AREAL GEOLOGY
OF THE
FIRESTEEL CREEK QUADRANGLE

STATE OF SOUTH DAKOTA
SIGURD ANDERSON, GOVERNOR

STATE GEOLOGICAL SURVEY
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Surveyed in 1951. Drawn by P. Rist
Coal-Test Holes Drilled in 1953.

Base Map By South Dakota State Geological Survey.

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

Vermillion, South Dakota
1954

EXPLANATION

SEDIMENTARY ROCKS

QUATERNARY

RECENT

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

Ql — Loess
(Wind transported and deposited silt. 1'-4' thick.)

PLEISTOCENE — Wisconsin

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

Qtg — Terrace Gravel
(Terrace deposits of sand and gravel. 1'-15' thick.)

Qwb — Glacial Boulder Bed
(Boulders and erratics deposited east of Firesteel Creek.)

CRETACEOUS

UPPER CRETACEOUS — Hell Creek Formation

Khu — Upper Hell Creek
("Somber beds" of lens-like bentonitic clays, silt, part loess, sands and peat-clays. Mn-Fe concretions. Local badlands. Few butte-top sandstones. Colluvium or slope wash in barren-slope areas. Residual, brown Tongue River orthoquartzite boulders and silicified wood of Tertiary age scattered on surface. Upper part missing. About 150' thick.)

Khi-f — Isabel-Firesteel Coal Member
(Black subbituminous coal 0'-6' thick, some lignite, often carries "blackjack", a carbonaceous clay, as partings in coal or super- and/or subjacent positions. Three brown clay-peat beds generally with coal. Pseudoscoria, a buff to red burned clay stone, is hill-forming. Coal ashes often found below pseudoscoria.)

Khl — Lower Hell Creek
(Medium to dark gray lens-like bentonitic clays, silts, part loess, sands, thin peat-clay beds. Mn-Fe concretions. Few Ostrea biostromes, occasional dinosaur (Trachodon or Triceratops(?)) bones. About 70' thick.)

Kfc — Colgate Sandstone Member
("Pepper-and salt" high-rank graywacke, calcareous cement, sometimes silica cement, cross-laminated, caps buttes in east part of area. Inoceramus. 2'-15' thick.)

Kfb — "Banded" Member
(Alternating light and medium gray clayey sand and silt with small brown limonite concretionary layers, some thin streaks of plant matter. About 130' thick.)

Kftl — Timber Lake Sand Member
(Buff-yellow sand, massive, few Tancredia, Ostrea, Melania. 20'-30' thick.)

Kftc — Trail City Member
(Dark gray, very silty bentonitic clay, few thin beds of sand, limonite streaks, medium gray, "popcorn" surface 84' exposed.)

CRETACEOUS

bf (Outline of boulder field.)

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
2323 Top Hole Altitude; 36' Overburden; 2' Thickness (coal) — Drill Holes

■ Quadrangle Location

AREAL GEOLOGY OF THE FIRESTEEL CREEK QUADRANGLE

by

Robert E. Curtiss

LOCATION

The quadrangle is situated in Corson County and is located approximately 40 miles west of the city of Mobridge and about 95 miles northwest of Pierre between parallels 45°30' and 45°45' north latitude and meridians 101°15' and 101°30' west longitude and comprises an area of about 211 square miles.

TOPOGRAPHY AND DRAINAGE

One conspicuous topographic feature is the Grand River valley which trends in an east-west direction across the northern sector of the quadrangle. The valley is a pronounced trench with sharp, precipitous banks, ranging in relief from 50 to 150 feet, and a fairly broad floodplain, averaging about one-half mile in width. The Grand River is the master stream and receives the surface water from the quadrangle.

The valley of Firesteel Creek, the largest tributary of the Grand River, attains dimensions which rival the Grand River valley in several areas.

The Grand River and the lower portion of Firesteel Creek are generally affluent the year around.

Much of the quadrangle area comprises a portion of the north slope of the Moreau-Grand interstream divide which exhibits a labyrinth of youthful, sharply-cut intermittent streams,constituting a dendritic drainage pattern. The area north of the Grand River is a part of the south slope of the Grand-Cannonball interstream divide.

