DEPARTMENT OF THE INTERIOR
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W. E. WRATHER, DIRECTOR

PREPARED AS PART OF THE DEPARTMENT OF THE INTERIOR PROGRAM
FOR THE DEVELOPMENT OF THE MISSOURI RIVER BASIN

COAL INVESTIGATIONS
MAP C 24, SHEET 2 OF 2

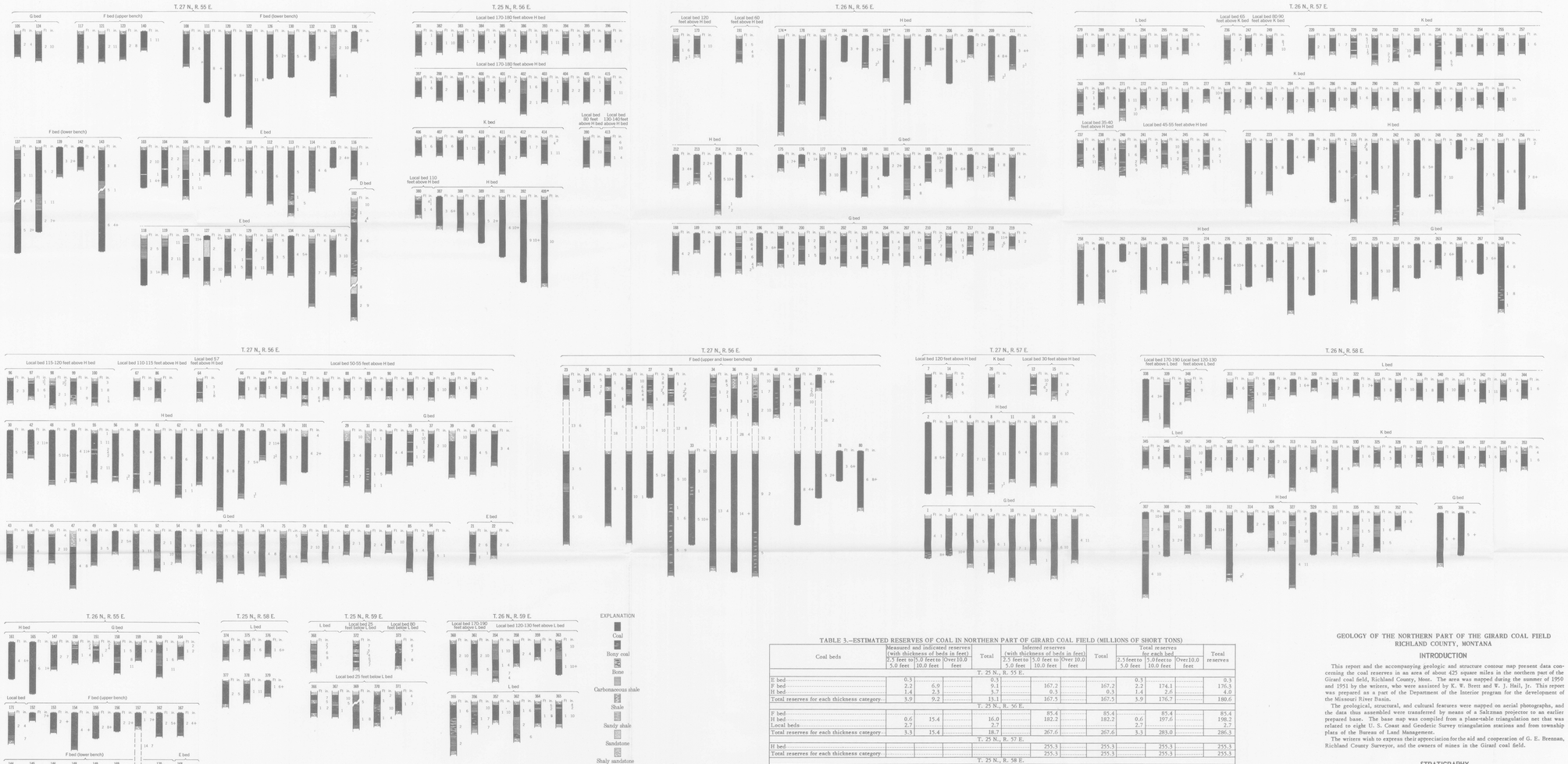

TABLE 1.–GRAVEL DEPOSITS AND ALLUVIUM IN GIRARD COAL FIELD

Number	Average height above Yellowstone River (feet)	Range in thickness (feet)	Average diameter of gravel (inches)	Maximum diameter of gravel (inches)	Correlation with Alden (1932)
Tr_7	700	10-80	2	8	Flaxville gravel or No. 1 bench.
Tr_8	600	10-25 Locally more.	2	10	
Qt_6	300	10-50 Locally more.	3	12	No. 2 bench.
Qt_4	80	5-20	3	12	
Qt_3	50	5-15	3	14	No. 3 bench.
Qt_2	20	3-10	4	36	
Qt_1	12	3-10	4	30	Qal.
Qal	0-10	0-10	3		

