UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

TEXT TO ACCOMPANY:

COAL RESOURCE OCCURRENCE

AND

COAL DEVELOPMENT POTENTIAL

MAPS

OF THE

CABIN CREEK NE QUADRANGLE,

SHERIDAN AND CAMPBELL COUNTIES, WYOMING

AND

POWDER RIVER COUNTY, MONTANA

REVISED TEXT, OCTOBER 1980

BY

INTRASEARCH INC.

ENGLEWOOD, COLORADO

OPEN-FILE REPORT 78-064
1978

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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/ metric ton
acre-feet	0.12335	hectare-meters
British thermal units/pound (Btu/lb)	2.326	kilojoules/kilogram (kj/kg)
British thermal units/pound (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 Cabin Creek NE Quadrangle, Campbell and Sheridan Counties, Wyoming, and Powder River County, Montana. This CRO and CDP map series includes 44 plates (U. S. Geological Survey Open-File Report 78-064). 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 a 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 Cabin Creek NE Quadrangle is located on the Wyoming-Montana border in Sheridan and Campbell Counties, Wyoming, and Powder River County, Montana. It encompasses all or parts of Townships 57 and 58 North, Ranges 76 and 77 West, in Wyoming, and Township 9 South, Ranges 46 and 47 East, in Montana, and covers the area: 44°52'30" to 45°00' north latitude; 106°00' to 106°07'30" west longitude.

A maintained gravel road provides access to the Cabin Creek NE Quadrangle where it parallels the Powder River. Minor roads and trails that branch from this gravel road constitute an avenue of access to much of the area. The Powder River Road extends northeastward to Broadus, Montana, and to the south it joins U. S. Highway 14-16 adjacent to its crossing of the Powder River between Gillette

and Sheridan, Wyoming. The closest railroad is the Burlington Northern trackage, 13 miles (21 km) to the south at Leiter, Wyoming.

The Powder River flows northeastward through the southeastern part of the quadrangle, and its valley floor is approximately 3,500 feet (1,067 m) above sea level. Fence Creek, and Big and Little Remington Creeks are tributary to the Powder River from the west, and drain fairly rugged terrain that attains elevations 700 (123 m) above river level. 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 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 Arvada, Wyoming, average wintertime minimums and summtertime maximums approach +5° to +15°F (-15° to -0°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 and the Sheridan County Courthouse in Sheridan, Wyoming, and the Powder River County Courthouse

in Broadus, Montana. 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 (resources), as well as recoverable tons (reserves). These coal tonnages are then categorized in measured, indicated, and inferred identified 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 3,000 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 4.5 billion tons (4.1 billion metric tons) of total, unleased federal coal-in-place in the Cabin Creek NE Quadrangle.

The suite of maps that accompanies 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 3,000 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 the 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. 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 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 member subdivisions 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 2 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 and in-filling of these areas 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 of 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 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 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 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 noticably to imperceptibly coarser than the underlying Fort Union clastics.

The Cabin Creek NE Quadrangle is located in an area where surface rocks are classified into the Wasatch Formation and the Tongue River Member of the Fort Union Formation. The bottom 100 feet

(30 m) of Wasatch Formation are exposed and 700 to 800 feet (213 to 244 m) of the Tongue River Member are exposed in this area. Olive (1957) correlated coal beds in the Spotted Horse coal field with coal beds in the northward extension of the Sheridan coal field, Montana (Baker, 1929), and Gillette coal field, Wyoming (Dobbin and Barnett, 1927), and with coal beds in the Ashland coal field (Bass, 1932) in southeastern Montana. This report utilizes, where possible, the coal bed nomenclature used in previous reports. The Smith and Deitz No. 1 coal beds were named by Taff (1909). Baker (1929) assigned names to the Anderson, Canyon, and Wall coal beds. The Cook coal bed was named by Bass (1932), and the Pawnee coal bed was named by Warren (1959).

Local. The Cabin Creek NE Quadrangle lies on the eastern flank of the Powder River Basin, where the strata dip gently westward. The Wasatch Formation and the Tongue River Member of the Fort Union Formation crop out within the Cabin Creek NE Quadrangle. The Wasatch Formation crops out along the western boundary of the quadrangle, and is composed of friable, coarse-grained to gritty, arkosic sandstones, fine to very fine-grained sandstones, siltstones, mudstones, claystones, brown-to-black carbonaceous shales, and coal beds. The Fort Union Formation is composed of very fine-grained sandstones, siltstones, claystones, shale, carbonaceous shales, and numerous coal beds.

Four southwest-trending faults with 10 to 15 feet (3 to 5 m) of displacement occur in the northeast corner of the quadrangle. Another small fault displaces strata in the northwest corner of the quadrangle.

The configuration of structural contours on the top of the Upper Canyon coal bed plate 20, indicates 90 feet (27 m) of displacement on a northeast-trending fault in section 4, T. 57 N., R. 76 W. The magnitude of this displacement may be excessive due to reconciliation of widely spaced subsurface structural control with structural elevations interpolated from Olive (1957) outcrop patterns adjusted to the recent U. S. Geological Survey topographic map compiled in 1971.

III. Data Sources

Areal geology of the coal outcrops and associated clinker is derived from the Spotted Horse coal field report (Olive, 1957). Coal bed correlations between Olive's Spotted Horse coal field publication and the Moorhead coal field publication (Bryson and Bass, 1973) are difficult due to the paucity of subsurface control and the difference in coal bed nomenclature between the two publications. The following table sets forth the coal bed nomenclature relationship between the Cabin Creek NE Quadrangle, Wyoming, that relates to Olive's work, and the Sayle Hall Quadrangle, Montana, that utilizes Bryson and Bass' publication.

Cabin Creek NE Quadrangle	Sayle Hall Quadrangle
Arvada	Arvada
Roland of Baker	Roland of Baker
Anderson	Anderson
Upper Canyon	Canyon
Lower Canyon	Upper Cook
Cook	Lower Cook
Wall	Pawnee
Pawnee	Cache
No equivalent	King
No equivalent	Knobloch
No equivalent	Flowers-Goodale
No equivalent	Broadus

The coal outcrops are adjusted to the current topographic maps of the area.

Geophysical logs from oil and gas test bores and producing wells compose 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 and its 3-mile perimeter area were scanned to select those with data applicable to Coal Resource Occurrence mapping. Paper copies of the logs

U. S. Bureau of Land Management in Cheyenne, Wyoming. This information is current to October 13, 1977.

IV. Coal Bed Occurrence

Wasatch Formation and Fort Union Formation coal beds that are potentially recoverable in all or part of the Cabin Creek NE Quadrangle include, in descending stratigraphic order: the Arvada, Roland of Baker, Smith, Anderson, Dietz No. 1, Upper Canyon, Lower Canyon, Cook, Wall, and Pawnee. A suite of maps composed of coal isopach and mining ratio, where appropriate; structure; overburden isopach; areal distribution of identified resources; identified resources and hypothetical resources, where applicable, was prepared for each of these coal beds. Mining ratios are presented on the isopach maps.

