UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

# TEXT TO ACCOMPANY:

# COAL RESOURCE OCCURRENCE

# AND

# COAL DEVELOPMENT POTENTIAL

# MAPS

# OF THE

# JEFFERS DRAW QUADRANGLE,

# CAMPBELL COUNTY, WYOMING

BY

INTRASEARCH INC.

DENVER, COLORADO

OPEN FILE REPORT 79-039
1979

This report is preliminary, and has not been edited or reviewed for conformity with United States Geological Survey standards or stratigraphic nomenclature.

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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 Jeffers Draw Quadrangle, Campbell County, Wyoming. This CRO and CDP map series (U. S. Geological Survey Open-File Report 79-039) includes 45 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 Jeffers Draw Quadrangle is located in Campbell County, in northeastern Wyoming. It encompasses all or parts of Townships 49, 50 and 51 North, Ranges 74 and 75 West, and covers the area: 44°15' to 44°22'30" north latitude; 105°45' to 105°52'30" west longitude.

Main access to the Jeffers Draw Quadrangle is provided by Montgomery Road which extends east to west across the southern half of the study area. Kingsbury Road branches from Montgomery Road in the southwest quarter of the quadrangle and extends southward intersecting Interstate 90 approximately 3.1 miles (5.0 km) south of the quadrangle boundary. Echeta Road traverses northwest to southeast across the northeast quarter of the quadrangle intersecting Montgomery Road approximately 4 miles (6.4 km) to the east, approximately 9 miles (14.5 km) west of Gillette, Wyoming. Minor roads and trails that branch from these maintained gravel roads provide access to the more remote areas. The closest railroad is the Burlington Northern trackage which traverses northwest to southeast across the northeast corner of the quadrangle.

The most significant drainage is provided by northward-flowing Wild Horse Creek and Kingsbury Creek which are present in the eastern half of the quadrangle. Fortification Creek and Barber Creek flow westward and supply the drainage along the western edge of the study area. Jeffers Draw, Sand Draw, Montgomery Draw and numerous other intermittent streams supplement the drainage throughout the study area. All of the streams throughout the quadrangle eventually drain into the Powder River to the northwest. Elevations attain heights of 4842 feet (1476 m) above sealevel in the southeast corner of the quadrangle, 550 to 650 feet (168 to 198 m) above the valley floors to the north. 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 11.9 billion tons (10.8 billion metric tons) of unleased federal coal resources in the Jeffers Draw 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 lightercolored 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 Jeffers Draw Quadrangle is located in an area where surface rocks are classified as 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), and the Ulm and Smith coal beds were 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 coal bed was named by Warren (1959). The Wildcat, Moyer, and Oedekoven coal beds were informally named by Intra-Search (1978b, 1979 and 1978a).

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.

Local. The Jeffers Draw 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 in the quadrangle indicate a regional dip to the west-southwest with a minor westward-plunging anticlinal high extending across the southeast quarter of the study area.

## III. Data Sources

Areal geology of the Ulm coal outcrop in the northeast quarter of the quadrangle is derived from the Lower Ulm coal bed of Dobbin and Barnett (1927). The remaining majority of the Ulm coal outcrop is projected by IntraSearch onto the current topographic base utilizing subsurface data. This projection of the coal outcrop configuration is to be considered a reasonable representation of the actual coal outcrop, necessary for estimating coal tonnage reserves. An insufficient data line in the southwest quarter of the quadrangle delimits the areal extent of reliable subsurface control.

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 indentification 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 published 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 Jeffers Draw 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 Jeffers Draw Quadrangle include, in descending stratigraphic order: the Ulm, Felix, Upper Smith, Lower Smith, Anderson, Upper Canyon, Lower Canyon, Upper Cook, Lower Cook, Wall-Pawnee, Wildcat, Moyer, Oedekoven, and three, deep, unnamed, local coal beds. A complete suite of maps (coal isopach, mining ratio where applicable, structure, overburden/

interburden isopach, identified resources, and areal distribution of identified resources) was prepared for the Ulm, Felix, Anderson and Wall-Pawnee coal beds, and for the Smith, Canyon, Cook, and Wildcat-Moyer-Oedekoven coal zones. Insufficient data, thickness, and areal extent precludes detailed mapping of the three, deep, local coal beds.