TABLE 2.–PROXIMATE ANALYSES OF COAL FROM GIRARD COAL FIELD AND SELECTED ANALYSES FROM ADJOINING FIELDS

Mine, location, and bed	Classification of coal by rank in accordance with American Society for Testing Materials.[1]	Bureau of Mines laboratory sample number and date of analysis	Form of analysis[2]	Moisture	Volatile matter	Fixed carbon	Ash	Sulphur	Heating value in British thermal units (Btu)
Jennison, sec. 17, T. 27 N., R. 56 E. F bed.	Lignite (55-71)	D-57773, 1951	A	38.9	24.9	29.1	7.1	0.4	6,540
			B		40.7	47.7	11.6	0.7	10,710
			C		46.1	53.9		0.8	12,120
O'Connor, sec. 9, T. 26 N., R. 57 E. H bed.	Lignite (53-67)	D-57776, 1951	A	41.5	24.6	27.2	6.7	0.7	6,270
			B		42.1	46.4	11.5	1.1	10,730
			C		47.6	52.4		1.3	12,120
Cossby, sec. 20, T. 25 N., R. 56 E. H bed.	Lignite (52-72)	D-57772, 1951	A	38.2	26.7	27.6	7.5	0.8	6,670
			B		43.3	44.6	12.1	1.4	10,790
			C		49.3	50.7		1.5	12,290
Elvirio, sec. 12, T. 24 N., R. 54 E. Lower Elvirio bed.	Lignite (56-71)	A-65451, 1950	A	38.3	25.7	30.0	6.0	0.5	6,710
			B		41.6	48.6	9.8	0.8	10,880
			C		46.1	53.9		0.9	12,060
Lane, sec. 26, T. 25 N., R. 53 E. Lane bed.	Lignite (53-76)	A-65454, 1950	A	36.5	26.9	30.0	6.6	0.9	7,150
			B		42.4	47.2	10.4	1.4	11,250
			C		47.4	52.6		1.5	12,560
Otto Past, sec. 28, T. 22 N., R. 55 E. Past bed.	Lignite (55-74)	A-65453, 1950	A	38.3	25.4	30.3	6.0	0.5	6,880
			B		41.1	49.2	9.7	0.8	11,140
			C		45.6	54.4		0.9	12,340
Chimney Rock, sec. 11, T. 20 N., R. 56 E. Past bed.	Lignite (55-76)	D-75580, 1951	A	33.7	27.3	32.2	6.8	0.5	7,090
			B		41.1	48.7	10.2	0.7	10,690
			C		45.8	54.2		0.8	11,910

[1] Standard specifications for classification of coals by rank (A. S. T. M. designation: D388-38, A. S. A. M20.1-1938): 1959 Book of A. S. T. M. Standards, pt. 3, p. 1–6. Rank expressed in condensed form: parenthesis signifies that the contained numbers are on the mineral-matter-free basis; first number represents fixed carbon on the dry basis, reported to the nearest whole percent; second number represents Btu on the moist basis, expressed as hundreds of Btu (to the nearest hundred).

[2] A, as received; B, moisture free; C, moisture and ash free.

TABLE 3.–ESTIMATED RESERVES OF COAL IN NORTHERN PART OF GIRARD COAL FIELD (MILLIONS OF SHORT TONS)