Springs are generally associated with coal outcrops and mark the stratigraphic boundary of the Isabel-Firesteel coal bed.

Many imposing, conical and flat-topped buttes form picturesque landmarks which tower above the relatively flat-lying terrain.

The maximum altitude in the quadrangle is 2,335 feet above sea level on a ridge of upper Hell Creek in NW¼, SW¼, Sec. 6, T. 18 N., R. 22 E. The minimum altitude is about 1,860 feet above sea level at the water level of the Grand River in NW¼, SW¼, Sec. 34, T. 21 N., R. 23 E. The relief is approximately 475 feet, and the average altitude of the quadrangle is about 2,097 feet above sea level.

STRATIGRAPHY

The surface formations range in age from Upper Cretaceous to Recent. The exposed stratigraphic sequence represents continuous deposition through the Hell Creek formation, and the stratigraphic contacts are conformable. No formation is exposed completely. Tertiary residuum from the Tongue River formation of the Paleocene series, Pleistocene gravels, boulders, and erratics, Pleistocene-Recent loess and older alluvium, and Recent alluvium complete the exposed sedimentational units in the quadrangle.

Trail City member Morgan and Petsch 1945, Fox Hills formation Meek and Hayden 1861. About 84 feet is exposed. It consists of dark gray silty bentonitic clay with several thin beds of light gray silt and sand, several thin intercalated seams of bentonitic clay, and three thin beds of yellow melanterite about 10 feet above the base. The member weathers light to medium gray, and the dry weathered surfaces exhibit a "popcorn" appearance. Disseminated bentonite constitutes most of the clay component of the member. A transition interval is arbitrarily placed at the base. It consists predominantly of bentonitic silt with subordinate quantities of bentonitic clay which resembles the Elk Butte member of the Pierre formation.

Timber Lake sand member Morgan and Petsch 1945, Fox Hills formation. The member, 20 to 30 feet thick, is composed of light gray-buff glauconite-quartz sand which weathers buff-yellow. Few pelecypods occur about 10 feet above the base.

"Banded" member Searight 1931, Fox Hills formation. This member attains a thickness of about 130 feet, and it consists of an alternating series of light to medium gray-buff clayey sands and silts with interspersed thin beds of silty and sandy bentonitic clays, bentonitic clayey silts and sands with thin streaks of plant matter, and several limonitic concretionary layers.

Colgate sandstone member Calvert 1912, Fox Hills formation. The member varies in thickness from 2 to 15 feet. The silica- and calcareous-cemented highrank graywacke sandstones are "pepper-and-salt", shaly to flaggy bedding, cross-laminated, with small particles of silicified wood, and brown limonite stain. The silica-cemented sandstone caps the buttes in the eastern portion of the quadrangle.

Lower Hell Creek, Hell Creek formation Brown 1907. This unit is about 70 feet thick and consists of admixtures of medium to dark gray bentonitic clays, silts, and sands which weather light gray and display lenticularity. Bentonitic clays are slippery and plastic when wet and susceptible to slump. Medium to dark brown clay-peat and peat-clay beds are characteristic. Clay-peat beds are compressed plant matter with minor amounts of silt and clay. Peat-clay seams contain more clay than plant matter. Manganese-limonitic concretions weather forming a temporary residual black rubble in eroded areas. Few discontinuous Ostrea glabra biostromes and inarticulated dinosaur bones occur spasmodically.

Isabel-Firesteel coal member Curtiss 1952, Hell Creek formation. The coal bed varies from zero to six feet in thickness. The coal is largely black, blocky subbituminous C coal and minor quantities of lignite. "Blackjack", a tough carbonaceous clay, occurs sometimes as partings in the coal or in super- and/or subjacent positions. Pseudoscoria, a buff to red burned claystone, marks the former presence of the coal, and light, fluffy ashes are occasionally found below the pseudoscoria. Fossil resin, marcasite, pyrite, melanterite, and limonite concretions and stain are occasionally associated with the coal.

