UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

TEXT TO ACCOMPANY:

COAL RESOURCE OCCURRENCE

AND

COAL DEVELOPMENT POTENTIAL

MAPS

OF THE

ORIVA NORTHWEST QUADRANGLE,

CAMPBELL COUNTY, WYOMING

BY

INTRASEARCH INC.

DENVER, COLORADO

OPEN FILE REPORT 79-035
1979

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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 Oriva Northwest Quadrangle, Campbell County, Wyoming. This CRO and CDP map series (U. S. Geological Survey Open-File Report 79-035) includes 57 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 Oriva Northwest Quadrangle is located in Campbell County, in northeastern Wyoming. It encompasses parts of Townships 51 and 52 North, Ranges 73 and 74 West, and covers the area: 44°22'30" to 44°30' north latitude; 105°37'30" to 105°45' west longitude.

Primary access to the Oriva Northwest Quadrangle is provided by a maintained gravel road that enters the area near the center of the eastern quadrangle boundary and extends southward across the southeastern quadrant. This road intersects U. S. Highway 14 and 16 approximately 4 miles (6 km) east of the Oriva Northwest Quadrangle. A complex network of roads and trails provides access to the remainder of the study area. The closest railroad is the Burlington Northern trackage approximately 3 miles (5 km) southwest of the quadrangle.

Jamison Prong of Wildcat Creek provides the principal drainage for the northern half of Oriva Northwest Quadrangle, and Road Prong of Rawhide Creek provides the principal drainage for the southern half of the quadrangle. These intermittent streams flow into the Little Powder River to the north. The topography of the Oriva Northwest Quadrangle is characterized by rather steep-sided valleys and numerous pinnacles. Topographic elevations within the quadrangle vary from less than 4160 feet (1268 m) above sealevel in the valley of Wildcat Creek to more than 4700 feet (1433 m) above sealevel in the southwestern quadrant.

The 13 to 14 inches (33 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 11.3 billion tons (10.3 billion metric tons) of unleased federal coal resources in the Oriva Northwest 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 Oriva Northwest Quadrangle is located in an area where surface rocks are classified within the Wasatch and Fort Union Formations. 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 Scott coal bed was named by Olive (1957), and the Daly coal bed was named by McLaughlin and Hayes (1973). The Ulm #2 and Felix coal beds were named by Stone and Lupton (1910). Kent (1976) named the Norfolk coal bed, and the Smith coal bed was named by Taff (1909). The Swartz coal bed was designated by McKay and Mapel (1973), and Baker (1929) assigned names to the Anderson, Canyon, and Wall coal beds. The Cook coal bed was named by Bass (1932), and the Pawnee and Cache coal beds were named by Warren (1959). The Wildcat, Moyer and Oedekoven coal beds were informally named by IntraSearch (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 suggest 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 Oriva Northwest Quadrangle lies on the eastern flank of the Powder River Basin, where the strata dip gently westward. The Wasatch Formation crops out over all of the quadrangle except for the northeastern portion.

III. Data Sources

Areal geology of the coal outcrops and associated clinker is derived from McLaughlin and Hayes (1973). This information is supplemented by data from Wackwitz (1977). The coal bed outcrops are adjusted to current topographic maps of the area.

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, additional subsurface control is available from U. S. Geological Survey open-file reports that include geophysical and lithologic logs of shallow holes drilled specifically for coal exploration. 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 Oriva Northwest Quadrangle is published by the U. S. Geological Survey, compilation date 1971. 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 Oriva Northwest Quadrangle include, in descending stratigraphic order: the Ulm #2, Scott, Daly, Felix, Norfolk, Smith, Swartz, Anderson, Canyon, Cook, Wall, Pawnee, Cache, Wildcat, Moyer, and Oedekoven coal beds. A complete suite maps (coal isopach, mining ratio where appropriate, structure, overburden isopach, areal distribution of identified resources, and identified resources) is prepared for each of these coal beds except the Ulm #2, that is eroded from most of the quadrangle, the Swartz and Anderson coal beds, which are mapped as a coal zone, the Cache coal bed, which is not mapped due to limited areal extent, and the Wildcat, Moyer, and Oedekoven coal beds, which are mapped as a coal zone.

