UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

TEXT TO ACCOMPANY:

COAL RESOURCE OCCURRENCE

AND

COAL DEVELOPMENT POTENTIAL

MAPS

OF THE

SOUTHEAST QUARTER OF ROSS 15' QUADRANGLE,

CONVERSE COUNTY, WYOMING

BY

INTRASEARCH INC.

DENVER, COLORADO

OPEN FILE REPORT 79-324
1979

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

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 Southeast Quarter of Ross 15' Quadrangle, Converse County, Wyoming. This CRO and CDP map series (U. S. Geological Survey Open-File Report 79-324) includes 24 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 Southeast Quarter of Ross 15' Quadrangle is located in Converse County, in northeastern Wyoming. It encompasses parts of Townships 38 and 39 North, Ranges 74 and 75 West, and covers the area: 43°15' to 43°22'30" north latitude; 105°45' to 105°52'30" west longitude.

Main access to the Southeast Quarter of Ross 15' Quadrangle is provided by a maintained gravel road (Ross Road) traversing north to south across the northeast quarter. Minor roads and trails provide additional access throughout the remaining area of the quadrangle. The closest railroad is the trackage serving the Dave Johnston coal mine, 17 miles (27 km) to the south.

The major drainage is provided by the northeast flowing Sand Creek and Stinking Water Creek which drain the northern and southern halves of the quadrangle, respectively. Bear Creek, Thompson Draw, Friday Draw, and other intermittent streams supplement the drainage throughout the quadrangle. The moderate terrain of the quadrangle attains heights of 5760 feet (1756 m) above sealevel in the western half. These elevations are

500 to 700 feet (152 to 213 m) above the valley floors in the eastern half of the quadrangle. A minimum elevation of less than 5120 feet (1561 m) is present in the valley floor of Sand Creek in the eastern part of the quadrangle.

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 Douglas, 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. 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 1.9 billion tons (1.7 billion metric tons) of unleased federal coal resources in the Southeast Quarter of Ross 15' Quadrangle.

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

II. Geology

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

Outcrops of the Wasatch Formation and the Tongue River Member of the Fort Union Formation cover most of the areas of major coal resource occurrence in the Powder River Basin. The Tongue River Member is composed of very fine-grained sandstones, siltstones, claystones, shales, carbonaceous shales, and numerous coal beds. The Lebo Member of the Fort Union Formation consists of light- to dark-gray very fine-grained to conglomeratic sandstone with interbedded siltstone, claystone, carbonaceous shale and thin coal beds. Thin bedded calcareous ironstone concretions interbedded with massive white sandstone and slightly bentonitic shale occur throughout the unit (Denson and Horn, 1975). The Lebo Member is mapped at the surface northeast of Recluse, Wyoming. Here, the Lebo Member is east of the principal coal outcrops and associated clinkers (McKay, 1974), and it presumably projects into the subsurface beneath much of the basin. One of the principal characteristics for separating the Lebo and Tullock Members (collectively referred to as the Ludlow Member east of Miles City, Montana) from the overlying Tongue River Member is the color differential between the lighter-colored upper portion and the somewhat darker lower portion (Brown, 1958). Although geologists are trying to develop criteria for subsurface recognition of the Lebo-Tullock and Tongue River-Lebo contacts through the use of subsurface data from geophysical logs, no definitive guidelines are known to have been published. Hence, for subsurface mapping purposes, the Fort Union Formation is not divided into its members for this study.

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

The uplift of areas surrounding the Powder River Basin created a structural basin of asymmetric character, with the steep west flank located on the eastern edge of the Big Horn Mountains. The axis of the Powder River Basin is difficult to specifically define, but it is thought to be located in the western part of the Basin and to display a north-south configuration some 15 to 20 miles (24 to 32 km) east of Sheridan, Wyoming. Thus, the sedimentary section described in this report lies on the east flank of the Powder River Basin, with gentle dips of two degrees or less disrupted by surface structure thought to relate to tectonic adjustment and differential compaction.

