UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

TEXT TO ACCOMPANY:

COAL RESOURCE OCCURRENCE

AND

COAL DEVELOPMENT POTENTIAL

MAPS

OF THE

CABIN CREEK SE QUADRANGLE,

SHERIDAN AND CAMPBELL COUNTIES, WYOMING

BY

INTRASEARCH INC.

ENGLEWOOD, COLORADO

OPEN FILE REPORT 79-165
1980

TABLE OF CONTENTS

TABLE OF CONTENTS (continued)

TABLE OF CONTENTS (continued)

TABLE OF CONTENTS (continued)

MAPS | PLATES

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 SE Quadrangle, Sheridan and Campbell Counties, Wyoming. This CRO and CDP map series includes 49 plates (U. S. Geological Survey Open-File Report 79-165). 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 SE Quadrangle is located in Sheridan and Campbell Counties, in northeastern Wyoming. It encompasses all or parts of Townships 55, 56 and 57 North, Ranges 76 and 77 West, and covers the area: 44°45' to 44°52'30" north latitude; 106°00' to 106°07'30" west longitude.

Main access to the Cabin Creek SE Quadrangle is provided by a light-duty, gravel road wich extends from north-to-south along the western side of the Powder River. Unimproved roads traverse the major valleys and ridges, providing access to more remote areas of the quadrangle. The closest railroad is the Burlington Northern trackage approximately 3.5 miles (5.6 km) to the southwest near Kendrick, Wyoming.

Drainage is provided by the Powder River which meanders northward across the western half of the quadrangle, and by Clear Creek which flows northeastward across the northwestern portion of the quadrangle and joins the Powder River approximately 0.5 miles (0.8 km) to the north. Minor intermittent streams drain the higher elevations of the quadrangle. The terrain attains elevations of 4,200 feet (1,280 km) above sea level in the northeastern corner of the quadrangle, where hills rise 600 to 700 feet (183 to 213 m) above the floor of the Powder River valley.

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 summertime maximums range from +5° to +15°F (-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 Sheridan and Campbell County Courthouses in Sheridan and Gillette, Wyoming, respectively. 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 (resources), as well as recoverable tons (reserves). These coal tonnages are then categorized in measured, indicated, and inferred parts of identified 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 5.8 billion tons (5.2 billion metric tons) of total, unleased federal coal-in-place resources in the Cabin Creek SE 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 overlying 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 SE Quadrangle is located in an area where surface rocks are classified within the Wasatch Formation and the underlying Tongue River Member of the Fort Union Formation. Although the Wasatch is reportedly up to 1,800 feet (549 m) thick (Denson and Horn, 1975), Olive (1957) mapped 700 to 800 feet (213 to 244 m). Only 200 to 300 feet (61 to 91 m) of Wasatch Formation and 300 to 400 feet (91 to 122 m) of the Tongue River Member of the Fort Union Formation are exposed in the quadrangle. 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 Anderson, Canyon, and Wall coal beds were named by Baker (1929). The Arvada coal bed was named by Stone and Lupton (1910), and the Smith coal bed was named by Taff (1909). Bass (1932) named the Cook coal bed, and Warren (1959) named the Pawnee coal bed. The Oedekoven and Wildcat coal beds were informally named by IntraSearch (1978a, 1978b), and the Moyer coal bed was informally named by IntraSearch (1979).

The CRO/CDP report on Kline Draw Quadrangle, Wyoming, adjacent to and east of the Cabin Creek SE Quadrangle, was published in 1978 (IntraSearch, 1978c). Since that time, additional subsurface data have been open-filed (Correia, 1980). The new drill hole information prevents the continuity of subsurface contours between the two quadrangles on the Upper Smith and Anderson coal beds. The Upper Smith coal bed in the Cabin Creek SE Quadrangle is equivalent to the Smith coal bed in the Cabin Creek NE Quadrangle to the north, and in the Kline Draw Quadrangle to the east. The Cook coal bed, which is composed of the Upper Cook and Lower Cook coal beds in the Cabin Creek SE Quadrangle, is equivalent to the Lower Cook coal bed in the Kline Draw Quadrangle to the east.

Local. The Cabin Creek SE Quadrangle lies on the eastern flank of the Powder River Basin, where the strata dip gently westward. The Wasatch Formation crops out over approximately 35 percent 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 Tongue River Member of the Fort Union Formation directly underlies the Wasatch Formation, and is composed of very fine-grained sandstones, siltstones, claystones, shales, carbonaceous shales, and numerous coal beds. The Tongue River Member crops out over approximately 65 percent of the quadrangle.

The dominant structural feature within the quadrangle is a southward-plunging anticline flanked on the east by a southward-plunging syncline. Structure contours drawn on top of the lower coal beds depict a west-southwestward-plunging syncline in the northwestern portion of the quadrangle. A gentle, southwestward regional dip is present on all coal beds within the quadrangle. There are five northeastward-trending normal faults within the study area, and one northward-trending normal fault. Vertical displacements of as much as 25 feet (8 m) exist, usually on the southern side of the faults.

