Text to accompany:

Open-File Report 78-051

1978

COAL RESOURCE OCCURRENCE AND COAL DEVELOPMENT POTENTIAL MAPS OF THE ELK MOUNTAIN QUADRANGLE, CARBON COUNTY, WYOMING

(Report includes 15 plates)

Prepared for:

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GEOLOGICAL SURVEY

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INTRODUCTION

Purpose

This text is to be used along with the accompanying Coal Resource Occurrence (CRO) maps and the Coal Development Potential (CDP) maps of the Elk Mountain quadrangle, Carbon County, Wyoming (15 plates; U.S. Geol. Survey Open-File Report 78-051),prepared by Texas Instruments Incorporated under contract to the U.S. Geological Survey. This report was prepared to support the land planning work of the U.S. Bureau of Land Management's Energy Minerals Activities Recommendation System (EMARS) program, and to contribute to a systematic coal resource inventory of Federal coal lands in Known Recoverable Coal Resource Areas (KRCRA) in the western United States. The Coal Resource Occurrence maps and the Coal Development Potential maps for this quadrangle cover part of the southeastern portion of the KRCRA of the Hanna coal field.

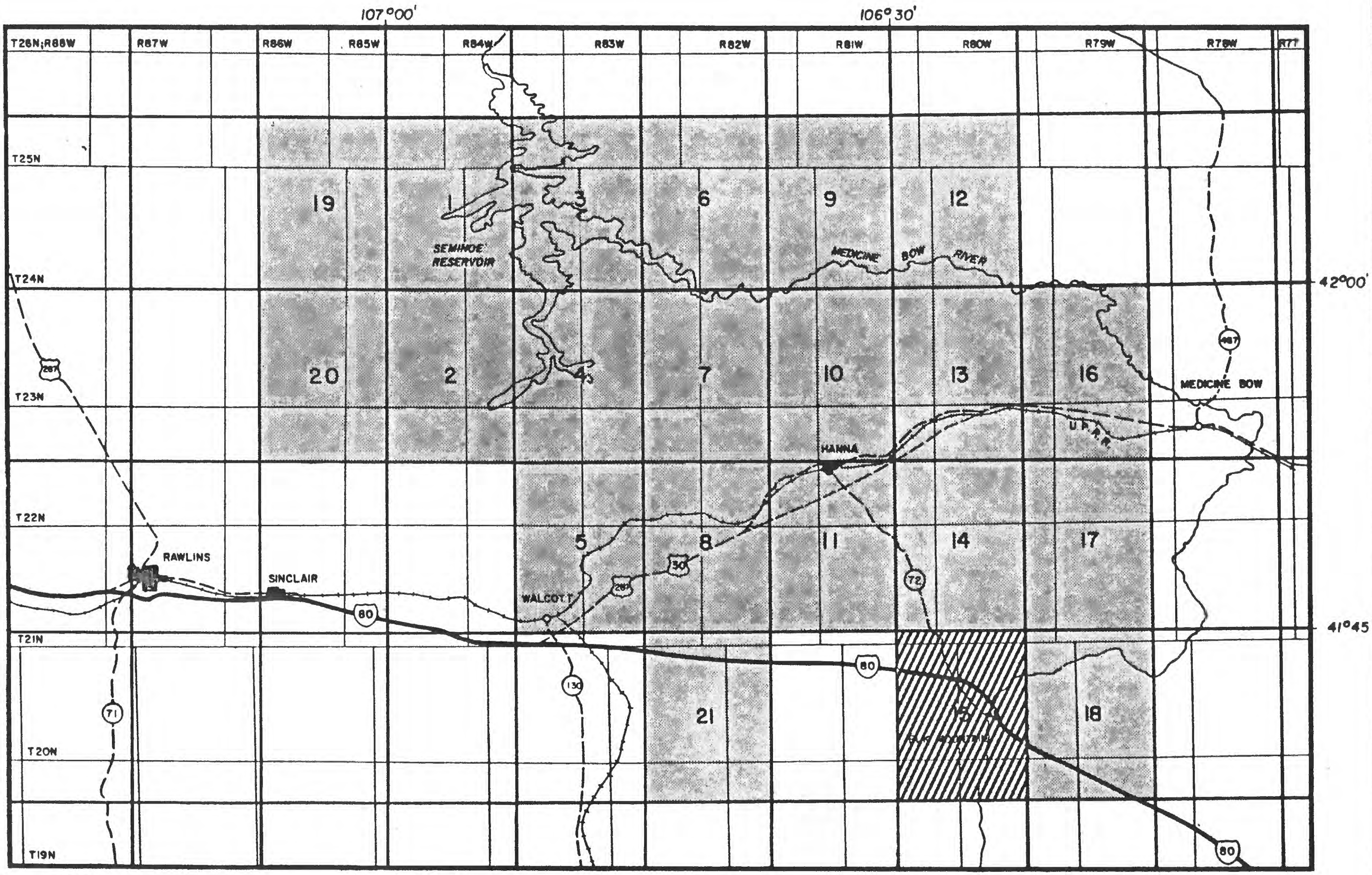
Acknowledgment

Texas Instruments Incorporated acknowledges the cooperation of the Rocky Mountain Energy Company, a wholly owned subsidiary of the Union Pacific Railroad Company, in supplying copies of survey sheets, driller's reports, electric logs, and coal analyses from the Union Pacific coal inventory program.

