UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

TEXT TO ACCOMPANY:

COAL RESOURCE OCCURRENCE

AND

COAL DEVELOPMENT POTENTIAL

MAPS

OF

THE GAP SOUTHWEST QUADRANGLE,

CAMPBELL COUNTY, WYOMING

BY

INTRASEARCH INC.

DENVER, COLORADO

OPEN FILE REPORT 79-054
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 ton
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 Gap Southwest Quadrangle, Campbell County, Wyoming. This CRO and CDP map series includes 14 plates (U. S. Geological Survey Open-File Report (79-054). 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 Resource Areas (KRCRA) in the western United States.

The Gap Southwest Quadrangle is located in Campbell County, in northeastern Wyoming. It encompasses all or parts of Townships 46, 47 and 48 North, Ranges 71 and 72 West, and covers the area: 44° 00' to 44° 07' 30" north latitude; 105° 22' 30" to 105° 30' west longitude.

Wyoming State Highway 59, connecting Douglas and Gillette, Wyoming, traverses north-south through the west-central portion of The Gap Southwest Quadrangle. Three east-west trending maintained gravel roads intersect Highway 59 in the northern, central, and southern thirds of the study area. The northernmost improved road extends eastward from Highway 59 to the Belle Ayr coal mine, located in Section 34, T. 48 N., R. 71 W. Due west of the mine, this road intersects another maintained gravel road which angles south through the extreme eastern portion of the quadrangle. Minor roads and trails that branch from the aforementioned roads provide additional access to the study area. The Burlington Northern trackage, partially completed from Gillette to Douglas, Wyoming, services the Belle Ayr coal mine. This trackage connects to the main Burlington Northern Railroad, approximately 9 miles (8 km) east of Gillette, Wyoming.

Caballo Creek, a tributary of the Belle Fourche River, flows eastward through the northern third of the quadrangle. The minimum elevation in the study area, approximately 4460 feet (1359 m) above sea level, occurs in the valley floor of Caballo Creek west of the Belle Ayr coal mine. Hot Creek drains northward into Cabollo Creek in the west-central part of the study area. A maximum elevation of 5008 feet (1526 m) above sea level is attained in the semi-rugged terrain in the southwestern corner of The Gap Southwest Quadrangle. The somber grays, yellows, and browns of outcropping shales and siltstones contrast strikingly with the brilliant reds, oranges, and purples of "clinker", and deep greens of the juniper and pine tree growth.

The 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 $-25^{\circ}F$ ($-32^{\circ}C$) to more than $100^{\circ}F$ ($38^{\circ}C$) have been recorded near Gillette, Wyoming, average wintertime minimums and summertime maximums approach $+5^{\circ}$ to $+15^{\circ}F$ (-15° and $-9^{\circ}C$) and 75° to $90^{\circ}F$ (24° to $32^{\circ}C$), 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 Cheyeene, 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, bituminous and anthracite coal 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 5.4 billion tons (4.9 billion metric tons) of total unleased federal coal resources in The Gap 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 Tonque 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 required a discrete 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 servicing 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 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 area.

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, in northwestern Campbell County, Wyoming, the contact is positioned near the top of the Roland coal bed as mapped by Olive (1957) 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 Gap Southwest Quadrangle is located in an area where surface rocks are classified into the Wasatch Formation. The Wasatch Formation is reportedly more than 700 feet (213 m) thick (Olive, 1957), and approximately this amount of section is 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. The Felix coal bed was 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 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).

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 The Gap Southwest Quadrangle. 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. The Wildcat, Moyer, and Oedekoven coal beds were informally named by

IntraSearch (1978b, 1979, and 1978a).

Local. The Gap Southwest Quadrangle lies on the eastern flank of the Powder River Basin, where the strata dip gently westward. The Wasatch Formation crops out over the entire quadrangle, and is comprised of friable, coarse-grained to gritty arkosic sandstones, fine-to very fine-grained sandstones, siltstones, mudstones, claystones, brown-to-black carbonaceous shales, and coal beds.