No physical or chemical analyses are known to have been published regarding the coal beds in the Cabin Creek NE Quadrangle. For northern Campbell County, Wyoming and southern Powder River County, Montana, coal beds, the "as received" proximate analysis; the Btu value computed on a moist, mineral-matter-free basis'* and the coal rank are as follows:

COAL BED NAME		DATA SOURCE IDENTIFICATION	AS RECEIVED BASIS							COAL RANK
			ASH %	FIXED CARBON %	MOISTURE %	VOLATILES %	SULFUR %	BTU/LB	MOIST, M-M-F BTU/LB	
Roland	(**)	Hole SH-7029	4.7	27.8	30.2	37.3	0.24	8086	8548	Subbtm. C
Smith	(U)	Hole 7340	3.5	38.0	30.0	28.5	0.31	8371	8700	Subbtm. C
Anderson	(U)	Hole 746	6.3	31.1	32.6	30.0	0.33	7498	8045	Lignite A
Canyon	(U)	Hole 744	4.3	32.9	35.1	27.8	0.31	7298	7650	Lignite A
Cook	(**)	Hole SH-64	3.1	36.2	30.8	30.0	0.15	7948	8225	Lignite A
Wall	(U)	Hole 7426	9.5	29.3	32.2	29.0	0.50	7279	8112	Lignite A
Pawnee	(U)	Hole 7424	7.9	31.0	31.9	29.2	0.39	7344	8025	Lignite A

* The moist, mineral-matter-free Btu values are calculated in the manner stipulated in the publications by American Society for Testing and Materials (1971).

** Matson, R. E., and Blumer, J. W. (1973).

(U) U. S. Geological Survey and Montana Bureau of Mines and Geology (1976).

were obtained and interpreted, and coal intervals were annotated. Maximum accuracy of coal bed identification was accomplished where gamma, density and resistivity curves were available. Coal bed tops and bottoms were identified on the logs at the midpoint between the minimum and maximum curve deflections. The correlation of coal beds within and between quadrangles was achieved utilizing a fence diagram to associate local correlations with regional coal occurrences.

The reliability of correlations, set forth by IntraSearch in this report, varies depending on: the density and quality of lithologic and geophysical logs; the details, 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 Cabin Creek NE 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

The Arvada coal bed is present in a small area located along the western boundary of the quadrangle. The areal extent of the coal bed covers less than 1 percent of the quadrangle. The coal bed thickness ranges from less than 5 feet to 8 feet (1.5 to 2.4 m) (figure 1). Vertical control for the structure map was compiled by transposing the coal bed outcrop configurations onto the topographic map and establishing elevations at outcrop-contour intersections. The structure contours drawn on top of the Arvada coal bed indicate gentle, southwestward dip (figure 2). The overburden attains a maximum thickness of approximately 55 feet (17 m) (figure 2).

The Roland of Baker coal bed lies approximately 40 feet (12 m) below the Arvada coal bed, and is present in 1 percent of the quadrangle. The coal is absent throughout the area except along the west and north boundaries of the northwest quarter of the study area. The Roland of Baker coal thickness ranges from 4 to 8 feet (1.2 to 2.4 m) (figure 4). The coal outcrop drawn on the topographic map indicates a gentle, southward dip (figure 5). The Roland of Baker coal bed is covered by a maximum of 95 feet (29 m) of overburden (figure 5).

The Smith coal bed, approximately 380 feet (116 m) beneath the Roland of Baker coal bed, is present in approximately 40 percent of the quadrangle. Surface and subsurface control indicates that the Smith coal bed attains a maximum thickness of 12 feet (4 m) in the northwest corner. The coal bed lenses out to the east and in the west-central area of the quadrangle (plate 4). The Smith coal bed

The Coal Data Sheet, plate 3, shows the down-hole 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 from producing sites. 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 Cook coal bed underlies the entire quadrangle, it is designated as datum for the correlation diagram. The Upper Canyon and the Cook coal beds show the thickest single bed occurrences throughout the quadrangle. The Wall and Pawnee coal beds have a rather uniform occurrence throughout the area. Due to coal bed outcrop patterns as they interrelate to the high relief existent east and west of the Powder River, subsurface data on the Arvada, Roland of Baker, Smith, Anderson, and Dietz No. 1 beds develop a sporadic geographic orientation. A deep coal bed, more than 300 feet (91 m) beneath the Pawnee coal bed, is mapped within this quadrangle as a local coal bed. Neither the amount of data existent on this coal bed nor the coal thickness indicate full-scale mapping of the coal bed to be appropriate. This coal is thought to be an equivalent of the Oedekoven coal bed existent in the eastern part of Campell County, Wyoming. The Oedekoven coal bed is informally named by IntraSearch in this report to represent a rather consistent, thin, deep coal bed 300 to 400 feet (91 to 122 m) beneath the Pawnee coal bed. The name Oedekoven is chosen because this coal bed appears to attain maximum development in the Recluse, Wyoming area, where the Oedekoven family has been one of the principal ranching entities since the late 1800's.

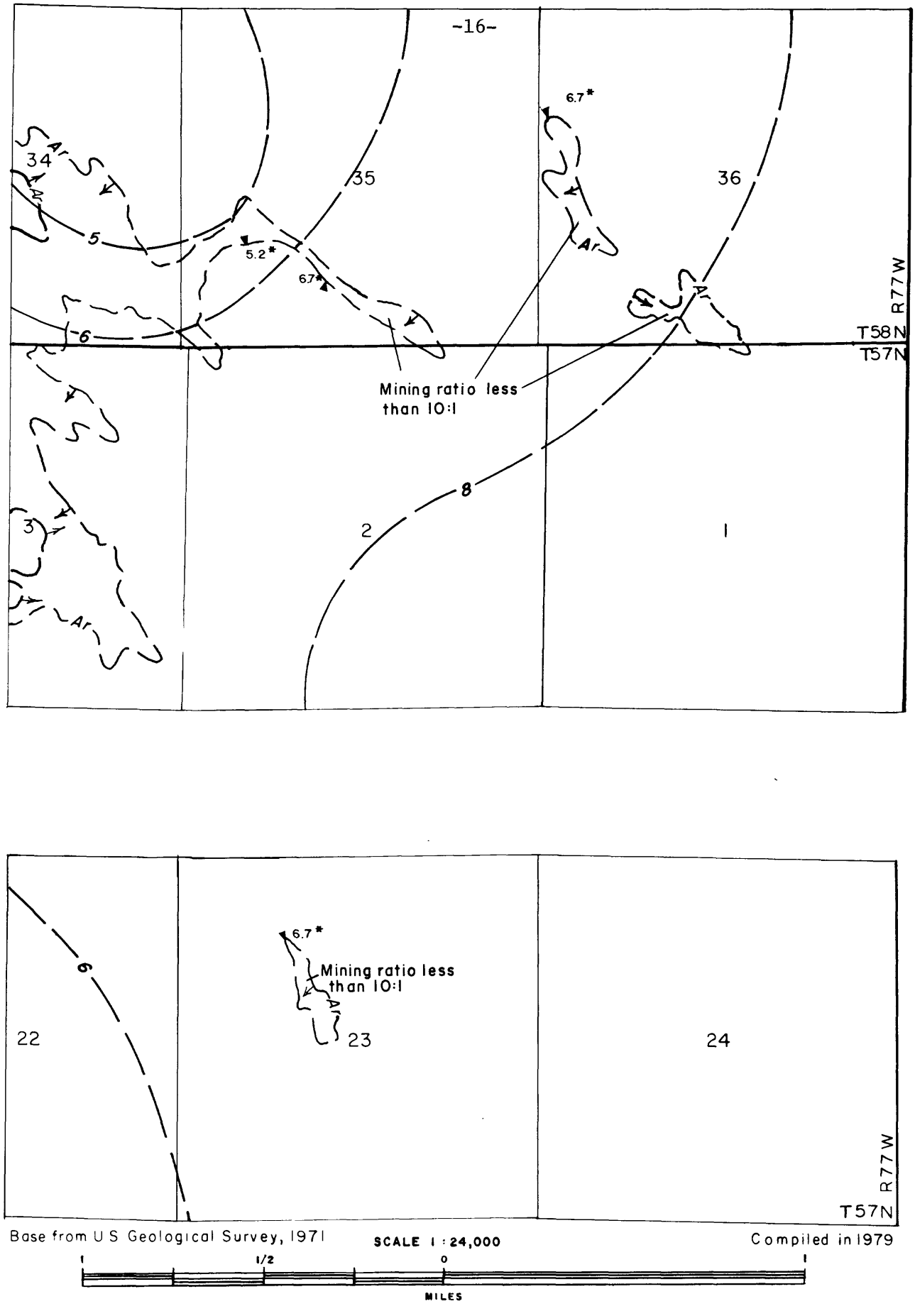
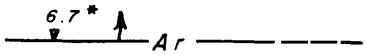