The Hanna and Carbon coal basins were studied as part of the inventory program and test drilling was conducted in 1970-1971. More than 650 Union Pacific coal drill holes have been evaluated as part of this contract study of 21 quadrangles in Carbon County, Wyoming, and the results and 230 coal analyses have been incorporated into these reports.

Location

The Elk Mountain 7½-minute quadrangle is in the southeastern part of Carbon County, Wyoming. The center of the quadrangle is approximately 19 miles (31 km) southwest of Medicine Bow and 14 miles (22 km) southeast of Hanna, Wyoming (Figure 1). The town of Elk Mountain is located in the east-central part of the quadrangle.



Elk Mountain quadrangle (15)

scale: 1:446,000

Figure 1. — Map of Hanna and Carbon Basins study area.

Accessibility

U.S. Interstate Highway 80 crosses the northern part of Elk Mountain quadrangle from the northwest to the east. State Highway 72 extends diagonally from the northwest border to the east-central part of the quadrangle connecting the town of Elk Mountain with Hanna 14 miles (22 km) to the northwest. Highway 72 connects to U.S. Highway 30/287 1 mile (1.6 km) south of Hanna.

Light-duty roads provide access to much of the area of the quadrangle and connections to neighboring quadrangles as follows:

- In the north, a light-duty road proceeds from state highway 72 eastward to Peterson Camp and continues northward out of the quadrangle to the old town of Carbon. Within the quadrangle several other light-duty and unimproved dirt roads leave this road and provide access to the abandoned mines in secs. 32 and 33, T. 21 N., R. 80 W. shown on Plate 1. Another fork from the road to Peterson Camp crosses the northeast quarter of the quadrangle and continues to the town of Medicine Bow.

- Rattlesnake Pass Road leaves state highway 72 in the northwest quarter of the quadrangle and provides access to several ranches west of the area.

- A light-duty road leaves the state highway 0.5 mile (0.8 km) west of Elk Mountain and proceeds south to several ranches, eventually connecting with state highway 130 west of the quadrangle.

- A light-duty road connects the town of Elk Mountain to Medicine Bow to the northeast.

- A light-duty road runs southeast from Elk Mountain to the towns of Arlington and McFadden.

- One other light-duty road proceeds south from Elk Mountain to the Medicine Bow Ranger Station in the Medicine Bow Mountains.

Unimproved dirt roads provide access to much of the remainder of the quadrangle.

The main east-west track of the Union Pacific Railroad is 14 miles (22 km) north of the center of the quadrangle, and it passes through the towns of Medicine Bow and Hanna northeast and northwest of the quadrangle, respectively.

Physiography

The quadrangle is located at the southern edge of the Carbon structural basin. Most of the area is typical high plains grasslands of southern Wyoming, except in the southwest corner of the quadrangle where the eastern slope of Elk Mountain rises about 900 feet (274 m) above the Medicine Bow River valley to the east. In the northeast corner of the quadrangle, a local escarpment is formed at the eroded edge of the Hanna Formation on the southern and western flanks of the Carbon Basin. The Mesaverde Formation forms a distinct ridge across the northern part of the quadrangle, with a local relief of 200 to 300 feet (61 to 91 m). Elevations within the quadrangle range from 7,094 feet (2,162 m) in a closed basin in the northeast to 8,380 feet (2,554 m) on the slope of Elk Mountain in the southwest.

The land area of the quadrangle lies in the drainage basin of the Medicine Bow River. The Medicine Bow River flows from the southern border north and off the eastern edge of the quadrangle. Halleck Creek flowing from the northwest quarter and Mill Creek flowing from the southwest quarter are two principal, perennial tributaries to the Medicine Bow River. There are a few small closed basins in the northern part of the quadrangle and several small lakes in the western and southern parts of the quadrangle.

Climate

Climate data for the Elk Mountain quadrangle were obtained from the Elk Mountain weather station located within this quadrangle at an elevation of 7,270 feet (2,216 m). Precipitation records are available for 65 years to 1970 and temperature records are available for 22 years to 1970.

The climate is semiarid with a mean annual temperature of 41°F (5°C) and extremes ranging from 95° to -42°F (35° to -41°C). July is the warmest month with a mean monthly temperature of 63°F (17°C) and January is the coldest month with 22°F (-6°C). For seven months of the year, April to October, the mean monthly temperature exceeds 32°F (0°C). Average annual precipitation is 15 inches (38 cm) with 50 percent of this total falling in the five months from March to July. Part of the precipitation in March, April, and May is in the form of snow. Average annual snowfall is 108 inches (274 cm) with 64 percent falling in the four months of January to April. Snow rarely falls in July and August but an inch or more of snow may fall in any other month. March is the month of maximum snowfall (18 inches or 46 cm).

High winds are common throughout most of the year. The prevailing wind direction, as recorded at four weather stations around the perimeter of the Hanna and Carbon Basins, is westerly for all twelve months of the year. The growing season is restricted to less than 100 days between late May and early September which are the average times of the last killing spring frost and the first killing fall frost, respectively.