Coal beds	Measured and indicated reserves (with thickness of beds in feet)			Total	Inferred reserves (with thickness of beds in feet)			Total	Total reserves for each bed			Total reserves
	2.5 feet to 5.0 feet	5.0 feet to 10.0 feet	Over 10.0 feet		2.5 feet to 5.0 feet	5.0 feet to 10.0 feet	Over 10.0 feet		2.5 feet to 5.0 feet	5.0 feet to 10.0 feet	Over 10.0 feet	
T. 25 N., R. 55 E.												
E bed	0.3			0.3					0.3			0.3
F bed	2.2	6.9		9.1		167.2		167.2	2.2	174.1		176.3
H bed	1.4	2.3		3.7		0.3		0.3	1.4	2.6		4.0
Total reserves for each thickness category	3.9	9.2		13.1		167.5		167.5	3.9	176.7		180.6
T. 25 N., R. 56 E.												
F bed						85.4		85.4		85.4		85.4
H bed	0.6	15.4		16.0		182.2		182.2	0.6	197.6		198.2
Local beds	2.7			2.7					2.7			2.7
Total reserves for each thickness category	3.3	15.4		18.7		267.6		267.6	3.3	283.0		286.3
T. 25 N., R. 57 E.												
H bed						255.3		255.3		255.3		255.3
Total reserves for each thickness category						255.3		255.3		255.3		255.3
T. 25 N., R. 58 E.												
H bed						241.7		241.7		241.7		241.7
Total reserves for each thickness category						241.7		241.7		241.7		241.7
T. 25 N., R. 59 E.												
H bed						220.7		220.7		220.7		220.7
Total reserves for each thickness category						220.7		220.7		220.7		220.7
T. 26 N., R. 55 E.												
F bed	7.5	10.6		18.1								
H bed						200.2		200.2	7.5	210.8		218.3
G bed		0.2		0.2						0.2		0.2
Total reserves for each thickness category	7.5	10.8		18.3		200.2		200.2	7.5	211.0		218.5
T. 26 N., R. 56 E.												
F bed							298.2	298.2			298.2	298.2
G bed	8.4			8.4	24.5	1.6		26.1	32.9	1.6		34.5
H bed	0.3	24.8		25.1		40.2		40.2	.3	65.0		65.3
Total reserves for each thickness category	8.7	24.8		33.5	24.5	41.8	298.2	364.5	33.2	66.6	298.2	398.0
T. 26 N., R. 57 E.												
F bed							60.9	60.9			60.9	60.9
G bed	3.9	13.7		17.6	85.0	18.4		103.4	88.9	32.1		121.0
H bed	0.8	62.2		63.0		180.3		180.3	0.8	242.5		243.3
Total reserves for each thickness category	4.7	75.9		80.6	85.0	198.7	60.9	344.6	89.7	274.6	60.9	425.2
T. 26 N., R. 58 E.												
G bed		6.1		6.1		130.7		130.7		136.8		136.8
H bed	2.3	27.4		29.7		165.8		165.8	2.3	193.2		195.5
K bed	0.9			0.9					0.9			0.9
Total reserves for each thickness category	3.2	33.5		36.7		296.5		296.5	3.2	330.0		333.2
T. 26 N., R. 59 E.												
H bed						116.5		116.5		116.5		116.5
Local beds	0.2			0.2					0.2			0.2
Total reserves for each thickness category	0.2			0.2		116.5		116.5	0.2	116.5		116.7
T. 27 N., R. 55 E.												
D bed		1.8		1.8		192.0		192.0		193.8		193.8
E bed	16.8	8.2		25.0					16.8	8.2		25.0
F bed	2.5	21.7	7.6	31.8		5.3	13.0	18.3	2.5	27.0	20.6	50.1
Total reserves for each thickness category	19.3	31.7	7.6	58.6		197.3	13.0	210.3	19.3	229.0	20.6	268.9
T. 27 N., R. 56 E.												
F bed	8.4		51.9	60.3			245.7	245.7	8.4		297.6	306.0
G bed	14.2	7.5		21.7	19.1	12.7		31.8	33.3	20.2		53.5
H bed	0.8	21.8		22.6		19.4		19.4	0.8	41.2		42.0
Total reserves for each thickness category	23.4	29.3	51.9	104.6	19.1	32.1	245.7	296.9	42.5	61.4	297.6	401.5
T. 27 N., R. 57 E.												
F bed			0.2	0.2			60.9	60.9			61.1	61.1
G bed	2.0	9.7		11.7	0.6	7.3		7.9	2.6	17.0		19.6
H bed		10.2		10.2		3.8		3.8		14.0		14.0
Total reserves for each thickness category	2.0	19.9	0.2	22.1	0.6	11.1	60.9	72.6	2.6	31.0	61.1	94.7
Grand total	76.2	250.5	59.7	386.4	129.2	2,247.0	678.7	3,054.9	205.4	2,497.5	738.4	3,441.3

GEOLOGY OF THE NORTHERN PART OF THE GIRARD COAL FIELD, RICHLAND COUNTY, MONTANA

By

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1955

INTRODUCTION

This report and the accompanying geologic and structure contour map present data concerning the coal reserves in an area of about 425 square miles in the northern part of the Girard coal field, Richland County, Mont. The area was mapped during the summer of 1950 and 1951 by the writers, who were assisted by K. W. Brett and W. J. Hail, Jr. This report was prepared as a part of the Department of the Interior program for the development of the Missouri River Basin.

