Text to Accompany:

Open-File Report 79-1018

1979

COAL RESOURCE OCCURRENCE AND COAL DEVELOPMENT POTENTIAL MAPS OF THE MEADOW DRAW QUADRANGLE, UINTA COUNTY, WYOMING

[Report includes 28 plates]

Prepared for

UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

By

DAMES & MOORE

DENVER, COLORADO

This report has not been edited for conformity with U.S. Geological Survey editorial standards or stratigraphic nomenclature.

CONTENTS

ILLUSTRATIONS

Illustrations--Continued

TABLES

INTRODUCTION

Purpose

This text is to be used in conjunction with Coal Resource Occurrence (CRO) and Coal Development Potential (CDP) Maps of the Meadow Draw quadrangle, Uinta County, Wyoming. This report was compiled to support the land planning work of the Bureau of Land Management to provide a systematic coal resource inventory of Federal coal lands in Known Recoverable Coal Resource Areas (KRCRA's) in the western United States. This investigation was undertaken by Dames & Moore, Denver, Colorado, at the request of the U.S. Geological Survey under contract number 14-08-0001-17104. The resource information gathered for this report is in response to the Federal Coal Leasing Amendments Act of 1976 (P.L. 94-377). Published and unpublished public information available through July, 1978, was used as the data base for this study. No new drilling or field mapping was performed, nor was any confidential data used.

Location

The Meadow Draw quadrangle is located in northwestern Uinta County, Wyoming, approximately 14 airline miles (23 km) northeast of the town of Evanston, and 21 airline miles (34 km) southwest of the town of Kemmerer, Wyoming. In general, the quadrangle is unpopulated.

Accessibility

Wyoming Highway 189, a paved medium-duty road, crosses the southeastern corner of the quadrangle and connects the town of Kemmerer with Interstate Highway 80 approximately 6 miles (10 km) southwest of the quadrangle. Numerous unimproved dirt roads and trails provide access throughout the remainder of the quadrangle (U.S. Bureau of Land Management, 1971; Wyoming State Highway Commission, 1978).

The main east-west line of the Union Pacific Railroad, approximately 3 miles (5 km) southeast of Wyoming Highway 189, crosses through the southern part of the adjacent Bridger quadrangle to the east and the northwestern part of the Leroy quadrangle to the southeast. It also passes through the town of Evanston, southwest of the quadrangle, providing railway service across southern Wyoming and connecting Ogden, Utah, to the west with Omaha, Nebraska, to the east (U.S. Bureau of Land Management, 1971 and 1978).

Physiography

The Meadow Draw quadrangle lies on the southeastern edge of the Wyoming Overthrust Belt. The landscape within the quadrangle is characterized by northeast-trending ridges, escarpments, buttes and the wide, relatively flat-lying valley of Cumberland Flats. The Hogsback (Oyster Ridge) in the southeastern corner of the quadrangle and the Little Hogsback in the north-central part of the quadrangle rise about 680 and 420 feet (207 and 128 m), respectively, above Cumberland Flats. Round Mountain rises to an elevation of 7,182 feet (2,189 m) above sea level in the central part of the quadrangle. Altitudes in the quadrangle range from approximately 6,640 feet (2,024 m) along the northeastern edge of the quadrangle to 7,653 feet (2,333 m) on a butte in the southwestern corner of the quadrangle.

Albert Creek and its easterly-flowing tributaries (Haystack Draw, Meadow Draw, Clear Creek, and Shurtleff Creek) drain the quadrangle. Albert Creek flows northeasterly along the western side of The Hogsback and joins Little Muddy Creek in the Cumberland Gap quadrangle to the northeast. Little Muddy Creek is a tributary of Blacks Fork and the Green River to the east. Streams in the quadrangle are intermittent and flow mainly in response to snowmelt in the spring (U.S. Bureau of Land Management, 1971).

Climate and Vegetation

The climate of southwestern Wyoming is semiarid, characterized by low precipitation, rapid evaporation, and large daily temperature variations. Summers are usually dry and mild, and winters are cold. The annual precipitation averages approximately 10 inches (25 cm) and is fairly evenly distributed throughout the year (Wyoming Natural Resources Board, 1966).

The average annual temperature of the area is 39° F (4° C). The temperature during January averages 17° F (-8° C) and typically ranges from 4° F (-16° C) to 30° F (-1° C). During July, the average temperature is 62° F (17° C), and the temperature typically ranges from 43° F (6° C) to 82° F (28° C) (Wyoming Natural Resources Board, 1966; U.S. Bureau of Land Management, 1978).

Winds are usually from the west and west-southwest with an average annual velocity of approximately 15 miles per hour (24 km per hr) (U.S. Bureau of Land Management, 1978).