III. Data Sources

Areal geology of the coal outcrops and associated clinker is derived from the Geologic Map and Coal Resources of The Gap Southwest Quadrangle by Grazis (1977). The Wasatch Formation contains four coal beds mapped by Grazis (1977). The Felix coal bed, the uppermost coal bed, is present in one section in the southwest corner; and, according to surface measured sections, is approximately 10 to 15 feet (3 to 5 m) thick.

The following data are derived from Gazis (1977):

1. The C" coal bed lies approximately 180 feet (55 m) beneath the Felix coal bed, and is 0 to 3 feet (0 to 0.9m) thick.
2. The C' coal zone consists of one or two lenticular coal beds and lies 85 to 90 feet (26 to 27 m) below the C" coal bed. The C' coal zone is 0 to 10 feet (0 to 3 m) thick.
3. Another thin, lenticular coal bed, the C coal bed, is 62 to 90 feet (19 to 27 m) below the C' coal zone, and is 0 to 5 feet (0 to 1.5 m) thick.

The C", C', and C coal beds were collectively named the C coal zone by Dobbin and Barnett (1928, p. 15), but separated by Grazis (1977).

In order to relate with the regional nomenclature of Intra-Search, from the surrounding quadrangles, the C" coal bed is considered a local coal bed, and the C' and C coal beds are correlated as the Upper and Lower Smith coal beds, respectively. These three coal beds are not mapped due to the paucity of data and the reported lenticular character of the coal beds. The S, V, and X coal beds of Grazis (1977) correspond to the IntraSearch nomenclature of Wildcat, Moyer, and Oedekoven.

The top of the Wyodak coal bed mapped by Grazis (1977) is the contact between the Wasatch Formation and the underlying Tongue River Member of the Fort Union Formation of Paleocene age. However, Grazis (1977) notes that recent palynological work by R. H. Tschudy indicates that several hundred feet of rock above the Wyodak, but below the Felix coal bed, may be of Paleocene age.

The major source of subsurface control, particularly on deep coal beds, is the geophysical logs from oil and gas test bores and producing wells. 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 eighty percent of the logs include resistivity, conductivity, and self-potential curves. Occasionally the logs include 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, 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.

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 down-hole data interpretation.

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 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 Gap Southwest Quadrangle is published by the U. S. Geological Survey, compilation date, 1971. Coal ownership data is compiled from land plats obtained from the U. S. Bureau of Land Management in Cheyenne, Wyoming. This information is current to October 13, 1977.

IV. Coal Bed Occurrence

The Wasatch Formation coal beds that are present in The Gap Southwest Quadrangle are the Felix, an unnamed local, Upper Smith and Lower Smith coal beds. The Felix coal bed is present in the extreme southwestern corner of the quadrangle. Figures 1, 2, and 3 depict the complete suite of maps for the Felix coal bed. The paucity of subsurface data preclude detailed mapping of the Upper and Lower Smith coal beds. Fort Union Formation coal beds that are present include, in descending stratigraphic order, the Wyodak, Wildcat, Moyer, and Oedekoven coal beds. A complete suite of maps (structure, isopach, mining ratio, overburden/interburden, identified resources and areal distribution of identified resources) is prepared for the Wyodak coal bed and the Wildcat-Moyer-Oedekoven coal zone.

Physical and chemical analyses are published regarding the Local, Upper Smith, and Lower Smith coal beds in The Gap Southwest Quadrangle. The "as received basis" proximate analyses for the Felix and Wyodak Coal beds are from drill holes on adjacent quadrangles. These proximate analyses are as follows:

COAL BED NAME	ASH	FIXED CARBON	MOISTURE	VOLATILES	SULPHUR	BTU/LB
Felix (U) Hole 7316	7.760	31.233	30.098	30.909	0.524	7743
Local (U) Hole 7311	11.344	30.006	28.410	30.239	4.156	7649
Upper Smith (U) Hole 7312C	16.323	29.797	25.376	38.503	2.598	7273
Lower Smith (U) Hole 7312C	6.167	33.340	29.610	30.883	1.068	8215
Wyodak (U) Hole 7310	5.852	33.938	29.060	31.150	0.435	8172

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

The Coal Data Sheet, Plate 3, shows the downhole identification of coal beds within the quadrangle as interpreted from U. S. Geological Survey and Montana Bureau of Mines and Geology drill holes, and 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) areas. Inasmuch as the Wildcat coal bed underlies most of the quadrangle, it is designated as datum for the correlation diagram.