FIGURE 1
ISOPACH AND MINING RATIO MAP
OF ARVADA COAL BED IN
CABIN CREEK NE QUADRANGLE
SHERIDAN AND CAMPBELL COUNTIES, WYOMING
AND POWDER RIVER COUNTY, MONTANA

EXPLANATION FOR FIGURE 1

ISOPACH OF COAL BED-Showing thickness in feet. Isopach interval 2 feet, with an intermediate 5 foot contour. Dashed where coal is burned or eroded.



TRACE OF COAL BED OUTCROP-Showing thickness of coal, in feet, measured at triangle. Asterisk designates measured section was used in isopach mapping. Arrow points toward the coal-bearing area. Coal bed dashed where inferred or projected.

10:1

MINING RATIO VALUE-Number indicates cubic yards of overburden per ton of recoverable coal by surface mining methods. Mining ratio value shown only in area suitable for surface mining within the stripping limit.

To convert feet to meters, multiply feet by 0.3048.

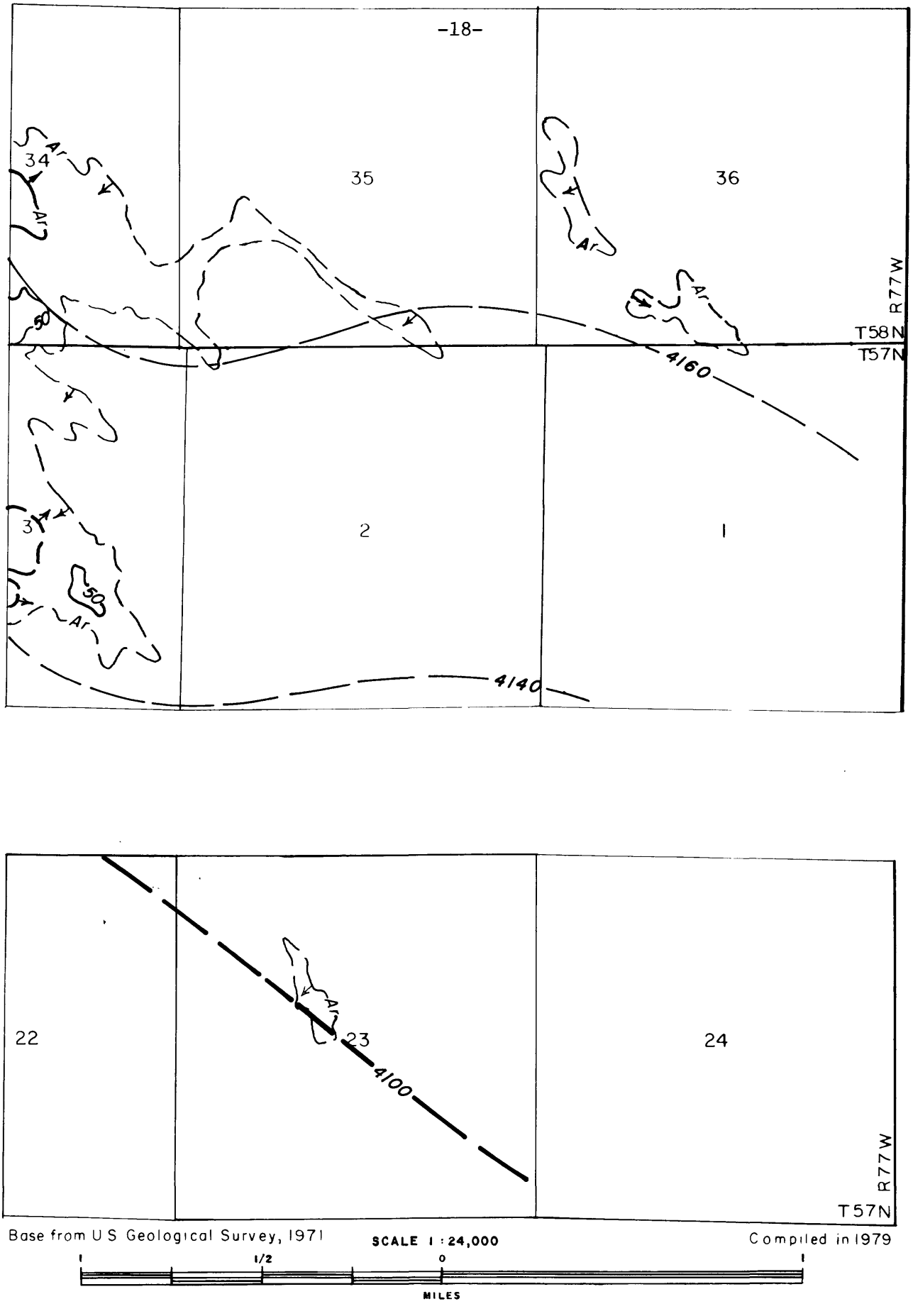
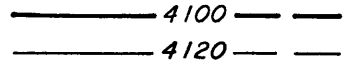
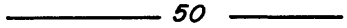


FIGURE 2
STRUCTURE CONTOUR AND ISOPACH OF OVERBURDEN MAP
OF ARVADA COAL BED IN
CABIN CREEK NE QUADRANGLE
SHERIDAN AND CAMPBELL COUNTIES, WYOMING
AND POWDER RIVER COUNTY, MONTANA

