UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

TEXT TO ACCOMPANY:

COAL RESOURCE OCCURRENCE

AND

COAL DEVELOPMENT POTENTIAL

MAPS

OF THE

CAMPBELL HILL QUADRANGLE,

CONVERSE AND NATRONA COUNTIES, WYOMING

BY

INTRASEARCH INC.

DENVER, COLORADO

OPEN FILE REPORT 79-469
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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 Campbell Hill Quadrangle, Converse and Natrona Counties, Wyoming. This CRO and CDP map series (U. S. Geological Survey Open-File Report 79-469) includes 8 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 Campbell Hill Quadrangle is located in Converse and Natrona Counties, in northeastern Wyoming. It encompasses parts of Townships 34 and 35 North, Ranges 76 and 77 West, and covers the area: 42°52'30" to 43°00' north latitude; 106°00' to 106°07'30" west longitude.

Main access to the Campbell Hill Quadrangle is provided by Cole Creek Road, a maintained gravel road that traverses the northern half of the area from east to west and intersects U. S. Highways 20 and 87, 11 miles (18 km) to the southwest of the quadrangle, at a point 5 miles (8.0 km) east of Casper, Wyoming. Branching roads and trails from Cole Creek Road provide access to the remainder of the quadrangle. The closest railroad is the Burlington Northern trackage, one mile (1.6 km) to the south of (and parallel to) the southern boundary of the quadrangle.

Sand dunes cover the southern two-thirds and the northwest corner of the Campbell Hill Quadrangle. These areas display low, rolling topography, with numerous dunes, blowouts, and a relief of 200 feet (61 m). Elevations in excess of 5700 feet (1737 m) above sealevel are located in the northeast corner of the quadrangle. The north flank of the North Platte River valley is approximately 5100 feet (1554 m) above sealevel. Cole Creek flows southward, drains the eastern half of the quadrangle, and joins the North Platte River one mile (1.6 km) south of the area.

The 10 to 12 inches (25 to 30 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 Glenrock, 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 Converse County Courthouse in Douglas, Wyoming or the Natrona County Courthouse in Casper, 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 39 million tons (35 million metric tons) of unleased federal coal resources in the Campbell Hill 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.

The final withdrawal of the Late Cretaceous sea left deposits of a nearshore marine sand that ultimately became the Fox Hills Sandstone. The Fox Hills Sandstone varies in thickness from 0 to 700 feet (0 to 213 m) over the Powder River Basin and is the demarcation line between marine deposition, characterized by the Lewis Shale below, and the continental deposits of the Lance, Fort Union and Wasatch Formations above.

The Lance Formation consists of the continental deposits that followed the withdrawal of the Cretaceous sea and represents the youngest Cretaceous non-marine strata present in the Powder River Basin. The formation of the Powder River Basin and adjacent basins marked a change in the depositional style to fluvial deposition in these individual basins formed by the Late Cretaceous uplift. In areas where subsidence was greater than aggradation, lakes and swamps formed where minor coal beds were depositied. These coal beds occur near the base of the Lance Formation. Volcanic activity contributed ash layers that were transformed to bentonite beds within the Lance Formation. The thickness of the formation varies from 650 feet (198 m) along the basin margins to 3000 feet (914 m) in the center of the basin.

III. Data 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 Campbell Hill Quadrangle is published by the U. S. Geological Survey, compilation date 1950. 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

Lance Formation coal beds that are present in part of the Campbell Hill Quadrangle include three unnamed Local coal beds. A complete suite of maps (coal isopach, structure, overburden isopach, areal distribution of identified resources and identified resources) is prepared for a coal zone consisting of the three Local coal beds. No mining ratio map has been constructed because the coal beds are less than 5 feet (1.5 m) thick in the areas with less than 500 feet (152 m) of overburden.

Analyses of Lance Formation coal beds mined in the Glenrock, Wyoming area are available in several publications (Glass, 1976). The average "as received" proximate analysis for these beds is as follows:

COAL BED NAME	ASH %	FIXED CARBON %	MOISTURE %	VOLATILES %	SULFUR %	BTU/LB
(*)	6.8	34.0	23.4	35.9	0.66	8742

(*) - Glass, 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. The Local $_3$ coal bed has been selected as the datum for the correlation diagram as it is more widespread and attains the greatest thickness. Local $_1$ and Local $_2$ coal beds are less than 5 feet (1.5 m) thick and are restricted to the northwest quadrant of the quadrangle. The Local $_2$ coal bed is also identified along the east central border of the quadrangle.