Principal types of vegetation in the quadrangle include grasses, sedges, sagebrush, greasewood, saltbush, rabbitbrush, mountain mahogany, and juniper (U.S. Bureau of Land Management, 1978).

Land Status

The Meadow Draw quadrangle lies in the south-central part of the Kemmerer Known Recoverable Coal Resource Area (KRCRA). Approximately 80 percent of the quadrangle's total area is within the KRCRA boundary and the Federal government owns the coal rights for less than half of this area. One active coal lease is present within the KRCRA boundary, as shown on plate 2.

GENERAL GEOLOGY

Previous Work

The geology and economic resources of a large part of Lincoln and Uinta Counties in southwestern Wyoming, including this quadrangle, were described by Veatch in 1907. Schultz (1914) investigated the geology and coal resources of the northern part of the Kemmerer coal field, Walker (1943) mapped the geology of the Cumberland Reservoir area on Little Muddy Creek, and Townsend discussed the coal geology and reserves of the Kemmerer coal field in 1960. Oriel and Tracey (1970) described the stratigraphy of the Evanston, Wasatch, and Green River Formations in the Kemmerer area, and the geology of the Kemmerer and Sage 15-minute quadrangles to the north were mapped by Rubey and others (1975). Glass reported coal analyses and measured sections of Adaville Formation coal in the Kemmerer coal field in 1975, and updated information on the Kemmerer coal field in 1977. Schroeder mapped the geology and coal resources of the Meadow Draw quadrangle in 1976. Roehler and others (1977) included the Meadow Draw quadrangle in a report on the geology and mineral resources of the Sweetwater-Kemmerer area. Cook (1977) described the stratigraphy and structural geology of the southern part of the Wyoming Overthrust Belt, and Worral (1977) discussed the structural geology of the Round Mountain area in the Meadow Draw quadrangle.

Stratigraphy

Formations cropping out in the Meadow Draw quadrangle range in age from Cretaceous to Eocene. The major coal-bearing formations are the Late Cretaceous Frontier and Adaville Formations which crop out in the southeastern corner and in the central part of the quadrangle.

The Bear River Formation of Early Cretaceous age crops out in the extreme southeastern corner of the quadrangle. This formation consists of dark-gray to black fissile shale and claystone, tan to greenish-brown fine-grained sandstone, a few thin fossiliferous limestone beds, and may contain a few thin stringers of impure coal. The Bear River Formation is approximately 500 to 600 feet (152 to 183 m) thick in the Meadow Draw quadrangle (Rubey and others, 1975; Schroeder, 1976; Cook, 1977; Glass, 1977).

Conformably overlying the Bear River Formation, the Aspen Shale of latest Early Cretaceous age crops out in the southeastern corner of the quadrangle. It consists of approximately 900 to 1,000 feet (274 to 305 m) of light- to dark-gray siltstone and shale, gray quartzitic sandstone, and thin porcelanite beds which form silver-gray hogbacks (Rubey and others, 1975; Schroeder, 1976).

The Frontier Formation is early Late Cretaceous in age and conformably overlies the Aspen Shale. It crops out in the southeastern corner of the quadrangle and west of the Round Mountain fault in the north-central part of the quadrangle. The lower unit of the formation is composed of dark-gray shale, tan siltstone, and thin white and brown sandstone beds which are less resistant to erosion than the rest of the formation. Coals of the Spring Valley coal zone, plus other thin coals and lignite beds, occur in the lower approximate 1,000 feet (305 m) of this unit. The upper unit of the Frontier Formation consists of a thick interval of shale (that contains the Willow Creek coal zone in the northern part of the Kemmerer area) overlain by the prominent hogback-forming Oyster Ridge Sandstone Member. This member consists of approximately 130 feet (40 m) of white to light-gray thick-bedded resistant sandstone containing abundant large fossil oyster shells, and is overlain by shale, lignitic claystone, thin beds of gray sandstone, and the Kemmerer coal zone. The upper unit of the Frontier Formation is approximately 1,200 feet (366 m) thick (Rubey and others, 1975; Schroeder, 1976).

The Hilliard Shale is early Late Cretaceous in age, conformably overlies the Frontier Formation, and is approximately 6,000 feet (1,829 m) thick. The formation crops out in the eastern third of the quadrangle and is composed of a thick sequence of non-resistant dark-gray to dark-brown marine shale and claystone, light-to medium-gray sandy siltstone, sandy shale, and, in the upper part of the formation, a few conspicuous light-gray to light-tan, fine-grained resistant sandstone beds (Rubey and others, 1975; Schroeder, 1976).