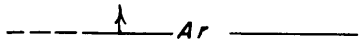
EXPLANATION FOR FIGURE 2



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

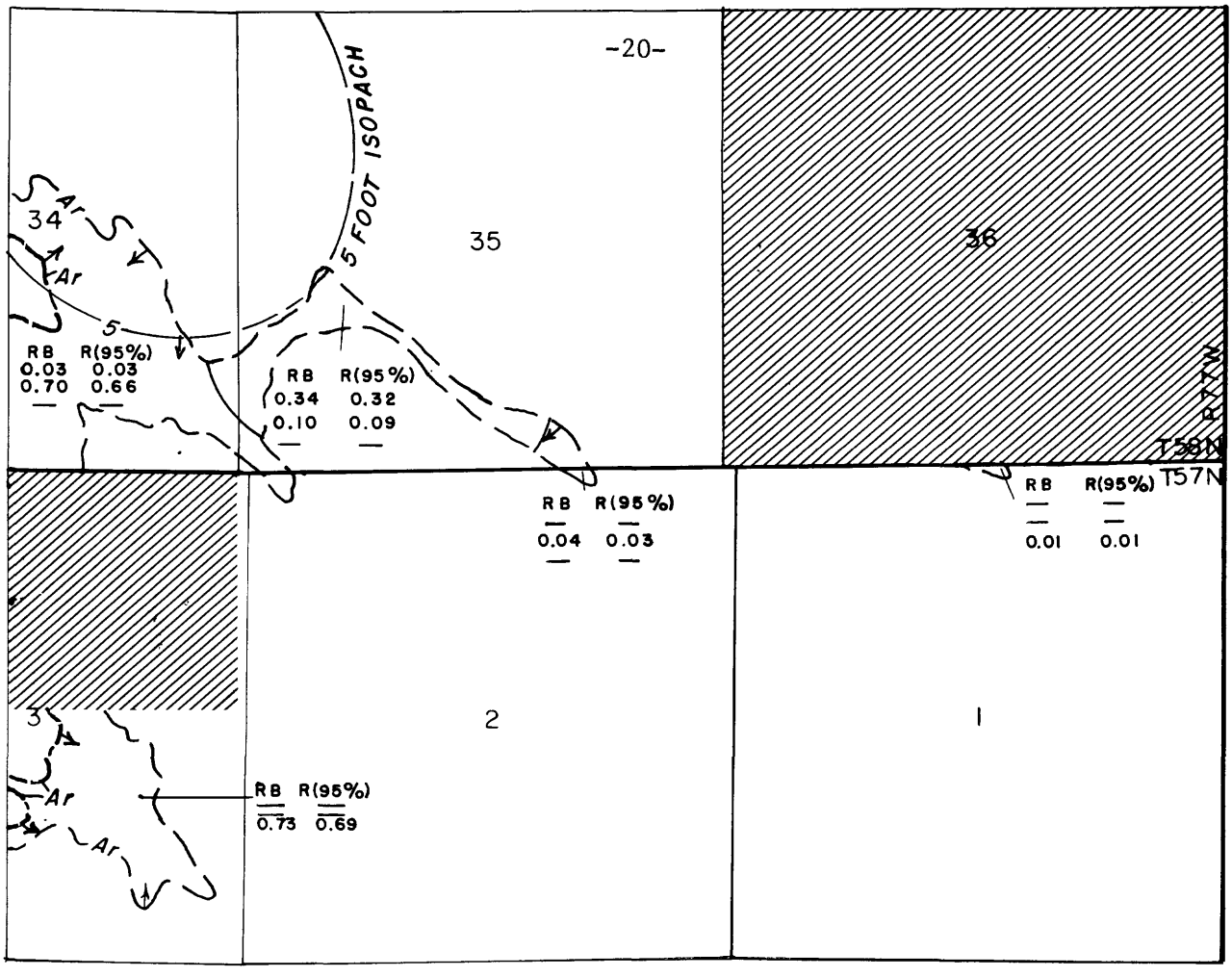


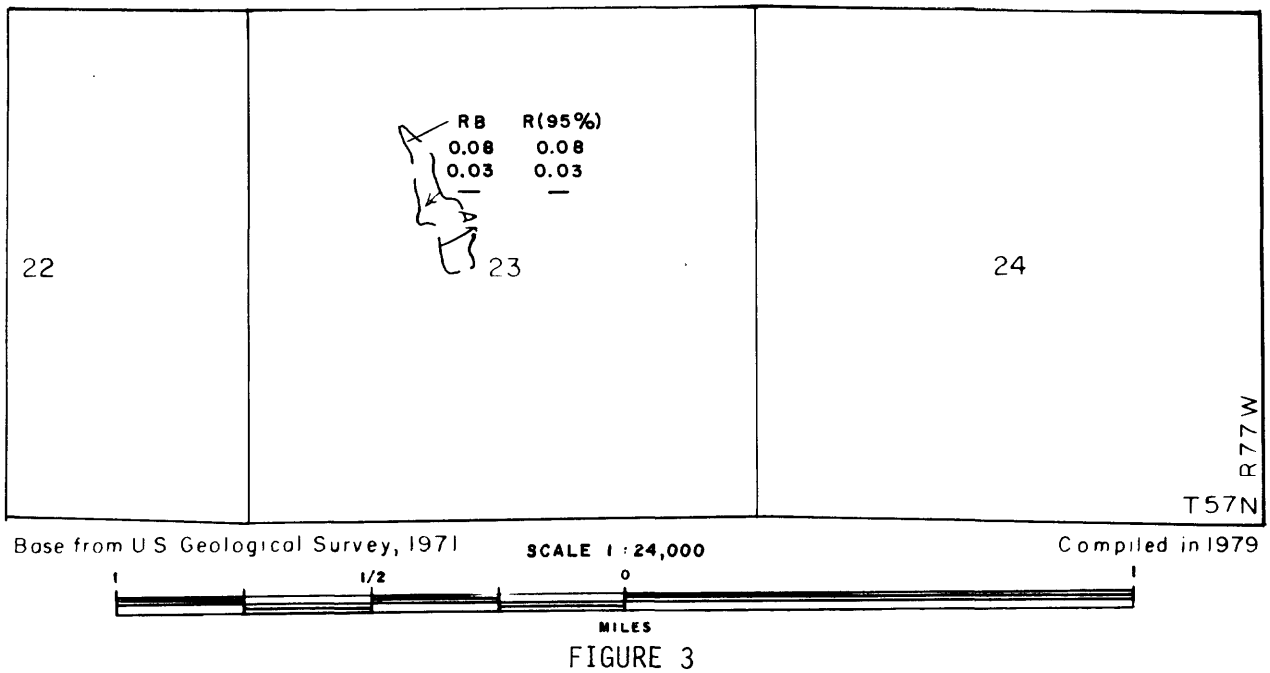
OVERBURDEN ISOPACH-Showing thickness of overburden in feet, from the surface to the top of the coal bed. Isopach interval 50 feet.



