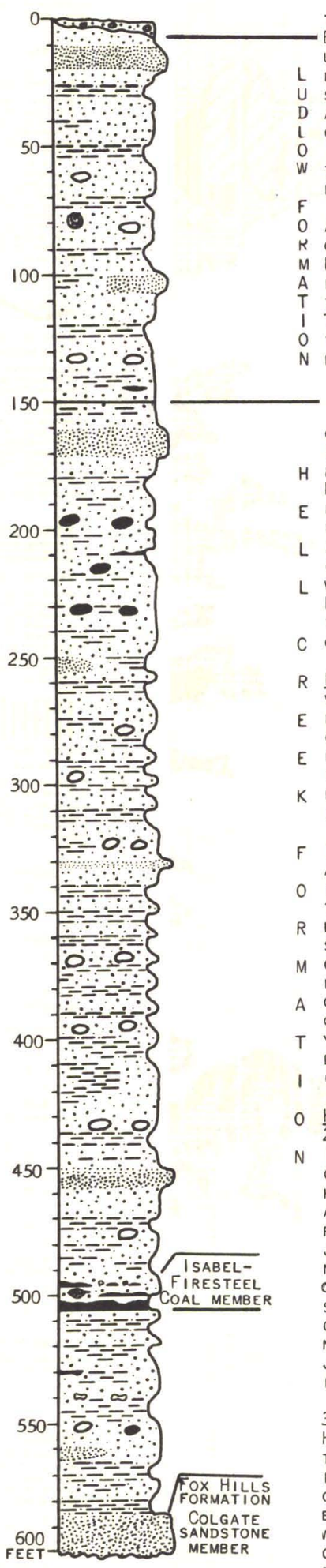
The Grand River valley is a distinctive topographic feature. The Grand River meanders across the northern part of the area from west to east. The valley, which varies in width from one-half to a little over one and three-fourths miles, is in the physiographic stage of middle maturity. Oxbow lakes and sloughs, meander scars, and slip-off slopes are evident. Alluvial terraces are situated inside of meanders that occupy the valley width. Meander bends are actively engaged in lateral planation, eroding 50 to 150-foot sharp, precipitous valleywalls. Black Horse Butte conspicuously towers above the fairly smooth Grand River-Black Horse Butte Creek interstream divide to the south and the picturesque, intricately dissected Hell Creek badlands to the north.

Surface runoff is controlled by the Grand River, the master stream, which is affluent in wet years. Black Horse Butte Creek, the Grand's principal tributary, traverses the area west to east, and at the eastern edge of the quadrangle the creek swings sharply north to enter the Grand River. The drainage pattern is dendritic. A few springs are associated with coal outcrops.

Extensive gravel terraces form broad flats on the north side of the Grand River. Smaller ones flank both sides of Black Horse Butte Creek.

The maximum altitude in the quadrangle is about 2,624 feet above sea level on Ludlow sandstone on top of Black Horse Butte in SE¼ Sec. 10, T.19N, R.18E. The minimum altitude is approximately 2,020 feet above sea level on the Colgate sandstone in the channel of the Grand River in the SW¼ Sec. 26, T.20N., R.19E. The relief is about 604 feet, and the average altitude is around 2,322 feet above sea level.

GENERALIZED COLUMNAR SECTION



STRATIGRAPHY

The exposed stratigraphic sequence, ranging geochronologically from Upper Cretaceous to Recent, is dominated by the completely-exposed Hell Creek formation (Upper Cretaceous age). The Fox Hills-Hell Creek and Hell Creek-Ludlow contacts are conformable and generally exhibit continuous deposition, excepting minor diastems and contemporaneous erosion and deposition. Tertiary residuum, represented by orthoquartzite cobbles and boulders and silicified wood from the Tongue River formation (Paleocene age). Pleistocene gravels, Pleistocene-Recent alluvial terraces and loess, and Recent alluvium complete the outcropping sedimentational units in the quadrangle.

Colgate sandstone member (Calvert 1912), Fox Hills formation (Meek and Hayden 1861). This unit varies in thickness from five to 15 feet. This high-rank graywacke sandstone may contain silica and calcareous cement, "pepper-and-salt" color, shaly to flaggy bedding, cross-bedding, weathered brown limonite stain, and a bumpy, pauky surface due to differential solution removal of calcareous cement. No invertebrate fossils were noted.