The Felix coal bed crops out in a small area, slightly more than one section, in high terrain in the southwest corner of The Gap Southwest Quadrangle. From the surface measured sections of Grazis (1977), it ranges from 10 to 15 feet (3 to 5 m) in thickness (Figure 2) and occurs generally in excess of 100 feet (30 m) beneath the surface. Structure contours on top of the Felix coal bed show a gentle northwestward dip (Figure 1).

The Wyodak coal bed lies approximately 650 feet (198 m) beneath the Felix coal bed. Thicknesses for the Wyodak coal bed range from less than 60 feet (18 m) in the southeast corner to 83 feet (25 m) in the west-central portion of the map (Plate 4). Structure contours on top of the Wyodak coal bed portray a westward dip of less than one degree (Plate 5). The overburden thickness above the Wyodak coal bed varies from less than 100 feet (30 m) in Caballo Creek in the northeastern area to more than 800 feet (244 m) in the southwest corner of the quadrangle (Plate 6).

The Wildcat-Moyer-Oedekoven coal zone lies approximately 500 to 650 feet (152 to 198 m) below the Wyodak coal bed, and is greater than 500 feet (152 m) beneath the surface throughout the quadrangle (Plate 11). The

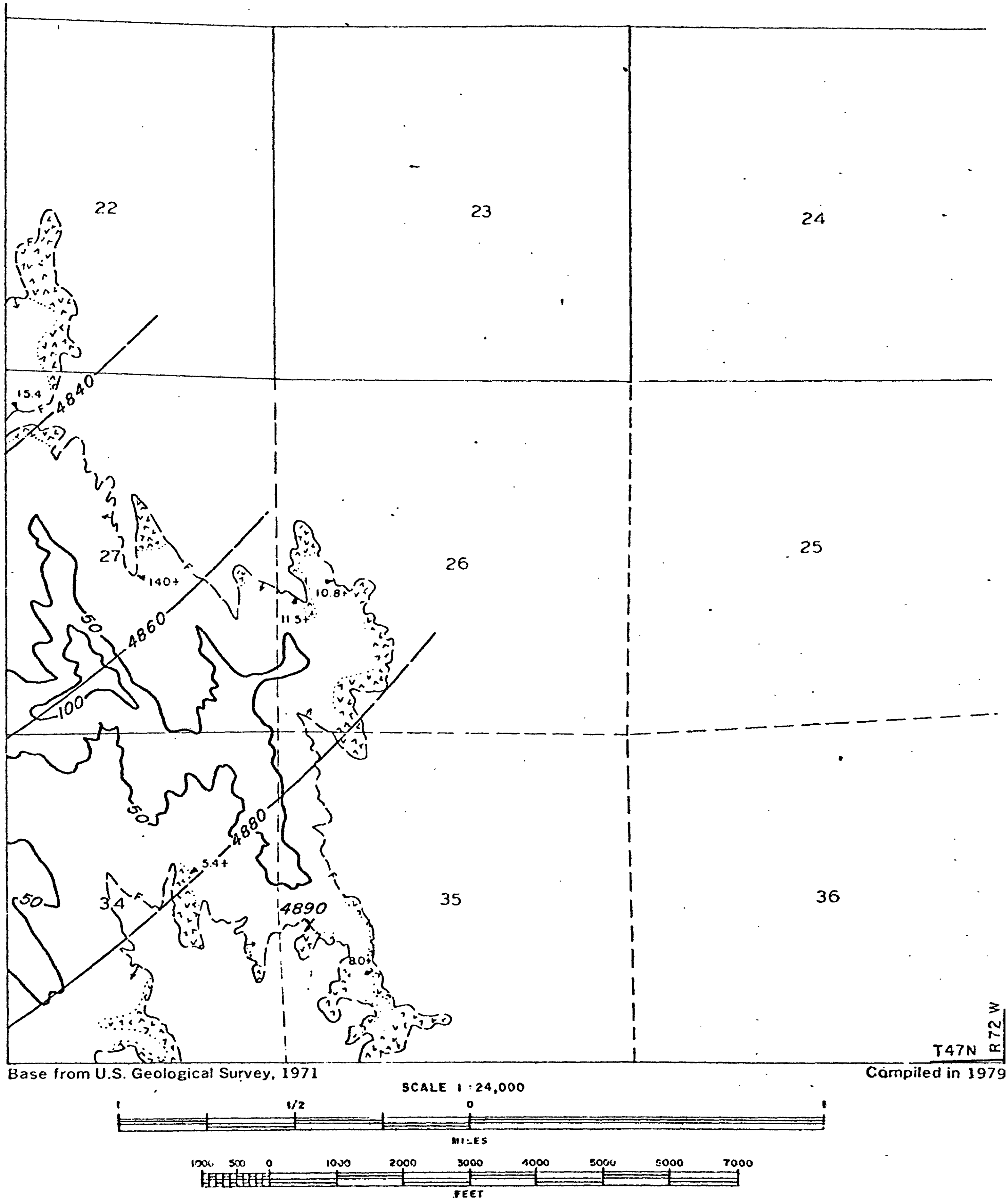


FIGURE 1
STRUCTURE CONTOUR AND ISOPACH OF OVERBURDEN MAP
OF FELIX COAL BED IN
THE GAP SW QUADRANGLE
CAMPBELL COUNTY, WYOMING
(See following page for Explanation)

EXPLANATION FOR FIGURE 1

4880

STRUCTURE CONTOURS-Drawn on top of coal bed. Contour interval 20 feet. Datum is mean sea level. Contour dashed where coal is burned or eroded.

100

OVERBURDEN ISOPACH-Showing thickness of overburden, in feet, from the surface to the top of the coal bed. Isopach interval 50 feet.

X 4890

INFERRED POINT-Derived from outcrop elevation plus coal thickness, showing elevation in feet.

F 10.8+

TRACE OF COAL BED OUTCROP-Showing coal thickness in feet, measured at triangle. Arrow points toward the coal-bearing area. "V" symbol indicates burned rock with dotted line showing limit of burning. Coal bed dashed where inferred.

To convert feet to meters multiply feet by 0.3048.