TRACE OF COAL BED OUTCROP-Arrow points toward the coal-bearing area. Coal bed dashed where inferred or projected.

To convert feet to meters, multiply feet by 0.3048.





Base from U S Geological Survey, 1971 SCALE 1 : 24,000 Compiled in 1979

1 1/2 0 1

MILES

FIGURE 3
AREAL DISTRIBUTION OF IDENTIFIED RESOURCES
AND IDENTIFIED RESOURCES MAP
OF ARVADA COAL BED IN
CABIN CREEK NE QUADRANGLE
SHERIDAN AND CAMPBELL COUNTIES, WYOMING
AND POWDER RIVER COUNTY, MONTANA

EXPLANATION FOR FIGURE 3

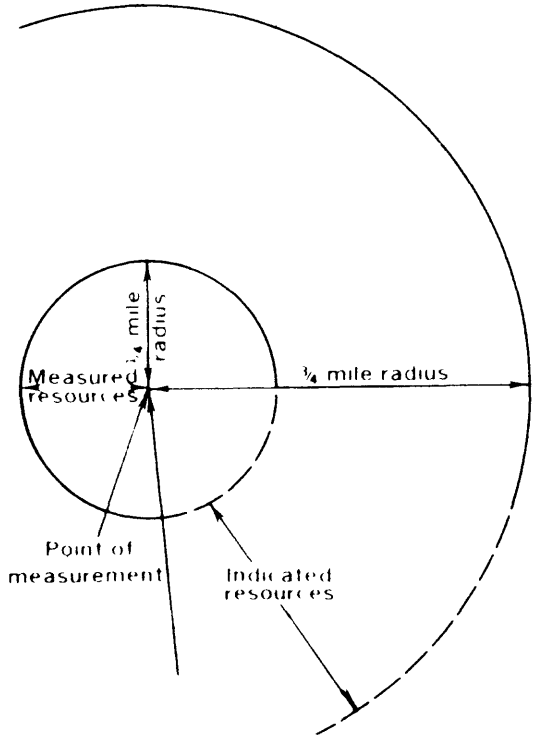
NON-FEDERAL COAL LAND-Coal tonnages not evaluated.

Ar

TRACE OF COAL BED OUTCROP-Arrow points toward the coal-bearing area. Coal bed dashed where inferred or projected.

RB	R(95%)	
—	—	(Measured)
—	—	(Indicated)
0.01	0.01	(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.

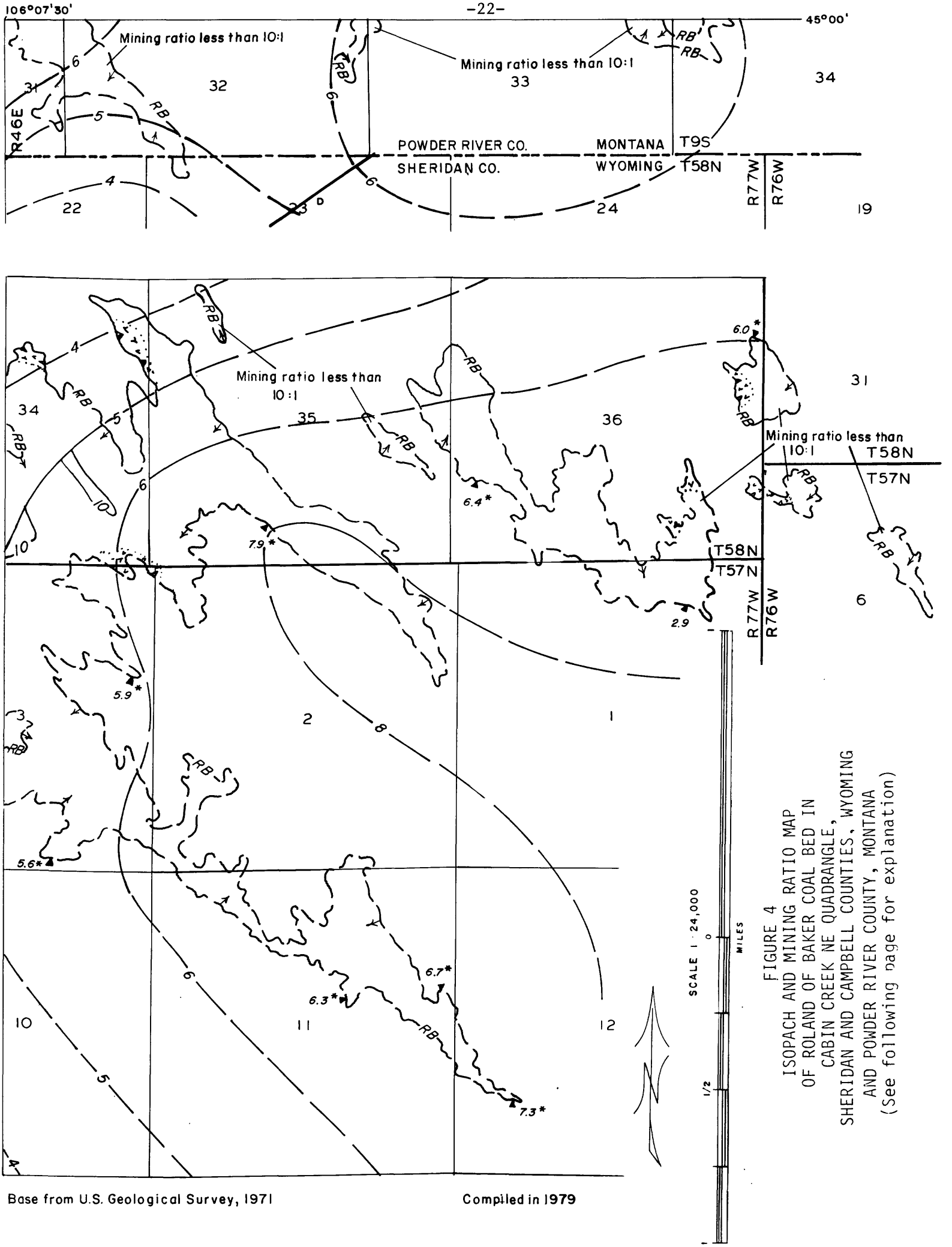
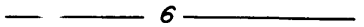
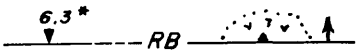


FIGURE 4
ISOPACH AND MINING RATIO MAP
OF ROLAND OF BAKER COAL BED IN
CABIN CREEK NE QUADRANGLE,
SHERIDAN AND CAMPBELL COUNTIES, WYOMING
AND POWDER RIVER COUNTY, MONTANA
(See following page for explanation)

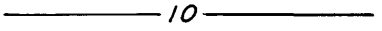
EXPLANATION FOR FIGURE 4



ISOPACH OF COAL BED-Showing thickness in feet. Isopach interval 2 feet, with an intermediate 5 foot contour. Dashed where coal is burned or eroded.



TRACE OF COAL BED OUTCROP-Showing coal thickness in feet, measured at triangle. Asterisk indicates measured section was was not honored due to localized attenuation. Arrow points toward the coal-bearing area. "V" symbol indicates baked rock with dotted line showing limit of burning. Coal bed dashed where inferred or projected.