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

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

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

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

The Southeast Quarter of Ross 15' Quadrangle is located in an area where surface rocks are classified within 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 Smith coal bed was named by Taff (1909). Baker (1929) assigned names to the Anderson and Canyon coal beds. The Cook coal bed was named by Bass (1932). The Wildcat coal bed was informally named by IntraSearch (1978). Regional correlations by IntraSearch indicate that the Smith coal bed is stratigraphically equivalent to the Badger coal bed (Baker, 1929), and the Anderson coal zone is stratigraphically equivalent to the School coal zone named by previous workers in the area.

Local. The Southeast Quarter of Ross 15' Quadrangle lies on the southern flank of the Powder River Basin, where the strata dip gently northward. 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 preliminary coal resource occurrence map of the Southeast Quadrant of Ross 15' Quadrangle, Converse County, Wyoming (Hausel, 1977) indicates that no outcrops are present on the quadrangle. No other publication indicates an outcrop configuration suitable for CRO-CDP mapping purposes for this quadrangle.

III. Data Sources

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.

In some parts of the Powder River Basin, a sparse scattering of subsurface data points are shown on unpublished CRO-CDP maps compiled by the U. S. Geological Survey, and where these data are utilized, the rock-coal intervals are shown on the Coal Data Map (Plate 1). Inasmuch as these drill holes have no identifier headings, they are not set forth on the Coal Data Sheet (Plate 3). The geophysical logs of these drill holes were not available to IntraSearch to ascertain the accuracy of horizontal location, topographic elevation, and downhole data interpretation.

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 Ross 15' Quadrangle is published by the U. S. Geological Survey, compilation date 1960. Expansion of the topographic base of the Ross 15' Quadrangle (scale 1:62,500) into 7 1/2' quadrangle maps (scale 1:24,000) was performed by the U. S. Geological Survey for Coal Resource Occurrence-Coal Development Potential mapping purposes. 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 coal beds that are present in all or part of the Southeast Quarter of Ross 15' Quadrangle include, in descending stratigraphic order: the Smith (Badger) coal bed, the Anderson (School) coal zone, the Canyon, local, Cook coal beds, and the Wildcat coal zone. A complete suite of maps (coal isopach, mining ratio where appropriate, structure, overburden/interburden isopach, areal distribution of identified resources, and identified resources) is prepared for the Smith, and Canyon coal beds, and for the Anderson and Wildcat coal zones. Insufficient data and areal extent preclude detailed mapping of the Cook and local coal beds.

No physical and chemical analyses are known to have been published regarding the coal beds in the Southeast Quarter of Ross 15' Quadrangle. However, the general proximate analyses performed on an "as received" basis for coal beds in southern Campbell County and Converse County are as follows:

COAL BED NAME		ASH %	FIXED CARBON %	MOISTURE %	VOLATILES %	SULFUR %	BTU/LB
Smith (Badger)	Sample (*) 74-35	8.48	28.47	29.02	34.03	0.41	7606
Anderson (School)	Sample (*) 74-37	9.68	29.48	26.41	34.43	0.52	7830
Canyon	Hole (U) 757	6.024	32.831	26.907	34.237	0.336	8366

(*) - Glass - 1975b
(U) - U. S. Geological Survey & Montana Bureau of Mines and Geology - 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 Smith (Badger) coal bed underlies the entire quadrangle, it is designated as datum for the correlation diagram.

The Smith (Badger) coal bed, the Anderson (School) coal zone and the Wildcat coal zone have a uniform coal bed occurrence. The Canyon coal bed is present along the eastern edge of the quadrangle and is thin throughout the quadrangle. The Cook and local coal beds are thin and lenticular with coal bed occurrences in localized areas of the quadrangle.