III. Data Sources

Areal geology of the coal outcrops is derived from the Spotted Horse coal field report (Olive, 1957), and the Powder River coal field report (Stone and Lupton, 1910). The coal outcrops are adjusted to fit the current topographic map 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 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 SE 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

The Watsatch Formation and Fort Union Formation coal beds that are present in all or part of the Cabin Creek SE Quadrangle include, in descending stratigraphic order: the Arvada, Upper Smith, Lower Smith, Anderson, Upper Canyon, local, Lower Canyon, Cook, Wall, Pawnee, Wildcat, Moyer, Oedekoven, and local coal beds. The Lower Canyon coal beds are mapped as a coal zone. The Wildcat coal bed was not mapped due to insufficient thickness. 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 or coal zones. Mining ratios are presented on the isopach maps of the Arvada, Upper Smith, Lower Smith, Anderson, Upper Canyon, Lower Canyon, and Cook coal beds.

No physical or chemical analyses are known to have been published regarding coal bed samples from the Cabin Creek SE Quadrangle. For eastern Sheridan County and western Campbell County 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						MOIST, M-M-F BTU/LB	COAL RANK
			ASH %	FIXED CARBON %	MOISTURE %	VOLATILES %	SULFUR %	BTU/LB		
Arvada	(**)	Hole 78-2	10.5	32.9	28.5	28.1	1.6	7575	8538	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	(1)	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 publication by American Society for Testing and Materials (1971).

** Correia, G. A. (U. S. Geological Survey, unpublished data).

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

(U) U. S. Geological Survey and Montana Bureau of Mines and Geology (1974, 1976).

Except for the Arvada coal analysis, the proximate analyses presented above are from core hole or outcrop locations in excess of 20 miles (32 km) from this quadangle. In order to simplify tonnage computations, all coal beds in the Cabin Creek SE Quadrangle are tentatively classified as subbituminous C rank.

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 Wall coal bed underlies the entire quadrangle, it is designated as datum for the correlation diagram. The Cook and Wall coal beds show the thickest coal bed occurrence throughout the study area. The other coal beds are relatively thin throughout the Cabin Creek SE Quadrangle.

The Arvada coal bed is eroded from the northern half of the Cabin Creek SE Quadrangle, and is present in approximately 20 percent of the quadrangle. The Arvada coal bed, ranging in thickness from 6 to 11.9 feet (1.8 to 3.6 m), diverges into two coal beds locally. The non-coal interval reaches a maximum of 3 feet (0.9 m) in thickness. The upper coal bed is approximately 5 feet (1.5 m) thick, and the lower coal bed is approximately 3 feet (0.9 m) thick. Coal isopach and structure contour mapping of the Arvada coal bed is determined from surface measured sections and coal outcrop elevations (Olive, 1957; and Stone and Lupton, 1910). Structure contours drawn on top of the Arvada coal bed depict a gentle, southwestward dip with minor flexures. The Arvada coal bed occurs from 0 feet (0 m) to greater than 150 feet (46 m) beneath the surface.

The Upper Smith coal bed lies 50 to 280 feet (15 to 85 m) beneath the Arvada coal bed and ranges in thickness from 2 feet (0.6 m) in the northeastern portion of the quadrangle to 25 feet (8 m) in the southeastern portion of the quadrangle, and is eroded from approximately 50 percent of the quadrangle. A maximum non-coal interval of 7 feet (2.1 m) is present within the various coal beds that compose the Upper Smith coal bed. Mapping of the Upper Smith coal bed isopach and structure contour maps is determined from surface measured sections and coal outcrop elevations (Olive, 1957; and Stone and Lupton, 1910). The main structural configuration on the Upper Smith coal bed is a closed, northward-trending anticline in the center of the quadrangle, flanked by a southwestward-plunging syncline to the northwest and a southward-plunging syncline to the east. The Upper Smith coal bed lies from 0 to 390 feet (0 to 119 m) beneath the surface.

The Lower Smith coal bed occurs approximately 200 feet (61 m) beneath the Upper Smith coal bed and is absent from approximately 95 percent of the Cabin Creek SE Quadrangle. The Lower Smith coal bed ranges in thickness from 0 to 10 feet (0 to 3 m) with maximum thicknesses in the southwestern corner of the quadrangle (figure 1). Mapping of the Lower Smith coal bed utilizes information located to the west and to the south of the Cabin Creek SE Quadrangle. Structure contours drawn on top of the Lower Smith coal bed depict a gentle, southwestward dip.
The Lower Smith coal bed occurs from less than 200 feet (61 m) to greater than 500 feet (152 m) beneath the surface (figure 2).