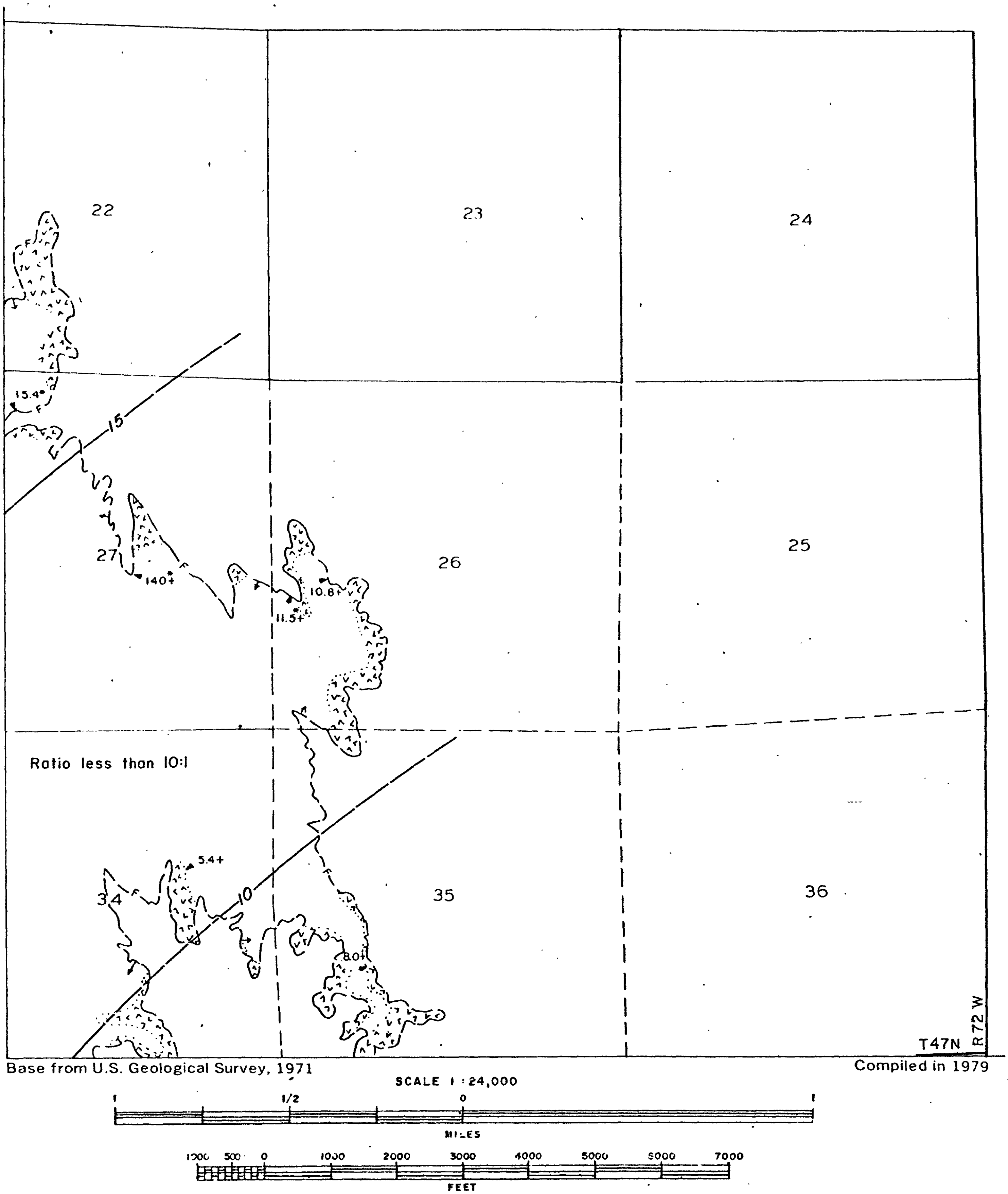


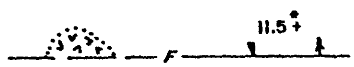
FIGURE 2
ISOPACH AND MINING RATIO MAP
OF FELIX COAL BED IN
THE GAP SW QUADRANGLE
CAMPBELL COUNTY, WYOMING
(See following page for Explanation)

EXPLANATION FOR FIGURE 2

ISOPACHS OF COAL BED-Showing thickness in feet, interval 5 feet. Dashed where coal is burned or eroded.

10:1

MINING RATIO-Number indicates cubic yards of overburden per ton of recoverable coal by surface mining methods. Ratio shown only in area suitable for surface mining.



TRACE OF COAL BED OUTCROP-Showing coal thickness in feet, measured at triangle. Asterisk indicates measured section was used in isopach mapping. Arrow points toward the coal-bearing area. "V" symbol indicates burned rock with dotted line showing limit of burning.

To convert feet to meters multiply feet by 0.3048.