The Adaville Formation of Late Cretaceous age lies conformably on the Hilliard Shale, cropping out in a northeast-trending band in the central and south-central parts of the quadrangle. At the base of the Adaville Formation is the Lazeart Sandstone Member, which is composed of approximately 200 to 400 feet (61 to 122 m) of light-gray to white fine- to coarse-grained sandstone. The main body of the Adaville Formation consists of interbedded yellowish-brown to reddish-brown sandstone and siltstone, gray-brown-weathering carbonaceous shale, mudstone, and the Adaville coal zone which contains numerous subbituminous coal beds. Sandstones in the main body are calcareous, fine- to coarse-grained, thin-bedded to massive and become partially conglomeratic in the upper part of the formation. The thicker coal beds occur in the lower part of the formation above the Lazeart Sandstone Member. The main body of the Adaville Formation is over 2,000 feet (610 m) thick in the Meadow Draw quadrangle (Rubey and others, 1975; Schroeder, 1976).

Unconformably overlying the Adaville Formation is the Evanston Formation. The basal member of this formation, the Hams Fork Conglomerate Member of latest Cretaceous age, crops out in a narrow north-south-trending band through the center of the quadrangle. It consists of up to 1,000 feet (305 m) of boulder-conglomerate beds with interbedded white to brown calcareous sandstone, and gray mudstone. The main body of the Evanston Formation, which is Paleocene in age, is covered by the Wasatch Formation and occurs only in the subsurface in this quadrangle. It consists of over 200 feet (61 m) of gray siltstone, red shaly mudstone, carbonaceous claystone, quartzitic siltstone, gray carbonaceous sandstone, and some dark-brown concretionary ironstone. Composition of the Evanston Formation varies both laterally and vertically (Oriel and Tracey, 1970; Rubey and others, 1975; Schroeder, 1976).

The Wasatch Formation of Eocene age unconformably overlies the Evanston Formation and crops out in the western third of the quadrangle. It is composed of up to 2,000 feet (610 m) of red, maroon, yellow, and gray mudstone; yellow, brown, and gray, fine- to coarse-grained sandstone; and a sequence of stream-channel conglomerate beds containing boulders, cobbles, and pebbles of quartzite, chert, and limestone (Oriel and Tracey, 1970; Schroeder, 1976).

Holocene deposits of alluvium cover the stream valleys of Shurtleff Creek, Clear Creek and Albert Creek. Recent deposits of gravel derived predominately from the Hams Fork Conglomerate Member of the Evanston Formation also cover small areas in the quadrangle, and colluvium and landslide deposits occur on some hillslopes.

The transgression and regressions of a broad, shallow, north-south trending Cretaceous seaway that extended across central North America are indicated by the Upper Cretaceous formations deposited in the Meadow Draw quadrangle. Sediments accumulated near the western edge of the Cretaceous sea and reflect the location of the shoreline (Weimer, 1960 and 1961).

Sediments of the Bear River Formation were deposited in fluvial, swamp, and marine environments. They mark a transgression and regression of the Cretaceous sea (Eyer, 1969; Roehler and others, 1977).

The marine shale, siltstone and sandstone of the Aspen Shale were deposited in water up to 120 feet (37 m) deep and marked a westward or landward movement of the sea (Hale, 1960).

Frontier Formation sediments were deposited during two major transgressions and regressions of the sea. Coal beds in the lower and upper parts of the formation were deposited in coastal swamps during periods when the sea retreated eastward. The Oyster Ridge Sandstone Member is a littoral or beach deposit marking the retreat of the Cretaceous sea from the area (Hale, 1960; Myers, 1977; Roehler and others, 1977).

The marine shale, claystone and sandstone of the Hilliard Shale indicate another transgression of the Cretaceous sea with minor fluctuations of the shoreline (Roehler and others, 1977).

The Lazeart Sandstone Member, at the base of the Adaville Formation, is a beach deposit marking a transition from the marine deposition of the Hilliard Shale to the continental coastal plain deposition of the Adaville Formation. The sandstone, siltstone, and coals of the Adaville Formation were deposited in flood plains and swamps along the coastal plain (Roehler and others, 1977).

After the final withdrawal of the Cretaceous sea, thick sections of detrital material, eroded from older deposits to the west, were deposited by large streams as the conglomerates of the Hams Fork Conglomerate Member of the Evanston Formation. Environments of deposition for the main body of the Evanston Formation included streams, marshes, and, probably, ponds (Oriel and Tracey, 1970).

The Wasatch Formation is composed of continental sediments. The bright-colored mudstones were probably deposited on a flood plain and then cut by stream channels now filled with well-sorted conglomerate (Oriel and Tracey, 1970).

Structure

The Meadow Draw quadrangle lies on the southeastern edge of the structurally complex Wyoming Overthrust Belt. Folded Paleozoic and Mesozoic rocks are thrust eastward over folded older Cretaceous formations with younger Cretaceous and Tertiary rocks resting unconformably on top of the older rocks. Coal-bearing strata crop out in eroded limbs of folds as long narrow belts bounded on the west by major thrust faults (Roehler and others, 1977).

