UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

TEXT TO ACCOMPANY:

COAL RESOURCE OCCURRENCE

AND

COAL DEVELOPMENT POTENTIAL

MAPS

OF THE

LANCE CREEK 3 SOUTHWEST QUADRANGLE,

CONVERSE AND NIOBRARA COUNTIES, WYOMING

BY

INTRASEARCH INC.

DENVER, COLORADO

OPEN FILE REPORT 79-468

1979

TABLE OF CONTENTS

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 Lance Creek 3 Southwest Qudadrangle, Converse and Niobrara Counties, Wyoming. This CRO and CDP map series includes 14 plates (U. S. Geological Survey Open-File Report 79-468). The project is compiled by IntraSearch Inc., 1600 Ogden Street, Denver, Colorado, under KRCRA Northeastern Powder River Basin, Wyoming Contract Number 14-08-0001-17180. This contract is a part of a program to provide an inventory of unleased federal coal in Known Recoverable Coal Areas (KRCRA's) in the western United States.

The Lance Creek 3 Southwest Quadrangle is located in Converse and Niobrara Counties in northeastern Wyoming. It encompasses parts of Townships 35 and 36 North, Ranges 67 and 68 West, and covers the area: 43° 00' to 43° 07' 30" north latitude; 104° 52' 30" to 105° 00' west longitude.

Access to the Lance Creek 3 Southwest Quadrangle is provided by a light duty paved road in the southeast quadrant, and unimproved dirt roads parallel to Walker Creek on top of the divides between the major drainages. Minor roads and trails that branch from these gravel roads provide additional access to remote areas. The town of Lance Creek, Wyoming, is approximately 8 miles (13 km) to the east, and State Highway 59, approximately 14 miles (23 km) to the west, extends southward 19 (31 km) miles to the town of Douglas, Wyoming. The closest railroad is the Chicago North Western trackage approximately 18 miles (29 km) to the south at Lost Springs, Wyoming. Trackage under construction by the Burlington Northern Railroad lies approximately 12 miles (19 km) to the west.

Walker Creek flows northeastward across the northern half of the study area at an approximate elevation of 4450 feet (1356 m). Providing the major drainage for the quadrangle, Walker Creek traverses fairly rugged terrain attaining elevations up to 4920 feet (1500 m) above sea level. A portion of Twentymile Creek crosses the southeast corner of the quadrangle. These intermittent streams discharge into the Cheyenne River to the northeast.

The thirteen to fourteen inches (33 to 36 cm) of annual precipitation that falls in this semi-arid region accrues principally in the springtime. Summer and fall precipitation usually originates from thunderstorms, and infrequent snowfalls of six 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 Douglas, Wyoming, average wintertime minimums and summertime maximums approach +5° to +15°F (-15° and -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 and Niobrara County Courthouses, located in Douglas and Lusk, 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: 1) the delineation of lignite, subbituminous coal, bituminous coal, and anthracite at the surface and in the subsurface on federal land; 2) the

identification of total tons in place as well as recoverable tons; 3) categorization of these tonnages into measured, indicated, and inferred reserves and resources, and hypothetical resources; and 4) recommendations 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 91 million tons (83 million metric tons) of unleased federal coal resources in the Lance Creek 3 Southwest Quadrangle.

The suite of maps that accompany this report set forth and portray 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, that includes 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 Lebo Member of the Fort Union Formation is mapped at the surface northeast of Recluse, Wyoming, east of the principal coal outcrops and associated clinkers (McKay, 1974), and 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 working with subsurface data, principally geophysical logs, in the basin are trying to develop criteria for subsurface recognition of the Lebo-Tullock and Tongue River-Lebo contacts, no definitive guidelines are known to have been published. Hence, for subsurface mapping purposes, the Fort Union Formation is not divided into its member subdivisions for this study.

