UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

TEXT TO ACCOMPANY:

COAL RESOURCE OCCURRENCE

AND

COAL DEVELOPMENT POTENTIAL

MAPS

OF THE

TWENTYMILE BUTTE QUADRANGLE,

CAMPBELL COUNTY, WYOMING

BY

INTRASEARCH INC.

DENVER, COLORADO

OPEN FILE REPORT 79-034
1979

TABLE OF CONTENTS

TABLE OF CONTENTS (continued)

TABLE OF CONTENTS (continued)

CONVERSION TABLE

TO CONVERT	MULTIPLY BY	TO OBTAIN
inches	2.54	centimeters (cm)
feet	0.3048	meters (m)
miles	1.609	kilometers (km)
acres	0.40469	hectares (ha)
tons (short)	0.9072	metric tons (t)
cubic yards/ton	0.8428	cubic meters per metric tons
acre feet	0.12335	hectare-meters
Btu/lb	2.326	kilojoules/kilogram (kJ/kg)
Btu/lb	0.55556	kilocalories/kilogram (kcal/kg)
Fahrenheit	5/9 (F-32)	Celsius

I. Introduction

This report and accompanying maps set forth the Coal Resource Occurrence (CRO) and Coal Development Potential (CDP) of coal beds within the Twentymile Butte Quadrangle, Campbell County, Wyoming. This CRO and CDP map series (U. S. Geological Survey Open-File Report 79-034) includes 40 plates. The project is compiled by IntraSearch Inc., 5351 South Roslyn Street, Englewood, Colorado, under KRCRA Eastern Powder River Basin, Wyoming Contract Number 14-08-0001-17180. This contract is part of a program to provide an inventory of unleased federal coal in Known Recoverable Coal Resource Areas (KRCRAs) in the western United States.

The Twentymile Butte Quadrangle is located in Campbell County, in northeastern Wyoming. It encompasses parts of Townships 51 and 52 North, Ranges 74 and 75 West, and covers the area: 44°22'30" to 44°30' north latitude; 105°45' to 105°52'30" west longitude.

Main access to the Twentymile Butte Quadrangle is provided by Echeta Road which trends northwest to southeast across the southern two-thirds of the study area. Minor roads and trails that branch from this maintained light-duty road provide additional access to the more remote areas. Gillette, Wyoming is located approximately 18 miles (29 km) to the southeast of the quadrangle on Echeta Road. The closest railroad is the Burlington Northern trackage which parallels Echeta Road across the southern two-thirds of the study area.

Drainage patterns generate from the high, rugged relief of Twentymile Butte located in a topographic high which extends northwest to southeast across the northern two-thirds of the study area.

Elevations attain heights of 4759 feet (1451 m) above sealevel, 650 to 750 feet (198 to 228 m) above the valley floors to the west and north. This ridge divides the drainage of the quadrangle into northeastern and southeastern portions. The most significant drainage of the quadrangle is provided by northwest-flowing Wild Horse Creek which meanders across the southern two-thirds of the quadrangle, draining the area to the southwest of Twentymile Butte. Northwest-flowing Twentymile Creek drains the area to the northeast of Twentymile Butte. Rough Creek, Mooney Draw, Barker Draw, and numerous intermittent streams supplement the drainage throughout the quadrangle. Wild Horse Creek and Twentymile Creek drain into the Powder River, approximately 15 miles (24 km) to the northwest. The somber grays, yellows, and browns of outcropping shales and siltstones contrast strikingly with the brilliant reds, oranges, and purples of "clinker," and deep greens of the juniper and pine tree growth.

The 12 to 14 inches (30 to 36 cm) of annual precipitation falling in this semi-arid region accrue principally in the springtime. Summer and fall precipitation usually originates from thunderstorms, and infrequent snowfalls of 6 inches (15 cm) or less generally characterize winter precipitation. Although temperatures ranging from less than -25°F (-32°C) to more than 100°F (38°C) have been recorded near Gillette, Wyoming, average wintertime minimums and summertime maximums range from +5° to +°15F (-15° to -9°C) and 75° to 90°F (24° to 32°C), respectively.

Surface ownership is divided among fee, state, and federal categories with the state and federal surface generally leased to ranchers for grazing purposes. Details of surface ownership are available at the Campbell County Courthouse in Gillette, Wyoming. Details of mineral ownership on federal lands are available from the U. S. Bureau of Land

Management in Cheyenne, Wyoming. Federal coal ownership is shown on Plate 2 of the Coal Resource Occurrence maps. The non-federal coal ownership comprises both fee and state coal resources.