No physical and chemical analyses are known to have been published regarding the coal beds in the Jeffers Draw Quadrangle. However, the proximate analyses performed on a general "as received" basis for central and southern Campbell County coal beds are as follows:

| COAL BED NAME | | | ASH % | FIXED CARBON % | MOISTURE % | VOLATILES % | SULFUR % | BTU/LB |
|---|---|---|---|---|---|---|---|---|
| Ulm | (U) | Hole 7329 | 8.587 | 29.228 | 30.239 | 31.946 | 1.911 | 7585 |
| Felix | (U) | Hole 7345 | 5.223 | 34.181 | 30.280 | 30.316 | 0.338 | 8111 |
| Smith | (U) | Hole 7340 | 3.505 | 38.036 | 29.280 | 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 | 29.332 | 32.150 | 28.985 | 0.500 | 7279 |
| Pawnee | (U) | Hole 7424 | 7.880 | 31.029 | 31.910 | 29.183 | 0.386 | 7344 |

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

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 Upper Cook coal bed underlies the entire quadrangle, it is designated as datum for the correlation diagram. The

Anderson and Wall-Pawnee coal beds show the thickest coal bed occurrences throughout the quadrangle. The Felix coal bed and the Smith, Canyon, Cook, and Wildcat-Moyer-Oedekoven coal zones show a moderately thick coal bed occurrence throughout approximately 40 percent of the quadrangle.

The Ulm coal bed is eroded from approximately 60 percent of the quadrangle, and occurs primarily in the higher elevations of the western half. The coal bed thickness ranges from less than 5 to 12 feet (less than 1.5 to 4 m). Thicknesses greater than 5 feet (1.5 m) occur only in minor areas in the northeast, northwest, and southwest quarters of the study area. The Ulm coal bed in the central portion of the quadrangle is less than 5 feet (1.5 m) thick. Structure contours drawn on top of the Ulm coal bed indicate a general westward dip with a broad, northward-plunging anticline extending from the southwest to northwest quarters of the study area. The Ulm coal bed, where present, lies approximately 0 to 200 feet (0 to 61 m) in depth beneath the surface.

The Felix coal bed lies approximately 450 feet (137 m) below the Ulm coal bed, and ranges in thickness from 18 to 29 feet (6 to 9 m). Maximum thicknesses extend east to west across the central portion of the study area, and thins to the north and south. Localized clastic intervals separating the Felix coal bed vary from 0 to 8 feet (0 to 2.4 m). Structure contours drawn on top of the Felix coal bed indicate a regional dip to the west-southwest with minor anticlinal and synclinal features occurring in the southeast and northeast quarters, respectively. The Felix coal bed lies less than 500 feet (152 m) in depth beneath the surface throughout approximately 40 percent of the quadrangle and varies in depth from 95 to 750 feet (29 to 229 m) beneath the surface.

The Smith coal zone occurs 344 to 382 feet (105 to 116 m) beneath the Felix coal bed, and is composed of two thin to moderately thick coal beds. The total combined thickness ranges from 5 to 33 feet (1.5 to 10 m) with maximum thicknesses occurring in the west-central portion of the study area. The clastic interval separating the coal beds varies from 0 to 97 feet (0 to 30 m). Structure contours drawn on top of the Smith coal zone depict a regional west-southwest dip showing two minor westward-plunging anticlines extending into the southeast quarter and along the northern boundary of the study area. The Smith coal zone lies greater than 500 feet (152 m) in depth beneath the surface throughout 98 percent of the quadrangle, and ranges in depth beneath the surface from 480 to 1260 feet (146 to 384 m).

The Anderson coal bed is separated from the overlying Smith coal zone by approximately 217 to 334 feet (66 to 102 m) of clastic sediment. The coal bed thickness ranges from 16 to 51 feet (5 to 16 m) with maximum thicknesses occurring along the southeastern boundary and the southwest corner of the quadrangle. The Anderson coal bed is relatively thin in an area which extends from the northwest throughout the central portion of the quadrangle. A non-coal interval varies from 0 to 7 feet (0 to 2.1 m) and locally separates the coal bed. Structure contours drawn on top of the Anderson coal bed indicate a regional westward dip with minor anticlinal features. The Anderson coal bed lies approximately 750 to 1525 feet (229 to 465 m) in depth beneath the surface throughout the entire quadrangle.