The geological, structural, and cultural features were mapped on aerial photographs, and the data thus assembled were transferred by means of a Saltzman projector to an outline prepared base. The base map was compiled from a plane-table triangulation net that was related to eight U. S. Coast and Geodetic Survey triangulation stations and from township plats of the Bureau of Land Management.

The writers wish to express their appreciation for the aid and cooperation of G. E. Brennan, Richland County Surveyor, and the owners of mines in the Girard coal field.

STRATIGRAPHY

TONGUE RIVER MEMBER OF THE FORT UNION FORMATION

Sedimentary strata exposed in the northern part of the Girard coal field are part of the Tongue River member of the Fort Union formation (Paleocene). The exposed strata of the Tongue River member are 800 feet thick, but the base of the member is not exposed and the upper part has been removed by erosion. The Tongue River strata consist of light-yellow to yellowish-gray lenticular, massive, and in part crossbedded sandstone beds interbedded with light-gray shale and a few extensive and thick beds as well as many lenticular or discontinuous thin beds of lignite. Zones of bench-forming calcareous concretions are present at irregular intervals, and most of the beds contain round ferruginous concretions generally less than an inch in diameter. Fragments of fossil plants and shells of freshwater mollusks are common, but their stratigraphic ranges are so great that they are nondiagnostic except for the purpose of general dating. The assignment of the strata to the Tongue River member of the Fort Union formation is based on the lithologic similarity of the beds with Tongue River strata in adjacent areas (Thom and Dobbin, 1924, p. 493-495; Parker, 1936, p. 131).

TERRACE GRAVEL AND ALLUVIUM

Deposits of sand and gravel occur on terrace remnants at several levels above the Yellowstone River and most of the larger tributaries. The terrace deposits within the Girard coal field are designated by the numbers 1 to 7 in ascending order above the Yellowstone River, but terraces numbered Qt_5, Qt_6, and Tr_8 do not extend into the northern part of the coal field. Inasmuch as no fossils were found in the terrace gravels shown in table 1 the ages of the terrace fore ace arbitrarily considered to be Quaternary and the upper two are designated Tertiary. The highest gravels are about 2,600 feet above sea level, or 700 feet above the Yellowstone and the Missouri Rivers. The gravel in the highest deposits is well-rounded pebbles and cobbles of various igneous and metamorphic rocks, quartzite being the most abundant. The highest deposits are composed chiefly of gravel, but the predominant constituents of the Quaternary deposits are coarse sand, lenses and layers of fine sand and silt, and locally layers of detrital coal.

WISCONSIN OR ILLINOIAN(?) GLACIAL DRIFT

The glacial drift that covers much of the area is grand moraine. Locally the drift is stratified, but the predominant material is till that consists of a mixture of angular to rounded pebbles, cobbles, and boulders of igneous and metamorphic rocks, limestone, and dolomite in a marrix of clay, silt, and sand. Although cross sections of the ground moraine are rarely exposed, in places it is as much as 50 feet thick. Most of the area south of the drainage divide of the Missouri and Yellowstone Rivers is covered by ground moraine, whereas north of the divide only the head upland areas and a few stream divides are covered by it. Criteria for identification of the moraine mapped in this area are the dark color of the soil, the erratic boulders scattered over the surface, the fragments of dolomite in the soil, and the smooth hummocky or rolling surface of the land. The till contains many rounded pebbles and cobbles of quartzitic, schistose, and porphyritic rocks probably derived from earlier gravel deposits and is commonly similar to the terrace deposits. Angular erratic boulders of granite, gneiss, limestone, or dolomite probably derived from areas to the north are scattered through the till. These erratics are commonly about 3 feet in diameter and the largest in the area is a rectangular block, 11 by 7 by 5 feet, of dolomitic limestone in the SW¼ sec. 3, T. 25 N., R. 59 E.

STRUCTURE

The northern part of the Girard coal field is about 25 miles east of the axis of Poplar anticline, which marks the western rim of the Williston basin as defined by Thom and Dobbin in 1924. The strata dip eastward about 25 feet per mile, and the structural relief in the area is about 750 feet. Structure contours have been drawn on the base of the H coal bed. Intervals between lenticular coal beds are not constant, and a few unavoidable errors probably were introduced when altitudes determined on higher coal beds were reduced to the datum plane on the H bed.