During the Paleocene epoch, the Powder River Basin tropic to subtropic depositional environment included broad, inland flood basins with extensive swamps, marshes, freshwater lakes, and a sluggish but active northeastward discharging drainage system, superimposed on a near base level, emerging sea floor. Much of the vast areas 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 characteristic, 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 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 discrete balance between subsidence of the earth's crust and in-filling by trememdous 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 low land 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, and is considered to disconformably descend 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 is made to differentiate the Wasatch and Fort Union Formations on geophysical logs or in the subsurface mapping program that is a part of this CRO-CDP 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 Lance Creek 3 Southwest Quadrangle is located in an area where surface rocks are classified into the Lebo and Tullock Members of the Fort Union Formation. Approximately 600 to 650 feet (183 to 198 m) of sediments are exposed in this area. 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.

Local. The Lance Creek 3 Southwest Quadrangle lies on the eastern flank of the Powder River Basin where the strata dip gently westward. The Fort Union Formation crops out over the entire quadrangle.

The Fort Union Formation is composed of very fine-grained sandstones, siltstones, claystones, carbonaceous shales, and numerous coal beds. Two thin local coals averaging 6 feet (1.8 m) thick each crop out in the Lance Creek 3 Southwest Quadrangle. The structure contours drawn on top of the local coal beds indicate a westward dip of one to two degrees.

III. Data Sources

Areal geology of the coal outcrops is derived from the Lost Spring Coal Field report (Winchester 1912). The outcrop configurations are enlarged from a 1:125,000 scale map. Numerous irregularities in outcrop elevations and the areal geology-topographic map relationship emphasize that the local coal bed maps present a generalized configuration of the coal bed outcrops. Horizontal accuracy of outcrop location is estimated at plus or minus 1000 feet (305 m).

Measured sections published by Winchester (1912) provide the major source of coal bed thickness mapping control. Geophysical logs from oil and gas test bores and producing wells supply sparse subsurface data. 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, interpreted, and coal intervals 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, vary 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 Lance Creek 3 Southwest Quadrangle is available from the U. S. Geological Survey, compilation date, 1978. 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

The Fort Union Formation coal beds that are present in all or part of the Lance Creek 3 SW Quadrangle include in descending stratigraphic order the Local $_1$ and Local $_2$ coal beds. A complete suite of maps (structure, isopach, mining ratio, overburden, identified resources and areal distribution of identified resources) is prepared for each of these coal beds.

No physical or chemical analyses are known to have been published regarding the local coal beds in the Lance Creek 3 SW Quadrangle. However, analyses for the local coal bed approximately 27 miles (43 km) northwest of the Lance Creek 3 Southwest Quadrangle are as follows:

COAL BED NAME	Lab. No.	ASH	FIXED CARBON	MOISTURE	VOLATILES	SULFUR	BTU/LB
Local	11447	4.3	38.5	27.8	29.4	0.27	8410

(Winchester 1912)

All analyses except for BTU/LB are expressed as a percentage.

The Coal Data Sheet, Plate 3, shows the downhole identification of coal beds within the quadrangle as interpreted from geophysical logs from oil and gas test bores and producing sites. Because there are no coal beds interpreted on the geophysical logs, sea level is used for datum.

Local 1 coal bed is not mapped in portions of the northeastern, northwestern, and southern regions of the Lance Creek 3 SW Quadrangle, an area that covers about seventy-five percent of the quadrangle. Due to the absences of subsurface data, mapping control is derived from outcrop elevations and surface measured sections published in the Lost Springs coal field report (Winchester 1912). Structural elevation control points established on the outcrop configuration are considered to be plus or minus 50 to 100 feet (15 to 30 m) in accuracy. The Local 1 coal bed varies in thickness from less than 5 feet (1.5 m) to slightly over 7 feet (2.1 m). Structural contours drawn on the top of the Local 1 coal bed define a gentle westward dip of one to two degrees. The Local 1 coal bed lies less than 250 feet (76 m) beneath the surface.