The axial trace of the asymmetric Lazeart syncline trends northeasterly in the central part of the quadrangle. It is truncated by the Round Mountain fault on the south and bisected by the Shurtleff Creek fault on the north. North of the Shurtleff Creek fault, the Lazeart syncline continues in a more northerly direction. Cretaceous formations dip approximately 30° on the eastern limb of the syncline, and from 30° to nearly 70° on the western limb of the syncline where they are cut by the Round Mountain fault. Part of the Cretaceous formations on the western limb of the syncline are covered by thick Tertiary formations (Schroeder, 1976).

Two large thrust faults, the Round Mountain fault and the Absaroka fault, trend northeasterly to the west of the Lazeart syncline. Both faults are cut by the younger Shurtleff Creek fault. The trace of the

Round Mountain fault is well exposed just east of Little Hogsback in the northern part of the quadrangle. In the southern part of the quadrangle, the trace of the Round Mountain fault is covered by Tertiary formations. Stratigraphic displacement on the Round Mountain fault may be as much as 7,000 feet (2,134 m) in the Meadow Draw quadrangle (Schroeder, 1976; Cook, 1977; Worral, 1977).

The Absaroka fault is located west of the Round Mountain fault in the northwestern part of the quadrangle, where it is covered by formations of Tertiary age. The Absaroka fault is an extensive thrust fault which has been traced for a linear distance of 205 miles (330 km) in Wyoming and Idaho. Stratigraphic displacement of the Absaroka fault is approximately 10,000 to 15,000 feet (3,048 to 4,572 m), and its lateral displacement is approximately 3 miles (4.8 km). Major movement along the fault occurred very late in Cretaceous time with probable minor movement in the Paleocene (Rubey and others, 1975; Schroeder, 1976; Worral, 1977).

The Shurtleff Creek fault is a major right-lateral fault which cuts all older structural features in the Meadow Draw quadrangle. It trends west to east in the northern half of the quadrangle. The amount of stratigraphic displacement on the Shurtleff Creek fault has not been reported, although it appears to be from 1,200 to 2,200 feet (366 to 671 m) (Schroeder, 1976).

Numerous unnamed overturned anticlines and synclines and other folds occur in the Frontier Formation between the Absaroka and Round Mountain faults. A small unnamed strike-slip fault offsets beds of the Adaville Formation in secs. 10 and 11, T. 16 N., R. 118 W. (Schroeder, 1976).

COAL GEOLOGY

Coal beds in both the Frontier and Adaville Formations have been identified in this quadrangle. The Kemmerer and Spring Valley coal zones of the Frontier Formation occur within the quadrangle although their lateral extent is limited by structural features in some areas. Coal beds in the Adaville Formation are stratigraphically above and separated from the Frontier Formation coal zones by the thick shales and siltstones of the Hilliard Shale. All of the Adaville coal beds are affected by the Lazeart syncline in the southern two thirds of the quadrangle.

Chemical analyses of coal.--No coal analyses were available from this quadrangle, but representative analyses from the southeast quarter of the Kemmerer 15-minute quadrangle to the north, and from the adjacent Ragan quadrangle to the south, are listed in table 1. In general, the Spring Valley and Kemmerer coals are high-volatile B bituminous in rank while most of the Adaville Formation coals rank as subbituminous B. The coals from these coal zones are ranked on a moist, mineral-matter-free basis according to ASTM Standard Specification D 388-77 (American Society for Testing and Materials, 1977).

Frontier Formation Coal Zones

The Frontier Formation, and its associated Spring Valley and Kemmerer coal zones, is exposed along the eastern limb of the Lazeart syncline in the southeastern corner of the quadrangle and along the western limb of the Lazeart syncline in the north-central part of the quadrangle. On the western limb of the Lazeart syncline, the Frontier Formation has been mapped in an area trending north-south, roughly bordered by the Absaroka and Round Mountain faults, as shown on plate 1. The rocks are intensely folded with steep dips to the east toward the axis of the syncline.

The Spring Valley coal zone, lowest of the coal zones identified in the quadrangle, is located near the base of the Frontier Formation. The Kemmerer coal zone is located near the top of the formation above the Oyster Ridge Sandstone Member. In areas to the north of the Meadow Draw quadrangle, the Willow Creek coal zone is found between the Spring Valley and Kemmerer coal zones, but it thins to the south and has not been mapped in this quadrangle.

