

**DESCRIPTION OF MAP UNITS**

**Qa** ALLUVIUM (HOLOCENE) - Silt, sand, and clay and a small amount of pebble gravel

**Qd** LANDSLIDE DEPOSITS (HOLOCENE AND PLEISTOCENE)

**Tc** TERRACE DEPOSITS (PLEISTOCENE - EARLY OR PRE-WISCONSIN) - Silt and sand and a small amount of gravel. About 75-135 feet above the Heart River and 40-90 feet above Plum Creek and local drainage lines. Terraces correlate with middle terraces along the Heart River in the White Butte NE quadrangle

**Tu** UNIFORMITY

**Tg** CHADRON FORMATION (OLIGOCENE) - Upper part, interbedded calcareous claystone and limestone beds, 15-40 feet thick; middle part, light-gray to light-olive-gray sandy claystone, 3-15 feet thick; basal part, grayish-yellow bentonitic and conglomeratic sandstone, 4-23 feet thick. Fluvial and lacustrine deposits

**Tg** UNIFORMITY

**Tg** GOLDEN VALLEY FORMATION (Eocene and Paleocene) - Siltstone and claystone, light-grayish-orange, grayish-yellow, and grayish-pink to pale-d, some beds are weathered to pale olive and shades of green; 0-10 feet thick. Siltstone and sandstone, light gray to white, kaolinitic, clayey, orange stain along joints and a few beds, 0-25 feet thick. Fluvial, lacustrine, and paludal deposits

**Tf** FORT UNION FORMATION (PALEOCENE) - Fluvial, lacustrine, and paludal deposits

**Tf** Sentinel Butte Member - Upper unit: sandstone, yellowish-gray, very fine grained to medium-grained, massive, friable, crossbedded, fine- to 6-60 feet thick. Middle unit: sandstone, yellowish-gray, very fine to fine-grained, interbedded with thin beds of dark-greenish-gray to medium-dark-gray siltstone and claystone, siltified siltstone and sandstone, and lignite; 185-210 feet thick. Lower unit: dark-gray clayey siltstone interbedded with light-gray and dark-olive-yellow silty claystone, brown carbonaceous claystone and siltstone, yellowish-gray sandstone, bentonitic, and lignite; contains siltified wood and in places siltified lignite; 25-50 feet thick

**Tf** Tongue River Member - Siltstone and claystone, medium- to light-gray and light-olive-gray; contains a few beds of yellowish-gray sandstone, brown carbonaceous siltstone and claystone, and lignite; 0-8 feet exposed

**EXPLANATION OF LINE SYMBOLS**

**COAL BED** - Dashed where approximately located; short dashed where inferred. Letters denote coal bed named in the generalized stratigraphic section. Circled number refers to plotted coal section measured at triangle. Equivalent thickness of coal, in feet, measured at triangle, calculated by method of Bass, Smith, and Horn, (1970), p. 6

**CONTACT** - Dashed where approximately located; short dashed where indefinite or inferred

**W [144]** WATER WELL - Showing depth, in feet in parentheses; queried if depth not known; reported thickness, in feet, of designated coal bed

