UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

TEXT TO ACCOMPANY:

COAL RESOURCE OCCURRENCE

AND

COAL DEVELOPMENT POTENTIAL

MAPS

OF THE

GILLETTE WEST QUADRANGLE,

CAMPBELL COUNTY, WYOMING

BY

INTRASEARCH INC.

DENVER, COLORADO

OPEN FILE REPORT 79-041
1979

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

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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 Gillette West Quadrangle, Campbell County, Wyoming. This CRO and CDP map series (U. S. Geological Survey Open-File Report 79-041) includes 30 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 Gillette West Quadrangle is located in Campbell County, in northeastern Wyoming. It encompasses all or parts of Townships 49, 50 and 51 North, Ranges 72 and 73 West, and covers the area: 44°15' to 44° 22'30" north latitude; 105°30' to 105°37'30" west longitude.

The main access to the Gillette West Quadrangle is provided by Interstate Highway 90 which traverses east-west across the southern half of the quadrangle and U. S. Routes 14-16 and State Highway 59, which extends from Gillette to the northern boundary in the eastern quarter of the study area. Maintained hard surface and light-duty improved surface roads branch from the main accesses permitting access to all quadrants of the quadrangle. Minor roads and trails that branch from the aforementioned roads provide additional access to the area. The Burlington Northern Railroad has trackage in the southern portion of the Gillette West Quadrangle, and it parallels Interstate 90.

Stonepile Creek and Donkey Creek located in the southern half of the Gillette West Quadrangle provide significant eastward drainage to the Belle Fourche River. Lone Tree Prong Creek in the northwest corner provides drainage for the fairly rugged terrain in the northwestern part of the quadrangle, while Little Rawhide Creek flows northward through relatively low relief in the northeastern part. These intermittent streams drain into the Little Powder River to the northeast. The terrain of the Gillette West Quadrangle attains maximum elevations of 4907 feet (1496 m) above sealevel in the west-central portion of the study area. Minimum elevations of 4260 feet (1298 m) above sealevel are located in the northeast corner of the quadrangle.

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 8.3 billion tons (7.5 billion metric tons) of unleased federal coal resources in the Gillette West 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 Gillette West Quadrangle is located in an area where surface rocks are classified into the Wasatch Formation. Approximately 600 to 650 feet (183 to 198 m) of Wasatch Formation 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). Taff (1909) named the Ulm and Smith coal beds, and the Anderson, Canyon and Wall coal beds were named by Baker (1929). The Cook coal bed was named by Bass (1932) and the Pawnee coal bed was 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 suggests 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 Gillette West 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 area, 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.

A single northeast-southwest trending fault in the northwest corner of the quadrangle with a vertical displacement of 50 to 200 feet (15 to 61 m) is delineated by IntraSearch from subsurface data for the Wyodak coal bed. Evidence for this fault is not available for the Pawnee coal bed or Wildcat-Moyer-Oedekoven coal zone and therefore not mapped on these horizons. This structural interpretation differs significantly from Law (1978) due to additional subsurface data.

III. Data Sources

Areal geology of the coal outcrops and associated clinker is derived from unpublished CRO-CDP maps for the Gillette West Quadrangle compiled by S. P. Buck (1977) of the U. S. Geological Survey. The coal bed outcrops are adjusted to the current topographic map in 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 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 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 Gillette West 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 Gillette West Quadrangle include, in descending stratigraphic order: the Ulm, Felix, Smith, local, Wyodak, Pawnee, local, Wildcat, Moyer and Oedekoven coal beds. A complete suite of maps (coal isopach, mining ratio where applicable, structure, overburden/interburden isopach, areal distribution of identified resources, and identified resources) was prepared for each of these coal beds except for the Wildcat, Moyer and Oedekoven coal beds, which are mapped together as a coal zone, and the local coal beds, where lack of areal extent precludes detailed mapping.