Spring Valley Coal Zone

Coal beds in the Spring Valley coal zone crop out along the western limb of the Lazeart syncline, west of the Round Mountain fault in the north-central part of the quadrangle and along the eastern limb of the Lazeart syncline in the southeastern corner of the quadrangle. Spring Valley coals dip approximately 50° toward the east on the western limb of the syncline and 30° toward the west on the eastern limb (Schroeder, 1976). The Spring Valley coal zone is named after Spring Valley located in T. 15 N., R. 118 W. (Glass, 1977).

The Spring Valley [1] is the only Spring Valley coal bed of Reserve Base thickness (5 feet or 1.5 meters) in this quadrangle. It has not been formally named, but is designated by a bracketed number for identification purposes in this quadrangle only. It crops out along the eastern limb of the Lazeart syncline and has a maximum reported cumulative coal thickness of 8 feet (2.4 m) in a drill hole located in sec. 5, T. 16 N., R. 117 W. (plate 4). A rock parting ranging from 1.2 to 3.0 feet (0.4 to 0.9 m) in thickness is usually present in the coal bed. The Spring Valley [1] coal bed thins to the northeast and is 4.5 feet (1.4 m) thick in the Bridger quadrangle. It also thins to the south, and reaches a maximum recorded thickness of 6.5 feet (2.0 m) in the Ragan quadrangle where the coal bed averages approximately 4 feet (1.2 m) thick.

Kemmerer Coal Zone

Coal beds in the Kemmerer coal zone usually occur approximately 100 feet (30 m) above the Oyster Ridge Sandstone Member of the Frontier Formation. The Kemmerer coals are traceable along their outcrop for more than 60 miles (97 km) in the Kemmerer area, and are named for the town of Kemmerer in the southeast quarter of the Kemmerer quadrangle where they were mined extensively around the turn of the century (Glass, 1977). Kemmerer coal beds occur on both limbs of the Lazeart syncline in this quadrangle. They dip at approximately 30° to the west on the eastern limb of the syncline and from 30° to nearly 70° to the east on the western limb. Also, the Round Mountain fault cuts the Kemmerer coal zone parallel to its outcrop at depth on the western limb of the syncline, effectively limiting the resources of the coal zone. The Shurtleff Creek fault also cuts the Kemmerer coal zone on the western limb. Measurements of coal beds in the Kemmerer Formation were not available south of the Shurtleff Creek fault.

Coal beds in the Kemmerer coal zone have not been mapped individually because they can not be correlated positively with well-known Kemmerer coal beds in other quadrangles. Therefore, cumulative thicknesses of the Kemmerer coal beds have been combined and the coal beds are isopached as a zone. Coal beds in the isopached zone usually include those coal beds that are equal to or greater than Reserve Base thickness. However, in some instances coal beds less than Reserve Base thickness have been included in the zone. Thin coal beds separated from the coal beds of Reserve Base thickness by 3 feet (0.9 m) of rock or less and equal to or greater than the thickness of the parting are included. Also, where two coal beds of less than Reserve Base thickness are separated from one another by a rock parting that is thinner than either coal bed, the cumulative thickness of the coal beds, excluding the rock parting, has been included. The isopach map of the Kemmerer coal zone is shown on plate 8.

The maximum recorded thickness of the Kemmerer coal zone in the Meadow Draw quadrangle is 18.7 feet (5.7 m) measured at the outcrop in sec. 6, T. 17 N., R. 117 W. To the north, in the Elkol SW quadrangle, this zone thickens to a maximum reported thickness of 23 feet (7.0 m). In the Ragan quadrangle to the south, the zone thins to a maximum of 7.9 feet (2.4 m).

Adaville Coal Zone

The Adaville Formation crops out in the central to south-central parts of the Meadow Draw quadrangle. Numerous thick coal beds are usually contained in the basal 1,200 feet (366 m) of the Adaville Formation which is considered to be one of the most prolific coal-bearing formations in the country (Hunter, 1950; Glass, 1977). In this quadrangle, beds in the Adaville coal zone have been localized by folding associated with the Lazeart syncline. Adaville Formation beds dip from 10° to 30° on the eastern limb of the syncline and from 10° to 45° on the western limb. The large range in dips is due, primarily, to shallowing of the dip of the beds as they near the syncline axis.