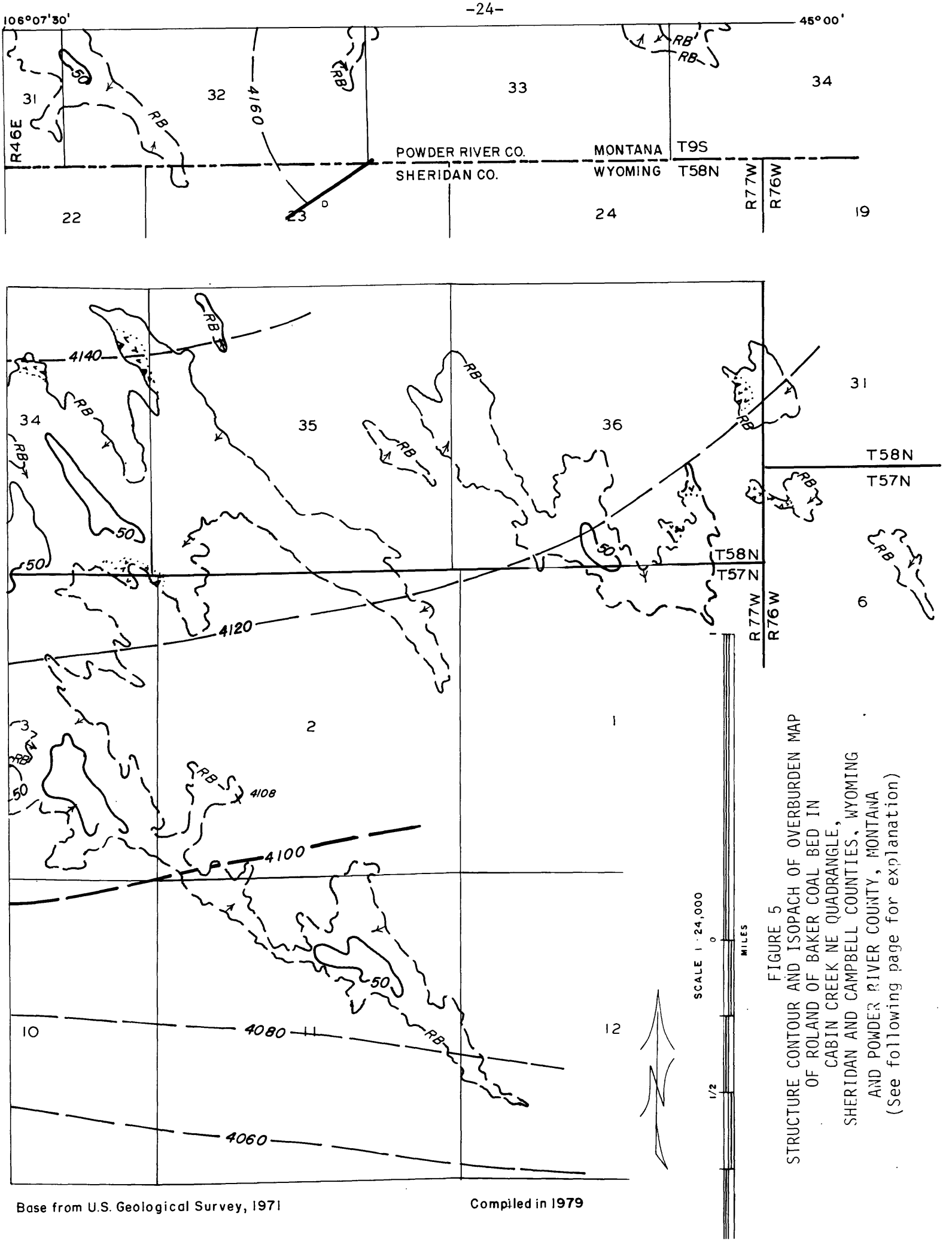


MINING RATIO CONTOUR-Number indicates cubic yards of overburden per ton of recoverable coal by surface mining methods. Contours shown only in area suitable for surface mining within the stripping limit.

10:1

MINING RATIO VALUE-Number indicates cubic yards of overburden per ton of recoverable coal by surface mining methods. Mining ratio value shown only in area suitable for surface mining within the stripping limit.

To convert feet to meters, multiply feet by 0.3048.



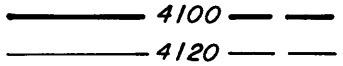
SCALE 1:24,000
0
1/2
MILES

FIGURE 5
STRUCTURE CONTOUR AND ISOPACH OF OVERBURDEN MAP
OF ROLAND OF BAKER COAL BED IN
CABIN CREEK NE QUADRANGLE,
SHERIDAN AND CAMPBELL COUNTIES, WYOMING
AND POWDER RIVER COUNTY, MONTANA
(See following page for explanation)

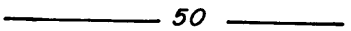
Base from U.S. Geological Survey, 1971

Compiled in 1979

EXPLANATION FOR FIGURE 5



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.

TRACE OF COAL BED OUTCROP-Arrow points toward the coal-bearing area. "V" symbol indicates baked rock with dotted line showing limit of burning. Coal bed dashed where inferred or projected.

INFERRED ELEVATION ON TOP OF COAL BED-Derived from outcrop elevation, plus coal thickness, showing elevation in feet.

To convert feet to meters, multiply feet by 0.3048.