COAL

PHYSICAL AND CHEMICAL PROPERTIES

The coal in the Girard field is lignite. A fresh surface is brownish black to black and brown where scratched or crushed. The fresh lignite has a subconchoidal fracture, and a surface transverse to the bedding commonly has a banded appearance owing to the alternation of bright and dull layers. In many beds the original texture of the woody material is preserved. The lignite rapidly loses moisture when exposed to the air, and the surface becomes dull and shows many small cracks. Slaking proceeds rapidly, and within a few months the exposed lignite is reduced to a fine powder.

Analyses of coal from the Girard field, and, for comparison, analyses of coals from adjoining fields are given in table 2. Samples 1 and 2 are fron mines that are now being operated commercially. In table 2, proximate analyses are given in three forms marked A, B, and C. Form A gives the composition and heating value of the sample as received in the laboratory and approximates closely the composition of the coal in the mine. Form B gives the calculated composition and heating value of the dry coal. Form C gives the approximate composition and heating value of the dry combustible matter. The volatile matter in each analysis was determined by the modified method, in which gradual heating in an electric furnace prevented mechanical loss of particles and steam. All the analyses were made by the U. S. Bureau of Mines.

UTILIZATION

Coal has been mined on a small scale for domestic use since the earliest settlement of the area. For many years coal beds were the only adequate source of fuel, and the ranchers have taken coal from most of the easily accessible outcrops. The Jennison mine is the largest commercial mine operating in the northern part of the Girard coal field. The Jennison, Benner, and Park mines in secs. 17 and 18, T. 27 N., R. 56 E., and the Crosby mine in sec. 20, T. 25 N., R. 56 E., produced an estimate aggregate of 14,200 tons of coal in 1950.

BURNING OF THE COAL BEDS

Clinker formed by the burning of coal beds, especially the F, G, and H beds along their lines of outcrop, is conspicuous north of the drainage divide of the Missouri and Yellowstone Rivers. Many of the fires probably started as a result of the generation of heat from the oxidation of iron sulfides. Human agencies and lightning have been contributing causes to the ignition of the coal beds. Several coal beds have burned since the early settlers came to the area, and in adjoining areas a few coal beds were burning in 1950. Clinker fragments in the terrace gravels of Miocene or Pliocene age and the unaltered ground moraine lying directly upon thick masses of clinker indicate that some of the beds must have burned before the advance of the ice sheet into this area.

The color and texture of the clinker depend on the intensity of heating and the rate of cooling of the clinkered rock material. Rogers (1917) described the physical and mineralogical changes that occur in rocks affected by the burning of adjacent coal beds. The baked and fused overburden collapses on the underlying strata as the burning of coal progresses. Thus the base of the clinker coincides stratigraphically with the base of the coal bed and is a reliable mapping horizon. Generally the clinker is red, pink, or purplish red, but it may be mottled or banded with yellow, green, or black.

THE COAL BEDS

The coal beds that crop out in the mapped area are in the Tongue River member of the Fort Union formation. The areal distribution of the outcrop of each bed is shown by a line on the geologic map. From bottom to top the beds have been designated as the D, E, F, G, H, K, and L beds, and isolated exposures of coal beds that occur above the L bed are designated as local beds. The numbers along the outcrop lines indicate selected localities where thicknesses were measured and also refer to the graphic sections of these measurements. A few of the sections were measured by means of drilling with a jeep-mounted power auger. The coal beds, especially the thin beds, are lenticular and discontinuous, and the intervals between them are not constant. Beds F and H are more nearly continuous than the other beds. The names of correlative coal beds in adjoining areas will be used instead of the letters after the entire coal field has been mapped.

D bed.–The D bed, about 140 feet above the base of the Tongue River member, is the lowermost coal bed that crops out within the mapped area. The bed, exposed in sec. 7, T. 27 N., R. 55 E., consists of an upper bench containing about 7 feet of coal separated by 8 feet of sandstone from a lower bench about 3 feet thick. Outside the mapped area in T. 27 N., R. 54 E., the lower bench of the D bed is not exposed and the upper bench is about 10 feet thick.