The Coal Resource Occurrence and Coal Development Potential program pertains to unleased federal coal and focuses upon the delineation of lignite, subbituminous coal, bituminous coal, and anthracite at the surface, and in the subsurface. In addition, the program identifies total tons of coal in place, as well as recoverable tons. These coal tonnages are then categorized into units of measured, indicated, and inferred reserves and resources, and hypothetical resources. Finally, recommendations are made regarding the potential for surface mining, underground mining, and in-situ gasification of the coal beds. This report evaluates the coal resources of all unleased federal coal beds in the quadrangle which are 5 feet (1.5 m) or greater in thickness and occur at depths down to 3000 feet (914 m). No resources or reserves are computed for leased federal coal, state coal, fee coal, or lands encompassed by coal prospecting permits and preference-right lease applications.

Surface and subsurface geological and engineering extrapolations drawn from the current data base suggest the occurrence of approximately 11.2 billion tons (10.2 billion metric tons) of unleased federal coal resources in the Twentymile Butte Quadrangle.

The suite of maps that accompany this report sets forth and portrays the coal resource and reserve occurrence in considerable detail. For the most part, this report supplements the cartographically displayed information with minimum verbal duplication of the CRO-CDP map data.

II. Geology

Regional. The thick, economic coal deposits of the Powder River Basin in northeastern Wyoming occur mostly in the Tongue River Member of the Fort Union Formation, and in the lower part of the Wasatch Formation. Approximately 3000 feet (914 m) of the Fort Union Formation, including the Tongue River, Lebo, and Tullock Members of Paleocene age, are unconformably overlain by approximately 700 feet (213 m) of the Wasatch Formation of Eocene age. These Tertiary formations lie in a structural basin flanked on the east by the Black Hills uplift, on the south by the Hartville and Casper Mountain uplifts, and on the west by the Casper Arch and the Big Horn Mountain uplift. The structural configuration of the Powder River Basin originated in Late Cretaceous time, with episodic uplift thereafter. The Cretaceous Cordillera was the dominant positive land form throughout the Rocky Mountain area at the close of Mesozoic time.

Outcrops of the Wasatch Formation and the Tongue River Member of the Fort Union Formation cover most of the areas of major coal resource occurrence in the Powder River Basin. The Tongue River Member is composed of very fine-grained sandstones, siltstones, claystones, shales, carbonaceous shales, and numerous coal beds. The Lebo Member of the Fort Union Formation consists of light- to dark-gray very fine-grained to conglomeratic sandstone with interbedded siltstone, claystone, carbonaceous shale and thin coal beds. Thin bedded calcareous ironstone concretions interbedded with massive white sandstone and slightly bentonitic shale occur throughout the unit (Denson and Horn, 1975). The Lebo Member is mapped at the surface northeast of Recluse, Wyoming. Here, the Lebo Member is east of the principal coal outcrops and associated clinkers (McKay, 1974), and it presumably projects into the

subsurface beneath much of the basin. One of the principal characteristics for separating the Lebo and Tullock Members (collectively referred to as the Ludlow Member east of Miles City, Montana) from the overlying Tongue River Member is the color differential between the lighter-colored upper portion and the somewhat darker lower portion (Brown, 1958). Although geologists are trying to develop criteria for subsurface recognition of the Lebo-Tullock and Tongue River-Lebo contacts through the use of subsurface data from geophysical logs, no definitive guidelines are known to have been published. Hence, for subsurface mapping purposes, the Fort Union Formation is not divided into its members for this study.

During the Paleocene epoch, the Powder River Basin tropical to subtropical depositional environment included broad, inland flood basins with extensive swamps, marshes, freshwater lakes, and a sluggish, but active, northeastward-discharging drainage system. These features were superimposed on an emerging sea floor, near base level. Much of the vast area where organic debris collected was within a reducing depositional environment. Localized uplifts began to disturb the near sea-level terrain of northeastern Wyoming following retreat of the Cretaceous seas. However, the extremely fine-grained characteristics of the Tongue River Member clastics suggest that areas of recurring uplift peripheral to the Powder River Basin were subdued during major coal deposit formation.

The uplift of areas surrounding the Powder River Basin created a structural basin of asymmetric character, with the steep west flank located on the eastern edge of the Big Horn Mountains. The axis of the Powder River Basin is difficult to specifically define, but it is

thought to be located in the western part of the Basin and to display a north-south configuration some 15 to 20 miles (24 to 32 km) east of Sheridan, Wyoming. Thus, the sedimentary section described in this report lies on the east flank of the Powder River Basin, with gentle dips of two degrees or less disrupted by surface structure thought to relate to tectonic adjustment and differential compaction.

Some coal beds in the Powder River Basin exceed 200 feet (61 m) in thickness. Deposition of these thick, in-situ coal beds requires a delicate balance between subsidence of the earth's crust and in-filling by tremendous volumes of organic debris. These conditions in concert with a favorable ground water table, non-oxidizing clear water, and a climate amenable to the luxuriant growth of vegetation produce a stabilized swamp critical to the deposition of coal beds.