The Anderson coal bed is located 20 to 160 feet (6 to 49 m) beneath the Lower Smith coal bed where present, and 80 to 320 feet

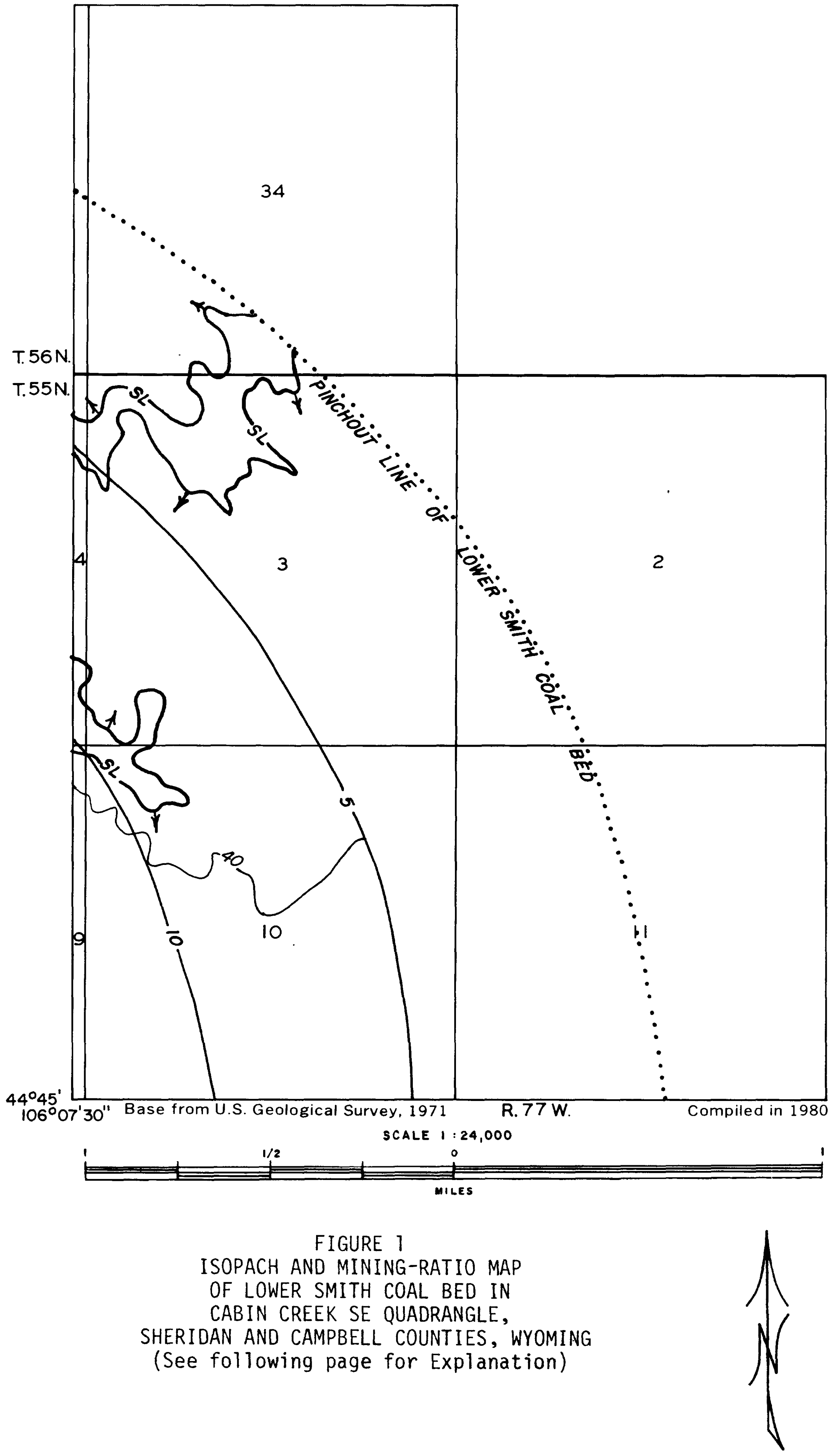


FIGURE 1
ISOPACH AND MINING-RATIO MAP
OF LOWER SMITH COAL BED IN
CABIN CREEK SE QUADRANGLE,
SHERIDAN AND CAMPBELL COUNTIES, WYOMING
(See following page for Explanation)

EXPLANATION FOR FIGURE 1

10

5

ISOPACHS OF COAL BED-Showing thickness in feet. Isopach interval 5 feet.

40

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.

SL

STRIPPING LIMIT LINE-500 foot overburden isopach boundary for surface mining of coal. Arrows point toward area suitable for surface mining.

To convert feet to meters, multiply feet by 0.3048.

