

DESCRIPTION OF MAP UNITS

- Qa** ALLUVIUM (HOLOCENE) - Silt, sand, clay, and a small amount of pebble gravel
- Qh** TERRACE DEPOSITS - Silt and sand and a small amount of gravel
- Qc** HOLOCENE AND PLEISTOCENE - About 5-20 feet above Thyrmy Creek. Deposits grade into alluvium
- Tc** 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; lower part, grayish-yellow bentonitic and conglomeratic sandstone, 4-23 feet thick. Fluvial and lacustrine deposits
- Tg** GOLDEN VALLEY FORMATION (Eocene and Paleocene) - Siltsstone and claystone, light-gray-olive, grayish-yellow, and grayish-buff to pale-red; a few areas are weathered to pale olive and shades of green; 0-10 feet thick. Siltsstone and sandstone, light-gray to white, kaolinitic, clayey; orange stain along joints and a few beds, 0-45 feet thick. Fluvial, lacustrine and paludal deposits
- Ts** SENTINEL BUTTE MEMBER OF FORT UNION FORMATION (PALEOCENE) - Upper unit, sandstone, yellowish-gray, very fine grained to medium-grained, massive, friable, crossbedded, clean, 50-90 feet thick. Middle unit, sandstone, yellowish-gray, very fine to fine-grained, interbedded with thin dark-green-gray to medium-dark-gray siltsstone and claystone, siltified siltsstone and sandstone, and lignite, 185-210 feet thick. Lower unit, dark-gray siltstone interbedded with light-olive-gray and dark-yellowish-orange silty claystone, brown carbonaceous claystone and siltsstone, yellowish-gray sandstone, bentonitic, and lignite, contains siltified wood and places siltified lignite, 25-50 feet thick, not exposed in map area. Fluvial, lacustrine and paludal deposits

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 RESOURCES

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 fourth mile (402 meters) of an outcrop or drill-hole measurement. The estimated coal 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 this 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 to 10 feet (0.76 to 3.05 meters) thick within 1,000 feet (305 meters) of the surface. About 53 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 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) of 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 township for each township or fractional part of a township is shown in table 2. The estimated coal resources by beds 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 economical 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 (Kepfert and Culbertson, 1955, p. 148-149).

PHYSICAL AND CHEMICAL PROPERTIES

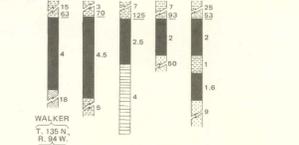
No coal analyses are available from the White Butte quadrangles but the results of analyses on six samples from drill holes in the Clark Butte quadrangles are given in table 1 (Smith, 1970, p. 4-17).

The lignite is hard and brittle and generally cracks in air. It is mainly arid and contains a small amount of pyritine lenses and some fusain. Jarosite, pyrite, gypsum, and partings of claystone, siltsstone, and siltified coal occur in some beds. Laterally the coal may vary considerably in thickness within short distances or may change in part or entirely to brown carbonaceous siltsstone or claystone.

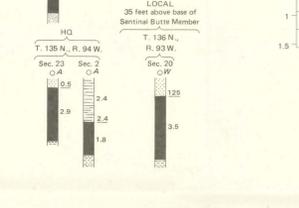
EXPLANATION OF LINE SYMBOLS

- HO-22** 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
- QUARTZITE BEDS AND BLOCKS - Material potentially valuable as riprap; contains petrified wood fragments and numerous molds of branches, stems, and roots; q. beds in place, dashed where approximately located; r. blocky tuffs or area littered by quartzite blocks
- W(1583)** TEST HOLE - Drilled by North Dakota State Water Commission and U.S. Geological Survey, showing number of hole and depth, in feet in parentheses
- W(1294)** WATER WELL - Showing depth, in feet in parentheses, and reported thickness, in feet, of designated coal bed
- A-2.9** HAND AUGER HOLE - Showing thickness, in feet, of designated coal bed
- W(13)** ABANDONED COAL MINE - Showing thickness, in feet, of designated coal bed

COAL SECTIONS



GENERALIZED SECTION SHOWING STRATIGRAPHIC RELATIONSHIP OF THE COAL BEDS



EXPLANATION

- W** Water well
- A** Hand auger hole
- Locality number of measured surface coal section
- 1** Depth, in feet, to top of coal from ground surface
- Interval omitted

(All stratigraphic measurements shown in feet. For metric equivalent, multiply by 0.3048)

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. Indicated resources are 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.