Deposition of the unusually thick coal beds of the Powder River Basin may be partially attributable to short-distance water transportation of organic detritus into areas of crustal subsidence. Variations in coal bed thickness throughout the basin relate to changes in the depositional environment. Drill hole data that indicate either the complete absence or extreme attenuation of a thick coal bed probably relate to location of the drill holes within the ancient stream channel system draining this lowland area in Early Cenozoic time. Where thick coal beds thin rapidly from the depocenter of a favorable depositional environment, it is not unusual to encounter a synclinal structure over the maximum coal thickness due to the differential compaction between organic debris in the coal depocenter and fine-grained clastics in the adjacent areas.

The Wasatch Formation of Eocene age crops out over most of the central part of the Powder River Basin and exhibits a disconformable contact with the underlying Fort Union Formation. The contact has been placed at various horizons by different workers; however, for the purpose of this report, the contact is positioned near the top of the Roland coal bed as mapped by Olive (1957) in northwestern Campbell County, Wyoming. It is considered to descend disconformably in the stratigraphic column to the top of the Wyodak-Anderson coal bed (Roland coal bed of Taff, 1909) along the eastern boundary of the coal measures. No attempt was made to differentiate the Wasatch and Fort Union Formations on geophysical logs or in the subsurface mapping program for this project.

Although Wasatch and Fort Union lithologies are too similar to allow differentiation in some areas, most of the thicker coal beds occur in the Fort Union section on the east flank of the Powder River Basin. Furthermore, orogenic movements peripheral to the basin apparently increased in magnitude during Wasatch time causing the deposition of friable, coarse-grained to gritty, arkosic sandstones, fine- to very fine-grained sandstones, siltstones, mudstones, claystones, brown-to-black carbonaceous shales, and coal beds. These sediments are noticeably to imperceptibly coarser than the underlying Fort Union clastics.

The Twentymile Butte Quadrangle is located in an area where surface rocks are classified into the Wasatch Formation. Olive (1957) correlated coal beds in the Spotted Horse coal field with coal beds in the Sheridan coal field (Baker, 1929) and Gillette coal field (Dobbin and Barnett, 1927), Wyoming, and with coal beds in the Ashland coal field (Bass, 1932) in southeastern Montana. This report utilizes, where possible, the coal bed nomenclature used in previous reports. The Felix coal bed

was named by Stone and Lupton (1910). Kent (1976) named the Norfolk coal bed and the Smith coal bed was named by Taff (1909). Baker (1929) assigned names to the Anderson, Canyon, and Wall coal beds. The Cook coal bed was named by Bass (1932), and the Pawnee and Cache coal beds were named by Warren (1959).

IntraSearch's correlation of thick coal beds from the Spotted Horse coal field to Gillette points out that the Wyodak coal bed, named the "D" coal bed by Dobbin and Barnett (1927), is equivalent to the Anderson, Canyon, and all or part of the Cook coal beds to the north and west of Gillette, Wyoming. Correlation of this suite of coal beds with the Wyodak coal bed south and southwest of Gillette suggests that the Anderson and Canyon coal beds equate with the upper 10 to 25 percent of the thick Wyodak coal bed, and the Cook and Wall or Upper Wall coal beds are equivalent to the major part of the Wyodak coal bed. Due to problematic correlations outside of the Gillette area, the name Wyodak has been informally used by many previous authors to represent the coal beds in the area surrounding the Wyodak coal mine. The Wildcat, Moyer, and Oedekoven coal beds were informally named by IntraSearch (1978b, 1979, and 1978a).

Local. The Twentymile Butte Quadrangle lies on the eastern flank of the Powder River Basin, where the strata dip gently westward. The Wasatch Formation crops out over the entire quadrangle, and is comprised of friable, coarse-grained to gritty, arkosic sandstones, fine- to very fine-grained sandstones, siltstones, mudstones, claystones, brown-to-black carbonaceous shales, and coal beds. The Fort Union Formation unconformably underlies the Wasatch Formation, and is composed of very fine-grained sandstones, siltstones, claystones, shales, carbonaceous shales, and numerous coal beds.

Structure contours drawn on top of the various coal beds present within the quadrangle indicate a general dip to the west. A minor westward-plunging anticline extends across the northern boundary of the quadrangle accompanied by a similarly plunging syncline low extending into the northwest quarter. A broad westward-plunging anticline extends across the southern two-thirds of the study area.

III. Data Sources

Areal geology of the Felix coal bed outcrop is derived from Allen (1977).

Geophysical logs from oil and gas test bores and producing wells comprise the source of subsurface control. Some geophysical logs are not applicable to this study, for the logs relate only to the deep, potentially productive oil and gas zones. More than 80 percent of the logs include resistivity, conductivity, and self-potential curves. Occasionally the suite of geophysical logs includes gamma, density, and sonic curves. These logs are available from several commercial sources.