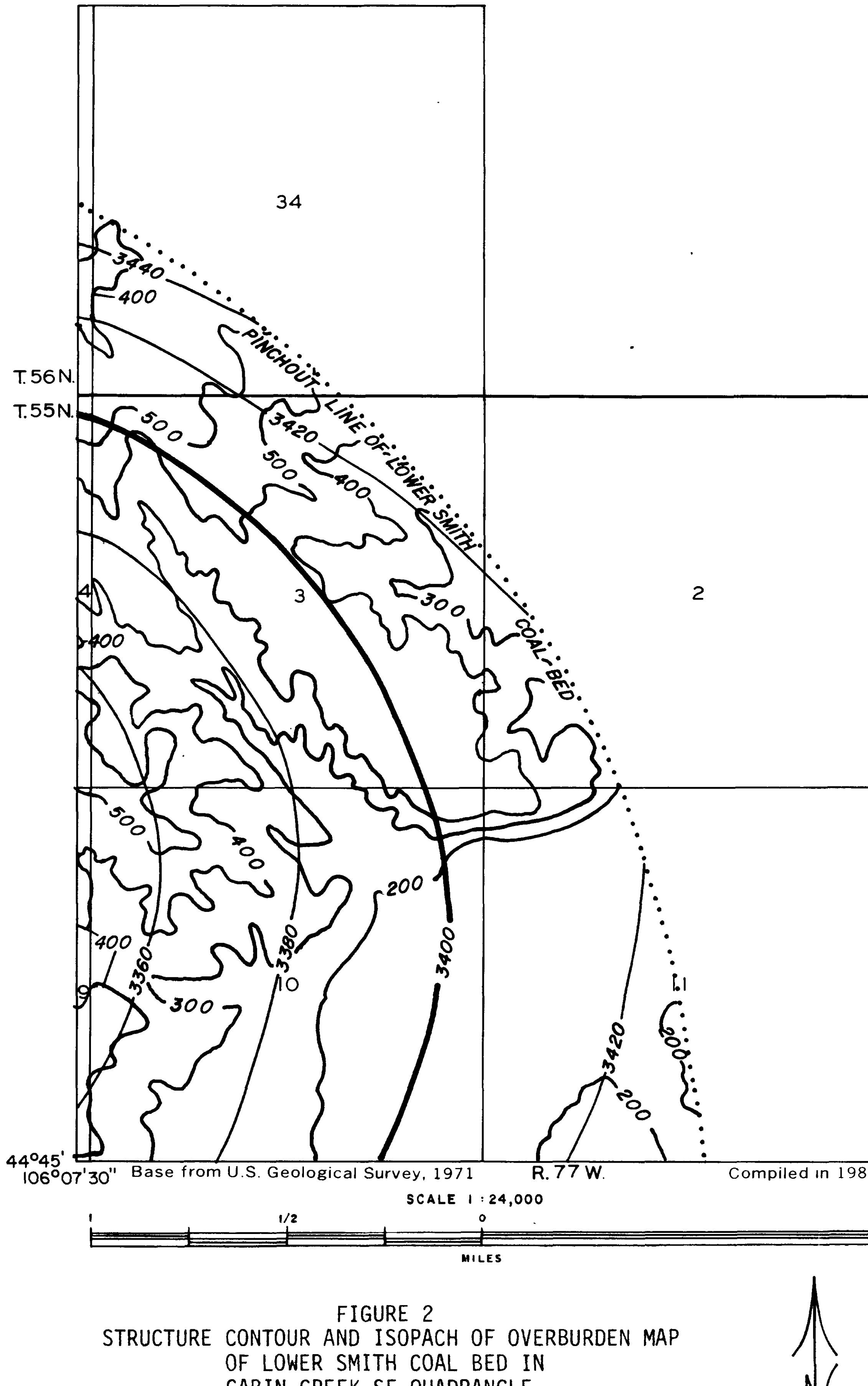


FIGURE 2
STRUCTURE CONTOUR AND ISOPACH OF OVERBURDEN MAP
OF LOWER SMITH COAL BED IN
CABIN CREEK SE QUADRANGLE,
SHERIDAN AND CAMPBELL COUNTIES, WYOMING
(See following page for Explanation)

EXPLANATION FOR FIGURE 2

3380 3400	STRUCTURE CONTOURS-Drawn on top of coal bed. Contour interval 20 feet. Datum is mean sea level.
400	OVERBURDEN ISOPACH-Showing thickness of overburden, in feet, from the surface to the top of the coal bed. Isopach interval 100 feet.

To convert feet to meters, multiply feet by 0.3048.