Separated from the overlying Local 1 coal bed by a non-coal interval of 50 to 100 feet (15 to 30 m), the Local 2 coal bed crops out in the central portion of the quadrangle. Mapping on the Local 2 coal bed is restricted to about fifteen percent of the Lance 3 SW Quadrangle due to the lack of surface measured sections and subsurface control. Local 2 coal bed thicknesses range from 2 feet (0.6 m) to over 7 feet (2.1 m). The Local 2 coal bed dips to the west one to two degrees, and it occurs less than 300 feet (991 m) beneath 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 plots the horizontal location of the the drill hole as described on the geophysical log heading. Occasionally this location is superimposed or near to a drillsite shown on the topographic map, and the topographic map horizontal locations is utilized. If the ground elevation on the geophysical log does not agree with the topographic elevation on 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 correctness. 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 considers this agreement mandatory for the proper construction of most subsurface maps, but in particular, the overburden isopach, the ratio, and Coal Development Potential maps.

Subsurface mapping is based on geologic data within and adjacent to the Lance Creek 3 Southwest 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 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 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 over-

estimation 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 to a particular coal bed under study. Mining ratio maps for this quadrangle are constructed utilizing a ninety-five 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 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 1770 (the number of tons of subbituminous C coal per acre-foot; 13,018 metric tons per hectare-meter), to determine total tons in place. Recoverable tonnage is calculated at ninety-five 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 complex curvilinear lines are discretely utilized, and resources and/or reserves are calculated within an estimated two to three 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 is as follows:

$$MR = \frac{t_o\ (0.911)}{t_c\ (rf)}$$

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

A surface mining potential map (Plate 14) is 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 is 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 most of the Lance Creek 3 Southwest Quadrangle where coal is present. Coal bed thicknessess greater than 5 feet (1.5 m) occur over approximately forty-five percent of the Lance Creek 3 Southwest Quadrangle. Due to the thin overburden, generally less than 200 feet (61 m), and the average coal bed thickness of 6 feet (1.8 m), the surface mining potential is high for approximately fifty percent of the area where coal is present. Ten percent of the coal occurrence area has a low or moderate surface mining potential due to steeper terrain and thicker overburden and interburden, and the area of unknown coal development potential encompasses approximately forty percent of the coal occurrence area. Table 1 sets forth the estimated strippable reserve base tonnages per coal bed for the quadrangle.

Underground Mining Coal Development Potential. Subsurface coal mining potential throughout the Lance Creek 3 Southwest Quadrangle is considered low.

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 500 feet

(152 m) to 3000 feet (914 m) beneath the surface, or 2) coal beds 5 feet (1.5 m) or more in thickness that lie 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).

There is no coal development potential for in-situ gasification in the Lance Creek 3 Southwest Quadrangle.

Table 1.--Strippable Coal Reserve Base Data (in short tons) for Federal Coal Lands in the Lance Creek 3 Southwest Quadrangle, Converse and Niobrara Counties, 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
Local 1	27,940,000	11,180,000	20,540,000	59,660,000
Local 2	17,260,000	5,440,000	4,180,700	26,880,000
TOTAL	45,200,000	16,620,000	24,720,000	86,540,000

SELECTED REFERENCES

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

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

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

Dobbin, C. E., and Barnett, V. H., 1927, The Gillette coal field, northeastern Wyoming, with a chapter on the Minturn district and north western part of the Gillette field by W. T. Thom, Jr.: U. S. Geol. Survey Bull. 796-A, p. 1-50.

Glass, G. B., 1975, Review of Wyoming coal field, 1975; Wyoming Geol. Survey Public Information circ. 4, p. 10.

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. Geol. 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. Geol. 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. Geol. Survey Open-File Report, scale 1:63,360.

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

Warren, W. C., 1959, Reconnaissance geology of the Birney-Broadus coal field, Rosebud and Powder River Counties, Montana: U. S. Geol. 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 Geol. Survey Resource Series 1, p. 9-27.

Winchester, D. E., 1912, The Lost Spring coal field, Converse County, Wyoming: U. S. Geol. Survey Bull. 471-F, p. 472-515.