Lower Hell Creek, Hell Creek formation (Brown 1907). This unit, which ranges in thickness from about 40-80 feet, is characterized by admixtures, intergrades, and lenses of medium to dark gray unctuous bentonitic clays, silts (part loess), sands, lime cemented siltstones, fine-grained, lime cemented sandstones, channel-floodplain deposits of heterogeneous sizes, thin peat-clay (florastrome) beds frequently containing small particles of fusain and/or vitrain coal and fossil resin pellets. Minor quantities of purple-black manganese-iron concretions, yellow melanterite nodules, discontinuous Ostrea biostromes, and isolated unarticulated dinosaur (Trachodon or Triceratops (?)) bones are present.

Isabel-Firesteel coal member (Curtiss 1952), Hell Creek formation. This member, approximating 20-feet in thickness, contains several various, interrelated, interbedded lithologies. Lignitic coals vary in thickness from zero to one and one-half feet and may contain "blackjack" or bone coal, a tough black carbonaceous clay, and peat-clay as partings, in the coal, or in super- and/or subjacent positions, and occasional pyrite, marcasite nodules, and fossil resin pellets. Small quantities of pseudoscoria, buff to brick red clinkered claystone, represents burned peat-clay overlaying burned coal beds. The coal beds retain no lateral homogeneity but may be partly or wholly replaced by "blackjack" and/or peat-clay. Splits form three coal beds in the northeast part of the quadrangle.

Upper Hell Creek, Hell Creek formation. About 340-360 feet of this unit are exposed between Black Horse Butte and the Grand River. Lithologically, this unit, sometimes termed "somber beds", is almost identical to the lower Hell Creek. However, peat-clay beds are fewer and thinner, and more "blackjack" beds appear. One local coal, about two-feet thick, was encountered by drilling. These strata are exceptionally susceptible to erosion, and rather extensive badlands exist south of the Grand River. Larger quantities of surficial manganese-iron concretions occur, but their distribution is patchy. Some cone-in-cone structures are present. Differential weathering in badlands areas reduce calcareous cemented sandstone ledges and limonitic concretionary layers to discontinuous, detached pieces that cap pedestals. Weathered barren slopes, consisting largely of bentonitic clays, exhibit "popcorn" surfaces, typical of the Pierre formation along the Missouri River. Several buttes are capped with high-rank graywacke sandstones.

Ludlow formation (Lloyd and Hares 1915). This formation varies between 100-150 feet in thickness. Much of the formation is grassed over, but scattered exposures reveal a heterogeneous Ludlow composed of interbedded, lenticular admixtures of medium gray to rose, slightly bentonitic clays, light gray to buff-yellow silts and sands, and softly indurated calcareous-cemented siltstones and sandstones, and orange-brown limonitic concretionary layers. The sandstones are usually buff-yellow or light gray, "pepper-and-salt", medium- to fine-grained graywackes that weather a limonite-stained brown. Thin, intercalated brown clays and peat-clays occur near the base. The basal Shadehill coal facies was not identified.

STRUCTURE

The quadrangle is located on the east flank of the Dakota (Williston) Basin. The regional dip is northwest about 10-20 feet per mile. The east flank is not structureless. It displays faults of small magnitude (heave and throw), ubiquitous slumping that is inherent in bentonitic clays of the Hell Creek formation, and possibly gentle flexures. One reversed dip of about 5°10', striking S 70° E, exists in Sec. 28, T.20N., R.18E. An "anticlinal" arching and numerous slump faults appear in the west face of an upper Hell Creek scarp (189 feet exposed) in Sec. 36, T.20N., R.18E.

The problem of determining surface structure is complicated by slumping and depositional irregularities such as large-scale lenticularity, cross-laminations, and the absence of a consistent mappable "key" bed.

ECONOMIC GEOLOGY

The quadrangle displays a number of mineral resources of current and potential values. None of the resources is currently-exploited on a large scale. Small quantities of coal were mined by ranchers during the "depression", but mining is nonexistent today. Small amounts of gravel are quarried periodically, while coal by-products and bentonitic clays may contribute to the area's future economy. Surficial deposits of manganese-iron concretions, containing about 51% metallic iron, are limited in area. Oil may exist in the subsurface rocks.