All geophysical logs available in the quadrangle are scanned to select those with data applicable to Coal Resource Occurrence mapping. Paper copies of the logs are obtained and interpreted, and coal intervals are annotated. Maximum accuracy of coal bed identification is accomplished where gamma, density, and resistivity curves are available. Coal bed tops and bottoms are picked on the logs at the midpoint between the minimum and maximum curve deflections. The correlation of coal beds within and between quadrangles is achieved utilizing a fence diagram to associate local correlations with regional coal occurrences.

The reliability of correlations, set forth by IntraSearch in this report, varies depending on: the density and quality of lithologic and geophysical logs; the detail, thoroughness, and accuracy of pub-

lished and unpublished surface geological maps; and interpretative proficiency. There is no intent on the part of IntraSearch to refute nomenclature established in the literature or used locally by workers in the area. IntraSearch's nomenclature focuses upon the suggestion of regional coal bed names applicable throughout the eastern Powder River Basin. It is expected, and entirely reasonable, that some differences of opinion regarding correlations, as suggested by IntraSearch, exist. Additional drilling for coal, oil, gas, water, and uranium, coupled with expanded mapping of coal bed outcrops and associated clinkers will broaden the data base for coal bed correlations and allow continued improvement in the understanding of coal bed occurrences in the eastern Powder River Basin.

The topographic map of the Twentymile Butte Quadrangle is published by the U. S. Geological Survey, compilation date 1972. Land network and mineral ownership data are compiled from land plats available from the U. S. Bureau of Land Management in Cheyenne, Wyoming. This information is current to October 13, 1977.

IV. Coal Bed Occurrence

Wasatch and Fort Union Formation coal beds that are present in all or part of the Twentymile Butte Quadrangle include, in descending stratigraphic order, the Felix, Norfolk, Smith, Anderson, Canyon, Cook, Wall, local, Pawnee, Cache, local, Wildcat, Moyer, Oedekoven, and two deep local coal beds. A complete suite of maps (coal isopach, mining ratio where appropriate, structure, overburden/interburden isopach, areal distribution of identified resources, and identified resources), was prepared for the Felix, Smith, Anderson, Canyon, and Cook coal beds and for the Wall-Pawnee and Cache-Wildcat-Moyer-Oedekoven coal zones. Insufficient data and areal extent preclude any detailed mapping of the Norfolk and local coal beds.

Published physical and chemical analyses include the following results for the Felix coal bed in the Twentymile Butte Quadrangle. The general "as received" basis proximate analyses for the deeper coal beds in central and northern Campbell County are as follows:

COAL BED NAME			ASH %	FIXED CARBON %	MOISTURE %	VOLATILES %	SULFUR %	BTU/LB
Felix	(U)	Composite (*)	5.0	33.4	30.9	30.7	0.7	7095
Smith	(U)	Hole 7340	3.505	38.036	29.980	28.474	0.309	8371
Anderson	(U)	Hole 7406	6.317	31.113	32.583	29.986	0.327	7498
Wall	(U)	Hole 7426	9.542	29.322	32.150	28.985	0.500	7279
Pawnee	(U)	Hole 7424	7.880	31.029	31.910	29.183	0.386	7344
Cache	(U)	Hole 741	9.481	30.517	31.420	28.582	0.488	7271

(U) - U. S. Geological Survey and Montana Bureau of Mines and Geology - 1974 and 1976.

(*)- Bohor and others - 1979, Composite sample D178107 - D178109.

In a recent publication, Bohor and others (1979) recognize the presence of the Truman, Parnell, and Daly coal beds in this quadrangle, but do not recognize the Norfolk coal bed as identified by IntraSearch. Their report was published after IntraSearch's study was completed in this quadrangle. IntraSearch was unaware of Bohor and others' investigation, and thus did not use their geologic map in compiling this report. Consequently, outcrop patterns and structural features shown on Bohor and others' (1979) report do not appear in this report, and stratigraphic correlations and nomenclature also differ slightly from those used by Bohor and others (1979).

The Coal Data Sheet, Plate 3, shows the down hole identification of coal beds within the quadrangle as interpreted from geophysical logs from oil and gas test bores, and producing sites. A datum coal bed is utilized to position columnar sections on Plate 3. This portrayal is schematic

by design; hence, no structural or coal thickness implications are suggested by the dashed correlation lines projected through no record (NR) intervals. Inasmuch as the Smith coal bed underlies the entire quadrangle, it is designated as datum for the correlation diagram. All of the coal beds mapped within the Twentymile Butte Quadrangle show a moderately thick to locally thick coal bed occurrence throughout most of the study area.