E bed.–The E bed, which is about 130 feet above the D bed, crops out in the western part of the area and ranges in thickness from 2 feet 6 inches to 7 feet 2 inches. Owing to the easterly dip of the strata, the E bed is concealed by alluvium in the E½ sec. 7, T. 27 N., R. 56 E., and is not exposed farther east. A lenticular and bony coal bed in the southwestern part of the area is correlated with the E bed, but in T. 25 N., R. 55 E., west of East Charley Creek carbonaceous shale occurs at the stratigraphic position of the E bed.

F bed.–Conspicuous clinker marks much of the line of outcrop of the F bed in the western part of the area. The F bed, 1 foot 1 inch thick in sec. 31, T. 25 N., R. 55 E., increases in thickness northward and attains the maximum measured thickness of 14 feet 2 inches in sec. 18, T. 27 N., R. 56 E. The average measured thickness of the F bed along the Missouri River is about 11 feet. The F bed is about 65 feet above the E bed. A lenticular and bony coal bed 10 to 30 feet above the F bed, which ranges in thickness from 1 foot to 4 feet, was mapped locally as an upper bench.

G bed.–In the northern part of the field the G bed, about 145 feet above the F bed, has a maximum measured thickness of 7 feet 4 inches, and the bed has burned along much of its outcrop. The bed thins southwestward and in less than 1 foot 6 inches thick in T. 26 N., R. 55 E. The G bed commonly includes one or more shale partings in the southwestern part of the area.

H bed.–The H bed occurs in most of the townships north of the drainage divide of the Missouri and Yellowstone Rivers, and much of its outcrop is marked by massive clinker. The H bed, commonly as much as 10 feet thick, is the most persistent bed in the area, and it contains a large part of the reserves in the field. The H bed is about 75 feet above the G bed. At several localities, the H bed has a thin shale parting and a thin bony zone near the base.

K bed.–Although generally less than 2 feet 6 inches thick, the K bed is persistent through T 26 N., Rs. 57 and 58 E. It attains a maximum thickness of 4 feet 5 inches at two localities. The K bed is about 45 feet above the H bed. At scattered localities thin coal beds that occur 40 to 55 feet above the H bed, designated local beds, are correlated tentatively with the K bed.

L bed.–In the eastern part of the field the lenticular and shaly L bed, commonly less than 2 feet 6 inches thick, crops out 155 to 155 feet above the H bed. Farther west at scattered localities thin lenticular local beds are in approximately the same stratigraphic position as the L bed. Isolated exposures of coal beds as much as 4 feet 8 inches thick occur up to 180 feet above the L bed in the highest part of the drainage divide of the Missouri and Yellowstone Rivers. These isolated beds, designated local beds, are identified on the graphic coal sections by the interval, given in feet, above the L bed.

ESTIMATE OF RESERVES

The classes of reserves measured and indicated and inferred are determined by the relative reliability and abundance of the data upon which the calculations are based. Measured and indicated reserves are computed for that part of the coal bed lying within a semicircle extending half a mile beyond the point of observation. The measured reserves are small and are not reported separately from indicated reserves. Because of the impossibility of determining the thinning or thickening or variations in the quality of the coal where it is not exposed, the estimate of the inferred reserves is very conservative. Inferred reserves are considered to underlie a spur enclosed by the outcrop of a bed and to extend beyond the area defined for measured and indicated reserves about 2 miles from the general line of outcrop. For each coal bed the tons of reserves in each class are calculated from planimeter measurements of the areas delineated on the map, from an average thickness of the bed that was determined from measurements at intervals of half a mile along the outcrop, and from the assumption that the weight of one acre-foot of lignite is 1,750 short tons.

The original reserves of lignite, in beds 2.5 feet or more thick in this part of the Girard coal field, are approximately 3,440,000,000 tons.

The reserves are in beds that crop out within the area and are everywhere within 1,000 feet of the surface. The H bed, of which 93 percent is in the 5 feet to 10 feet thickness category, contains about 45 percent of the total reserves, 44 percent of the measured and indicated reserves, and 47 percent of the inferred reserves. The outcrops of coal beds 1.5 feet or more thick are shown on the map, but the reserves in beds less than 2.5 feet thick are not included in the summary total.

Coal stripping operations have been sporadically attempted in many localities by the farmers and ranchers, but open cut mines have not been commercially successful. Many small wagon mines have been in operation at various times since about 1890, but no record of their production is available. On the basis of field observations and incomplete records from commercial mines, the total output of coal from the beginning of mining in this area to 1950 is estimated to be about 500,000 tons.

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COAL INVESTIGATIONS
MAP C 24, SHEET 2 OF 2