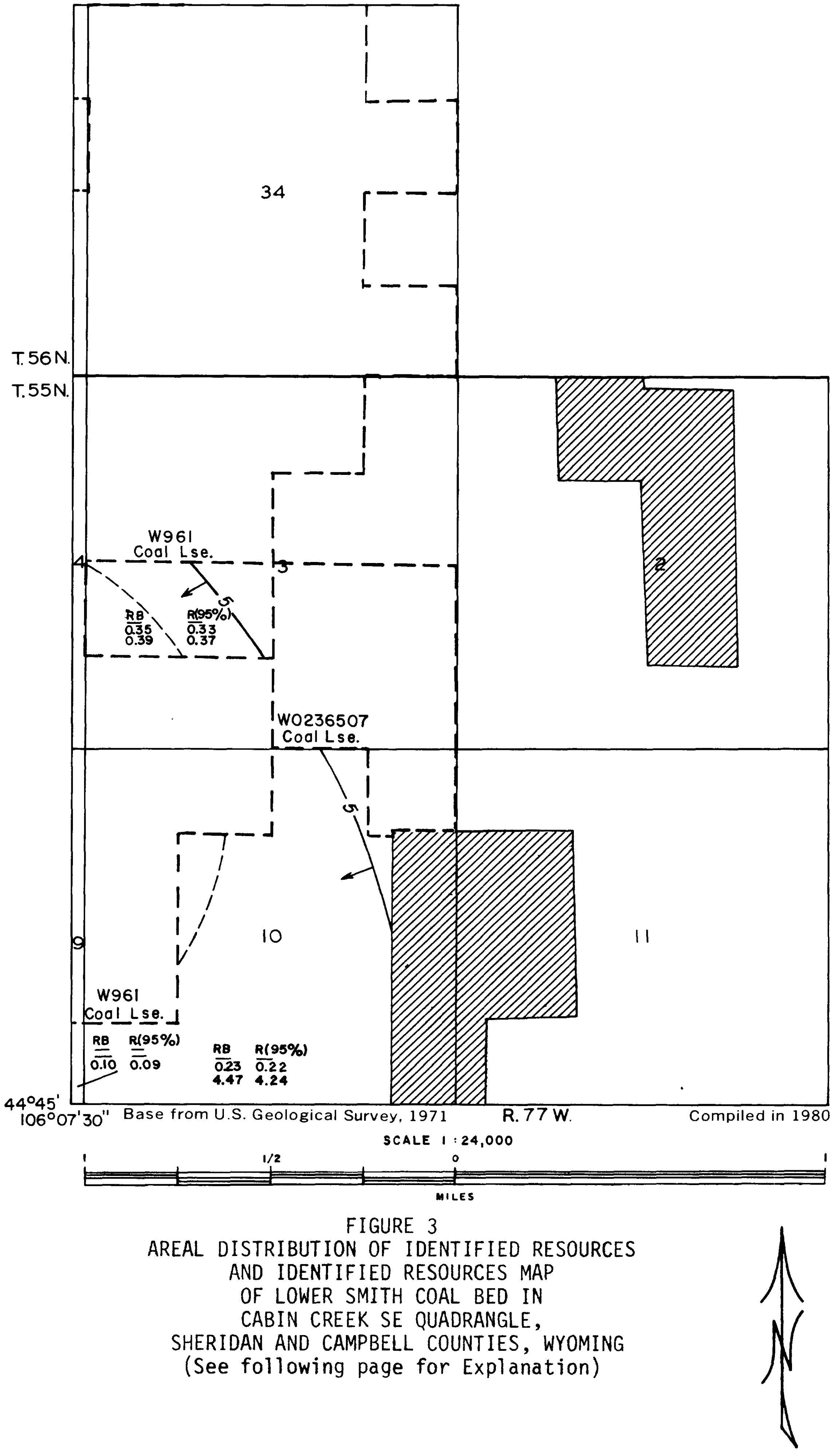
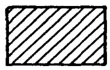
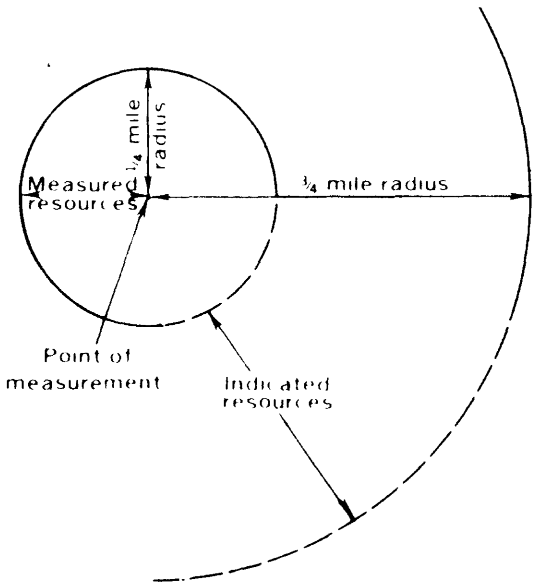


FIGURE 3
AREAL DISTRIBUTION OF IDENTIFIED RESOURCES
AND IDENTIFIED RESOURCES MAP
OF LOWER SMITH COAL BED IN
CABIN CREEK SE QUADRANGLE,
SHERIDAN AND CAMPBELL COUNTIES, WYOMING
(See following page for Explanation)

EXPLANATION FOR FIGURE 3



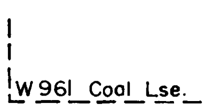
NON-FEDERAL COAL LAND-Coal tonnages not evaluated.



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

RB	R(95%)	
—	—	(Measured)
0.23	0.22	(Indicated)
4.47	4.24	(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).



COAL LEASE-Coal Lse. Coal tonnages not evaluated.

Reserves are not calculated for coal beds greater than 500 feet in depth.

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

To convert miles to kilometers, multiply miles by 1.609.