Physical and chemical analyses have been published for the Felix and Smith coal beds in the Oriva Northwest Quadrangle. The proximate analyses performed on an "as received" basis for some of the coal beds in northern Campbell County are as follows:

COAL BED NAME		ASH %	FIXED CARBON %	MOISTURE %	VOLATILES %	SULFUR %	BTU/LB
Felix (U)	Hole 7345	5.223	34.181	30.280	30.316	0.338	8111
Smith (U)	Hole 7340	3.505	38.036	29.980	28.474	0.309	8371
Swartz (U)	Hole 7334	6.442	34.001	29.260	30.297	0.707	7738
Anderson (U)	Hole 7406	6.317	31.113	32.583	29.986	0.327	7498
Wall (U)	Hole 7426	9.542	29.322	32.150	28.985	0.500	7279
Pawnee (U)	Hole 7424	7.880	31.029	31.910	29.183	0.386	7344

(U) - U. S. Geological Survey & Montana Bureau of Mines & Geology - 1973 & 1974.

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 Swartz-Anderson coal zone underlies the entire quadrangle, it is designated as datum for the correlation diagram. The Swartz-Anderson, and Canyon-Cook coal zones, where undivided, show the thickest single coal bed occurrences throughout the quadrangle. The Scott, Daly, Norfolk and Wall coal beds are relatively thin throughout most of the area.

Eroded from approximately 75 percent of the quadrangle, the Scott coal bed crops out around the higher topographic elevations throughout the study area. Limited subsurface control available for the Scott coal bed necessitates heavy reliance on previously published outcrop data (McLaughlin and Hayes, 1973). The thickness of the Scott coal bed ranges from 2 to 8 feet (0.6 to 2.4 m), with maximum thicknesses occurring in the east-central part of the quadrangle. The Scott coal bed is less than 5 feet (1.5 m) thick throughout most of its area of occurrence, especially in the western half of the study area. Structure contours drawn on top of the Scott coal bed indicate a broad northward-plunging anticline extending from the southwest to northwest quarters of the quadrangle. Synclinal lows occur to the east and west of the dominant anticlinal feature, most significantly in the southwest quarter of the quadrangle. The Scott coal bed lies approximately 0 to 150 feet (0 to 46 m) beneath the surface of the quadrangle.

The Daly coal bed lies approximately 50 to 100 feet (15 to 30 m) below the Scott coal bed, and is eroded from approximately 50 percent of the study area. The coal bed thickness ranges from 3 to 15 feet (0.9 to (5 m) with maximum thicknesses occurring in the southeast quarter of the quadrangle, thinning to the west. A non-coal interval ranging from 0 to 58 feet (0 to 18 m) locally separates the coal bed into as many as four thin coal beds. Structure contours drawn on top of the Daly coal bed depict a broad, east- to west- trending anticline extending across the central part of the study area. Two synclinal features occur in the northwest and southeast quarters of the quadrangle. The Daly coal bed lies approximately 0 to 250 feet (0 to 76 m) in depth beneath the surface of the quadrangle.

The Felix coal bed is eroded from approximately 20 percent of the quadrangle, and occurs 27 to 180 feet (8 to 55 m) below the overlying Daly coal bed. The coal bed thickness ranges from 18 to 28 feet (5 to 9 m) with maximum thicknesses extending from the northwest boundary of the study area into the southern half. Clastic intervals ranging from 0 to 5 feet (0 to 1.5 m) locally separate the Felix coal bed. The Felix coal bed dips one to two degrees to the west. A broad southwest-plunging anticline extends across the northern two-thirds of the quadrangle. A similarly plunging syncline occurs in the southwestern part of the quadrangle. The Felix coal bed lies approximately 0 to 400 feet (0 to 122 m) in depth beneath the surface of the quadrangle.

The Norfolk coal bed occurs approximately 205 to 326 feet (62 to 99 m) beneath the overlying Felix coal bed, and ranges in thickness from 0 to 17 feet (0 to 5 m). Maximum thicknesses occur along the east-central boundary of the quadrangle. The coal bed thins significantly to the west. The Norfolk coal bed is absent from approximately 20 percent of the study area, primarily in the southwest quarter. Structure contours drawn on top of the Norfolk coal bed indicate a regional dip to the west-southwest with minor anticlinal and synclinal features occurring in the eastern half of the quadrangle. The Norfolk coal bed lies approximately 40 to 700 feet (12 to 213 m) in depth beneath the surface throughout approximately 80 percent of the study area.