Upper Hell Creek, Hell Creek formation. This unit measures about 150 although the upper part is missing. It is lithologically similar to the lower Hell Creek; however, pseudoscoria and ashes are absent, and fewer clay-peat beds occur. Light to medium gray high-rank graywacke sandstones occasionally cap buttes. Manganese-limonitic concretions are locally abundant.

STRUCTURE

The quadrangle is situated on the east flank of the Dakota (Williston) Basin. The regional dip is northwest at a rate of about 10 to 25 feet per mile. The flank is not a structurally smooth surface or homocline as small faults and perhaps gentle anticlines and synclines exist. Structures impose no particular difficulty to mining.

Twenty-six coal-test borings were made by the Survey to determine thicknesses of coal and overburden and the structural tendencies indicated by sea level altitudes established on the coal, the most reliable "key" bed. Structure contours indicate a small "high" around SW¼, SW¼, Sec. 9, T. 18 N., R. 22 E. Another possible "high" may be present in Sec. 26, T. 20 N., R. 23 E., as the Colgate sandstone appears to be structurally higher than the same sandstone to the northwest unless the regional dip steepens locally.

Normal faults occur in the Keller Mine, SW¼, Sec. 36, T. 19 N., R. 21 E. The coal bed is downthrown about 50 to 60 feet to the west of the mine, and in the mine the coal bed dips about four degrees south.

Slumping is prevalent in the Hell Creek formation. The absence of bedrock outcrops, characteristic lenticularity in the Hell Creek, and slumping complicate structural determinations.

ECONOMIC GEOLOGY

The quadrangle contains a variety of mineral resources, both of present-day and potential value. Coal is the most valuable currently-exploited resource, while sand and gravel and sandstone are quarried occasionally. Potential resources include coal by-products and bentonitic clay. Surficial deposits of manganese-limonitic concretions contain 51.37% metallic iron, but are limited in areal extent. Oil may exist in the subsurface rocks.

COAL

Areal extent. The approximate boundary of the Isabel-Firesteel coal bed is shown on the map. This boundary was determined by natural outcrops, coal mines, and Survey drill holes. Coal underlies about 65 square miles in the quadrangle.

Thickness. Coal ranges in thickness from zero to six feet. The Isabel-Firesteel coal consists of one minable seam in the quadrangle.

Physical character. The coal is banded, black in color and streak, hard, brittle, smooth surfaced, vertically jointed or blocky, occasionally displays brown limonite stain along the bedding and joints,spasmodic subrounded amber-colored resin pellets, small quantities of gypsum, pyrite, and marcasite. The coal shows four alternating, visibly distinct varieties of primary coals--durain, fusain, vitrain, and clarain. The coal slacks moderately upon drying and is noncoking. The specific gravity of the coal varies between 1.20 and 1.25.

Splits divide the coal bed into three beds in SW¼, SW¼, Sec. 30, T.20N., R. 21 E., and SW¼, Sec. 31, T. 21 N., R. 23 E. Splits are composed of medium gray silty bentonitic clay with fragments of plant matter, vitrain, and fusain and vary in thickness from 10 to 25 feet. Partings of "Blackjack" sometimes occur in the coal bed and vary from less than an inch to several inches in thickness.

Chemical character. Chemical analyses provide a satisfactory basis for comparing the 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). The moisture, volatile matter, and fixed carbon are resolved into carbon, hydrogen, oxygen, and nitrogen by the ultimate analysis.

Coal samples from the Keller Mine and the abandoned Blackhorse Mine were analyzed as received, meaning the samples represent the coal as mined. Proximate analyses reveal the following:

Mine	Moisture	Volatile Matter	Fixed Carbon	Ash	Sulphur	B.t.u.
Keller	25.98%	38.04%	29.89%	6.09%	0.48%	7,712
Blackhorse	33.39%	26.67%	20.02%	19.92%	0.38%	5,527

The Isabel-Firesteel coal contains little ash and sulphur. The burned coal leaves a light, fluffy ash which does not clinker and will not corrode boiler pipes.