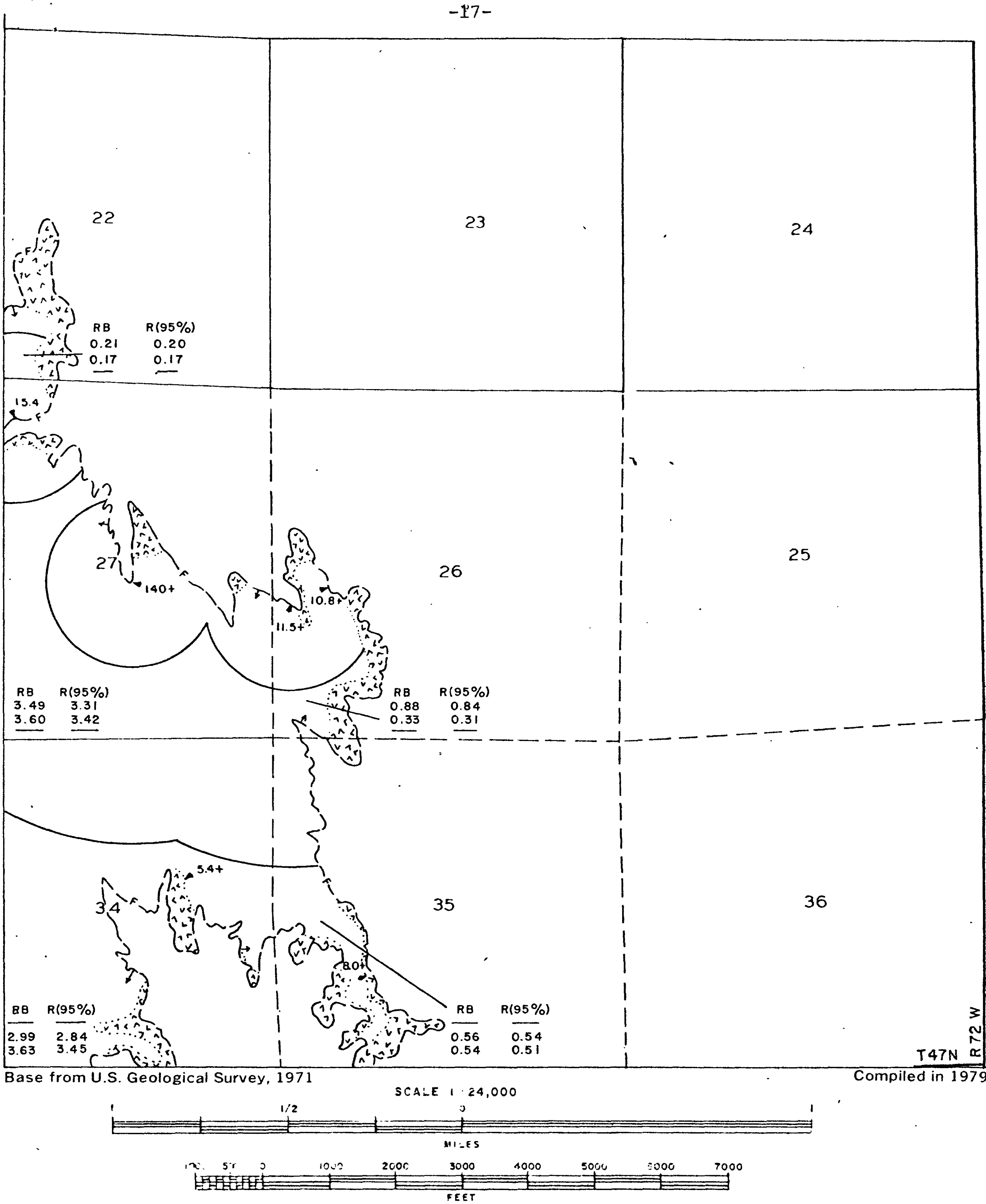
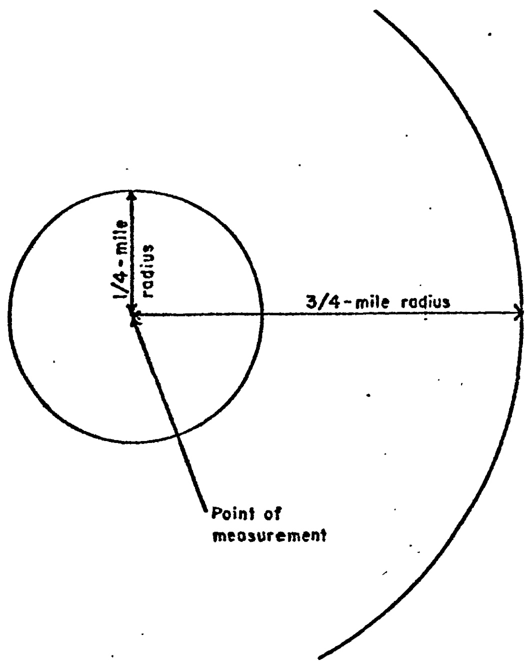


FIGURE 3
AREAL DISTRIBUTION OF IDENTIFIED RESOURCES
AND IDENTIFIED RESOURCES MAP
OF FELIX COAL BED IN
THE GAP SW QUADRANGLE
CAMPBELL COUNTY, WYOMING
(See following page for Explanation)

EXPLANATION FOR FIGURE 3



BOUNDARY LINES-Enclosing areas of measured and indicated coal resources of the coal bed. Inferred resources beyond 3/4 mile.