Adaville No. 1 Coal Bed and Splits

The Adaville No. 1, stratigraphically the lowest of the thick Adaville coal beds, usually rests directly on top of the Lazeart Sandstone Member. In this quadrangle the Adaville No. 1 coal bed is split in several areas (secs. 19, 20, 30 and 31, T. 17 N., R. 117 W.), and the resulting upper and lower coal beds are separated by as much as 53 feet (16.2 m) of rock. Where the Adaville No. 1 coal bed is split, Rocky Mountain Energy Company (RMEC) has designated the upper coal bed as the Adaville No. 1B and the lower coal bed as the Adaville No. 1A. The Adaville No. 1 coal bed and its upper split, the Adaville No. 1B, are shown on plate 4. The Adaville No. 1A is mapped separately and is shown on plate 12. The maximum thickness of the Adaville No. 1 coal bed is 62 feet (18.9 m), with no partings, measured at the outcrop in sec. 31, T. 17 N., R. 117 W. The maximum cumulative coal thickness for the Adaville No. 1 coal bed where it is split is 41 feet (12.5 m) where measured in a drill hole in sec. 19, T. 17 N., R. 117 W. Here, the Adaville No. 1A coal bed is 37 feet (11.3 m) thick and is separated from the Adaville No. 1B coal bed by 13 feet (4.0 m) of rock. The Adaville No. 1B coal bed is 4 feet (1.2 m) thick. In most other areas where the Adaville No. 1 coal bed is split, both the upper and lower coal beds are greater than Reserve Base thickness. The Adaville No. 1 coal bed thins in the southern part of the Meadow Draw quadrangle, but averages approximately 21 feet (6.4 m) in thickness in the Ragan quadrangle.

Adaville No. 2A Coal Bed and Splits

The Adaville No. 2A coal bed is approximately 250 to 300 feet (76 to 91 m) above the Adaville No. 1 coal bed. It is split in part of sec. 31, T. 17 N., R. 117 W., and in that area the lower coal bed retains the name Adaville No. 2A while the upper coal bed is designated the Adaville No. 2B (RMEC). The Adaville No. 2A coal bed and the lower split are shown on plate 14; the upper split, the Adaville No. 2B, is shown on plate 18. In this quadrangle, the Adaville No. 2A coal bed attains a maximum recorded cumulative coal thickness of 56 feet (17.1 m), with an intervening rock interval 72 feet (21.9 m) thick where measured in a drill hole located in sec. 31, T. 17 N., R. 117 W. The maximum recorded thickness for the Adaville No. 2A coal bed, where it is not split, is 42 feet (12.8 m) where measured in a drill hole located in sec. 30, T. 17 N., R. 117 W.

Adaville No. 3A Coal Bed and Splits

The Adaville No. 3A coal bed lies approximately 65 to 100 feet (20 to 30 m) stratigraphically above the Adaville No. 2A coal bed. This coal bed also splits in a small area in secs. 19 and 30, T. 17 N., R. 117 W., where both splits retain the Adaville No. 3A designation (RMEC). The Adaville No. 3A coal bed, including the upper split, is shown on plate 14; the lower split is shown on plate 18. Maximum recorded thickness of the Adaville No. 3A coal bed is 75 feet (22.9 m), with no partings, where measured in a drill hole in sec. 30, T. 17 N., R. 117 W. The maximum cumulative coal thickness for the Adaville No. 3A in the split area is 14 feet (4.3 m), excluding a rock parting of 27 feet (8.2 m). Although the Adaville No. 3A has the thickest measurement of any coal bed in the Meadow Draw quadrangle, it is not laterally persistent, and in many drill holes it is very thin or absent.

Adaville No. 3A Rider Coal Bed

The Adaville No. 3A Rider (3AR) is a minor coal bed with very limited areal distribution (plate 18). It has a maximum reported thickness of 10 feet (3.0 m) with no splits in sec. 3, T. 16 N., R. 118 W.

Adaville No. 4A Coal Bed

The Adaville No. 4A coal bed is a very lenticular coal bed that is of Reserve Base thickness in a few locations only. In sec. 3, T. 16 N., R. 118 W., this coal bed is 22 feet (6.7 m) thick (plate 20), but pinches out in less than 1,000 feet (305 m) in all directions. Several miles to the north, in sec. 19, T. 17 N., R. 117 W., the Adaville No. 4A coal bed attains a thickness of 9 feet (2.7 m) but again pinches out very rapidly. This coal bed is absent in most drill holes between these isolated areas.

Adaville No. 5 Coal Bed

The Adaville No. 5 coal bed is also very lenticular as shown on plate 22. It ranges from 7 to 15 feet (2.1 to 4.6 m) thick where it has been encountered in drill holes in this quadrangle (secs. 19, 30, and 31, T. 17 N., R. 117 W.).

Adaville No. 6 Coal Bed

The Adaville No. 6 coal bed (plate 24) is, stratigraphically, the highest coal bed reported in the Adaville Formation in this quadrangle. It has a limited areal extent, and has a maximum reported thickness of 14 feet (4.3 m) in sec. 30, T. 17 N., R. 117 W.

Areal distribution and identified resources maps were not prepared for the Adaville No. 3A Rider, Adaville No. 4A, Adaville No. 5, and Adaville No. 6 coal beds because the areas in which they contain coal of Reserve Base thickness lie on non-Federal lands or on Federal lands already leased for coal mining.