Land Status

The quadrangle is in the southeast part of the KRCRA of the Hanna and Carbon basins. The Federal Government owns approximately 10 percent of the coal rights in the quadrangle; the remaining 90 percent is non federally owned. Approximately 5 percent of the area of the quadrangle is included in the KRCRA, and within this area, about 50 percent of the land is federally owned. Plate 2 of the CRO maps illustrates the ownership status of the land in the quadrangle and the boundary of the KRCRA.

There are 6 abandoned strip mines and 8 abandoned underground mines shown on Plate 1. The 6 abandoned strip mines are the Elk Mountain Strip 1, 2, 3, 4, and 5 (secs. 32 and 33, T. 21 N., R. 80 W.), and the Elk Mountain Valley Strip (sec. 32, T. 21 N., R 80 W.). Five of the eight abandoned underground mines are located in sec. 32, T. 21 N., R. 80 W.: the Carbon County mine, the Garey mine, the Gebhart mine, the Johnson No. 3 mine, and the West mine. Of the remaining three unnamed, abandoned, underground mines, two are located in sec. 6, T. 20 N., R. 80 W. and the third is in sec. 4, T. 20 N., R. 80 W. There are no known active leases, permits or licenses, and no known active mining operations.

GENERAL GEOLOGY

Previous Work

Veatch (1907), in reconnaissance mapping of east-central Carbon County, included the northern third of Elk Mountain quadrangle. Dobbin, Bowen and Hoots (1929), mapped the quadrangle immediately to the north and extended their mapping to include the north-eastern corner of Elk Mountain quadrangle. Beckwith (1941) mapped the western part of the quadrangle and described the rock units exposed. Weitz and Love (1952) compiled a geologic map of Carbon County which incorporated available data, published and unpublished, to that date.

Stratigraphy

Rocks exposed in the Elk Mountain quadrangle range in age from Late Cretaceous to Quaternary. Coal occurrences mapped in the quadrangle include five coal beds and one local coal lens in the Hanna Formation which is exposed in the northeast corner of the quadrangle. Dobbin, Bowen, and Hoots (1929) mapped five Mesaverde coal beds on the crest of the Saddleback Hills anticline in the quadrangle immediately to the north but these coal beds were not traced south into the Elk Mountain quadrangle.

The oldest rocks that are possibly exposed in the quadrangle are the limestones and shales of the Niobrara Formation of Late Cretaceous age. Weitz and Love (1952) show a small exposure of Niobrara Formation in the extreme southeastern corner of Elk Mountain quadrangle; however, Hyden and McAndrews (1967) in their mapping to the east show the Niobrara Formation to be covered by Quaternary deposits in this area. Older rocks in the quadrangle are known in the subsurface from the logs of several oil wells, one of which reached Precambrian basement 6,389 feet (1,947 m). The stratigraphic succession encountered in the deep oil wells include rocks of Precambrian, Mississippian, Pennsylvanian, Permian, Triassic, Late Jurassic, Early Cretaceous, and Late Cretaceous age.

The Steele Shale is a marine formation of Late Cretaceous age which conformably overlies the Niobrara Formation. The formation is exposed across the entire southern portion of Elk Mountain quadrangle and also in the extreme northwestern corner. The outcrops of the Steele Shale are of very limited areal extent, however, due to a thick mantle of Quaternary deposits. Beckwith (1941) gives a measured thickness of 2,400 feet (731 m) for the Steele Shale in Elk Mountain quadrangle and an oil well drilled in the quadrangle in section 2, T. 20 N., R. 81 W. logged a thickness of 2,825 feet (861 m) for the formation. The unit consists predominantly of dark-gray shales with dark-gray thin sandstones occurring in the upper part.

The Mesaverde Formation of Late Cretaceous age conformably overlies the Steele Shale. Recent studies in south-central Wyoming by Gill, Merewether, and Cobban (1970) have resulted in elevating the Mesaverde to group status and measuring and defining four separate formations within the group. The formations have not been delineated by surface mapping in the Elk Mountain quadrangle and consequently the group is treated as a single unit. The Mesaverde is exposed in the broad band extending from the northwestern corner of the quadrangle to the northern part of the eastern border and in several small isolated outcrops associated with Quaternary mantle near the northwestern border. Dobbin, Bowen, and Hoots (1929) report a measured thickness for the Mesaverde of 2,200 feet (671 m) in the quadrangle immediately to the north of Elk Mountain quadrangle. Beckwith (1941) obtained a thickness of 3,500 feet (1,067 m) for the Mesaverde in the Elk Mountain district, but states that he has included 1,200 feet (366 m) of sandstones and sandy shales at the base of the formation, that were assigned to the Steele Shale by Dobbin, Bowen, and Hoots (1929). Hyden and McAndrews (1967) measured a thickness of 1,950 feet (594 m) for the Mesaverde in the quadrangle immediately to the east. Beckwith (1941) describes the Mesaverde Formation in the Elk Mountain quadrangle as consisting of brown, gray and white sandstones alternating with light-gray to carbonaceous shales. He mentions that thin coal beds appear in the upper part of the formation, but he did not map them. The lower part of the formation is marine and the upper part was deposited in a brackish-water to fluvial environment.