The Felix coal bed is eroded from 10 percent of the quadrangle along the Wild Horse Creek and Twentymile Creek valleys in the northern and western parts of the quadrangle. The coal bed thickness ranges from 15 to 30 feet (5 to 9 m) with maximum thicknesses occurring in the north-central part of the study area. Structure contours drawn on top of the Felix coal bed indicate a regional dip to the west with a narrow, westward-plunging anticline extending across the northwest quarter of the quadrangle. The Felix coal bed lies from 0 to 600 feet (0 to 183 m) in depth beneath the surface throughout the entire quadrangle. The overburden above the Felix coal bed ranges in thickness from less than 0 feet (0 m) to more than 600 feet (183 m).

The Smith coal bed lies approximately 400 feet (122 m) below the overlying Felix coal bed, and ranges in thickness from 3 to 40 feet (0.9 to 12 m). Maximum thicknesses occur along the northern boundary of the quadrangle, with the coal bed thinning to the south. A localized non-coal interval varies from 0 to 8 feet (0 to 2.4 m) within the Smith coal bed. Structure contours drawn on top of the Smith coal bed indicate a broad, northwest-plunging syncline extending into the central part of the study area. A broad, similarly plunging anticline extends across the southwest corner of the quadrangle. The Smith coal bed occurs from less than 400 feet (122 m) to more than 1100 feet (335 m) beneath the surface.

The Anderson coal bed occurs approximately 15 to 90 feet (5 to 27 m) beneath the Smith coal bed. The coal bed thickness ranges from 20 to 59 feet (6 to 18 m), with maximum thicknesses occurring in the southern half of the study area. A non-coal interval separating the coal bed varies from 6 to 79 feet (1.8 to 24 m). The Anderson coal bed dips gently to the west. A small synclinal feature is present in the northwest quarter of the study area. The Anderson coal bed lies at depths varying from less than 450 feet (137 m) to more than 1400 feet (427 m).

The Canyon coal bed lies approximately 50 to 203 feet (15 to 62 m) below the Anderson coal bed, and ranges in thickness from 7 to 40 feet (2.1 to 12 m). Maximum thicknesses are located in the northwest quarter of the quadrangle. The coal bed thins to the east. A clastic interval locally separates the coal bed and varies from 0 to 46 feet (0 to 14 m) in thickness. Structure contours drawn on top of the Canyon coal bed indicate a regional dip to the west. Two broad, westward-plunging anticlines extend across the southern half and along the northern boundary of the quadrangle. The Canyon coal bed occurs at depths ranging from less than 700 feet (213 m) to more than 1550 feet (472 m) below the surface.

The Cook coal bed occurs approximately 79 to 314 feet (24 to 96 m) beneath the overlying Canyon coal bed, and ranges in thickness from 0 to 25 feet (0 to 8 m). Maximum thicknesses occur in the southwest and northwest quarters of the quadrangle, with the coal bed thinning significantly to the southeast. The Cook coal bed is absent from approximately 5 percent of the study area in the southeast quarter. Structure contours drawn on top of the Cook coal bed indicate a broad, northwestward-plunging anticline extending across the southern three-fourths of the quadrangle. A synclinal low also extends across the northern fourth of the study area.

The overburden above the Cook coal bed varies from less than 900 feet (274 m) to more than 1600 feet (488 m).

The Wall-Pawnee coal zone is separated from the overlying Cook coal bed by approximately 30 to 421 feet (9 to 129 m) of clastic sediments. It is composed of the moderately thick Wall and Pawnee coal beds and a thin local coal bed. The total coal zone thickness ranges from 18 to 100 feet (5 to 31 m) with maximum thicknesses extending from the southwest quarter into the northeast quarter of the quadrangle. The total clastic interval separating the various coal beds comprising the coal zone ranges from 0 to 206 feet (0 to 63 m). The Wall-Pawnee coal zone dips gently to the west. A synclinal low occurs in the northwest quarter of the study area. The Wall-Pawnee coal zone lies at depths varying from less than 1100 feet (335 m) to more than 2000 feet (610 m).

The Cache-Wildcat-Moyer-Oedekoven coal zone lies approximately 90 to 210 feet (27 to 64 m) below the overlying Wall-Pawnee coal zone, and is composed of four to five thin to moderately thick coal beds. The total coal zone thickness ranges from 15 to 65 feet (5 to 20 m). Maximum thicknesses of the coal zone occur along the east-central boundary of the quadrangle with thinning to the northwest. The total clastic interval separating the various coal beds comprising the coal zone varies from 368 to 527 feet (112 to 161 m). Structure contours drawn on top of the Cache-Wildcat-Moyer-Oedekoven coal zone indicate a regional dip to the west. Two broad anticlines extend across the northwest corner and west-central parts of the study area. A small synclinal low is present in the northwest quarter of the quadrangle. The Cache-Wildcat-Moyer-Oedekoven coal zone occurs at depths ranging from less than 1450 feet (442 m) to more than 2350 feet (716 m) below the surface.