Physical and chemical analyses are known to have been published regarding the Felix coal bed in the Gillette West Quadrangle. The general proximate analyses performed on an "as received" basis for the Felix coal bed, and selected central and southern Campbell County coal beds are as follows:

COAL BED NAME			ASH %	FIXED CARBON %	MOISTURE %	VOLATILES %	SULFUR %	BTU/LB
Ulm	(U)	Hole 7331	8.224	30.181	31.753	29.842	1.807	7524
Felix	(U)	Hole 7332	11.235	30.436	26.932	31.397	1.413	7755
Smith	(U)		6.440	31.390	35.370	26.800	0.450	7125
Wyodak	(U)	Hole 7363	6.830	30.574	31.710	30.885	0.652	7807
Pawnee	(U)	Hole 7424	7.880	31.029	31.910	29.183	0.386	7344
(Wildcat) "D"	(*)	Lab. No. 11447	4.3	29.4	27.8	29.4	0.27	8410

(*) - Winchester (1912)

(U) - U. S. Geological Survey & Montana Bureau of Mines & Geology - 1974 & 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 Wyodak coal bed underlies the entire quadrangle, it is designated as datum for the correlation diagram. The Wyodak coal bed is the thickest single coal bed in the quadrangle.

The Ulm coal bed is eroded from approximately 95 percent of the quadrangle and is present only in the southwest corner of the quadrangle. Maps for the Ulm coal bed are presented on 8½" by 11" (22 by 28 cm) sheets (Figures 1, 2, and 3) included in this report. Due to the sparsity of subsurface data for structure and isopach maps; mapping control is supplemented by outcrop parameters. The Ulm coal bed varies in thickness from 20 to 25 feet (6 to 8 m) thick with maximum thicknesses occurring near the eastern outcrops (Figure 2). Structure contours drawn on top of the Ulm coal bed define a gentle westward dip (Figure 1). The Ulm coal bed lies less than 150 feet (46 m.) beneath the surface throughout the quadrangle (Figure 1).

The Felix coal bed crops out in the northern and central portion of the quadrangle and is separated from the overlying Ulm coal bed by 300 to 350 feet (91 to 107 m) of clastics. Thicknesses range from 10 to 30 feet (3 to 9 m) with maximum thicknesses in the central western portion of the quadrangle (Plate 4). Localized partings occur throughout the quadrangle, with interburden ranging from 4 to 7 feet (1.2 to 2.1 m) thick. The structural configuration drawn on the top of the Felix coal bed defines several synclines and anticlines plunging to the southwest (Plate 5). The