Conformably overlying the Mesaverde Formation is the Lewis Shale of Late Cretaceous age. The unit is exposed near the northwestern border of the quadrangle and as an arcuate band in the northeastern corner. Beckwith (1941) gives a thickness of 3,000 feet (914 m) for the Lewis Shale in the Elk Mountain district. He describes the unit as being predominantly dark-gray shales with bands of light-gray sandstones and sandy shales that contain hard, brown "ironstone" concretions. The formation was deposited in a marine environment.

Unconformably overlying the Lewis Shale in the northeast corner of the quadrangle is the Hanna Formation which is now considered to be Paleocene in age (Gill and others, 1970, p. 48). Dobbin, Bowen, and Hoots (1929) give a thickness of 7,000 feet (2,134 m) for the Hanna Formation, while Gill, Merewether, and Cobban (1970) state that their later field observations indicate the formation might be as thick as 13,500 feet (4,115 m) thick. Dobbin, Bowen, and Hoots (1929) describe the formation as consisting of alternating beds of dark-gray yellowish, and carbonaceous shales, white, gray and brown sandstones that are massive to thin-bedded and commonly cross-bedded, and conglomerates and conglomeratic sandstones that contain pebbles of chert, granite, quartzite, and sandstone. Numerous coal beds occur throughout the formation. The Hanna Formation is of continental origin.

In the southwestern part of the quadrangle, Beckwith (1941) has mapped a small exposure of the North Park Formation. The same outcrop is labeled Browns Park Formation and North Park Formation, undivided, by Weitz and Love (1952). The continental Browns Park Formation is of Miocene age. McGrew (1951) states that the formation is variable in thickness from a few feet to 850 feet (259 m) and consists of a basal conglomerate which grades up into gray to nearly white fine sandstones with thin lenses and beds of marl, clay, and green and gray volcanic ash. The unit unconformably overlies all older rocks. The North Park Formation overlies the Browns Park Formation, but lies unconformably on all older rock units. The North Park is of Pliocene age and consists of continental deposits of pinkish-buff fine sand, bentonitic clay, stream gravels, marl and volcanic ash. Beckwith (1941) states that the North Park Formation varies from 0 to 400 feet (122 m) in thickness in the Elk Mountain district.

Quaternary alluvium, colluvium, and terrace gravels are extensively deposited across the southern two-thirds of the quadrangle. The Quaternary deposits generally do not exceed 100 feet (30 m) in thickness but they effectively mantle most of the older rocks.

Structure

The northeastern corner of the Elk Mountain quadrangle lies on the southwestern edge of the Carbon structural basin. The Mesaverde ridge in the northwestern corner of the quadrangle defines the southeastern border of the Hanna structural basin. South of the Mesaverde ridge the remaining part of the Elk Mountain quadrangle lies in what Beckwith (1941) has called the

Pass Creek Basin. The Hanna and Carbon Basins form a comparatively small but very deep intermontane structural trough. The trough extends about 40 miles (64 km) east-west, 25 miles (40 km) north-south, and in the central portion contains approximately 30,000 to 35,000 feet (9,140 to 10,670 m) of sediments overlying crystalline basement. The Pass Creek Basin is a shallow depression that lies between a northwestern arm, terminating at Elk Mountain, and a northeastern arm, terminating at Rock Mountain, of the Medicine Bow Range. The Medicine Bow Range is an uplifted block of Precambrian rocks. The Pass Creek Basin is approximately 13 miles (21 km) wide, 22 miles (35 km) long and contains, in the northern and deepest part, about 6,400 feet (1,951 m) of sediments overlying the Precambrian basement.

In the Elk Mountain quadrangle, Beckwith (1941) has mapped several folds which trend northeasterly. In the northwestern part of the quadrangle, the Halleck Creek syncline plunges to the northeast at approximately a 20° angle. The syncline is asymmetric with beds on the west flank standing nearly vertical and dips on the east flank varying from 20° to 40°. The syncline dies out in the Lewis Shale approximately 2.5 miles (4 km) north of the quadrangle boundary. One to two miles (1.6 to 3 km) east of the Halleck Creek syncline, and parallel to it, is the Simpson Ridge anticline which is also known as the Saddleback Hills anticline. The anticline plunges to the northeast and dips are steeper on the east flank. This structure extends to the north of the quadrangle boundary for approximately 13 miles (21 km) and is the structure that divides the Hanna Basin on the northwest from the Carbon Basin on the southeast. One mile (1.6 km) east of the south end of Simpson Ridge anticline is a small shallow syncline which trends southwest. The syncline can be traced for approximately 3 miles (5 km). The northern end of the syncline has been offset to the west by a small, east-west trending fault.

COAL GEOLOGY

Previous Work

The coal deposits of the Hanna and Carbon Basins have been studied by Veatch (1907), Dobbin, Bowen, and Hoots (1929), Berryhill and others (1950), and Glass (1972 and 1975).

Twenty-six coal analyses have been published since 1913 for coal beds of the Mesaverde Group and the Medicine Bow, Ferris, and Hanna Formations within the Hanna and Carbon Basins (Appendices 1 and 2). Samples collected and analyzed prior to 1913 have not been considered in this report (American Society for Testing and Materials, 1977, p. 218). An average analysis of coal beds in each of these four stratigraphic units has also been calculated for the 230 analyses from the Union Pacific Coal inventory program (Appendices 1 and 2). An apparent rank has been calculated from the average analysis for coal in each of the four stratigraphic units. A standard rank determination (ASTM, 1977, p. 216, sec. 6.2.2) cannot be made because: (a) some of the published analyses are from weathered coal samples; and (b) the procedure and quality of sampling for the Union Pacific coal evaluation program are not known.