(24 to 98 m) beneath the Upper Smith coal bed. The Anderson coal bed ranges in thickness from 5 feet (1.5 m) to 17 feet (5 m) with maximum thicknesses along the northern boundary. The Anderson coal bed is eroded from approximately 25 percent of the quadrangle. Locally, the Anderson coal bed diverges into as many as three coal beds with a maximum non-coal interval of 7 feet (2.1 m). In many areas along the outcrop, the Anderson coal bed has burned to produce minor clinkering. Mapping of the Anderson coal bed is determined from surface measured sections and coal outcrop elevations (Olive, 1957). The main structural contours drawn on the top of the Anderson coal bed depict a southward-plunging syncline through the center of the quadrangle, flanked by a broad, southeastward-plunging anticline to the northwest. The Anderson coal bed lies from 0 feet (0 m) to greater than 600 feet (183 m) beneath the surface.

The Upper Canyon coal bed occurs 120 to 460 feet (37 to 140 m) beneath the Anderson coal bed. In the southeastern corner of the quadrangle, the Upper Canyon coal bed and the Lower Canyon coal bed converge to form the Canyon coal bed, which is approximately 30 feet (9 m) thick. The Upper Canyon coal bed ranges in thickness from 10 feet (3 m) to 15 feet (5 m) in the Cabin Creek SE Quadrangle, with maximum thicknesses occurring in the southeastern quarter and along the northern boundary. The main structural features on the Upper Canyon coal bed are a southward-plunging anticline in the western portion of the quadrangle, and a southward-plunging syncline in the eastern portion. The Upper Canyon coal bed occurs from less than 100 feet (30 m) to greater than 900 feet (274 m) beneath the surface.

The Lower Canyon coal bed lies 0 to 350 feet (0 to 107 m) beneath the Upper Canyon coal bed. The Lower Canyon coal bed is pinched out in the southeastern corner of the quadrangle and attains a maximum thickness of 16 feet (5 m) in the northeastern quarter. The Lower Canyon coal bed contains clastic sediments ranging from 3 to 11 feet (1.9 to 3 m) thick. Structure contours drawn on top of the Lower Canyon coal bed depict a gentle, southwestward dip with a broad, southeastward-plunging syncline located in the central portion of the quadrangle, flanked by a southward-plunging anticline to the west. The Lower Canyon coal bed occurs from less than 400 feet (122 m) to greater than 1,000 feet (305 m) beneath the surface.

The Cook coal bed lies 30 to 220 feet (9 to 67 m) beneath the Lower Canyon coal bed. The Cook coal bed ranges in thickness from 18 to 46 feet (5 to 14 m). In the northern part of the quadrangle, the Cook coal bed contains more than 22 feet (7 m) of non-coal sediments. Structure contours drawn on top of the Cook coal bed depict a southwestward-plunging anticline through the central area, flanked by a southwestward-plunging syncline to the east. The Cook coal bed lies from less than 500 feet (152 m) to greater than 1,100 feet (335 m) beneath the surface.

The Wall and Pawnee coal beds occur 40 to 130 feet (12 to 40 m) beneath the Cook coal bed. The Wall coal bed ranges in thickness from 14 to 27 feet (4 to 8 m), and the Pawnee coal bed is from 0 feet (0 m) to 8 feet (2.1 m) thick. Total coal bed thicknesses range from 20 to 40 feet (6 to 12 m), with maximum thicknesses in the southeast corner.

The non-coal interval between the two coal beds ranges from 41 to 70 feet (13 to 24 m). The main structural feature on the Wall and Pawnee coal beds within the quadrangle is a southwestward-plunging syncline in the northwest quarter. The Wall and Pawnee coal beds occur from less than 700 feet (213 m) to greater than 1,250 feet (381 m) beneath the surface.

The Moyer coal bed lies 240 to 324 feet (73 to 99 m) beneath the Pawnee coal beds. The Moyer coal bed is absent in the eastern portion of the quadrangle, and attains a maximum thickness of 6 feet (1.8 m) in the south-central portion. Structure contours drawn on top of the Moyer coal bed depict a southwestward-plunging syncline in the northern portion of the quadrangle, and a southwestward dip in the southern portion of the study area. The Moyer coal bed lies from less than 1,100 feet (335 m) to greater than 2,000 feet (610 m) beneath the surface.

The Oedekoven coal bed occurs 170 to 400 feet (52 to 122 m) beneath the Moyer coal bed, and approximately 600 feet (183 m) beneath the Pawnee coal bed where the Moyer coal bed is absent. The Oedekoven coal bed is absent along the eastern edge, and in the northeastern and southeastern corners of the quadrangle, and attains a maximum thickness of 10 feet (3 m) in the north-central area. The coal bed is separated locally into two, thin coal beds by a non-coal interval of 4 feet (1.2 m). The main structural features on the Oedekoven coal bed are a southwestward-plunging syncline in the northwest portion of the quadrangle, flanked by a southwestward-plunging anticline in the northeastern portion of the quadrangle. Gentle, southwestward dip occurs in the southwestern corner of the quadrangle. The Oedekoven coal bed lies from less than 1,400 feet (427 m) to greater than 2,200 feet (671 m) beneath the surface.

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 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 SE 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. 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, and 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 49) 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 following mining-ratio criteria are utilized for coal beds greater than 40 feet (12 m) thick:

1. Low development potential = 7:1 and greater ratio.
2. Moderate development potential = 5:1 to 7:1 ratio.
3. High development potential = 0 to 5:1 ratio.