**H 14.4** SEISMIC SHOT HOLE - Showing reported thickness, in feet, of designated coal bed

**A H 10.0** HAND AUGER HOLE - Showing thickness, in feet, of designated coal bed

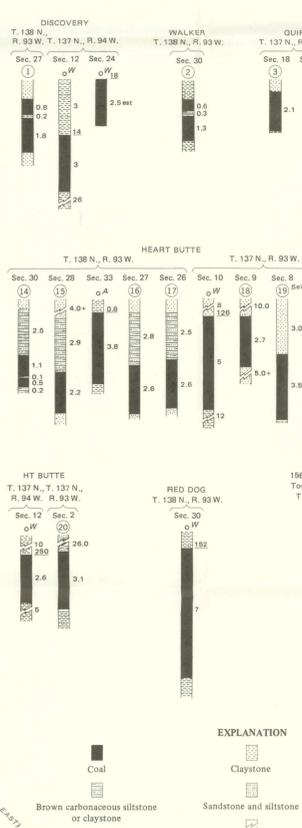
**ABANDONED COAL MINE**

<sup>1</sup> To convert feet to meters, multiply by 0.3048

**TABLE 1. - Analyses of coal from the Clark Butte quadrangles**  
(Results in percent except as indicated)

Source of sample and depth (feet) <sup>1</sup>	Moisture	Volatile matter	Fixed carbon	Ash	Sulfur	Heating value (Btu) <sup>2</sup>
Dell hole 1: NENWENEN sec. 6, T. 137 N., R. 92 W., Mary Springs bed, 265.65-168.70	37.0	26.5	28.1	7.5	1.0	6,720
Dell hole 2: SWWENEN sec. 8, T. 135 N., R. 91 W., Heart Butte bed, 37.8-40.8 and 41.8-45.55	40.1	26.1	26.0	7.4	1.0	6,380
Dell hole 3: SEWENEN sec. 26, T. 136 N., R. 92 W., Mary Springs bed, 214.2-217.8	38.9	26.9	26.9	7.3	0.6	6,600
Dell hole 4: NENWENEN sec. 12, T. 136 N., R. 92 W., Mary Springs bed, 178.21-179.38 and 179.85-181.25	35.9	26.0	26.1	16.0	2.0	5,790
Dell hole 5: SWWENEN sec. 22, T. 138 N., R. 90 W., Spring Valley bed, 107.3-114.2	34.8	28.8	28.8	25.8	5.0	7,220
Average	36.6	26.9	26.9	11.8	1.2	6,200

<sup>1</sup> To convert feet to meters, multiply by 0.3048.  
<sup>2</sup> As analyzed, B. and C. method, moist basis, and ash-free.  
<sup>3</sup> To convert Btu to joules, multiply by 1.05505 x 10<sup>3</sup>.



**ECONOMIC GEOLOGY**

The White Butte NE, NW, East, and West quadrangles were mapped as part of the U.S. Geological Survey program of classifying Federal lands and to make a systematic study and evaluation of the coal resources. Economic resources in the White Butte quadrangles consist of coal, oil and gas, sodium chloride, limestone, rubble, and sand and gravel.

**COAL**

Coal resources in the map area are in the nonmarine members of the Fort Union Formation of Paleocene age. The approximate stratigraphic relationships of the coal beds are shown in the generalized sections. The lowest exposed coal bed in the quadrangles is the Mary Springs bed about 95 feet (29 meters) below the top of the Tongue River Member. The highest exposed coal bed is the Discovery bed about 225 feet (69 meters) above the base of the Sentinel Butte Member. The Spring Valley and Heart Butte beds are the thickest and most extensive of the exposed beds and range in thickness from 0 to 10 feet (0 to 3.0 meters) and 0 to 7 feet (0 to 2.1 meters), respectively. The Hummel, Schank, and Shell coal beds are the thickest and most extensive in the subsurface. Driller's logs of water wells north of the quadrangles indicate that (1) the Hummel bed is as much as 9.5 feet (2.9 meters) thick in sec. 19, T. 138 N., R. 92 W. (2) the Schank bed is 6.0 feet (1.8 meters) thick in sec. 15, T. 137 N., R. 92 W.; and (3) the Shell bed may be as much as 6.5 feet (2.0 meters) thick in sec. 28 and 33, T. 136 N., R. 92 W. The Schank and Hummel beds may be benches of the same coal.

Correlations of coal beds in the White Butte quadrangles with the coal beds in the Clark Butte NW and SW quadrangles are seemingly reliable, and the same names are used generally for coal beds at the same stratigraphic position.

A ground-water survey of Stark and Hettinger Counties was made in 1966 by the Water Resources Division, U.S. Geological Survey, in cooperation with the North Dakota State Water Commission. Henry Trapp, Jr., U.S. Geological Survey, hydrologist-in-charge, made available the logs of many water wells, test holes, and auger holes drilled in and near the White Butte quadrangles. The thickness of coal in many of the water wells and driller who are reported by Gerald Moe of Mott, N. Dak., an experienced water-well driller who supplied many water-well records. These records aided greatly in correlation of coal beds, in construction of the structure contour map, and in calculation of resources.