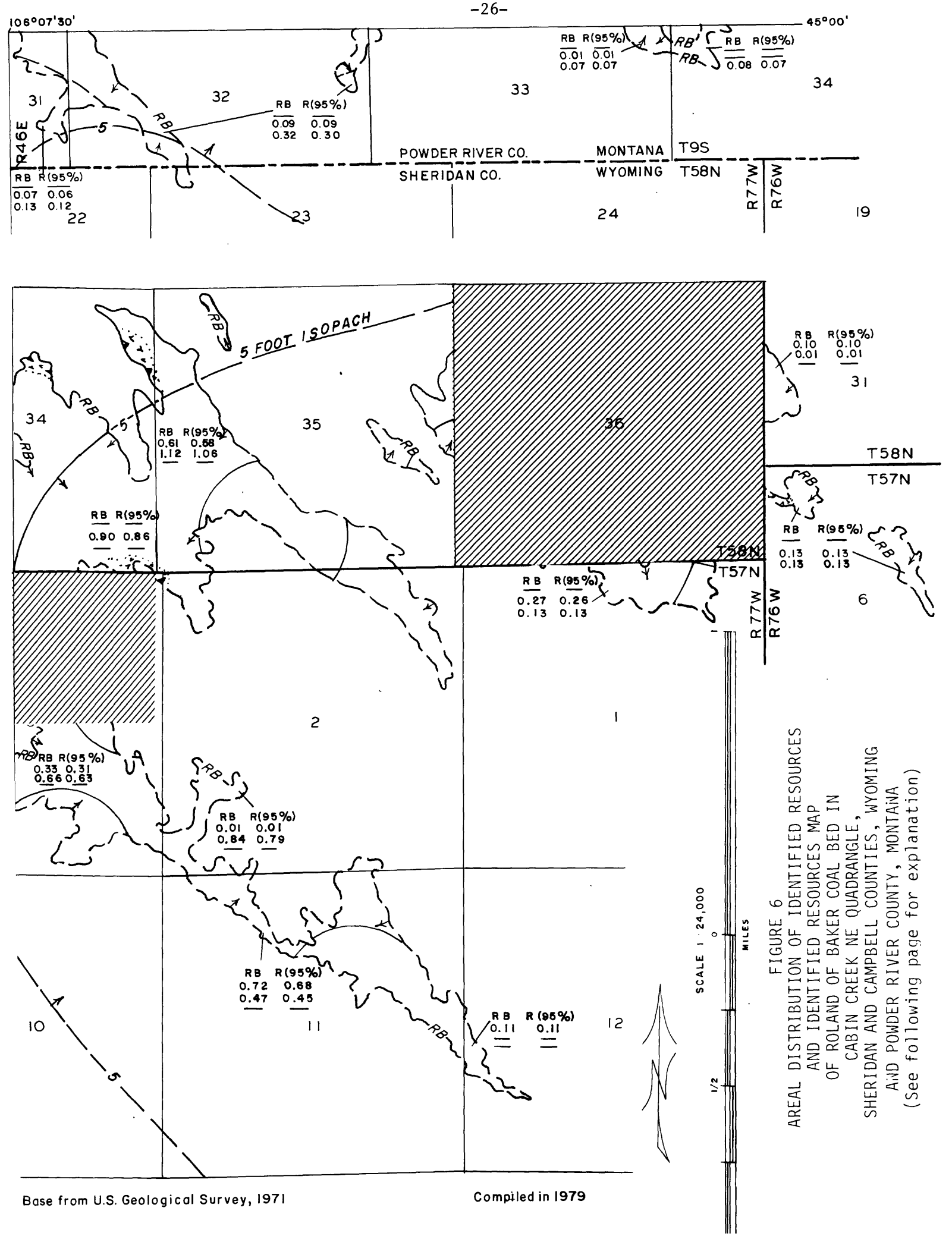
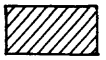


FIGURE 6
AREAL DISTRIBUTION OF IDENTIFIED RESOURCES
AND IDENTIFIED RESOURCES MAP
OF ROLAND OF BAKER COAL BED IN
CABIN CREEK NE QUADRANGLE,
SHERIDAN AND CAMPBELL COUNTIES, WYOMING
AND POWDER RIVER COUNTY, MONTANA
(See following page for explanation)

Base from U.S. Geological Survey, 1971

Compiled in 1979

EXPLANATION FOR FIGURE 6

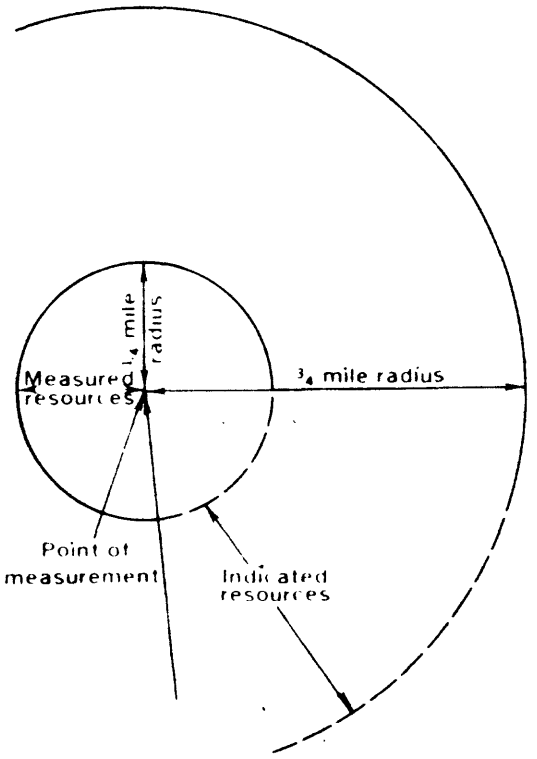


NON-FEDERAL COAL LAND-Coal tonnages not evaluated.

TRACE OF COAL BED OUTCROP-Arrow points toward the coal-bearing area. "V" symbol indicates baked rock with dotted line showing limit of burning. Coal bed dashed where inferred or projected.

RB	R(95%)	
0.10	0.10	(Measured)
0.01	0.01	(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).



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.

configuration in the southwestern corner is drawn from the Spotted Horse coal field report (Olive, 1957). In the northwestern area, the coal bed configuration is projected from the intersection of structure contours with the topographic base map. The structure contours drawn on top of the Smith coal bed indicate a northeast-southwest-trending syncline in the northeast corner, and a southwest-plunging anticline in the west-central portion of the quadrangle (plate 5). The Smith coal bed lies a maximum of 450 feet (137 m) beneath the surface in the study area.

The Anderson coal bed lies from 39 feet (12 m) to approximately 140 feet (43 m) below the Smith coal bed. The coal bed ranges in thickness from 3 feet (0.9 m) in the west-central part of the study area to 35 feet (11 m) in the northeast corner (plate 9). The structure contour map indicates a southwest-plunging anticline trending from the northeast corner to the southwest corner. The anticline is flanked on the northwest by a parallel syncline (plate 10). The overburden thickness ranges from 0 feet (0 m) at the outcrop to greater than 500 feet (152 m) (plate 11).

The Dietz No. 1 coal bed occurs 15 to 90 feet (5 to 27 m) below the Anderson coal bed and ranges in thickness from 0 to slightly more than 8 feet (2 m). The zero line of the Dietz No. 1 coal bed delimits an area in the central and southwestern part of the quadrangle where the Dietz No. 1 bed grades into a carbonaceous shale (plate 14). The structure contour map defines a west-southwest-plunging anticline in the

northeast portion of the quadrangle. The anticline is flanked by two synclines (plate 15). The Dietz No. 1 coal bed is covered by a maximum of 550 feet (168 m) of overburden (plate 16).

The Upper Canyon coal bed lies 115 to 225 feet (35 to 69 m) beneath the Anderson coal bed, and ranges in thickness from 18 to 33 feet (5 to 10 m). A maximum thickness of more than 30 feet (9 m) occurs in the norheastern part of the quadrangle (plate 19). Structure contours drawn on top of the Upper Canyon coal bed depict a series of two, southwest-northeast-trending synclines and anticlines located in the northern half of the study area (plate 20). The coal bed occurs up to a maximum of 660 feet (201 m) beneath the surface (plate 21).

From 84 to 144 feet (26 to 44 m) of clastic rock separates the Lower and Upper Canyon coal beds. The Lower Canyon coal bed is of minor significance in the total coal column inasmuch as it ranges from 4 feet (1.2 m) in thickness in the northeastern part of the quadrangle to greater than 14 feet (4 m) to the southeast and northwest (plate 24). The major structural feature drawn on top of this coal bed is a sinuous, bifurcated anticline, trending generally east-west, and located in the northern portion of the quadrangle. Additional minor folds exist along the flanks of the major anticline (plate 25). The Lower Canyon coal bed lies from approximately 60 to 830 feet (18 to 253 m) beneath the surface of the quadrangle (plate 26).