V. Geological and Engineering Mapping Parameters

The correct horizontal location and elevation of drill holes utilized in subsurface mapping are critical to map accuracy. Intra-

Search Inc., plots the horizontal location of the drill hole as described on the geophysical log heading. Occasionally this location is superimposed on or near to a drillsite shown on the topographic map, and the topographic map, horizontal location is utilized. If the ground elevation on the geophysical log does not agree with the topographic elevation of the drillsite, the geophysical log ground elevation is adjusted to conformance. If there is no indication of a drillsite on the topographic map, the "quarter, quarter, quarter" heading location is shifted within a small area until the ground elevation on the heading agrees with the topographic map elevation. If no elevation agreement can be reached, the well heading or data sheet is rechecked for footage measurements and ground elevation accuracy. Inquiries to the companies who provided the oil and gas geophysical logs frequently reveal that corrections have been made in the original survey. If all horizontal location data sources have been checked and the information accepted as the best available data, the drillsite elevation on the geophysical log is modified to agree with the topographic map elevation. IntraSearch Inc., considers this agreement mandatory for the proper construction of most subsurface maps, but in particular, the overburden isopach, the mining ratio, and Coal Development Potential maps.

Subsurface mapping is based on geologic data within, and adjacent, to the Twentymile Butte Quadrangle area. Data from geophysical logs are used to correlate coal beds and control contour lines for the coal thickness, structure, and overburden maps. Structure contour maps are constructed on the tops of the main coal beds. Where subsurface data are scarce, supplemental structural control points are selected from the topographic map along coal outcrops.

In preparing overburden isopach maps, no attempt is made to identify coal beds that occur in the overburden above a particular coal bed under study. Mining ratio maps for this quadrangle are constructed utilizing a 95 percent recovery factor. Contours of these maps identify the ratio of cubic yards of overburden to tons of recoverable coal. Where ratio control points are sparse, interpolated points are computed at the intersections of coal bed and overburden isopach contours using coal structure, coal isopach, and topographic control. On the Areal Distribution of Identified Resources Map (ADIR), coal bed reserves are not calculated where the coal is less than 5 feet (1.5 m) thick, where the coal occurs at a depth greater than 500 feet (152 m), where non-federal coal exists, or where federal coal leases, preference-right lease applications, and coal prospecting permits exist.

Coal tonnage calculations involve the planimetering of areas of measured, indicated, inferred reserves and resources, and hypothetical resources to determine their areal extent in acres. An Insufficient Data Line is drawn to delineate areas where surface and subsurface data are too sparse for CRO map construction. Various categories of resources are calculated in the unmapped areas by utilizing coal bed thicknesses mapped in the geologically controlled area adjacent to the insufficient data line. Acres are multiplied by the average coal bed thickness and 1750, or 1770--the number of tons of lignite A or subbituminous C coal per acre-foot, respectively (12,874 or 13,018 metric tons per hectare-meter, respectively), to determine total tons in place. Recoverable tonnage is calculated at 95 percent of the total tons in place. Where tonnages are computed for the CRO-CDP map series, resources and reserves are expressed in millions of tons. Frequently the planimetering of coal resources on a sectionized basis involves complexly curvilinear lines (coal bed outcrop and 500-foot stripping limit

designations) in relationship with linear section boundaries and circular resource category boundaries. Where these relationships occur, generalizations of complexly curvilinear lines are discretely utilized, and resources and/or reserves are calculated within an estimated 2 to 3 percent, plus or minus, accuracy.

VI. Coal Development Potential

Strippable Coal Development Potential. Areas where coal beds are 5 feet (1.5 m) or more in thickness and are overlain by 500 feet (152 m) or less of overburden are considered to have potential for surface mining and are assigned a high, moderate, or low development potential based on the mining ratio (cubic yards of overburden per ton of recoverable coal). The formula used to calculate mining ratios for subbituminous coal is as follows:

$$MR = \frac{to\ (0.911)^*}{tc\ (rf)}$$

where MR = mining ratio
to = thickness of overburden
tc = thickness of coal
rf = recovery factor
0.911*= conversion factor (cu. yds./ton)

*A conversion factor of 0.922 is used for lignite.

A surface mining development potential map (Plate 39) was prepared utilizing the following mining ratio criteria for coal beds 5 to 40 feet (1.5 to 12 m) thick:

1. Low development potential = 15:1 and greater ratio.
2. Moderate development potential = 10:1 to 15:1 ratio.
3. High development potential = 0 to 10:1 ratio.

The following mining ratio criteria are utilized for coal beds greater than 40 feet (12 m) thick:

1. Low development potential = 7:1 and greater ratio.
2. Moderate development potential = 5:1 to 7:1 ratio.
3. High development potential = 0 to 5:1 ratio.