The Canyon coal zone lies approximately 7 to 186 feet (2.1 to 57 m) below the Anderson coal bed, and is composed of two moderately thick coal beds. The total coal zone thickness ranges from 10 to 42 feet (3 to 13 m) with maximum thickness occurring in the western half of the study area, and thins to the east and south. A non-coal interval ranging from 0 to 151 feet (0 to 46 m) separate the coal beds. The coal beds merge together throughout most of the northern and western portions of the quadrangle. The structure contours drawn on top of the Canyon coal zone indicate a regional dip to the west with a minor westward-plunging syncline extending across the eastern half of the quadrangle. The Canyon coal zone lies approximately 900 to 1775 feet (274 to 541 m) in depth beneath the surface throughout the entire quadrangle.

The Cook coal zone occurs approximately 31 to 200 feet (9 to 61 m) beneath the Canyon coal zone, and is composed of two, thin to moderately thick coal beds. The total coal zone thickness ranges from 5 to 38 feet (1.5 to 15 m) with maximum thicknesses occurring in the southwest quarter, and with thinning to the east. The clastic interval separating the thin coals varies from 26 to 97 feet (8 to 30 m). The structural configuration drawn on top of the Cook coal zone depicts a regional southwestern dip with only minor anticlinal and synclinal features. The Cook coal zone lies approximately 950 to 1900 feet (290 to 579 m) in depth beneath the surface throughout the entire quadrangle.

The Wall-Pawnee coal bed occurs approximately 98 to 212 feet (30 to 64 m) below the Cook coal zone, and ranges in thickness from 40 to 110 feet (12 to 34 m). Thickest occurrences are located along the western boundary of the quadrangle and thin to the east. Structure contours drawn on top of the Wall-Pawnee coal bed depict a regional dip to the west showing minor anticlinal and synclinal features. The Wall-Pawnee coal bed lies approximately 1250 to 2150 feet (381 to 655 m) in depth beneath the surface throughout the entire quadrangle.

The Wildcat-Moyer-Oedekoven coal zone lies approximately 157 to 258 feet (48 to 79 m) below the Wall-Pawnee coal bed, and is composed of three thin to moderately thick, uniform coal beds. The total coal zone thickness ranges from 20 to 60 feet (6 to 18 m). Maximum thicknesses occur in the southwest quarter and the east-central portion of the quadrangle, with an area of relatively thin coal trending northwest to southeast across the study area. The Wildcat and Oedekoven coal beds average over 15 feet (5 m) in thickness and comprise the majority of the coal zone. The thinner Moyer coal bed averages approximately 6 feet (1.8 m). The total clastic interval separating the various coal beds comprising the coal zone varies from 123 to 400 feet (38 to 122 m). Structure contours drawn on top of the Wildcat coal bed indicate a regional dip to the west showing little structural variation. The Wildcat-Moyer-Oedekoven coal zone lies approximately 1700 to 2450 feet (518 to 748 m) in depth beneath the surface throughout the entire quadrangle.

## 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 Jeffers Draw 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 44) 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 development potential is high for approximately 20 percent of the quadrangle, and is attributed to low overburden-to-coal ratios for the Ulm and Felix coal beds. The high potential rating occurs in areas of shallow coal bed occurrence overlying the Ulm coal bed in the southwest quarter of the quadrangle, and in the major drainages of the eastern half where erosion has decreased the overburden thickness overlying the Felix coal bed. Moderate and low development potential ratings cover approximately 15 and 20 percent of the quadrangle, respectively, and can be attributed to increasing overburden to coal ratios for the Ulm, Felix, and Smith coal beds. The remainder of the quadrangle is designated as non-federal coal land, or as no development potential for surface mining, or as a unknown development potential where the area contains insufficient data.

Underground Mining Coal Development Potential. Subsurface coal mining potential throughout the Jeffers Draw 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).

The coal development potential for in-situ gasification is moderate to high for most of the Jeffers Draw Quadrangle. The high development potential rating covers approximately 40 percent of the quadrangle, primarily throughout the western third of the study area. The moderate development potential rating covers the eastern 45 percent of the quadrangle. A low development potential rating covers a small percentage in the northeast quarter and along the southeastern boundary of the study area. The remaining precentage 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 potentials are listed on Table 3.