The surface-mining development potential is high for approximately 30 percent of the quadrangle. These high development potential areas result from low overburden-to-coal thickness ratios where the Arvada, Upper Smith, Anderson, and Upper Canyon coal beds crop out throughout the quadrangle. These areas of high development occur primarily in the northern one-third and in the southeastern quarter. Approximately 30 percent of the Cabin Creek SE Quadrangle is rated as low development potential due to thin coal beds overlain by thick overburden. The surface-mining development potential is moderate for approximately 5 percent of the quadrangle, existing throughout the quadrangle. The remaining 35 percent of the study area is classified as non-federal coal land or leased federal coal, and is not evaluated in this study. Table 1 sets forth the estimated strippable reserve base tonnages per coal bed for this quadrangle.

Underground Mining Coal Development Potential. Subsurface coal mining development potential throughout the Cabin Creek SE Quadrangle is considered low. Inasmuch as recovery factors have not been established for the underground development of coal beds in this quadrangle, reserves (recoverable coal tonnages) 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 SE Quadrangle is rated as low. This rating results from the coal beds 5 feet (1.5 m) or more in thickness which occur between 500 feet (152 m) and 1,000 feet (305 m) beneath the surface. The total coal section more than 1,000 feet (305 m) beneath the surface is less than 100 feet (30 m) thick throughout the quadrangle. The coal resource tonnage totals for in-situ gasification are listed by coal bed on table 3.

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

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

Coal Bed	High Development Potential (0-10:1 Mining Ratio)	Moderate Development Potential (10:1-15:1 Mining Ratio)	Low Development Potential (>15:1 Mining Ratio)	Total
Reserve Base Resources				
Arvada	17,240,000	2,360,000	340,000	19,940,000
Upper Smith	111,680,000	43,790,000	31,860,000	187,330,000
Lower Smith	-	-	5,540,000	5,540,000
Anderson	59,260,000	15,070,000	139,030,000	213,360,000
Upper Canyon	18,650,000	27,240,000	287,100,000	332,990,000
Lower Canyon	-	230,000	477,200,000	477,430,000
Cook	-	470,000	1,172,720,000	1,173,190,000
Total	206,830,000	89,160,000	2,113,790,000	2,409,760,000
Hypothetical Resources				
Anderson	-	-	29,930,000	29,930,000
Upper Canyon	-	-	60,060,000	60,060,000
Lower Canyon	-	-	23,760,000	23,760,000
Cook	-	-	15,050,000	15,050,000
Total	-	-	128,800,000	128,800,000
Grand Total	206,830,000	89,160,000	2,242,590,000	2,538,580,000

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

Coal Bed Name	High Development Potential	Moderate Development Potential	Low Development Potential	Total
Reserve Base Resources				
Anderson	-	-	2,290,000	2,290,000
Upper Canyon	-	-	79,960,000	79,960,000
Lower Canyon	-	-	386,660,000	386,660,000
Cook	-	-	1,154,920,000	1,154,920,000
Wall-Pawnee	-	-	1,034,550,000	1,034,550,000
Moyer	-	-	68,830,000	68,830,000
Oedekoven	-	-	138,180,000	138,180,000
Total	-	-	2,865,390,000	2,865,390,000
Hypothetical Resources				
Anderson	-	-	460,000	460,000
Upper Canyon	-	-	158,400,000	158,400,000
Lower Canyon	-	-	5,060,000	5,060,000
Cook	-	-	50,910,000	50,910,000
Wall-Pawnee	-	-	21,380,000	21,380,000
Total	-	-	236,210,000	236,210,000
GRAND TOTAL	-	-	3,101,600,000	3,101,600,000

Table 3.--Coal Reserve Base and Hypothetical Resource Data (in short tons) for In-Situ Gasification for Federal Coal Lands in the Cabin Creek SE Quadrangle, Sheridan and Campbell Counties, Wyoming.

Coal Bed Name	High Development Potential	Moderate Development Potential	Low Development Potential	Total
Reserve Base Resources				
Anderson	-	-	2,290,000	2,290,000
Upper Canyon	-	-	79,960,000	79,960,000
Lower Canyon	-	-	386,660,000	386,660,000
Cook	-	-	1,154,920,000	1,154,920,000
Wall-Pawnee	-	-	1,034,550,000	1,034,550,000
Moyer	-	-	68,830,000	68,830,000
Oedekoven	-	-	138,180,000	138,180,000
Total	-	-	2,865,390,000	2,865,390,000
Hypothetical Resources				
Anderson	-	-	460,000	460,000
Upper Canyon	-	-	158,400,000	158,400,000
Lower Canyon	-	-	5,060,000	5,060,000
Cook	-	-	50,910,000	50,910,000
Wall-Pawnee	-	-	21,380,000	21,380,000
Total	-	-	236,210,000	236,210,000
GRAND TOTAL	-	-	3,101,600,000	3,101,600,000

SELECTED REFERENCES

American Society of Testing and Materials, 1971, Standard specifications for classification of coals by rank (ASTM Designation D 388-66) in Gaseous fuels, coal, and coke: American Society for Testing and Materials, pt. 19, p. 57-61.