Glass (1975) and U.S. Department of Interior (1975) published not only proximate coal analyses for 17 samples collected in the Hanna Basin, but also assays for 10 major and minor oxides, 12 major and minor elements, and up to 32 trace elements. Glass (1975, p. 1) stresses that his assay data are insufficient to characterize the chemical and physical properties of any individual coal bed, but that this will be possible at a later date as the study continues. Assay results of the 17 Hanna Basin samples show that these coals contain no significantly greater amounts of trace elements of environmental concern than are found in the 42 samples collected in six other Wyoming coal fields.

General Features

In the Elk Mountain quadrangle, 8 coal beds have been mapped by Dobbin, Bowen, and Hoots (1929) and 36 local coal lenses have been identified in the subsurface (Plates 1 and 3). Several Mesaverde coal beds mapped by Dobbin, Bowen, and Hoots (1929) along the Simpson Ridge anticline (also known as Saddleback Hills anticline) in Carbon quadrangle to the north were not traced in Elk Mountain quadrangle. All of the coal beds mapped in this quadrangle are within the Hanna Formation. Finch coal bed and Johnson coal bed were selected for the production of derivative maps. Analyses of samples from these two coal beds are shown in Appendix 3. Two of these analyses are published by the U.S. Bureau of Mines (1931); the remaining samples were collected and analyzed in the Union Pacific coal inventory program.

The Finch and Johnson coal beds in this area were the subject of much mining activity in the past. In sec. 32, T. 21 N., R. 80 W. the Johnson coal bed was mined in the Carbon County and the Gebhart underground mines and in the Elk Mountain Strips 3 and 4. One unknown underground mine in sec. 6, T. 20 N., R. 80 W. also worked the Johnson coal bed.

The Finch coal bed in sec. 32, T. 21 N., R. 80 W. was mined underground in the Garey Johnson No. 3 and West mines, and strip mined in Elk Mountain Strip 1, 2 and 5 and Elk Mountain Valley Strip.

Two abandoned underground mines are shown in secs. 4 and 6, T. 20 N., R. 80 W., but it is uncertain what beds were mined and the operators are unknown. There are no operating mines in the quadrangle.

Hanna Coal Beds

In the Hanna Formation, 8 coal beds were mapped and an additional 36 local coal lenses were identified in the subsurface. The coal beds cropping out are: JB, EML1, FB, CL2, EML3, 105, 106, and 107. They all crop out along the south and west flanks of the Carbon Basin in the northeast part of the quadrangle. The outcropping beds dip north and east toward the basin at 9° to 20°. Coal thicknesses range from 1 to 23 feet (0.3 to 7 m). Coal bed CL2 is a bench that splits from the Finch coal bed in sec. 29, T. 21 N., R. 80 W., immediately north of this quadrangle. Dobbin, Bowen, and Hoots (1929) also suggest the possibility that coal bed EML3 may be an outlier of coal bed 106.

The Johnson coal bed is the lowest coal bed in the Hanna Formation. Along the south flank of the basin it dips at 9° north. The Johnson coal bed ranges in thickness from 10 to 23 feet (3 to 7 m) and averages 15 feet (5 m). The bed thickens to the east and to the north.

The interval between Finch coal bed and Johnson coal bed varies but, in sec. 34, T. 21 N., R. 80 W., is as much as 100 feet (30 m). Finch coal bed dips to the north at 9°. The coal thickness varies from 3 to 17 feet (1 to 5 m), with an average of 11 feet (3 m), and greater thicknesses are found to the north and to the west.

COAL RESOURCES AND RESERVES

Previous Work

Coal reserves of the Hanna and Carbon Basins have been estimated or calculated by Dobbin, Bowen, and Hoots (1929), Berryhill and others (1950), and Glass (1972).

Method of Calculating Resources and Reserves

Data from Dobbin, Bowen, and Hoots (1929), oil and gas well logs, and coal drill holes (written communications, Rocky Mountain Energy Company, 1977, and U.S. Geological Survey, 1978) were used to construct the coal data map (Plate 1) and coal data sheet (Plate 3). U.S. Geological Survey reviewed these 2 plates and on the basis of Reserve Base criteria, selected two coal beds for the calculation of coal resources in the Elk Mountain quadrangle. The coal data map and coal data sheet were used to construct structure contour, coal isopach, and overburden isopach maps of the correlatable coal beds (Plates 4-6, 9-11). The maps were drawn using, as control points, thicknesses measured at outcrop and subsurface data from drill hole information. Where coal beds are split, cumulative coal thicknesses were used, excluding non-coal partings.

Plates 4-6, 9-11 provide the data for calculating the coal resources and reserves within the KRCRA boundary of the quadrangle in accordance with the classification system given in U.S. Geological Survey Bulletin 1450-B and the instructions provided by U.S. Geological Survey on approval of these six plates. Calculation of the resources and reserves is in accordance with the following criteria:

- Identified coal resources of the quadrangle, as selected by U.S. Geological Survey, are contained within the Finch and the Johnson coal beds.