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TABLE 2.—Estimated coal resources, by township and coal beds, in the White Butte quadrangles, North Dakota

| Lignite bed   | Resources (in millions of short tons) |                            |                           | Totals |
|---|---------------------------------------|----------------------------|---------------------------|--------|
|   | Measured (F) <sup>1</sup>             | Indicated (I) <sup>2</sup> | Inferred (I) <sup>3</sup> |        |
|   | 2.5-5                                 | 5-10                       | 10-25                     |        |
| T. 135 N., R. 92 W. (fractional)                              | 0.5                                   | 1.0                        | 1.0                       | 2.5    |
| Spring Valley   | 1.1                                   | 4.4                        | 1.6                       | 10.1   |
| Local, 37 ft above base of Sentinel Butte                     | 3                                     | 8                          | 1.9                       | 1.1    |
| Red Dog   | 3                                     | 1.1                        | 1.9                       | 1.9    |
| Many Springs  | 5                                     | 1.1                        | 1.6                       | 1.6    |
| Shell   | 16                                    | 2.5                        | 3.1                       | 39.1   |
| Hummel  | 4                                     | 4.2                        | 4.2                       | 4.2    |
| Totals  | 2.4                                   | 1.2                        | 7.3                       | 1.6    |
| T. 136 N., R. 93 W. (fractional)                              | 0.5                                   | 1.0                        | 2.5                       | 22.5   |
| Heart Butte   | 0.8                                   | 1.1                        | 3.7                       | 5.6    |
| Kit Fox   | 3                                     | 8                          | 1.8                       | 2.9    |
| Local   | 9                                     | 1.8                        | 31.0                      | 33.7   |
| Red Dog   | 7                                     | 2.0                        | 12.4                      | 20.1   |
| Hummel  | 7                                     | 4                          | 2.3                       | 2.2    |
| Totals  | 3.4                                   | 1.5                        | 11.1                      | 2.6    |
| T. 137 N., R. 92 W. (fractional)                              | 0.5                                   | 1.0                        | 8.2                       | 4.8    |
| Discovery   | 0.5                                   | 1.0                        | 1.0                       | 0.5    |
| Heart Butte   | 1.7                                   | 4.3                        | 28.8                      | 34.8   |
| Kit Fox   | 1.0                                   | 16.0                       | 16.0                      | 16.0   |
| Spring Valley   | 2.5                                   | 25.0                       | 25.0                      | 25.0   |
| Totals  | 1.7                                   | 2.2                        | 70.3                      | 5      |
| T. 138 N., R. 93 W. (fractional)                              | 0.5                                   | 1.0                        | 2.5                       | 7.7    |
| Spring Valley   | 1.2                                   | 2.2                        | 4.1                       | 4.1    |
| Local (HT)  | 1.2                                   | 3.3                        | 7.9                       | 12.4   |
| Red Dog   | 1.0                                   | 3.9                        | 5.2                       | 5.2    |
| Shell   | 19.1                                  | 33.6                       | 32.7                      | 32.7   |
| Totals  | 1.7                                   | 1.4                        | 3.3                       | 27.1   |
| T. 136 N., R. 92 W. (fractional)                              | 0.5                                   | 1.0                        | 22.5                      | 35.4   |
| Heart Butte   | 1.9                                   | 9.9                        | 27.1                      | 35.4   |
| Kit Fox   | 1.2                                   | 1.3                        | 0.9                       | 2.5    |
| Spring Valley   | 1.1                                   | 3.0                        | 6.9                       | 7.5    |
| Local   | 2.4                                   | 16.7                       | 16.7                      | 20.1   |
| Red Dog   | 4                                     | 1.4                        | 2.7                       | 4.5    |
| Guinch  | 3                                     | 2.4                        | 24.9                      | 27.0   |
| Totals  | 4.8                                   | 3.2                        | 1.8                       | 68.5   |
| T. 136 N., R. 94 W. (fractional)                              | 0.7                                   | 1.6                        | 1.0                       | 3.3    |
| Discovery   | 0.7                                   | 1.6                        | 1.0                       | 1.0    |
| Kit Fox   | 2                                     | 12.5                       | 16.4                      | 16.4   |
| Heart Butte   | 8                                     | 2.3                        | 37.0                      | 40.1   |
| Kit Fox   | 4                                     | 4.0                        | 24.9                      | 26.4   |
| Totals  | 3.4                                   | 9.9                        | 58.1                      | 71.4   |
| T. 137 N., R. 92 W. (fractional)                              | 2.6                                   | 2.6                        | 2.6                       | 2.6    |
| Heart Butte   | 1.3                                   | 2.4                        | 3.3                       | 1.3    |
| Red Dog   | 4                                     | 4                          | 4                         | 4.3    |