Baker, A. A., 1929, The northward extension of the Sheridan coal field, Big Horn and Rosebud Counties, Montana: U. S. Geological Survey Bull. 806-B, p. 15-67.

Bass, N. W., 1932, The Ashland coal field, Rosebud, Powder River, and Custer Counties, Montana: U. S. Geological Survey Bull. 831-B, p. 19-105.

Brown, R. W., 1958, Fort Union Formation in the Powder River Basin, Wyoming: Wyoming Geological Association Guidebook, Thirteenth Annual Field Conf., p. 111-113.

Correia, G. A., 1980, Preliminary results of 1978 coal assessment drilling in Northern and Western Recluse Geologic Analysis Area, northern Campbell County and eastern Sheridan County, Wyoming: U. S. Geological Survey Open-File Report 80-80, 70 p.

Culbertson, W. C., Kent, B. H., and Mapel, W. J., 1979, Preliminary diagrams showing correlation of coal beds in the Fort Union and Wasatch Formations across the northern Powder River Basin, northeastern Wyoming and southeastern Montana: U. S. Geological Survey Open-File Report 79-1201, 11 p.

Denson, N. M., and Horn, G. H., 1975, Geologic and structure map of the southern part of the Powder River Basin, Converse, Niobrara, and Natrona Counties, Wyoming: U. S. Geological Survey Miscellaneous Investigations Series, Map I-877, scale 1:125,000.

Dobbin, C. E., and Barnett, V. H., 1927 (1928), The Gillette coal field, northeastern Wyoming: U. S. Geological Survey Bull. 796-A, 50 p.

IntraSearch Inc., 1978a, Coal resource occurrence and coal development potential maps of the Cabin Creek NE Quadrangle, Sheridan and Campbell Counties, Wyoming, and Powder River County, Montana: U. S. Geological Survey Open-File Report 78-064, 21 p.

_____1978b, Coal resource occurrence and coal development potential maps of the Rocky Butte Quadrangle, Campbell County, Wyoming: U. S. Geological Survey Open-File Report 78-830, 22 p.

_____1978c, Coal resource occurrence and coal development potential maps of the Kline Draw Quadrangle, Campbell County, Wyoming: U. S. Geological Survey Open-File Report 78-831, 25 p.

_____1979, Coal resource occurrence and coal development potential maps of the Larey Draw Quadrangle, Campbell County, Wyoming: U. S. Geological Survey Open-File Report 79-023, 29 p.

Jacob, A. F., 1973, Depositional environments of Paleocene Tongue River Formation: Am. Assoc. of Petroleum Geologists Bull., vol. 56, no. 6, p. 1038-1052.

Matson, R. E., and Blumer, J. W., 1973, Quality and reserves of strippable coal, selected deposits, southeastern Montana: Montana Bureau of Mines and Geology Bull. 91, 135 p.

McKay, E. J., 1974, Preliminary geologic map of the Bertha 2 NW (Rocky Butte) Quadrangle, Campell County, Wyoming: U. S. Geological Survey Open-File Report 74-173, scale 1:24,000.

McKay, E. J., and Mapel, W. J., 1973, Preliminary geologic map of the Calf Creek Quadrangle, Campbell County, Wyoming: U. S. Geological Survey Open-File Report, 1973.

Olive, W. W., 1957, The Spotted Horse coal field, Sheridan and Campbell Counties, Wyoming: U. S. Geological Survey Bull. 1050, 83 p.

Stone, R. W., and Lupton, C. T., 1910, The Powder River coal field, Wyoming, adjacent to the Burlington Railroad: U. S. Geological Survey Bull. 381-B, p. 115-136.

Taff, J. A., 1909, The Sheridan coal field, Wyoming: U. S. Geological Survey Bull. 341-B, p. 123-150.

U. S. Bureau of Mines and U. S. Geological Survey, 1976, Coal resource classification system of the U. S. Bureau of Mines and U. S. Geological Survey: U. S. Geological Survey Bull. 1450-B, 7 p.

U. S. Geological Survey and Montana Bureau of Mines and Geology, 1974, Preliminary report of coal drill-hole data and chemical analyses of coal beds in Campbell County, Wyoming: U. S. Geological Survey Open-File Report 74-97, 241 p.

_____1976, Preliminary report of coal drill-hole data and chemical analyses of coal beds in Campbell and Sheridan Counties, Wyoming: Custer, Prairie, and Garfield Counties, Montana; and Mercer County, North Dakota: U. S. Geological Survey Open-File Report 76-319, 377 p.

Warren, W. C., 1959, Reconnaissance geology of the Birney-Broadus coal field, Rosebud and Powder River Counties, Montana: U. S. Geological Survey Bull. 1072-J, p. 561-585.

Weimer, R. J., 1977, Stratigraphy and tectonics of western coals _in_ Geology of Rocky Mountain Coal, A Symposium, 1976: Colorado Geological Survey Resources Series 1, p. 9-27.