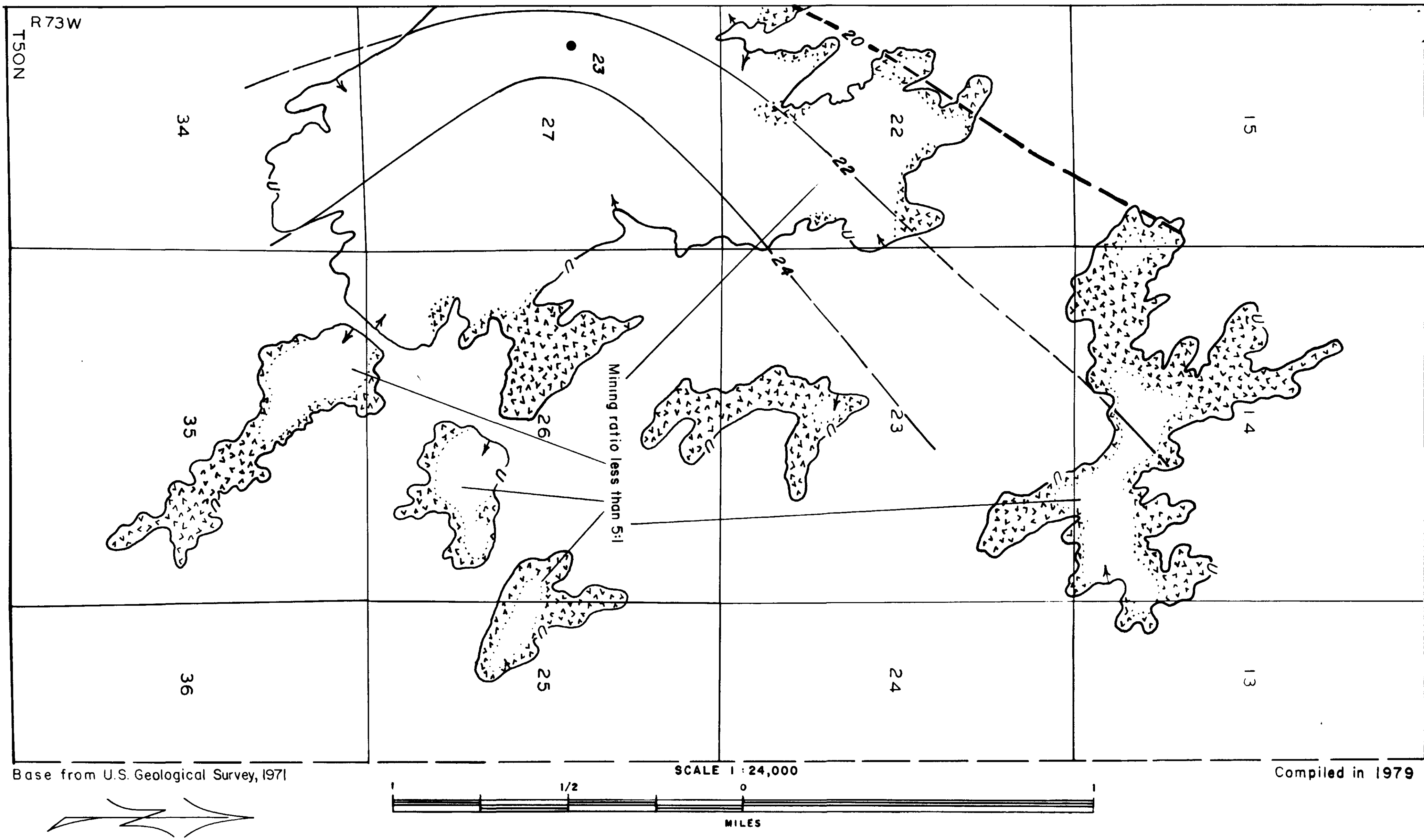
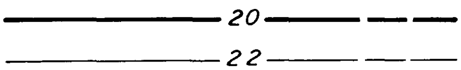


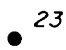
FIGURE 1
ISOPACH AND MINING RATIO MAP
OF ULM COAL BED IN
GILLETTE WEST QUADRANGLE
CAMPBELL COUNTY, WYOMING
(See following page for Explanation)

EXPLANATION FOR FIGURE 1

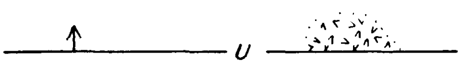


ISOPACHS OF COAL BED-Showing thickness in feet, interval 2 feet. Dashed where coal is burned or eroded.

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 within the stripping limit.



DRILL HOLE-Showing coal thickness in feet.



TRACE OF COAL BED OUTCROP-Showing coal thickness in feet. Arrow points toward the coal-bearing area. "V" symbol indicates baked rock with dotted line showing limit of burning.

To convert feet to meters multiply feet by 0.3048.