The Local $_{1,2,3}$ coal zone exists primarily in the northeastern half of the quadrangle. The relationship between these subsurface coal beds and those mined at the surface (Glass, 1976) is unclear because of the paucity of data. The isopach map of the Local $_{1,2,3}$ coal zone (Plate 4) indicates a combined thickness range of 0 to 17 feet (0 to 5 m). The thickest coal is located in the northwest quadrant in Sections 21 and 22, Township 45 North, Range 77 West where all three Local coal beds are present. The coal zone is not present in the northeast corner of the southwest quarter of the quadrangle. The average thickness for the coal zone, consisting almost entirely of the Local $_3$ coal bed, is approximately 5 feet (1.5 m). Structure contours are drawn primarily on the Local $_3$ coal bed and secondarily on the Local $_1$ and Local $_2$ coal beds. They define a large anticline plunging southeastward from the northwest quadrant toward the east-central border of the quadrangle. Whereas the southwestern flank of the anticline exhibits a dip in excess of 1000 feet per mile (190 m per km), the northeastern flank dips approximately 300 feet per mile (57 m per km) (Plate 5). The Local $_1$ and Local $_2$ coal beds lie within 500 feet (152 m) of the surface in the northwest quadrant near the apex of this anticline. Except for this small area, the coal beds of the Local $_{1,2,3}$ coal zone occur approximately 480 to 2520 feet (146 to 768 m) beneath the surface (Plate 6).

V. Geological and Engineering Mapping Parameters

The correct horizontal location and elevation of drill holes utilized in subsurface mapping are critical to map accuracy. IntraSearch 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 Campbell Hill Quadrangle area. Data from geophysical logs are used to correlate coal beds and control contour lines for the coal thickness, structure, and overburden maps. Isopach lines are also drawn to honor selected surface measured sections where there is sparse subsurface control. Where isopach contours do not honor surface measured sections, the surface thicknesses are thought to be attenuated by oxidation and/or erosion; hence, they are not reflective of total coal thickness. Isopach lines extend to the coal bed outcrops, the projections of coal bed outcrops, and the contact between porcellanite (clinker) and unoxidized coal in place. Attenuation of total coal bed thickness is known to take place near these lines of definition; however, the overestimation of coal bed tonnages that results from this projection of total coal thickness is insignificant to the Coal Development Potential 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. 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.

No surface mining potential map is generated for the Campbell Hill Quadrangle because none of the coal beds within 500 feet (152 m) of the surface are greater than 5 feet (1.5 m) thick. Therefore, the entire quadrangle is considered to have no coal development potential for surface mining.

Underground Mining Coal Development Potential. Subsurface coal mining potential throughout the Campbell Hill 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).

Approximately 10 percent of the area within the Campbell Hill Quadrangle is rated low coal development potential for in-situ gasification, because the Local $_{1,2,3}$ coal zone is less than 100 feet (30 m) thick, hence no CDP map is generated for this map series. The low development potential area is located in a narrow strip from the northwest corner to the east-central area of the quadrangle. The remaining 90 percent of the study area is rated as no development potential. The coal resource tonnage for in-situ gasification with low development potential totals approximately 39 million tons (35 million metric tons) (Table 2). None of the coal beds in the Campbell Hill Quadrangle qualify for a moderate or high development potential rating.

Table 1.--Coal Resource Base and Data (in short tons) for Underground Mining Methods for Federal Coal Lands in the Campbell Hill Quadrangle, Converse and Natrona Counties, Wyoming.

Coal Zone Name	High Development Potential	Moderate Development Potential	Low Development Potential	Total
Local 1,2,3	-----	-----	39,230,000	39,230,000
TOTAL	-----	-----	39,230,000	39,230,000

Table 2.--Coal Resource Base Data (in short tons) for In-Situ Gasification for Federal Coal Lands in the Campbell Hill Quadrangle, Converse and Natrona Counties, Wyoming.

Coal Zone Name	High Development Potential	Moderate Development Potential	Low Development Potential	Total
Local 1,2,3	-----	-----	39,230,000	39,230,000
TOTAL	-----	-----	39,230,000	39,230,000

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