- Coal bed thicknesses from surface mapping are true thicknesses; thicknesses from subsurface data are apparent thicknesses for the Finch and Johnson coal beds.

- Strippable coal resources (the resources capable of being extracted by strip mining methods) are comprised of single coal beds at least 5 feet (1.5 m) thick and having 200 feet (61 m) or less of overburden.

- Nonstrippable coal resources (subsurface resources capable of being mined by underground methods) are single or multiple coal beds with a minimum thickness of 5 feet (1.5 m); a maximum dip of 15°; an overburden, or combined overburden and interburden, thickness of 0 to 3,000 feet (914 m). To avoid duplicating strippable coal Reserve Base and reserve values, no nonstrippable coal Reserve Base and reserve values are calculated where a coal bed(s) occurs above the stripping limit. When calculating nonstrippable coal Reserve Base values, an average thickness for each coal bed is determined from the coal bed thickness at control points within a measured area. When calculating nonstrippable coal reserve values, the average thickness for each coal bed is determined in a like manner, after coal bed thicknesses greater than 12 feet (3.7 m) have been reduced to 12 feet (3.7 m).

- All coal deeper than 3,000 feet (914 m) is excluded.

- Reliability or geologic assurance categories (measured, indicated and inferred resources) are defined according to proximity of the coal to a data point. Measured resources occur within 0.25 mile (402 m) of a data point; indicated resources occur within an area that is 0.25 to 0.75 mile (402 m to 1.2 km) from a data point; inferred resources occur within an area that is 0.75 to 3 miles (1.2 to 4.8 km) from a data point. A data point is either a measured coal thickness in a drill hole or a measured coal thickness location on a mapped outcrop.

- Coal resources and reserves are calculated for unleased Federal land within the KRCRA boundary (Plate 2). Information pertaining to leased or fee acreage and to private land is considered proprietary and not for publication.

Results

The areal distribution of leasable Federal coal resources within the KRCRA boundary is shown on Plates 7 and 12 for the two selected coal beds.

The coal resource acreage within each area of unleased Federal land was determined by planimeter. Coal Reserve Base values are obtained by multiplying the coal resource acreage for the planimetric portion of each area of unleased Federal land by the average isopach value of the selected coal bed, times the conversion factor for subbituminous coal, 1,770 short tons (1,606 t) of coal per acre-foot. The coal Reserve Base tonnages assigned to measured, indicated, or inferred categories for the Johnson and Finch coal beds are shown on Plates 7 and 12 and included in the coal Reserve Base totals shown on Plate 2.

In summary, the total Reserve Base for the Johnson and Finch coal beds where they lie less than 3,000 feet (914 m) below the ground surface of unleased Federal land within the KRCRA in the Elk Mountain quadrangle, is 24.14 million short tons (21.90 million t).

Coal reserves for the quadrangle are calculated by applying recovery factors to the identified resources of the Finch and Johnson coal beds. For strippable resources, a recovery factor of 0.85 is used; for nonstrippable resources, the recovery factor is 0.50. Reserve tonnages, to the nearest ten thousand short tons, are shown on Plates 7 and 12. Total coal reserves for unleased Federal land within the KRCRA in the Elk Mountain quadrangle, are 15.50 million short tons (14.06 million tons), consisting of 11.81 million short tons (10.71 million t) recoverable by strip mining or by underground mining, and 3.69 million short tons (3.35 million t) recoverable by underground mining only.

COAL DEVELOPMENT POTENTIAL

Method of Calculating Development Potential

Following the calculation of Reserve Base values and coal reserves, the coal resources of the KRCRA of the Elk Mountain quadrangle are evaluated for their development potential in each of two mining-method categories, surface and subsurface.

Strippable and nonstrippable resources are assigned to one of four development potential categories (high, moderate, low, and unknown) according to the following criteria:

Strippable Resources

- Assignment is based on calculated mining-ratio values for subsurface data points (wells and drill holes) and for points of intersection of coal isopachs (Plates 5 and 10) and overburden isopachs (Plates 6 and 11).

- Formula used to calculate mining ratios was provided by U.S. Geological Survey as follows:

$$MR = \frac{t_o\ (0.911)}{t_c\ (rf)}$$

where

MR = mining ratio

t_o = thickness of overburden, in feet

t_c = thickness of coal, in feet

rf = recovery factor (0.85 for strip mining)

0.911 = a constant

- If mining ratio is 0-10, resources have high development potential.

  If mining ratio is 10-15, resources have moderate development potential.

  If mining ratio is greater than 15, resources have low development potential.

- If insufficient data prevent the construction of mining-ratio contours, the resources are assigned to unknown development potential category, provided that there is reasonable assurance the coal bed is present in that area.

Nonstrippable Resources

- Coal beds must be more than 5 feet thick (1.5 m). Coal beds less than 5 feet (1.5 m) are excluded from the Reserve Base coal resources; where coal beds are more than 12 feet (3.7 m) thick, thickness values are reduced to 12 feet (3.7 m) thick.

- If the overburden is between 0 and 1,000 feet (0 and 305 m), resources have high development potential; if the overburden is between 1,000 and 2,000 feet (305 and 610 m), resources have moderate development potential; if the overburden is between 2,000 and 3,000 feet (610 and 914 m), resources have low development potential.