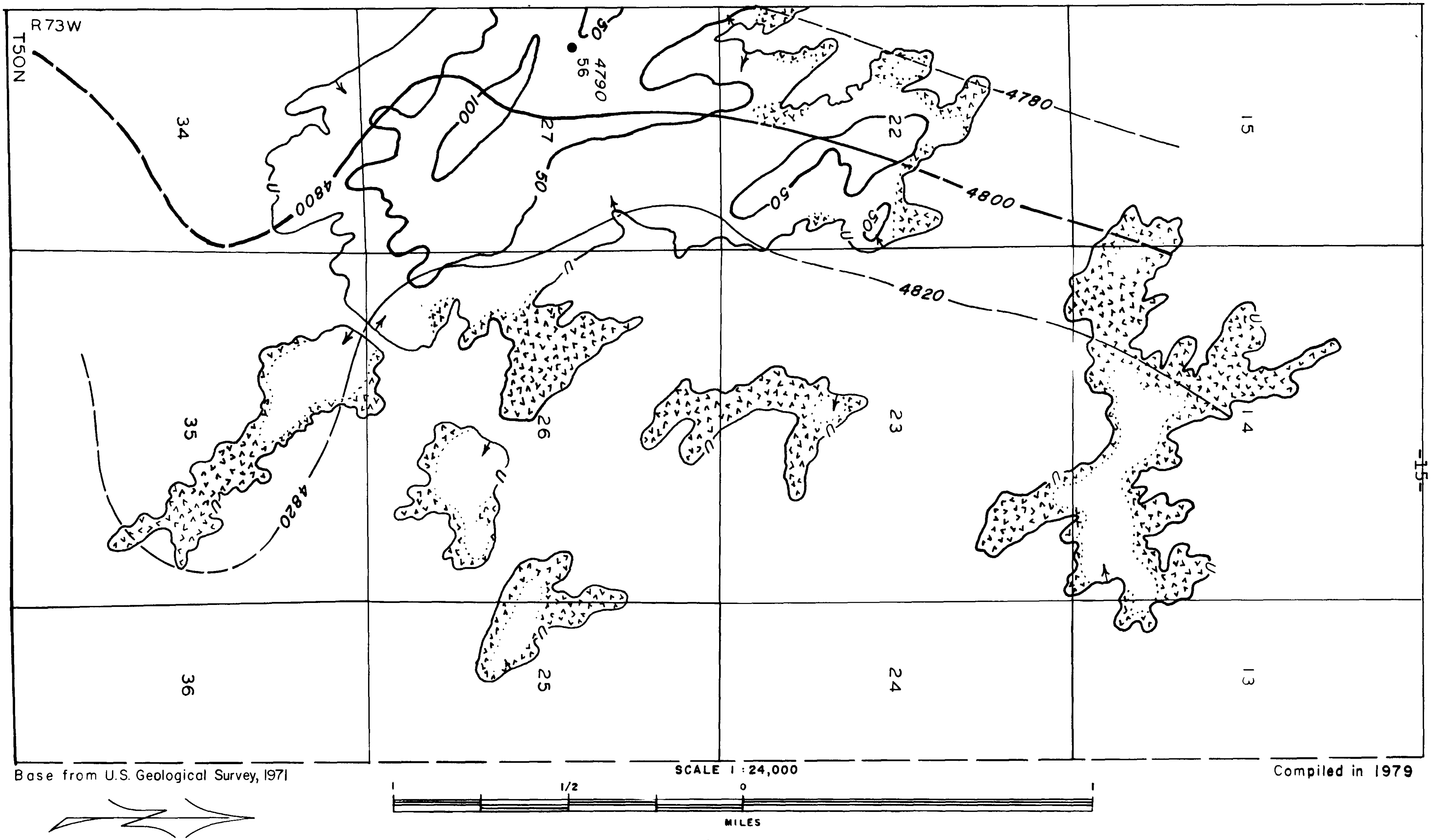
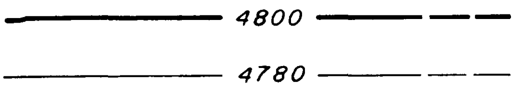
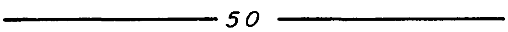


FIGURE 2
STRUCTURE CONTOUR AND ISOPACH OF OVERBURDEN MAP
OF ULM COAL BED IN
GILLETTE WEST QUADRANGLE
CAMPBELL COUNTY, WYOMING
(See following page for Explanation)

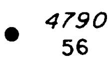
EXPLANATION FOR FIGURE 2



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



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



DRILL HOLE-Slanted number showing elevation at top of coal bed; vertical number showing thickness of overburden from the surface to the top of coal bed. Measurements in feet.

TRACE OF COAL BED OUTCROP-Arrow points toward the coal-bearing area. "V" symbol indicates baked rock with dotted line showing limit of burning.

To convert feet to meters multiply feet by 0.3048.