| Many Springs  | 3                                     | 4                          | 5.0                       | 5.7    |
| Koehler   | 6                                     | 4.1                        | 15.0                      | 18.7   |
| Schank or Hummel  | 4.5                                   | 2.6                        | 14.4                      | 8.5    |
| Schank  | 2.2                                   | 5.9                        | 49.7                      | 57.8   |
| Hummel  | 5                                     | 1.6                        | 16.6                      | 18.7   |
| Guinch  | 1.8                                   | 12.9                       | 12.3                      | 27.0   |
| Totals  | 10.4                                  | 11.2                       | 120.2                     | 123    |
| T. 137 N., R. 93 W. (fractional)                              | 0.5                                   | 0.5                        | 0.5                       | 0.5    |
| Discovery   | 0.5                                   | 4.6                        | 12.0                      | 12.0   |
| Heart Butte   | 10.4                                  | 9.0                        | 3.2                       | 21.9   |
| Kit Fox   | 2.2                                   | 2.2                        | 2.2                       | 2.2    |
| Spring Valley   | 9                                     | 1.2                        | 1.5                       | 11.5   |
| Shell   | 9                                     | 6.7                        | 6.7                       | 67.2   |
| Hummel  | 3.6                                   | 3.6                        | 3.6                       | 33.6   |
| Totals  | 21.1                                  | 16.1                       | 115.2                     | 152.4  |
| T. 137 N., R. 94 W. (fractional)                              | 0.8                                   | 2.4                        | 3.2                       | 3.2    |
| Discovery   | 0.8                                   | 2.4                        | 4.7                       | 8.3    |
| Spring Valley   | 3                                     | 1.3                        | 2.0                       | 11.4   |
| HT  | 5                                     | 2.0                        | 4.4                       | 4.4    |
| HT Butte  | 5                                     | 2.2                        | 2.7                       | 2.7    |
| Totals  | 2.6                                   | 1.3                        | 8.6                       | 28.6   |
| T. 138 N., R. 92 W. (fractional)                              | 6.1                                   | 6.1                        | 6.1                       | 6.6    |
| Spring Valley   | 4.4                                   | 4.4                        | 4.4                       | 4.4    |
| Beaver Creek  | 1.0                                   | 3.3                        | 3.0                       | 3.8    |
| Red Dog   | 5                                     | 4.1                        | 15.0                      | 18.7   |
| Many Springs  | 4.5                                   | 2.6                        | 14.4                      | 8.5    |
| Koehler   | 6                                     | 4.1                        | 15.0                      | 18.7   |
| Schank  | 4.5                                   | 2.6                        | 14.4                      | 8.5    |
| Hummel  | 8                                     | 3                          | 21.0                      | 28.7   |
| Totals  | 11.0                                  | 8                          | 10.3                      | 21     |
| T. 138 N., R. 93 W. (fractional)                              | 1.4                                   | 1.4                        | 1.4                       | 1.4    |
| Discovery   | 1.4                                   | 1.4                        | 1.4                       | 1.4    |
| Heart Butte   | 5.4                                   | 5.4                        | 5.4                       | 5.4    |
| Spring Valley   | 4.4                                   | 4.4                        | 4.4                       | 4.4    |
| HT Butte  | 1.1                                   | 1.1                        | 1.1                       | 4.0    |
| Red Dog   | 1.1                                   | 1.4                        | 1.3                       | 4.9    |
| Koehler   | 1.1                                   | 1.4                        | 1.3                       | 8.3    |
| Local, 155 ft below Sentinel Butte contact                    | 1                                     | 1.5                        | 10.0                      | 11.6   |
| Local, about 215 ft below Tongue River                        | 1.3                                   | 1.3                        | 1.3                       | 1.3    |
| Sentinel Butte contact  | 6.5                                   | 6.5                        | 6.5                       | 6.5    |
| Hummel  | 1.8                                   | 1.8                        | 21.2                      | 24.0   |
| Totals  | 18.1                                  | 1.1                        | 4.0                       | 13.2   |
| T. 138 N., R. 94 W. (fractional)                              | 10.5                                  | 10.5                       | 10.5                      | 10.5   |
| Spring Valley   | 10.5                                  | 10.5                       | 10.5                      | 10.5   |
| Red Dog   | 4.4                                   | 1.4                        | 5.8                       | 5.8    |
| Local, 155 ft below Tongue River-Sentinel Butte contact       | 7.4                                   | 7.4                        | 7.4                       | 7.4    |
| Local, about 215 ft below Tongue River-Sentinel Butte contact | 7.6                                   | 7.6                        | 7.6                       | 7.6    |
| Totals  | 29.9                                  | 1.4                        | 31.3                      | 31.3   |
| Grand Totals  | 80.6                                  | 10.0                       | 104.8                     | 12.7   |