Some areas in the White Butte quadrangles do not have any known coal beds as thick as 2.5 feet (0.76 meters). Although definite data are not available, the thickness of coal-bearing sediments and sparse drill-hole data indicate that future exploration will prove that these areas are underlain by coal beds 2.5 feet (0.76 meters) or more in thickness.

Small abandoned open-pit mines were worked by local residents to produce coal for their own use. These pits, which now have dumped sides and in most places no exposed coal beds, are shown on the geologic maps. The largest mine opened was in the W3 sec. 13, and the N6 sec. 14, T. 135 N., R. 94 W., White Butte West quadrangle, where 10-12 acres (4.0-4.9 hectares) of the 4-5-foot (1.2-1.5 meters) thick Heart Butte bed was strip mined between 1906 and 1944.

**TABLE 2. - Estimated coal resources, by township and coal bed, in the White Butte quadrangles, North Dakota**

Lignite bed	Resources (millions of short tons) <sup>1</sup>				Totals
	Measured (ft) <sup>2</sup>	Inferred (ft) <sup>3</sup>	Inferred (ft) <sup>3</sup>	Inferred (ft) <sup>3</sup>	
T. 135 N., R. 93 W. (fractional)	2.5	5.0	5.0	5.0	17.5
Kit Fox	0.5	1.0	1.0	1.0	3.5
Spring Valley	1.1	1.2	4.4	1.6	10.1
Local, 37 ft above base of Sentinel Butte	3	3	3	3	1.1
Red Dog	3	3	3	3	1.9
Mary Springs	3	3	3	3	1.6
Shell	3	3	3	3	39.1
Hummel	3	3	3	3	4.2
Totals	2.8	1.2	2.3	1.6	25.5
T. 135 N., R. 93 W. (fractional)	4.7	4.7	4.7	4.7	4.7
Heart Butte	0.8	1.1	3.7	3.7	2.6
Kit Fox	0.8	1.1	3.7	3.7	2.6
Spring Valley	1.1	1.2	4.4	1.6	8.0
Local	3	3	3	3	2.9
Red Dog	9	1.8	31.0	31.0	35.7
Mary Springs	7	6	2.0	1.8	20.1
Hummel	7	4	2.5	8	23.2
Shell	7	4	2.5	8	23.2
Totals	3.4	1.0	11.1	2.6	82.0
T. 135 N., R. 94 W. (fractional)	0.5	0.5	0.5	0.5	10.9
Discovery	0.7	1.6	6.0	6.0	3.3
Heart Butte	1.7	4.3	28.8	28.8	34.8
Kit Fox	1.7	4.3	28.8	28.8	16.0
Spring Valley	1.7	4.3	28.8	28.8	25.0
Local	1.7	4.3	28.8	28.8	76.8
Spring Valley	1.1	1.2	4.4	1.6	7.7
Local (HTT)	1.2	3.3	3.3	3.3	12.4
Red Dog	5	1.1	3.9	3.9	5.5
Shell	5	1.1	3.9	3.9	52.7
Totals	1.7	1.4	3.3	3.3	41.5
T. 136 N., R. 92 W. (fractional)	1.9	1.1	9.9	22.5	35.4
Heart Butte	1.9	1.1	9.9	22.5	35.4
Kit Fox	1.9	1.1	9.9	22.5	35.4
Spring Valley	1.9	1.1	9.9	22.5	35.4
Local	1.9	1.1	9.9	22.5	20.1
Red Dog	1.9	1.1	9.9	22.5	27.0
Shell	1.9	1.1	9.9	22.5	27.0
Totals	4.8	3.2	18.7	1.8	68.5
T. 136 N., R. 94 W. (fractional)	0.7	1.6	6.0	6.0	3.3
Discovery	0.7	1.6	6.0	6.0	13.5
Heart Butte	0.7	1.6	6.0	6.0	37.0
Kit Fox	1.0	4.0	10.0	6.6	11.6
Totals	3.4	9.9	38.1	28.1	71.4
T. 137 N., R. 93 W. (fractional)	2.6	2.6	2.6	2.6	2.6