The Smith (Badger) coal bed occurs approximately 100 to 700 feet (30 to 213 m) beneath the surface throughout the quadrangle. The coal bed thickness ranges from 9 to 16 feet (2.7 to 5 m) with maximum thicknesses found in the western half of the study area (Plate 4). Structure contours drawn on top of the Smith (Badger) coal bed indicate a north-plunging syncline bisecting the quadrangle (Plate 5). The Smith (Badger) coal bed is buried from less than 100 feet (30 m) to greater than 600 feet (183 m) beneath the surface (Plate 6).

The Anderson (School) coal zone lies approximately 142 to 165 feet (43 to 50 m) below the Smith (Badger) coal bed and the coal thickness ranges from 5 to 15 feet (1.5 to 5 m). Maximum thicknesses occur in the southwest and northern portions of the quadrangle with a thinning trend eastward (Plate 9). The structure contours drawn on top of the Anderson (School) coal zone indicate a northeast-plunging anticline and a syncline in the southern area, and a regional northward dip in the northern two-thirds of the quadrangle (Plate 10). The Anderson (School) coal zone lies from less than 300 feet (91 m) to greater than 750 feet (229 m) beneath the surface of the quadrangle (Plate 11). The non-coal interval within the Anderson (School) coal zone varies from 16 feet to 59 feet (5 to 18 m).

The Canyon coal bed occurs approximately 252 feet (77 m) beneath the overlying Anderson (School) coal zone along the eastern edge of the quadrangle. The thin, Canyon coal bed ranges from 0 to 7 feet (0 to 2.1 m) in thickness (Plate 14) and has a small non-coal separation averaging 3 feet (0.9 m). Structure contours drawn on top of the Canyon coal bed (Plate 15) indicate a gentle northeast dip. The Canyon coal bed is absent from the western 85 percent of the quadrangle and occurs from less than 600 feet (183 m) to greater than 700 feet (213 m) beneath the surface throughout the area of coal bed occurrence (Plate 16).

The Wildcat coal zone occurs approximately 1050 to 1150 feet (320 to 351 m) beneath the Canyon coal bed in areas of Canyon coal bed occurrence and approximately 1239 to 1335 feet (378 to 407 m) beneath the overlying Anderson (School) coal zone. It is composed of three thin coal beds having a combined coal zone thickness ranging from 5 to 40 feet (1.5 to 12 m) (Plate 19). Maximum thickness occurs in the southeast quarter of the quadrangle with thinning to the west. The non-coal interval between the coal beds comprising the coal zone varies from 92 to 132 feet (28 to 40 m). A broad northeast-plunging anticline is present extending across the southern two-thirds of the quadrangle (Plate 20). The northern two-thirds of the quadrangle displays a gentle dip to the north. The structure contour map is drawn on the top of the Lower Wildcat coal bed where the Middle Wildcat coal bed is absent near the southern boundary. The Wildcat coal zone lies from less than 1750 feet (533 m) to greater than 2000 feet (610 m) beneath the surface of the quadrangle (Plate 21).

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 Southeast Quarter of Ross 15' 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. 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 24) 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 only 1 percent of the quadrangle along the eastern edge and in the southeast corner. A moderate potential rating covers 12 percent of the quadrangle and is located in scattered areas of the west-central, northeastern, east-central and south-central portions of the study area. These high and moderate potential ratings can be attributed to the low overburden in the primary drainages and the moderately thick Smith (Badger) coal bed. The low potential classification for surface mining methods covers approximately 60 percent of the study area and is attributed to high overburden to coal ratios for the Smith (Badger) coal bed, and Anderson (School) coal zone. The low development potential area is concentrated in northwestern, east-central, and southern areas of the quadrangle. Table 1 sets forth the estimated strippable reserve and hypothetical resources base tonnages per coal bed for the quadrangle.

Underground Mining Coal Development Potential. Subsurface coal mining potential throughout the Southeast Quarter of Ross 15' 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 within the Southeast Quarter of Ross 15' Quadrangle is low, hence no CDP map is generated for this map series. The coal resource tonnage for in-situ gasification with low development potential totals approximately 971 million tons (882 million metric tons) (Table 3). None of the coal beds in the Southeast Quarter of Ross 15' Quadrangle qualify for a moderate or high development potential rating.