- If insufficient data prevents the construction of coal isopachs or overburden isopachs, or if the correlatable coal bed in the area is located completely above the stripping limit, the resources are assigned to the unknown development potential category, provided that there is reasonable assurance the correlatable coal bed is present in the area.

By applying the above criteria, mining-ratio maps (Plates 8 and 13) were prepared for the Finch and Johnson coal beds.

Development potential acreages were then blocked out, as shown on CDP Plates 14 and 15. Acreage for strippable and nonstrippable resources of selected coal beds is shown in Table 1 for each of the four development potential categories. In accordance with a constraint imposed by the U.S. Bureau of Land Management, the highest development potential affecting any portion of a 40 acre (16 ha) parcel is applied to the entire parcel. For example, if 5 acres (2 ha) within a parcel are assigned a high development potential, 25 acres (10 ha) a moderate development potential, and 10 acres (4 ha) a low development potential, then the entire 40 acres (16 ha) are assigned a high development potential.

Development Potential for Strippable Resources

Development potential for strippable coal resources within unleased Federal land in the KRCRA of this quadrangle, is shown in Table 1 for each selected coal bed. Plate 14 and Table 2 show the highest surface development potentials for the selected coal beds. The totals are obtained after assigning the highest assessed development potential for any coal bed within the smallest legal subdivision to each subdivision.

There are approximately 940 acres (380 ha) of unleased Federal land within the KRCRA of this quadrangle. Of this area, 920 acres (372 ha) or 98 percent of the total, are estimated to be underlain by coal resources from the selected coal beds, with development potential for surface mining. Of the 920 acres (372 ha), a high development potential is assigned to 840 acres (340 ha) and an unknown development potential to 80 acres (32 ha).

Development Potential for Nonstrippable Resources

Development potential for nonstrippable coal resources within unleased Federal land in the KRCRA of this quadrangle, is shown in Table 1 for each selected coal bed. Plate 15 and Table 2 show the highest subsurface development potentials for the selected coal beds. The totals are obtained after assigning the highest assessed development potential for any coal bed within the smallest legal subdivision to each subdivision.

Of the 940 acres (380 ha) of unleased Federal land within the KRCRA of this quadrangle, 860 acres (348 ha) or 91 percent of the total, are estimated to be underlain by coal resources from the selected coal beds, with development potential for underground mining. Of the 860 acres (348 ha), a high development potential is assigned to 640 acres (259 ha) and an unknown development potential to 220 acres (89 ha).

Table 1. — Development potential for identified resources of the selected coal beds within the KRCRA of the Elk Mountain quadrangle

	Development potential (acres)							
	Strippable resources			Nonstrippable resources			Unknown category	
Coal bed	High	Moderate	Low	High	Moderate	Low	Strippable	Nonstrippable
JB	640	120	0	680	0	0	0	320
FB	560	40	0	360	0	0	80	320
Totals	1200	160	0	1040	0	0	80	640

To convert acres to hectares, multiply by 0.4046.

Table 2. — Highest development potential for identified resources of the selected coal beds within the KRCRA of the Elk Mountain quadrangle

Development potential (acres)							
Strippable resources			Nonstrippable resources			Unknown category	
High	Moderate	Low	High	Moderate	Low	Strippable	Nonstrippable
840	0	0	640	0	0	80	220

To convert acres to hectares, multiply by 0.4046

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Appendix 1. — Average analyses of coal samples from the Hanna and Carbon Basins

Source of Data	Number of samples (1)	Total footage		Average analyses — as received basis						Calorific Value, Btu/lb	Apparent rank of coal (3)
				Percent							
		Ft	in	Moisture	Ash	Volatile matter	Fixed carbon	Sulfur	Btu/lb	Moist, mineral-matter-free basis (2)	
Published analyses	26	318	6	12.5	7.1	36.2	44.2	0.6	10,553	11,438	sub A or hvCb
Union Pacific coal inventory program	230	1,605	10	12.48	8.74	35.12	43.68	0.82	10.398	11,494	sub A or hvCb

Notes:

(1) Published data from USBM (1931, p. 40-45, sample nos. 2623, 2624, 22800, 22972, 93486, 93488, 93541, A14123, A14124); Glass (1975, p. 16-19, sample nos. 74-23 to 74-34, inclusive); Dept. of Interior (1975, p. 38, sample nos. D169597-99, D169607-08). Union Pacific coal inventory program data from company files, Rocky Mountain Energy Company (1977).

(2) Moist, mineral-matter-free Btu/lb calculated from average analyses, as received basis, using Parr formula (ASTM, 1977, p. 216, sec. 8.2).

(3) Sub A — subbituminous A; hvCb — high volatile C bituminous (ASTM, 1977, p. 215, sec 4.2, and p. 217).

[To convert feet and inches to meters, multiply feet by 0.3048 and inches by 0.0254. To convert Btu/lb to kilojoule/kilogram, multiply by 2.326].