The surface mining potential is high for approximately 75 percent of the Twentymile Butte Quadrangle, and is attributed to low overburden to coal ratios for the Felix coal bed. The high development potential area is concentrated in the northeastern, south-central and west-central areas of the quadrangle. A moderate potential rating covers 10 percent of the quadrangle and is located in scattered areas of the southwestern, southeastern and northwestern portions of the study area. The low potential classification for surface mining methods covers approximately 7 percent of the study area and is concentrated in the southwestern and northwestern quarters of the quadrangle. These ratings can be attributed to the increasing overburden to coal ratios for the Felix and Smith coal beds under areas of high topographic relief. The remaining 8 percent is classified as non-federal coal land and not evaluated for surface mining. Table 1 sets forth the the estimated strippable reserve base tonnages per coal bed for the quadrangle.

Underground Mining Coal Development Potential. Subsurface coal mining potential throughout the Twentymile Butte Quadrangle is considered low. Inasmuch as recovery factors have not been established for the underground development of coal beds in this quadrangle, reserves are not calculated for coal beds that occur more than 500 feet (152 m) beneath the surface. Table 2 sets forth the estimated coal resources in tons per coal bed.

In-Situ Gasification Coal Development Potential. The evaluation of subsurface coal deposits for in-situ gasification potential relates to the occurrence of coal beds more than 5 feet (1.5 m) thick buried from 500 to 3000 feet (152 to 914 m) beneath the surface. This categorization is as follows:

1. Low development potential relates to: 1) a total coal

section less than 100 feet (30 m) thick that lies 1000 feet (305 m) to 3000 feet (914 m) beneath the surface, or 2) a coal bed or coal zone 5 feet (1.5 m) or more in thickness which lies 500 feet (152 m) to 1000 feet (305 m) beneath the surface.

2. Moderate development potential is assigned to a total coal section from 100 to 200 feet (30 to 61 m) thick and buried from 1000 to 3000 feet (305 to 914 m) beneath the surface.

3. High development potential involves 200 feet (61 m) or more of total coal thickness buried from 1000 to 3000 feet (305 to 914 m).

An in-situ gasification map (Plate 40) was prepared using the above criteria. Approximately 70 percent of the Twentymile Butte Quadrangle is rated as moderate potential for in-situ gasification development. The moderate potential rating occurs primarily in the northeastern, west-central and south-central areas of the quadrangle. A high potential rating covers approximately 6 percent of the study area, primarily in the southwest quarter. The low potential rating occurs chiefly in the northwest and southeast quarter of the quadrangle and covers approximately 14 percent of the study area. The remaining 8 percent of the quadrangle is classified as non-federal coal land and not evaluated for in-situ gasification development. The coal resource tonnage totals for in-situ gasification with low, moderate, and high development potential are listed on Table 3.

Table 1.--Strippable Coal Reserve Base and Hypothetical Resource Data (in short tons) for Federal Coal Lands in the Twentymile Butte Quadrangle, Campbell County, Wyoming.

Development potentials are based on mining ratios (cubic yards of overburden/ton of recoverable coal).

Coal Bed	High Development Potential (0-10:1 Mining Ratio)	Moderate Development Potential (10:1-15:1 Mining Ratio)	Low Development Potential (>15:1 Mining Ratio)	Total
RESERVE BASE TONNAGE				
Felix	868,590,000	186,950,000	31,380,000	1,086,920,000
Smith	5,250,000	69,310,000	54,420,000	128,980,000
	(0-5:1 Mining Ratio)	(5:1-7:1 Mining Ratio)	(>7:1 Mining Ratio)	
Anderson	-----	-----	1,500,000	1,500,000
TOTAL	873,840,000	256,260,000	87,300,000	1,217,400,000
HYPOTHETICAL RESOURCE TONNAGE				
Felix	-----	-----	141,150,000	141,150,000
TOTAL	-----	-----	141,150,000	141,150,000
GRAND TOTAL	873,840,000	256,260,000	228,450,000	1,358,550,000

Table 2.--Coal Resource Base and Hypothetical Resource Data (in short tons) for Underground Mining Methods for Federal Coal Lands in the Twentymile Butte Quadrangle, Campbell County, Wyoming.

Coal Bed Name	High Development Potential	Moderate Development Potential	Low Development Potential	Total
RESOURCE BASE				
Felix	-----	-----	2,360,000	2,360,000
Smith	-----	-----	770,710,000	770,710,000
Anderson	-----	-----	2,086,010,000	2,086,010,000
Canyon	-----	-----	1,084,500,000	1,084,500,000
Cook	-----	-----	550,280,000	550,280,000
Wall-Pawnee	-----	-----	3,421,030,000	3,421,030,000
Cache-Wildcat-Moyer-Oedekoven	----	-----	1,759,190,000	1,759,190,000
TOTAL	-----	-----	9,674,080,000	9,674,080,000
HYPOTHETICAL RESOURCES				
Smith	-----	-----	17,820,000	17,820,000
Anderson	-----	-----	22,620,000	22,620,000
Canyon	-----	-----	11,210,000	11,210,000
Cook	-----	-----	8,520,000	8,520,000
Wall-Pawnee	-----	-----	48,470,000	48,470,000
Cache-Wildcat-Moyer Oedekoven	-----	-----	19,980,000	19,980,000
TOTAL	-----	-----	128,620,000	128,620,000
GRAND TOTAL	-----	-----	9,802,700,000	9,802,700,000

Table 3.--Coal Resource Base and Hypothetical Resource Data (in short tons) for In-Situ Gasification for Federal Coal Lands in the Twentymile Butte Quadrange, Campbell County, Wyoming.