Table 1.--Strippable Coal Reserve Base and Hypothetical Resource Data (in short tons) for Federal Coal Lands in the Southeast Quarter of Ross 15' Quadrangle, Converse County, Wyoming.

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

Coal Bed	High Development Potential (0-10:1 Mining Ratio)	Moderate Development Potential (10:1-15:1 Mining Ratio)	Low Development Potential (>15:1 Mining Ratio)	Total
RESERVE BASE				
Smith (Badger)	1,310,000	60,700,000	495,340,000	557,350,000
Anderson (School)	-----	-----	308,490,000	308,490,000
TOTAL	1,310,000	60,700,000	803,830,000	865,840,000
HYPOTHETICAL RESOURCES				
Smith (Badger)	-----	-----	29,900,000	29,900,000
Anderson (School)	-----	-----	26,540,000	26,540,000
TOTAL	-----	-----	56,440,000	56,440,000
GRAND TOTAL	1,310,000	60,700,000	860,270,000	922,280,000

Table 2.--Coal Resource Base and Hypothetical Resource Data (in short tons) for Underground Mining Methods for Federal Coal Lands in the Southeast Quarter of Ross 15' Quadrangle, Converse County, Wyoming.

Coal Bed Name	High Development Potential	Moderate Development Potential	Low Development Potential	Total
RESERVE BASE				
Smith (Badger)	-----	-----	28,910,000	28,910,000
Anderson (School)	-----	-----	240,820,000	240,820,000
Canyon	-----	-----	7,360,000	7,360,000
Wildcat	-----	-----	690,610,000	690,610,000
TOTAL	-----	-----	967,700,000	967,700,000
HYPOTHETICAL RESOURCES				
Anderson (School)	-----	-----	190,000	190,000
Canyon	-----	-----	720,000	720,000
Wildcat	-----	-----	2,490,000	2,490,000
TOTAL	-----	-----	3,400,000	3,400,000
GRAND TOTAL	-----	-----	971,100,000	971,100,000

Table 3.--Coal Resource Base and Hypothetical Resource Data (in short tons) for In-Situ Gasification for Federal Coal Lands in the Southeast Quarter of Ross 15' Quadrangle, Converse County, Wyoming.

Coal Bed Name	High Development Potential	Moderate Development Potential	Low Development Potential	Total
RESERVE BASE				
Smith (Badger)	-----	-----	28,910,000	28,910,000
Anderson (School)	-----	-----	240,820,000	240,820,000
Canyon	-----	-----	7,360,000	7,360,000
Wildcat	-----	-----	690,610,000	690,610,000
TOTAL	-----	-----	967,700,000	967,700,000
HYPOTHETICAL RESOURCE				
Anderson (School)	-----	-----	190,000	190,000
Canyon	-----	-----	720,000	720,000
Wildcat	-----	-----	2,490,000	2,490,000
TOTAL	-----	-----	3,400,000	3,400,000
GRAND TOTAL	-----	-----	971,100,000	971,100,000

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

_____, 1975b, Analyses and measured sections of 54 Wyoming coal samples (collected in 1974): Wyoming Geological Survey Report of Investigation No. 11, p. 156-160, 164-167.

Hausel, W. D., 1977, Preliminary coal resource occurrence map of the southeast quadrant of the Ross Fifteen-Minute quadrangle, Converse County, Wyoming: U. S. Geological Survey unpublished report scale 1:24,000.

IntraSearch Inc., 1978, 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.

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.

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, 1976, Preliminary report of coal drill-hole data and chemical analyses of coal beds in Campbell, Converse, and Sheridan Counties of Wyoming; and Big Horn, Richland, and Dawson Counties, Montana: U. S. Geological Survey Open-File Report 76-450, 382 p.

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.