An ultimate analysis (as received) of a sample from the Johnson Mine, about four miles south of the quadrangle, showed the following: hydrogen, 5.24 per cent; carbon, 58.98 per cent; nitrogen, 1.24 per cent; oxygen, 27.12 per cent; sulphur, 0.46 per cent; and, ash, 6.96 per cent.

Samples of coal from the Isabel-Firesteel area have been air dried, and the heating values were raised to an average 9,238 B. t. u. Therefore, an increase in the heating value will result if the coal is allowed to air dry prior to domestic and industrial consumption.

The coal in this area has been called lignite. However, comparative chemical and physical characteristics of lignite and subbituminous coal indicate this coal may be classified subbituminous C rank.

Character of overburden. The character of the overburden is not a detriment to strip mining. The overburden, which is upper Hell Creek is composed chiefly of lenticular bentonitic clays, silts, sands, and soft, partly indurated siltstones and sandstones. Bulldozers easily remove the overburden. The average thickness of overbruden removed at the Keller Mine is less than 20 feet, while about 32 feet were removed at the abandoned Blackhorse Mine.

Estimated coal reserves. The estimated coal tonnage, based on data from potential stripping areas, is approximately 17,066,585 tons. Tonnage is computed on the basis of a minimum thickness of 2½ feet, a specific gravity of 1.25, and 1700 tons per acre-foot. The tonnage is further resolved into three categories: measured (coal reserves located within 0.5 miles from outcrops, strip mines, or drill holes) 4,127,770 tons; indicated (coal reserves located between 0.5 and 1.5 miles from outcrops,strip mines,or drill holes) 7,092,685 tons; and, inferred (coal reserves located more than 1.5 miles from outcrops, strip mines, or drill holes), 5,846,130 tons.

Potential mining areas. Minable thicknesses of coal exist in the Keller Mine area in Secs. 35, 36, T. 19 N., R. 21 E.

Data from 26 Survey drill holes indicate the following potential stripping areas: in T. 18 N., R. 22 E., Sec. 21, five and one-half feet of coal underlies 38½ feet of overburden; Sec. 15, four and one-half feet of coal underlies 42½ feet of overburden; Sec.10, three feet of coal underlies 27½ feet of overburden; Sec. 1, three and one-tenth feet of coal underlies 23 feet of overburden; and, in Sec. 28, T. 20 N., R. 22 E., four and two tenths feet of coal underlies 33 feet of overburden. Systematic detailed drilling is necessary in determining the exact quantities of coal and overburden in these areas.

SAND AND GRAVEL

Sand and gravel deposits occur as terraces along the Grand River and Firesteel Creek. These deposits contain considerable limonite which breaks fairly easily, but these materials are adequate for road metal. Terraces along the Grand River are the largest in the quadrangle, with thicknesses ranging from zero to about 13 feet,and offer good possibilities for extensive quarrying. The estimated volume of sand and gravel is approximately 28,985,000 cubic yards.

The largest individual sand and gravel deposits constitute the following:

Sec.	Twp.	Rge.	Ave. Thickness	Acres	Cubic yards
10,11,14,15,16,20, 21,22,27,28	T.20N.	R.22E	3	1689	8,174,760
12,13,16,17,18 19,20,21	T.20N.	R.22-23E	2	1135	3,662,267
3,4,9	T.20N.	R.23E	6	365	3,533,200
7,8,9,17	T.20N.	R.23E	6	189	1,829,520
2,3,10	T.20N.	R.23E	5	222	1,790,800
13,14,18,19	T.20N.	R.21-23E	3	359	1,737,560
19,24	T.20N.	R.22-23E	6	175	1,694,000
13,14,22,23	T.20N.	R.22E	5	175	1,411,667
23,24,25,26	T.20N.	R.22E	5	135	1,089,000

Seven other terraces average less than 1,000,000 cubic yards.

SANDSTONE

The silica-cemented sandstone, which caps the Fox Hills buttes in the eastern portion of the quadrangle, attains thicknesses of 15 feet and would provide block or building stone. This sandstone has been used to a limited extent for foundations and rip-rap.

CLAY

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