The Smith coal bed is separated from the overlying Norfolk coal bed by approximately 57 to 230 feet (17 to 70 m) of clastic debris. The coal bed thickness ranges from 7 to 30 feet (2.1 to 9 m) with maximum thicknesses occurring along the northern, eastern and southern boundaries of the study area. The Smith coal bed thins in the southwest and central parts of the quadrangle, and the trend of this coal bed thinning is northeastward. The Smith coal bed regionally dips to the west with a north-to south-trending anticlinal feature extending throughout the eastern two-thirds of the study area. A similarly trending syncline is also present to the east of the anticlinal feature in the eastern half of the quadrangle. The Smith coal bed lies approximately 100 to 850 feet (30 to 259 m) in depth beneath the surface throughout the entire quadrangle.

The Swartz-Anderson coal zone lies approximately 10 to 190 feet (3 to 58 m) below the Smith coal bed, and is composed of a thick, upper Swartz-Anderson coal bed overlying a thinner, lower Anderson coal bed. The total coal thickness ranges from 25 to 60 feet (8 to 18 m), with maximum thicknesses located along the northeastern boundary and southeastern corner of the quadrangle. Clastic intervals separating the various coal beds comprising the coal zone range from 0 to 93 feet (0 to 28 m). Structure contours drawn on top of the Swartz-Anderson coal zone indicate a regional dip to the west with numerous minor anticlinal and synclinal features occurring in the eastern half of the study area. The Swartz-Anderson coal zone lies approximately 200 to 900 feet (61 to 274 m) in depth beneath the surface throughout the entire quadrangle.

The Canyon-Cook coal zone is composed of the Canyon coal bed and Cook coal bed, which merge near the eastern boundary of the Oriva Northwest Quadrangle. It is separated from the Swartz-Anderson coal zone by 92 to 265 feet (28 to 81 m) of clastic rocks. In the area where the two coal beds are joined, the coal isopach varies from 48 to 100 feet (15 to 30 m) with the thickest coal near the east-central edge of the map (Plate 34). West of the split line the coal isopachs of the Canyon and Cook coal beds are mapped separately. The Canyon coal bed thickness varies from 10 feet (3 m) along the western boundary to 60 feet (18 m) near the southeast corner of the quadrangle. The Cook coal bed is absent in approximately 12 percent of the quadrangle in the southwest quadrant and attains a maximum thickness of 56 feet (17 m) near the northeast corner of the quadrangle. The structure contour map (Plate 35) drawn on top of the Canyon-Cook coal zone depicts a complex, bifurcated, northwest-plunging syncline in the central part of the area. A broad, west-plunging anticline is mapped in the northern area, and a northwest-plunging anticline is shown in the southwest portion of the quadrangle. In the western three-fourths of the quadrangle, where the Canyon and Cook coal beds are separate, the structure contours drawn on top of the Cook coal bed show a south to southwest-plunging anticline trending from the northeast into the central area. A south to southwest-plunging syncline occurs subparallel to the anticline to the south-southeast. The Cook coal bed structure map in the southern half of the quadrangle displays a complex series of anticlines and synclines. The non-coal interval within the Canyon-Cook coal zone attains a maximum thickness of 364 feet (111 m) near the western edge in the northwest quadrant of the quadrangle. Except for about 20 acres (8 ha) in the northeast corner, the Canyon-Cook coal zone lies approximately 550 to 1200 feet (168 to 366 m) below the surface throughout the quadrangle (Plate 36).

The Wall coal bed lies between 57 and 275 feet (17 to 84 m) below the Canyon-Cook coal zone and varies in thickness from 0 to 20 feet (0 to 6 m). The coal bed is absent in 15 percent of the quadrangle along the eastern border and is thickest in the northwest and southwest corners of the quadrangle (Plate 39). Structure contours drawn on top of the Wall coal bed portray a broad northwest-plunging syncline from the west-central part of the quadrangle into the southeast corner, with a parallel anticline to the south (Plate 40). A series of two west-southwest anticlines and synclines is present in the northeast quadrant. The Wall coal bed is approximately 690 to 1575 feet (210 to 480 m) in depth beneath the surface throughout the entire quadrangle.