Heart Butte	1.3	2.4	3.0	3.0	3.7
HT Walker bed	1.3	2.4	3.0	3.0	4.3
Red Dog	1.3	2.4	3.0	3.0	5.7
Mary Springs	1.3	2.4	3.0	3.0	33.0
Koehler	1.3	2.4	3.0	3.0	33.0
Schank or Hummel	1.3	2.4	3.0	3.0	33.0
Shell	1.3	2.4	3.0	3.0	33.0
Hummel	1.3	2.4	3.0	3.0	18.7
Gunche	1.3	2.4	3.0	3.0	27.0
Totals	10.4	11.2	120.2	123.3	154.1
T. 137 N., R. 93 W. (fractional)	0.5	0.5	0.5	0.5	0.5
Discovery	0.4	4.6	0.5	0.5	12.0
Heart Butte	10.6	3.2	1.0	1.0	21.8
Kit Fox	2.2	2.2	2.2	2.2	2.2
Spring Valley	2.2	2.2	2.2	2.2	11.5
HT Butte	2.2	2.2	2.2	2.2	3.6
Shell	2.2	2.2	2.2	2.2	67.2
Schank and (or) Hummel	2.2	2.2	2.2	2.2	33.6
Totals	21.1	16.1	115.2	115.2	152.4
T. 137 N., R. 94 W. (fractional)	0.8	1.3	2.4	4.7	3.3
Discovery	0.8	1.3	2.4	4.7	8.2
Heart Butte	1.0	2.0	11.4	11.4	14.6
Spring Valley	1.0	2.0	11.4	11.4	24.8
Totals	2.6	1.3	8.6	16.1	35.8
T. 138 N., R. 92 W. (fractional)	6.6	6.6	6.6	6.6	6.6
Spring Valley	4.4	9	3.0	3.0	4.4
W Walker bed	1.0	1.0	1.0	1.0	1.0
Discovery	5	3.3	3.0	3.0	3.8
Red Dog	4.5	2.6	1.4	1.4	8.5
Koehler	6	4.1	15.0	19.7	19.7
F Kit Fox bed	2.2	8.9	49.7	49.7	14.2
SV Spring Valley bed	3.1	3.1	10.5	28.7	42.4
T Turtle bed	3.1	3.1	10.5	28.7	42.4
HT HT Butte bed	3.1	3.1	10.5	28.7	42.4
B Beaver Creek bed	3.1	3.1	10.5	28.7	42.4
R Red Dog bed	3.1	3.1	10.5	28.7	42.4
M Many Springs bed	3.1	3.1	10.5	28.7	42.4
K Koehler bed	3.1	3.1	10.5	28.7	42.4
L Local bed	3.1	3.1	10.5	28.7	42.4
S Schank bed horizon	3.1	3.1	10.5	28.7	42.4
HT Hummel bed	3.1	3.1	10.5	28.7	42.4
S Schank bed horizon	3.1	3.1	10.5	28.7	42.4
Local, about 215 ft below Tongue River	3.1	3.1	10.5	28.7	42.4
S Sentinel Butte contact	3.1	3.1	10.5	28.7	42.4
S Sentinel Butte contact	3.1	3.1	10.5	28.7	42.4
S Sentinel Butte contact	3.1	3.1	10.5	28.7	42.4
Totals	18.1	1.1	4.0	1.3	64.2
T. 138 N., R. 94 W. (fractional)	10.5	10.5	10.5	10.5	10.5
Spring Valley	4.4	4.4	4.4	4.4	5.8
Red Dog	4.4	4.4	4.4	4.4	5.8
Local, 155 ft below Tongue River	4.4	4.4	4.4	4.4	7.4
Local, about 215 ft below Tongue River	4.4	4.4	4.4	4.4	7.4
S Sentinel Butte contact	4.4	4.4	4.4	4.4	7.4
S Sentinel Butte contact	4.4	4.4	4.4	4.4	7.4
S Sentinel Butte contact	4.4	4.4	4.4	4.4	7.4
Totals	80.6	10.0	104.8	12.7	724.8
Grand Totals	80.6	10.0	104.8	12.7	724.8

<sup>1</sup> To convert short tons to metric tons, multiply short tons by 0.9072.  
<sup>2</sup> To convert feet to meters, multiply by 0.3048.  
<sup>3</sup> These beds are known in test holes at some distance from this township, and it is inferred that one or more of the other underlies the western and southwestern parts of T. 137 N., R. 92 W.