Isolated Data Points

In instances where isolated measurements of coal beds thicker than 5 feet (1.5 m) are encountered, the standard criteria for construction of isopach, structure contour, mining ratio, and overburden isopach maps are not available. The lack of data concerning these beds limits the extent to which they can be reasonably projected in any direction which usually precludes correlations with other, better known beds. For this reason, isolated data points are included on a separate sheet (in U.S. Geological Survey files) for non-isopached coal beds. The isolated data points in this quadrangle are listed on the next page:

Source	Location	Coal Bed or Zone	Thickness
Schroeder, 1976	sec. 7, T. 17 N., R. 117 W.	K[1]	7.0 ft (2.1 m)
Schroeder, 1976	sec. 7 T. 17 N., R. 117 W.	K[2]	8.6 ft (2.6 m)

COAL RESOURCES

Information from coal test holes provided by RMEC, and Schroeder (1976 and 1978), as well as surface mapping and measured sections by Veatch (1907) and Schroeder (1976), were used to construct outcrop, isopach, and structure contour maps of the coal beds in this quadrangle. The source of each indexed data point shown on plate 1 is listed in table 4.

Coal resources were calculated using data obtained from the coal isopach maps (plates 4, 8, 12, and 14). The coal bed acreage (measured by planimeter) multiplied by the average isopached thickness of the coal bed, and by a conversion factor of 1,770 short tons of coal per acre-foot (13,018 metric tons per hectare-meter) for subbituminous coal, or 1,800 short tons of coal per acre-foot (13,238 metric tons per hectare-meter) for bituminous coal, yields the coal resources in short tons for each isopached coal bed. Coal beds thicker than 5 feet (1.5 m) that lie less than 3,000 feet (914 m) below the ground surface are included. These criteria differ somewhat from those used in calculating Reserve Base and Reserve tonnages as stated in U.S. Geological Survey Bulletin 1450-B, which calls for a minimum thickness of 28 inches (70 cm) for bituminous coal and a maximum depth of 1,000 feet (305 m) for both subbituminous and bituminous coal. Only Reserve Base tonnages (designated as inferred resources) are calculated for areas influenced by the isolated data points in this quadrangle.

Reserve Base and Reserve tonnages for the Spring Valley [1], Kemmerer coal zone, Adaville No. 1, Adaville No. 2A, and Adaville No. 3A coal beds are shown on plates 7, 11, and 17, and are rounded to the nearest 10,000 short tons (9,072 metric tons). Only Reserve Base tonnages (designated as inferred resources) are calculated for areas influenced by isolated data points. Coal Reserve Base tonnages per Federal section are shown on plate 2 and total approximately 27.64 million short tons (25.08 million metric tons) for the entire quadrangle, including tonnages from isolated data points.

Dames & Moore has not made any determination of economic recoverability for any of the coal beds described in this report.

COAL DEVELOPMENT POTENTIAL

Coal development potential areas are drawn so as to coincide with the boundaries of the smallest legal land subdivisions shown on plate 2. In sections or parts of sections where no land subdivisions have been surveyed by the BLM, approximate 40-acre (16-ha) parcels have been used to show the limits of the high, moderate, or low development potentials. A constraint imposed by the BLM specifies that the highest development potential affecting any part of a 40-acre (16-ha) lot, tract, or parcel be applied to that entire lot, tract, or parcel. For example, if 5 acres (2 ha) within a parcel meet criteria for 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 Surface Mining Methods

Areas where the coal beds of Reserve Base thickness are overlain by 200 feet (61 m) or less of overburden are considered to have potential for strip mining and were 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 surface mining of coal is shown on the following page:

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

where MR = mining ratio

t_o = thickness of overburden in feet

t_c = thickness of coal in feet

rf = recovery factor (85 percent for this quadrangle)

cf = conversion factor to yield MR value in terms of cubic yards of overburden per short tons of recoverable coal:
0.911 for subbituminous coal
0.896 for bituminous coal

Note: To convert mining ratio to cubic meters of overburden per metric ton of recoverable coal, multiply MR by 0.8428.

Areas of high, moderate, and low development potential for surface mining methods are defined as areas underlain by coal beds having respective mining ratio values of 0 to 10, 10 to 15, and greater than 15. These mining ratio values for each development potential category are based on economic and technological criteria and were provided by the U.S. Geological Survey.

Areas where the coal data is absent or extremely limited between the 200-foot (61-m) overburden line and the outcrop are assigned unknown development potentials for surface mining methods. This applies to areas where coal beds 5 feet (1.5 m) or more thick are not known, but may occur, and to those areas influenced by isolated data points. Limited knowledge pertaining to the areal distribution, thickness, depth, and attitude of the coal beds prevents accurate evaluation of the development potential in the high, moderate, or low categories. The areas influenced by the isolated data points in this quadrangle contain approximately 90,000 short tons (82,000 metric tons) of coal available for surface mining. Reserve Base tonnages in the various development potential categories for surface mining methods are listed in table 2.