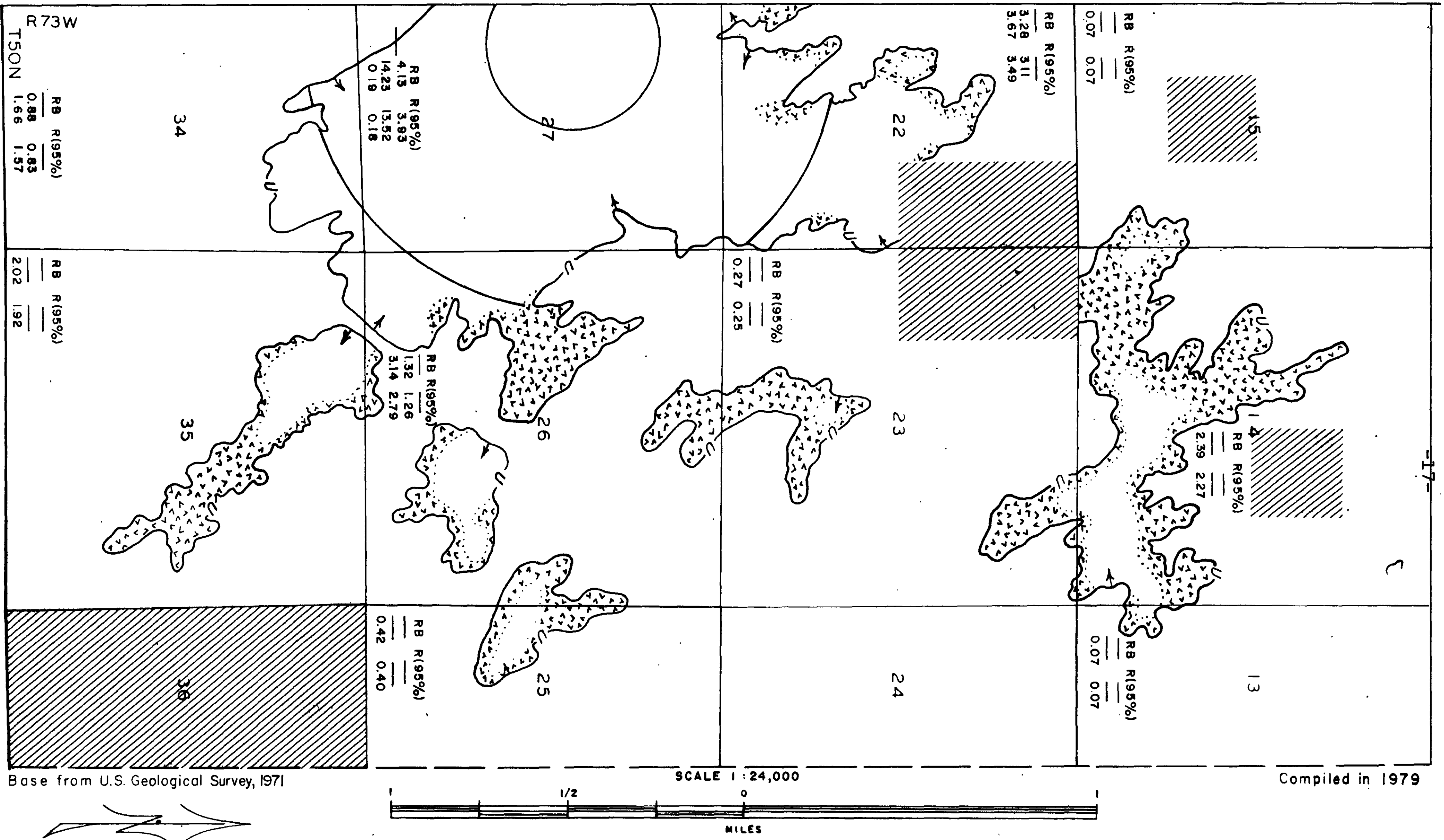
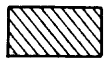
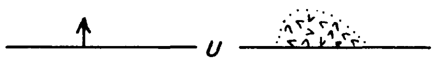


FIGURE 3
AREAL DISTRIBUTION OF IDENTIFIED RESOURCES
AND IDENTIFIED RESOURCES MAP
OF ULM COAL BED IN
GILLETTE WEST QUADRANGLE
CAMPBELL COUNTY, WYOMING
(See following page for Explanation)