**COAL RESOURCES**

The resources are reported in three separate classes—measured, indicated, and inferred, based on the relative abundance of reliable information. Measured resources are within one-fourth mile (402 meters) of an outcrop or drill-hole measurement. The computed tonnage is expected to be within 20 percent of the true value. Where beds have a relatively uniform thickness and a high degree of continuity, a half-mile (805 meters) width from outcrops is used. Indicated resources are generally within half a mile of an outcrop or drill-hole measurement and outside the area of measured reserves, but a band as much as 2 miles (3.219 meters) from outcrops was used in areas of uniform widespread beds. Inferred resources are computed from less data, are outside the area of indicated reserves, and lie farther from measured points. These parameters are based on a broad general knowledge of the geology and the coal beds.

Using outcrop measurements and drill-hole information, an estimate was made on all beds on which data were available. Coal thicknesses used are equivalent thicknesses (Bass and others, 1970, p. 6). The area underlain by each class was measured by a planimeter, the volume in acre-feet was determined for each class, and tonnages were calculated using a factor of 1,750 tons per acre-foot (12,870 metric tons per hectare meter or 1,287 kilograms per cubic meter) of coal.

Coal resources in the White Butte quadrangles are estimated to be 1,052,500,000 tons (955 x 10<sup>6</sup> metric tons) in beds 2.5-10 feet (0.76-3.05 meters) thick within 1,000 feet (305 meters) of the surface. About 3 percent of the coal resources are in 7 beds that do not crop out. Four of these beds contain 47 percent of the total resources, and they are 180-710 feet (55-216 meters) below the top of the Tongue River Member or from 100 to 1,000 feet (30 to 305 meters) below the ground surface. Of the 11 beds that do crop out, two beds, Heart Butte and Spring Valley, contain 24 percent of the coal resources. Although the total coal resources in the four quadrangles are large, the widespread occurrences of the beds, over an area of 205 square miles (531 square kilometers) and throughout as much as 1,000 feet (305 meters) stratigraphic section, reduce the importance of the resources to the extent that exploitation is many years in the future. Distribution of the resources by bed and by class for each township or fractional part of a township is shown in table 2. The estimated coal resources by township and coal bed in the White Butte quadrangles are given in table 3.

None of the lignite deposits in these quadrangles are considered as potentially stripable. The near-surface beds rarely reach the minimum thickness of 5 feet (1.5 meters) that is generally considered to be necessary for commercial strip mining, and the deeper, thicker beds have a strip ratio of more than 10 to 1 that is sometimes mentioned as the maximum for a profitable operation (Kerferle and Culbertson, 1955, p. 148-149).

**TABLE 3. - Estimated coal resources in the White Butte quadrangles**  
(In millions of short tons)

Coal bed	Measured (ft) <sup>1</sup>	Inferred (ft) <sup>2</sup>	Inferred (ft) <sup>3</sup>	Inferred (ft) <sup>3</sup>	Total
Discovery	2.9	2.9	4.0	4.0	13.8
WD (local)	1.9	1.9	2.0	2.0	13.5
Heart Butte	23.0	1.1	24.1	24.1	96.2
Kit Fox	4.7	1.9	7.4	7.4	27.1
Spring Valley	4.6	3.3	16.8	15.3	39.2
Local	1.6	4.0	4.0	4.0	18.1
HT Butte	5.8	1.2	7.0	4.5	7.9
Red Dog	1.8	1.2	4.5	3.3	12.1
Beaver Creek	3.6	1.1	4.7	11.4	13.7
Red Dog	3.6	1.1	4.7	11.4	13.7
Koehler	3.6	1.1	4.7	11.4	13.7
Schank	3.6	1.1	4.7	11.4	13.7
Shell	3.6	1.1	4.7	11.4	13.7
Hummel	3.6	1.1	4.7	11.4	13.7
Gunche	3.6	1.1	4.7	11.4	13.7
Totals	81.6	8.7	90.3	105.9	119.8

<sup>1</sup> To convert short tons to metric tons, multiply short tons by 0.9072.  
<sup>2</sup> To convert feet to meters, multiply