RB	R(95%)	
0.21	0.20	(Measured)
0.17	0.17	(Indicated)
—	—	(Inferred)

IDENTIFIED RESOURCES OF COAL BED-In millions of short tons. Dash indicates no resources in that category. Reserve Base (RB) x the recovery factor (95%) = Reserves (R).

TRACE OF COAL BED OUTCROP-Showing coal thickness in feet, measured at triangle. Arrow points toward the coal-bearing area. "V" symbol indicates burned rock with dotted line showing limit of burning. Coal bed dashed where inferred.

To convert miles to kilometers multiply miles by 1.609.

To convert short tons to metric tons multiply short tons by 0.9072.

aggregate coal thickness for the Wildcat-Moyer-Oedekoven coal zone varies from 24 feet (7 m) in the southeast corner to more than 65 feet (20 m) in the west-central part of the quadrangle (Plate 9). This coal zone consists of two to six separate coal beds which contain numerous non-coal intervals with total interburden thicknesses varying from 15 to 279 feet (5 to 85 m). Structure contours are drawn on top of the Wildcat coal bed. Where the Wildcat coal bed is absent from the east-central part of the quadrangle, the structure contours are drawn on top of the Moyer coal bed. The structure contours on the Wildcat-Moyer-Oedekoven coal zone display a gentle westward dip of one to two degrees (Plate 10).

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 plots the horizontal location of 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 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 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 Gap 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 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 is 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 1750, or 1770 (the number of tons of lignite A or subbituminous C 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 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 conversion factor of 0.922 is used for lignite.

A surface mining potential map 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 map is based on the Felix and Wyodak coal beds. High development potential in the eastern half of the quadrangle results from the thick Wyodak coal bed beneath a maximum overburden thicknesses of 300 to 400 feet (91 to 122 m), and high development potential in the southwest corner relates to the occurrence of the Felix coal bed at shallow depth. The moderate and low surface mining potential areas in the western portion of the study area are located between the Felix outcrop in the higher terrain and the 5:1 ratio line on the Wyodak coal bed. 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 Gap Southwest 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 buried 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 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).

The coal development potential for in-situ gasification on The Gap Southwest 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 2.6 billion tons (2.4 billion metric tons) (Table 3). None of the coal beds in The Gap Southwest Quadrangle qualify for a moderate or high development potential rating.

Table 1.--Strippable Coal Reserve Base Data (in short tons) for Federal Coal Lands in The Gap Southwest 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
Felix	15,590,000	——	——	15,590,000
	(0-5:1 Mining Ratio)	(5:1-7:1 Mining Ratio)	(>7:1 Mining Ratio)	
Wyodak	1,674,720,000	960,270,000	5,740,000	2,640,730,000
TOTAL	1,690,310,000	960,270,000	5,740,000	2,656,320,000

Table 2.-- Coal Resource Base Data (in short tons) for Underground Mining Methods for Federal Coal Lands in The Gap Southwest Quadrangle, Campbell County, Wyoming.

Coal Bed Name	High Development Potential	Moderate Development Potential	Low Development Potential	Total
Wyodak	—	—	526,620,000	526,620,000
Moyer	—	—	2,103,040,000	2,103,040,000
TOTAL	—	—	2,629,660,000	2,629,660,000

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

Coal Bed Name	High Development Potential	Moderate Development Potential	Low Development Potential	Total
Wyodak	—	—	526,620,000	526,620,000
Moyer	—	—	2,103,040,000	2,103,040,000
TOTAL	—	—	2,629,660,000	2,629,660,000

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