Table 1.--Strippable Coal Reserve Base and Hypothetical Resource Data (in short tons) for Federal Coal Lands in the Jeffers Draw 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 |
|---|---|---|---|---|
| RESOURCE BASE | | | | |
| Ulm | 14,430,000 | 14,850,000 | 7,870,000 | 37,150,000 |
| Felix | 149,690,000 | 263,430,000 | 307,560,000 | 720,680,000 |
| TOTAL | 164,120,000 | 278,280,000 | 315,430,000 | 757,830,000 |
| HYPOTHETICAL RESOURCE | | | | |
| Felix | ----- | ----- | 11,360,000 | 11,360,000 |
| TOTAL | ----- | ----- | 11,360,000 | 11,360,000 |
| GRAND TOTAL | 164,120,000 | 278,280,000 | 326,790,000 | 769,190,000 |

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

| Coal Bed Name | High Development Potential | Moderate Development Potential | Low Development Potential | Total |
|---|---|---|---|---|
| RESOURCE BASE | | | | |
| Felix | ----- | ----- | 464,530,000 | 464,530,000 |
| Smith | ----- | ----- | 715,340,000 | 715,340,000 |
| Anderson | ----- | ----- | 1,433,060,000 | 1,433,060,000 |
| Canyon | ----- | ----- | 1,558,710,000 | 1,558,710,000 |
| Cook | ----- | ----- | 1,145,930,000 | 1,145,930,000 |
| Wall-Pawnee | ----- | ----- | 3,321,830,000 | 3,321,830,000 |
| Wildcat-Moyer-Oedekoven | ----- | ----- | 2,049,790,000 | 2,049,790,000 |
| TOTAL | ----- | ----- | 10,689,190,000 | 10,689,190,000 |
| HYPOTHETICAL RESOURCES | | | | |
| Felix | ----- | ----- | 34,510,000 | 34,510,000 |
| Smith | ----- | ----- | 33,720,000 | 33,720,000 |
| Anderson | ----- | ----- | 58,730,000 | 58,730,000 |
| Canyon | ----- | ----- | 73,200,000 | 73,200,000 |
| Cook | ----- | ----- | 62,780,000 | 62,780,000 |
| Wall-Pawnee | ----- | ----- | 136,390,000 | 136,390,000 |
| Wildcat-Moyer-Oedekoven | ----- | ----- | 34,250,000 | 34,250,000 |
| TOTAL | ----- | ----- | 433,580,000 | 433,580,000 |
| GRAND TOTAL | ----- | ----- | 11,122,770,000 | 11,122,770,000 |

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

| Coal Bed Name | High Development Potential | Moderate Development Potential | Low Development Potential | Total |
|---|---|---|---|---|
| RESOURCE BASE | | | | |
| | 5,958,010,000 | 3,677,700,000 | 1,053,480,000 | 10,689,190,000 |
| HYPOTHETICAL RESOURCE | | | | |
| | ----- | ----- | 433,580,000 | 433,580,000 |
| TOTAL | 5,958,010,000 | 3,677,700,000 | 1,487,060,000 | 11,122,770,000 |

SELECTED REFERENCES

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.

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.

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.

U. S. Bureau of Mines and U. S. Geological Survey, 1976, Coal Resource classification system of the U. S. Bureau of Mines and U. S. Geological Survey: U. S. Geological Survey Bull. 1450-B, 7 p.

U. S. Geological Survey and Montana Bureau of Mines and Geology, 1974, Preliminary report of coal drill-hole data and chemical analyses of coal beds in Campbell County, Wyoming: U. S. Geological Survey Open-File Report 74-97, 241 p.

_____, 1976, Preliminary report of coal drill-hole data and chemical analyses of coal beds in Campbell and Sheridan Counties, Wyoming; Custer, Prairie, and Garfield Counties, Montana; and Mercer County, North Dakota: U. S. Geological Survey Open-File Report 76-319, 377 p.

Warren, W. C., 1959, Reconnaissance geology of the Birney-Broadus coal field, Rosebud and Powder River Counties, Montana: U. S. Geological Survey Bull. 1072-J, p. 561-585.

Weimer, R. J., 1977, Stratigraphy and tectonics of western coals, _in_ Geology of Rocky Mountain Coal, A Symposium, 1976: Colorado Geological Survey Resource Series 1, p. 9-27.