EXPLANATION FOR FIGURE 3



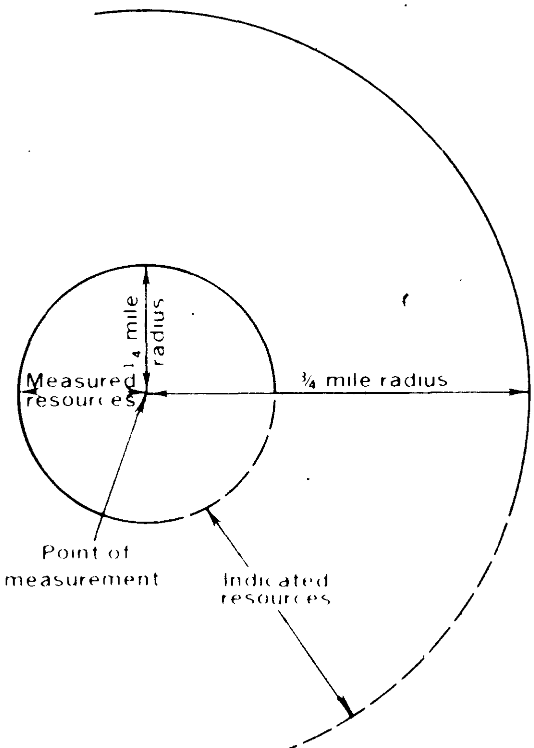
NON-FEDERAL COAL LAND



TRACE OF COAL BED OUTCROP-Arrow points toward the coal-bearing area. "V" symbol indicates baked rock with dotted line showing limit of burning.

RB	R(95%)	
—	—	(Measured)
1.32	1.26	(Indicated)
3.14	2.79	(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).



BOUNDARY LINES-Enclosing areas of measured, indicated and inferred coal resources of the coal bed. Dashed where projected from adjacent quadrangles.

To convert miles to kilometers multiply miles by 1.609.

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

Felix coal bed lies between 0 and just over 400 feet (0 to 122 m) beneath the surface in the quadrangle (Plate 6).

The Smith coal bed lies approximately 200 to 360 feet (61 to 110 m) beneath the Felix coal bed. The coal bed thickness varies from 0 to 25 feet (0 to 8 m) with maximum thicknesses in the northwest corner. A pinchout line traverses north-to-south across the central part of the quadrangle (Plate 9). Localized partings occur throughout the quadrangle with interburdens of 4 to 24 feet (1.2 to 7 m) thick. An east-west trending syncline occurs in the southwest corner of the quadrangle. A less prominent west-plunging syncline and adjacent anticline occurs in the northern and central portions of the quadrangle respectively (Plate 10). The Smith coal bed lies less than 500 feet (152 m) beneath the surface throughout approximately 50 percent of the western half of the Gillette West Quadrangle (Plate 11). A maximum overburden in excess of 700 feet (213 m) and a minimum overburden of less than 100 feet (30 m) are observed in the area.

Approximately 100 to 250 feet (30 to 76 m) of clastic sediments separate the Smith coal bed from the Wyodak coal bed. The Wyodak coal bed is divided into several units throughout 90 percent of the quadrangle with non-coal intervals between the units ranging from 3 to 197 feet (0.9 to 60 m). It is undivided only in the northeast corner. The thicknesses of the combined Wyodak coal beds range from 54 to 120 feet (16 to 37 m) with maximum thickness occurring in the northeast quadrant, and minimum thickness in the northwest corner (Plate 14). A series of prominent synclines and anticlines trending northeast-southwest define the structure on top of the Wyodak coal bed. A syncline in the northeast corner is distorted by a fault. The fault location and displacement of 200 feet (61 m) is defined by subsurface data taken from the U.S. Geological Survey and the Montana Bureau of Mines and Geology drill hole 731 (NWNW Sec. 9, T. 50 N., R. 72 W). This drill hole does not penetrate the Pawnee or lower coals. IntraSearch's structural interpretation of the Wyodak coal bed differs significantly from Law (1978). The Wyodak lies less than 500 feet (152 m) beneath the surface throughout 45 percent of the Gillette West Quadrangle, an area largely confined to the eastern half (Plate 16). The range of overburden is from less than 100 feet to greater than 750 feet (30 to 229 m).