Coal Bed Name	High Development Potential	Moderate Development Potential	Low Development Potential	Total
RESOURCE BASE				
	601,400,000	4,756,310,000	4,316,370,000	9,674,080,000
HYPOTHETICAL RESOURCE				
	-----	-----	128,620,000	128,620,000
TOTAL	601,400,000	4,756,310,000	4,444,990,000	9,802,700,000

SELECTED REFERENCES

Allen, D. D., 1977, Preliminary coal development potential map of the Twentymile Butte and part of the Jeffers Draw quadrangle, Campbell County, Wyoming: U. S. Geological Survey unpublished report, scale 1:24,000.

Baker, A. A., 1929, The northward extension of the Sheridan coal field, Big Horn and Rosebud Counties, Montana: U. S. Geological Survey Bull. 806-B, p. 15-67.

Bass, N. W., 1932, The Ashland coal field, Rosebud, Powder River, and Custer Counties, Montana: U. S. Geological Survey Bull. 831-B, p. 19-105.

Bohor, B. F., Kent, B. H., Haddock, D. R., 1979, Geologic map and coal sections of the Twentymile Butte Quadrangle, Campbell County, Wyoming: U. S. Geological Survey Misc. Field Studies Map MF-1073, scale 1:24,000.

Brown, R. W., 1958, Fort Union Formation in the Powder River Basin, Wyoming: Wyoming Geological Association Guidebook, Thirteenth Annual Field Conf., p. 111-113.

Denson, N. M., and Horn, G. H., 1975, Geologic and structure map of the southern part of the Powder River Basin, Converse, Niobrara, and Natrona Counties, Wyoming: U. S. Geological Survey Miscellaneous Investigations Series Map I-877, scale 1:125,000.

Dobbin, C. E., and Barnett, V. H., 1927 (1928), The Gillette coal field, northeastern Wyoming: U. S. Geological Survey Bull. 796-A, p. 1-50.

Glass, G. B., 1975, Review of Wyoming coal fields, 1975: Wyoming Geological Survey Public Information Circ. 4, p. 10.

IntraSearch Inc., 1978a, Coal resource occurrence and coal development potential of the Cabin Creek Northeast Quadrangle, Sheridan and Campbell Counties, Wyoming, and Powder River County, Montana: U. S. Geological Survey Open-File Report 78-064, 21 p.

_____, 1978b, Coal resource occurrence and coal development potential of the Rocky Butte Quadrangle, Campbell County, Wyoming: U. S. Geological Survey Open-File Report 78-830, 22 p.

_____, 1979, Coal resource occurrence and coal development potential of the Larey Draw Quadrangle, Campbell County, Wyoming: U. S. Geological Survey Open-File Report 79-023, 29 p.

Jacob, A. F., 1973, Depositional environments of Paleocene Tongue River Formation: Am. Assoc. of Petroleum Geologists Bull., vol. 56, no. 6, p. 1038-1052.

Kent, B. H., 1976, Geologic map and coal sections of the Recluse Quadrangle, Campbell County, Wyoming: U. S. Geological Survey Misc. Field Studies Map MF-732, scale 1:24,000.

McKay, E. J., 1974, Preliminary geologic map of the Bertha 2 NW (Rocky Butte) Quadrangle, Campbell County, Wyoming: U. S. Geological Survey Open-File Report 74-173, scale 1:24,000.

Olive, W. W., 1957, The Spotted Horse coal field, Sheridan and Campbell Counties, Wyoming: U. S. Geological Survey Bull. 1050, 83 p.

Schell, E. M., and Mowat, G. D., 1972, Reconnaissance map showing some coal and clinker beds in the Fort Union and Wasatch Formations in the eastern Powder River Basin, Campbell and Converse Counties, Wyoming: U. S. Geological Survey Open-File Report, scale 1:63,360.

Stone, R. W., and Lupton, C. T., 1910, The Powder River coal field, Wyoming, adjacent to the Burlington Railroad: U. S. Geological Survey Bull. 381-B, p. 115-136.

Taff, J. A., 1909, The Sheridan coal field, Wyoming: U. S. Geological Survey Bull. 341-B, p. 123-150.