The Pawnee coal bed is separated from the Wall coal bed by from 28 to 225 feet (9 to 69 m) of clastic interburden. The Pawnee coal bed is from 5 to 35 feet thick (1.5 to 11 m) and locally contains minor non-coal intervals. The thinnest coal thickness is in the southwest quadrant and in the northwest quadrant of the area (Plate 44). The structural configuration on the top of the coal bed shows a westward-plunging syncline in the southwest quadrant flanked by westward plunging anticlines to the north and south. Minor folding in the eastern half of the quadrangle is superimposed on a gentle westward dip (Plate 45). The Pawnee coal bed is approximately 850 to 1650 feet (259 to 503 m) in depth beneath the surface, throughout the quadrangle.

The Wildcat-Moyer-Oedekoven coal zone underlies the Pawnee coal bed at an interval ranging from 191 to 409 feet (58 to 125 m). The coal zone is composed of the Wildcat, Moyer and Oedekoven coal beds each of which may be split into two or more coal beds. The combined thickness of the coal beds in the coal zone varies from 40 feet (12 m) in the northwest and southwest corners and in the central portion of the northern boundary to 72 feet (22 m) in the western half of the southeast quadrant (Plate 49). The Wildcat coal bed varies in thickness from 10 to 29 feet (3 to 9 m), the Moyer coal bed is from 8 to 22 feet (2.4 to 7 m) in thickness, and the coal isopach of the Oedekoven coal bed varies from 4 to 28 feet (1.2 to 9 m). Structure contours drawn on top of the Wildcat coal bed depict gentle dip to the west interrupted by a minor south-plunging anticline and syncline in the northeast quadrant (Plate 50). Total interburden with the Wildcat-Moyer-Oedekoven coal zone ranges from 199 to 358 feet (61 to 109 m). The Wildcat-Moyer-Oedekoven coal zone is approximately 1150 to 1900 feet (351 to 579 m) in depth beneath the surface in the Oriva Northwest 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 Oriva Northwest 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 54) 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 75 percent of the Oriva Northwest Quadrangle due to the relatively high relief and large number of shallow-lying coal beds. A high potential rating covers the entire quadrangle except for low relief areas, primarily in the north-central and southwest parts of the study area. The remaining 25 percent of the quadrangle is considered to have moderate to low development potential for surface mining methods. 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 Oriva Northwest 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. <u>Moderate development</u> 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. <u>High development</u> 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 Oriva Northwest Quadrangle is moderate for approximately 25 percent of the quadrangle occurring in small scattered areas along the western boundary of the quadrangle. A low potential rating covers the remaining 75 percent of the study area. The in-situ gasification potential map (Plate 55) shows the distribution of moderate and low potential areas, and Table 3 shows the coal resource tonnages for the two categories.

Table 1.--Strippable Coal Reserve Base Data (in short tons) for Federal Coal Lands in the Oriva Northwest 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
Scott	11,980,000	-----	-----	11,980,000
Daly	97,480,000	12,740,000	26,940,000	137,160,000
Felix	723,380,000	246,240,000	14,400,000	984,020,000
Norfolk	23,830,000	21,840,000	153,970,000	199,640,000
Smith	1,820,000	58,760,000	272,110,000	332,690,000
	(0-5:1 Mining Ratio)	(5:1-7:1 Mining Ratio)	(>7:1 Mining Ratio)	
Swartz-Anderson	269,060,000	276,360,000	-----	545,420,000
TOTAL	1,127,550,000	615,940,000	467,420,000	2,210,910,000

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

Coal Bed Name	High Development Potential	Moderate Development Potential	Low Development Potential	Total
Norfolk	-----	-----	11,520,000	11,520,000
Smith	-----	-----	542,910,000	542,910,000
Swartz-Anderson	-----	-----	1,695,000,000	1,695,000,000
Canyon	-----	-----	2,470,430,000	2,470,430,000
Wall	-----	-----	349,170,000	349,170,000
Pawnee	-----	-----	1,039,330,000	1,039,330,000
Wildcat-Moyer Oedekoven	-----	-----	2,956,960,000	2,956,960,000
TOTAL	-----	-----	9,065,320,000	9,065,320,000

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

Coal Bed Name	High Development Potential	Moderate Development Potential	Low Development Potential	Total
	-----	803,590,000	8,261,730,000	9,065,320,000
TOTAL	-----	803,590,000	8,261,730,000	9,065,320,000

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