COAL

Areal extent. The approximate boundary of the Isabel-Firesteel coal bed is shown on the map. The boundary was determined by natural exposures, prospect pits, and 14 State Geological Survey coal-test holes.

Thickness. The Isabel-Firesteel coal ranges in thickness from zero to one and one-half feet.

Physical character. The coal is generally brownish black (5YR2/1) in color and streak, hard, banded, blocky, smooth surfaced, containing varying amounts of brown limonite stain along bedding and joints with occasional amber-colored resin pellets, and minor quantities of gypsum, pyrite, and marcasite. The coal slacks moderately upon drying and is noncoking. The specific gravity averages about 1.2.

Splits divide the coal into three beds, two of which are coal and the other peat-clay, in Sec. 2, T.19N., R.19E. These splits, composed largely of light to medium gray silty bentonitic clay with small fragments of plant debris, vary from six to 12 feet in thickness.

Chemical character. Chemical analyses provide a satisfactory basis for comparing this coal with other coals and determining the rank and grade of coal and its commercial qualities. The proximate analysis furnishes necessary data concerning the quality and combustion properties of the coal (moisture, volatile or gaseous matter, fixed carbon or the principal heat-producing constituent, ash, and sulphur).

Coal samples from outcrops, (sample number 1) 13-inches thick, Sec. 14, T.19N, R.19E., and (sample number 2) 7-inches thick, Sec. 34, T.20N., R.19E., were analyzed as received, meaning the samples represent the coal as mined. Proximate analyses show the following:

TABLE 1

SAMPLE	MOISTURE	VOLATILE MATTER	FIXED CARBON	ASH	SULPHUR	B.T.U.	DRY B.T.U.
1	38.53%	29.68%	24.50%	7.29%	0.45%	6,298	10,246
2	25.67%	33.69%	18.19%	21.73%	0.40%	5,219	7,021

The sulphur content is small, and the coal ashes are light, containing but a small amount of clinkers.

Economically, an air-dried coal, prior to commercial or domestic consumption, will increase the heating value (See Dry B.T.U. in TABLE 1).

Character of overburden. Lithologically, the overburden does not present any problem to stripping operations. The upper Hell Creek is easily removed by earth-moving equipment in other quadrangles.

Estimated coal reserves. The maximum thickness of coal measured in 18 inches. This coal is covered by 41½ feet of overburden. The overburden-coal thickness ratio is about 27:1. This ratio is excessive for strip mining by present-day commercial standards. However, about 2,360,000 tons are estimated on an inferred basis (coal reserves located more than 1.5 miles from outcrops, strip mines, or drill holes).

SAND AND GRAVEL

Sand and gravel occur as terrace deposits along the north side of the Grand River and both sides of Black Horse Butte Creek. The major portion of the deposits along the Grand River is composed of orthoquartzite, arkosic and sandstone pebbles, limonite, silicified wood, chalcedony, milky and rock crystal quartz, etc.

The estimated volumes of sand and gravel for large-scale operations total in excess of 110,000,000 cubic yards. The larger terrace estimates follow:

TABLE 2

SECTIONS	TWP. N	RGE. E	ACRES	AVE. THICKNESS	EST. CUBIC YARDS
36	21	17			
31,32,33	21	18			
3,4,5,10	20	18	2,193	10'	35,380,400
34	21	18			
6,7,8,9,16,17,18	20	19			
1,2,10,11,12,13	20	18	4,382	5'	35,348,133
6	20	18			
25,36	21	17	562	15'	13,600,400
14,15,16,21,22,23	20	19	1,061	4'	6,846,987
26,27,35	21	17	219	18'	6,359,760
27,34	21	17	134	15'	3,242,800

More than 30 terraces contain lesser amounts.

MANGANESE-IRON

Locally-abundant surficial deposits of purple-black colored manganese-iron concretions exist south of the Grand River in the upper Hell Creek badlands. Concretions, analyzed from the Gopher quadrangle to the east, contain about 51% metallic iron, almost identical with some of the iron ore of the Mesabi Iron Range, Minnesota.

CLAY

Many bentonitic clayey horizons in the Hell Creek formation can be used to seal leaking stock dams, thus conserving water.