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

| Source of sample and depth (feet)  | Moisture | Volatile matter | Fixed carbon | Ash  | Sulfur | Heating value (Btu/lb) |
|--|----------|-----------------|--------------|------|--------|------------------------|
| Drill hole 1: NENSWENEN sec. 4, T. 135 N., R. 90 W., Many Springs bed, 180-184-185.5       | 37.9     | 26.5            | 28.1         | 7.3  | 1.8    | 4,728                  |
| Drill hole 2: SWNWENEN sec. 4, T. 135 N., R. 91 W., Heart Butte bed, 178-180 and 184-185.5 | 45.7     | 45.2            | 12.1         | 1.4  | 18,910 |                        |
| Drill hole 3: SWNWENEN sec. 4, T. 135 N., R. 91 W., Heart Butte bed, 178-180 and 184-185.5 | 40.3     | 26.1            | 24.0         | 7.4  | 18,200 |                        |
| Drill hole 4: SWNWENEN sec. 4, T. 135 N., R. 91 W., Heart Butte bed, 178-180 and 184-185.5 | 17.8     | 36.0            | 33.9         | 10.3 | 10,490 |                        |
| Drill hole 5: SWNWENEN sec. 4, T. 135 N., R. 91 W., Heart Butte bed, 178-180 and 184-185.5 | 31.1     | 34.3            | 14.8         | 1.3  | 8,960  |                        |
| Drill hole 6: SWNWENEN sec. 36, T. 136 N., R. 92 W., Many Springs bed, 294-307.8           | 38.3     | 39.1            | 49.9         | 1.9  | 10,070 |                        |
| Drill hole 7: SWNWENEN sec. 36, T. 136 N., R. 92 W., Many Springs bed, 294-307.8           | 18.0     | 36.1            | 36.0         | 9.9  | 8,870  |                        |
| Drill hole 8: SWNWENEN sec. 36, T. 136 N., R. 92 W., Many Springs bed, 294-307.8           | 46.0     | 44.0            | 12.0         | 0.8  | 12,350 |                        |
| Drill hole 9: SWNWENEN sec. 22, T. 138 N., R. 90 W., Spring Valley bed, 107.8-114.2        | 34.8     | 29.3            | 22.0         | 19.7 | 3,810  |                        |
| Drill hole 10: SWNWENEN sec. 22, T. 138 N., R. 90 W., Spring Valley bed, 107.8-114.2       | 30.4     | 28.4            | 23.8         | 5.0  | 7,250  |                        |
| Drill hole 11: SWNWENEN sec. 22, T. 138 N., R. 90 W., Spring Valley bed, 107.8-114.2       | 36.1     | 33.7            | 30.2         | 8.8  | 6,450  |                        |
| Drill hole 12: SWNWENEN sec. 22, T. 138 N., R. 90 W., Spring Valley bed, 107.8-114.2       | 48.1     | 48.1            | 10.1         | 8.3  | 12,100 |                        |
| Average  | 37.4     | 35.3            | 25.3         | 11.8 | 1.6    | 6,187                  |
|  | 34.4     | 30.4            | 28.4         | 23.8 | 5.0    | 7,250                  |
|  | 40.5     | 40.0            | 18.4         | 2.3  | 2.9    | 12,913                 |
|  | 49.0     | 50.1            | 3.2          | 13.7 | 1.0    | 12,913                 |

<sup>1</sup>To convert feet to meters, multiply by 0.3048.  
<sup>2</sup>A, as measured; B, as dried; C, moisture from D, moisture and ash free.  
<sup>3</sup>Area from 1 to 6, as dried; moisture from 1, 18,000; D, 10,000.

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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. Indicated resources are 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.

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TABLE 2.—Estimated coal resources, by township and coal beds, in the White Butte quadrangles, North Dakota

| Lignite bed |
|-------------|
|-------------|