Appendix 2. — Average analyses of coal grouped by coal-bearing formations in the Hanna and Carbon Basins

Source of data	Formation or Group	Number of samples (1)	Total footage Ft	Total footage in	Average analyses — as received basis: Percent Moisture	Ash	Volatile matter	Fixed carbon	Sulfur	Btu/lb	Calorific Value, Btu/lb Moist, mineral-matter-free basis (2)	Apparent rank of coal (3)
Published analyses	Mesaverde	1	4	0	14.1	7.8	36.5	41.6	1.1	10,290	11,251	sub A or hvCb
	Medicine Bow	2	10	1	12.8	3.8	33.3	50.2	0.8	11,050	11,534	hvCb
	Ferris	10	93	1	.13.0	8.3	34.3	44.3	0.4	9,970	10,956	sub A or hvCb
	Hanna	13	211	4	12.0	6.6	38.1	43.3	0.7	11,946	11,797	hvCb
Union Pacific coal inventory program	Mesaverde	13	70	5	9.45	8.41	35.42	46.72	0.77	11,112	12,237	hvCb
	Medicine Bow	16	93	4	13.09	4.03	35.46	47.42	0.80	10,927	11,446	sub A or hvCb
	Ferris	114	863	1	12.69	7.96	34.39	44.97	0.44	10,331	11,309	sub A or hvCb
	Hanna	87	579	0	12.51	10.67	35.96	40.85	1.33	10,280	11,640	hvCb

Notes:

(1) Published data from USBM (1931, p. 40-45, sample nos. 2623, 2624, 22800, 22972, 93486, 93488, 93541, A14123, A14124); Glass (1975, p. 16-19, sample nos. 74-23 to 74-34, inclusive); Dept. of Interior (1975, p. 38, sample nos. D169597-99, D169607-08). Union Pacific coal inventory program data from company files, Rocky Mountain Energy Company (1977).

(2) Moist, mineral-matter-free Btu/lb calculated from average analyses, as received basis, using Parr formula (ASTM, 1977, p. 216, sec. 8.2).

(3) Sub A — subbituminous A; hvCb — high volatile C bituminous (ASTM, 1977, p. 215, sec. 4.2, and p. 217).

[To convert feet and inches to meters, multiply feet by 0.3048 and inches by 0.0254. To convert Btu/lb to kilojoule/kilogram, multiply by 2.326].

Appendix 3. — Coal analyses, Elk Mountain quadrangle

Drill hole	Location			Coal bed	Sample interval				Sample width		Analyses — as received basis					
					From		To				Percent					
	Sec.	Twp.	Rge.		Ft	in	Ft	in	Ft	in	Moisture	Ash	Volatile matter	Fixed carbon	Sulfur	Btu/lb
2	5	20N	80W	FB	59	0	65	3	6	3	10.08	9.23	39.29	41.40	0.67	10,962
2	5	20N	80W	JB	207	8	220	9	13	1	9.95	9.21	39.52	41.32	0.53	11,025
3	5	20N	80W	FB	89	2	98	10	9	8	8.80	9.43	41.26	40.51	0.53	11,247
3	5	20N	80W	JB	234	9	244	1	9	4	9.37	7.35	39.71	43.57	0.37	11,350
4	5	20N	80W	FB	67	0	75	11	8	11	8.86	12.58	40.19	38.37	0.59	10,795
4	5	20N	80W	JB	233	0	244	7	11	7	9.41	8.54	38.95	43.10	0.47	11,235
5	5	20N	80W	FB	58	0	68	10	10	10	9.50	7.44	39.50	43.56	0.52	11,322
5	5	20N	80W	JB	228	0	239	9	11	9	9.18	6.94	41.70	42.18	0.45	11,334
Sample Number																
93486	32	21	80	unnamed	-	-	-	-	8	0	9.5	8.4	39.3	42.8	0.5	11,160
A14123	32	21	80	JB	-	-	-	-	6	0	10.9	3.5	37.9	47.7	0.7	11,530

Drill hole data from Rocky Mountain Energy Company (1977).

Data for samples 93486 and A14123 from U.S. Bureau of Mines (1931).

[To convert feet and inches to meters (m), multiply feet by 0.3048 and inches by 0.02.
To convert Btu/lb to kilojoules/kilogram (kJ/kg), multiply by 2.326].

Appendix 4. — Coal Reserve Base Data for Federal coal lands (in short tons) in the Elk Mountain quadrangle, Carbon County, Wyoming.

Strippable coal Reserve Base data for Federal coal lands (in short tons) in the Elk Mountain quadrangle, Carbon County, Wyoming [Development potentials are based on mining ratios (cubic yards of overburden/ton of underlying coal). To convert short tons to metric tons, multiply by 0.9072]

Coal Bed	High Development Potential (0-10 mining ratio)	Moderate Development Potential (10-15 mining ratio)	Low Development Potential (>15 mining ratio)	Total
FB	3,750,000	1,960,000	600,000	6,310,000
JB	4,450,000	2,880,000	0	7,330,000
Total	8,200,000	4,840,000	600,000	13,640,000

Non-strippable coal Reserve Base data for Federal coal lands (in short tons) in the Elk Mountain quadrangle, Carbon County, Wyoming. (To convert short tons to metric tons, multiply by 0.9072)

Coal Bed	High Development Potential (0-1000 ft of overburden)	Moderate Development Potential (1000-2000 ft of overburden)	Low Development Potential (2000-3000 ft of overburden)	Total
FB	3,630,000	0	0	3,630,000
JB	6,670,000	0	0	6,670,000
Total	10,300,000	0	0	10,300,000