The Pawnee coal bed is separated from the Wyodak coal bed by a sedimentary interval of approximately 150 to 330 feet (46 to 101 m). The Pawnee coal bed was not deposited along the eastern border in the southeast quadrant of the study area and along the east-central border of the northeast quadrant. The maximum thickness of the coal bed is 18 feet (5 m) in the east-central part of the quadrangle. The structural configuration drawn on the top of the Pawnee coal bed defines a gentle westward dip (Plate 20). The Pawnee coal bed lies from less than 750 (229 m) to greater than 1500 feet (457 m) beneath the surface in the quadrangle (Plate 21).

The Wildcat, Moyer and Oedekoven coal beds were mapped as a coal zone due to their depth of burial and relatively small thicknesses. The Wildcat coal bed lies 160 to 330 feet (49 to 101 m) beneath the Pawnee coal bed. The Wildcat coal bed is divided into two units throughout 70 percent of the Gillette West Quadrangle with non-coal intervals of up to 108 feet (33 m). The Wildcat coal bed is separated from the Moyer coal bed by 30 to 193 feet (9 to 59 m), and the Moyer coal bed from the Oedekoven coal bed by 86 to 240 feet (26 to 73 m) of clastics. Localized partings occur in the Oedekoven coal bed throughout the quadrangle with total interburden reaching 76 feet (23 m) thick. The total thickness of the combined coal beds varies from 11 to 61 feet (3 to 19 m), with maximum thicknesses occurring in the northeast quadrant of the study area, and minimum thicknesses in the south-central part (Plate 24). The structural contours drawn on the top of the Upper Wildcat coal bed indicate a gentle westward dip. Inasmuch as the Upper Wildcat coal bed pinches out in the south-central part of the quadrangle, structural contours are drawn on top of the Lower Wildcat coal bed. Here, a southwest-plunging anticline and syncline are evident (Plate 25). The Wildcat coal bed lies from less than 1000 feet (305 m) to greater than 1750 feet (533 m) beneath the surface throughout the Gillette West Quadrangle (Plate 26).

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 Gillette West 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 29) 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 potential is high for most of the Gillette West Quadrangle. The Gillette West Quadrangle contains four coal beds (Ulm, Felix, Smith and Wyodak coal beds) that are positioned less than 500 feet (152 m) beneath the surface. They are more than 5 feet (1.5 m) thick over all or portions of the quadrangle, accounting for high surface mining development potential in the valleys as well as the steeper terrain. Approximately 20 percent of the quadrangle is of moderate or low surface mining development potential. This classification occurs in the southern half of the quadrangle where the Smith and Wyodak coal beds are more than 500 feet (152 m) deep and the Felix coal bed has a mining ratio greater than ten to one. 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 Gillette West 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 Gillette West 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 5.3 billion tons (4.3 billion metric tons) (Table 3). None of the coal beds in the Gillette West Quadrangle qualify for a moderate or high development potential rating, for in-situ gasification.

Table 1.--Strippable Coal Reserve Base Data (in short tons) for Federal Coal Lands in the Gillette West 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
Ulm	35,660,000	-----	-----	35,660,000
Felix	410,250,000	120,770,000	34,770,000	565,790,000
Smith	27,820,000	25,180,000	57,070,000	110,070,000
Wyodak	1,356,890,000	723,180,000	94,310,000	2,174,380,000
TOTAL	1,830,620,000	869,130,000	186,150,000	2,885,900,000

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

Coal Bed Name	High Development Potential	Moderate Development Potential	Low Development Potential	Total
Smith	-----	-----	134,580,000	134,580,000
Wyodak	-----	-----	2,532,050,000	2,532,050,000
Pawnee	-----	-----	447,200,000	447,200,000
Wildcat-Moyer-Oedekoven	-----	-----	2,151,560,000	2,151,560,000
TOTAL	-----	-----	5,265,210,000	5,265,210,000

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

Coal Bed Name	High Development Potential	Moderate Development Potential	Low Development Potential	Total
Smith	-----	-----	134,580,000	134,580,000
Wyodak	-----	-----	2,532,050,000	2,532,050,000
Pawnee	-----	-----	447,200,000	447,200,000
Wildcat-Moyer-Oedekoven	-----	-----	2,151,560,000	2,151,560,000
TOTAL	-----	-----	5,265,210,000	5,265,210,000

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