The Cook coal bed occurs 70 to 180 feet (21 to 55 m) beneath the Lower Canyon coal bed and averages approximately 23 feet (7 m) in thickness.

It ranges from less than 10 feet (3 m) to 29 feet (9 m) in thickness (plate 29). The structure contours drawn on top of the Cook coal bed reveal a closed anticline trending southwestward from the northeastern part of the quadrangle. Parallel synclines flank the anticline (plate 30). Between 120 and 1,030 feet (37 and 314 m) of overburden cover the coal bed within the study area (plate 31).

The Wall coal bed is separated from the overlying Cook coal bed by 80 to 250 feet (24 to 76 m) of clastic sediments. This coal bed ranges from 20 feet (6 m) in thickness in the southern part of the quadrangle to 0 feet (0 m) in thickness where an area of non-coal deposition occurred in the northwestern and east-central parts of the quadrangle (plate 34). The structure contour map (plate 35) defines a closed, bifurcated anticline trending southwest from the northeast portion of the map. Closed synclinal depressions flank the anticline to the northeast and northwest. A syncline is located southeast of and parallel to the anticline. The Wall coal bed lies from 360 to 1,180 feet (110 to 360 m) below the surface of the Cabin Creek NE Quadrangle (plate 36).

Thirty to 120 feet (9 to 37 m) of rock interval separate the overlying Wall coal bed from the Pawnee coal bed. The Pawnee coal bed ranges from less than 4 feet (1.2 m) to more than 14 feet (4 m) in thickness from the south-central part of the quadrangle to the northeastern and north-central sectors (plate 39). The structure contour map shows a bifurcated, northeast-southwest-trending anticline located in the northern half of the quadrangle. A closed synclinal depression is present in the

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 Cabin Creek NE 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 coal 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.

northeast corner of the map, and two synclines flank the anticlinal feature (plate 40). The Pawnee coal bed lies from 380 to 1,280 feet (116 to 390 m) below the surface of the study area (plate 41).

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 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 considers this agreement mandatory

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), and 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 parts of identified 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 1,750, or 1,770--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 tonnages (reserves) are 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 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 44) was prepared utilizing the following mining-ratio criteria for coal beds 5 feet 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 surface mining development potential is high for most of the Cabin Creek NE Quadrangle due to the presence of the thick Anderson and Upper Canyon coal beds at shallow depths. Also, numerous

thin coal beds crop out throughout the area. Table 1 sets forth the strippable reserve base tonnages per coal bed for this quadrangle.

Underground Mining Coal Development Potential. Subsurface coal mining development potential throughout the Cabin Creek NE 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 development potential relates to the occurrence of coal beds more than 5 feet (1.5 m) thick buried from 500 to 3,000 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 1,000 feet (305 m) to 3,000 feet (914 m) beneath the surface, or 2) a coal bed or coal zone 5 feet (1.5 m) or more in thickness that lies 500 feet (152 m) to 1,000 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 1,000 to 3,000 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 1,000 to 3,000 feet (305 to 914 m).

The coal development potential for "in-situ" gasification on the Cabin Creek NE Quadrangle is low, hence no CDP map is generated for this map series. The resource tonnage for "in-situ" gasification with low development potential is presented on table 3. None of the coal beds in the Cabin Creek NE Quadrangle qualifies for a moderate or high development potential rating for "in-situ" gasification.

Table 1.--Strippable Coal Reserve Base and Hypothetical Resource Data (in short tons) for Federal Coal Lands in the Cabin Creek NE Quadrangle, Sheridan and Campbell Counties, Wyoming, and Powder River County, Montana.

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

Coal Bed	High Development Potential (0-10:1 Mining Ratio)	Moderate Development Potential (10:1-15:1 Mining Ratio)	Low Development Potential (>15:1 Mining Ratio)	Total
Reserve Base				
Arvada	1,930,000	-	-	1,930,000
Roland of Baker	6,760,000	200,000	-	6,960,000
Smith	18,550,000	24,880,000	56,020,000	99,450,000
Anderson	366,450,000	106,410,000	63,120,000	535,980,000
Dietz	49,340,000	30,270,000	31,110,000	110,720,000
Upper Canyon	489,110,000	396,450,000	150,570,000	1,031,130,000
Lower Canyon	6,840,000	21,200,000	242,970,000	271,010,000
Cook	14,840,000	55,750,000	290,280,000	360,870,000
Wall	-	-	31,570,000	31,570,000
Pawnee	-	-	5,600,000	5,600,000
Total	948,820,000	635,160,000	871,240,000	2,455,220,000
Hypothetical Resources				
Lower Canyon	-	-	25,500,000	25,500,000
Total	-	-	25,500,000	25,500,000
GRAND TOTAL	948,820,000	635,160,000	896,740,000	2,480,720,000

Table 2.--Coal Reserve Base and Hypothetical Resource Data (in short tons) for Underground Mining Methods for Federal Coal Lands in the Cabin Creek NE Quadrangle, Sheridan and Campbell Counties, Wyoming, and Powder River County, Montana.

Coal Bed Name	High Development Potential	Moderate Development Potential	Low Development Potential	Total
Reserve Base				
Anderson	-	-	320,000	320,000
Dietz	-	-	1,010,000	1,010,000
Upper Canyon	-	-	134,440,000	134,440,000
Lower Canyon	-	-	152,850,000	152,850,000
Cook	-	-	786,170,000	786,170,000
Wall	-	-	432,430,000	432,430,000
Pawnee	-	-	368,460,000	368,460,000
Total	-	-	1,875,680,000	1,875,680,000
Hypothetical Resources				
Cook	-	-	4,600,000	4,600,000
Wall	-	-	3,500,000	3,500,000
Total	-	-	8,100,000	8,100,000
GRAND TOTAL	-	-	1,883,780,000	1,883,780,000

Table 3.--Coal Reserve Base Data (in short tons) for In-Situ Gasification for Federal Coal Lands in the Cabin Creek NE Quadrangle, Sheridan and Campbell Counties, Wyoming, and Powder River County, Montana.

Coal Bed Name	High Development Potential	Moderate Development Potential	Low Development Potential	Total
Reserve Base				
Anderson	-	-	320,000	320,000
Dietz	-	-	1,010,000	1,010,000
Upper Canyon	-	-	134,440,000	134,440,000
Lower Canyon	-	-	152,850,000	152,850,000
Cook	-	-	786,170,000	786,170,000
Wall	-	-	432,430,000	432,430,000
Pawnee	-	-	368,460,000	368,460,000
Total	-	-	1,875,680,000	1,875,680,000
Hypothetical Resources				
Cook	-	-	4,600,000	4,600,000
Wall	-	-	3,500,000	3,500,000
Total	-	-	8,100,000	8,100,000
GRAND TOTAL	-	-	1,883,780,000	1,883,780,000

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