The coal development potential for surface mining methods is shown on plate 26. Of the Federal land areas having a known development potential for surface mining methods, 91 percent are rated high, 3 percent are rated moderate, and 6 percent are rated low. The remaining Federal lands within the KRCRA boundary are classified as having unknown development potential for surface mining methods.

Development Potential for Subsurface and In-Situ Mining Methods

Areas considered to have a development potential for conventional subsurface mining methods include those areas where the coal beds are between 200 and 3,000 feet (61 and 914 m) below the ground surface and have dips of 15° or less. Areas of high, moderate, and low development potential for conventional subsurface mining methods are defined as areas underlain by coal beds at depths ranging from 200 to 1,000 feet (61 to 305 m), 1,000 to 2,000 feet (305 to 610 m), and 2,000 to 3,000 feet (610 to 914 m), respectively.

Areas where the coal data is absent or extremely limited between 200 and 3,000 feet (61 and 914 m) below the ground surface are assigned unknown development potentials. This applies to the areas where coal beds of Reserve Base thickness are not known, but may occur.

The coal development potential for conventional subsurface mining methods is shown on plate 27. All of the Federal land areas having known development potential for conventional subsurface mining methods are rated high. The remaining Federal lands within the KRCRA boundary are classified as having unknown development potentials for conventional subsurface mining methods.

Unfaulted coal beds lying between 200 and 3,000 feet (61 and 914 m) below the ground surface, dipping greater than 15°, are considered to have a development potential for in-situ mining methods. Based on criteria provided by the U.S. Geological Survey, coal beds of Reserve Base thickness dipping between 35° and 90° with a minimum Reserve Base of

50 million short tons (45.4 million metric tons) for bituminous coal and 70 million short tons (63.5 million metric tons) for subbituminous coal have a moderate potential for in-situ development; coal beds dipping from 15° to 35°, regardless of tonnage, and coal beds dipping from 35° to 90° with less than 50 million short tons (45.4 million metric tons) of coal have a low development potential for in-situ mining methods. Coal lying between the 200-foot (61 m) overburden line and the outcrop is not included in the total coal tonnages available as it is needed for cover and containment in the in-situ process.

Areas where faulted coal beds of Reserve Base thickness dip greater than 15° between 200 and 300 feet (61 and 914 m) below the ground surface are classified as having an unknown development potential for in-situ mining methods. This criteria also applies to those areas influenced by isolated data points where the coal beds are not faulted. The areas influenced by isolated data points in this quadrangle contain approximately 310,000 short tons (281,000 metric tons) of coal available for in-situ mining.

Coal development potential for in-situ mining methods is shown on plate 28. All of the Federal land areas classified as having known development potential for in-situ mining methods are rated low. The remaining Federal lands within the KRCRA boundary are classified as having unknown development potential for in-situ mining methods. Reserve Base tonnages in the various development potential categories for conventional subsurface and in-situ mining methods are listed in table 3.

Table 1. Chemical analyses of coals in the Meadow Draw quadrangle, Uinta County, Wyoming.

Location	COAL BED NAME	Form of Analysis	Proximate				Ultimate					Heating Value	
			Moisture	Volatile Matter	Fixed Carbon	Ash	Sulfur	Hydrogen	Carbon	Nitrogen	Oxygen	Calories	Btu/Lb
SE¼, NE¼, sec. 19, T. 21 N., R. 116 W., Sorenson Mine (Glass, 1975)	Adaville No. 5	A	17.5	35.1	43.7	3.7	0.4	-	-	-	-	-	10,180
		C	0.0	42.5	53.0	4.5	0.4	-	-	-	-	-	12,330
SW¼, SW¼, sec. 11, T. 21 N., R. 116 W., Elkol Mine (Glass, 1975)	Adaville No. 1	A	16.7	36.5	42.8	4.0	1.3	-	-	-	-	-	10,530
		C	0.0	43.8	51.4	4.8	1.5	-	-	-	-	-	12,640
SW¼, NE¼, sec. 12, T. 21 N., R. 116 W., Kemmerer No. 1 Mine (U.S. Bureau of Mines, 1931)	Kemmerer No. 1	A	5.9	37.6	49.0	7.5	1.4	-	-	-	-	-	12,370
		C	0.0	39.9	52.1	8.0	1.5	-	-	-	-	-	13,140
NW¼, sec. 12, T. 15 N., R. 118 W., Richardson Mine (U.S. Bureau of Mines, 1931)	Spring Valley	A	6.9	35.6	43.8	13.7	0.9	-	-	-	-	-	11,350
		C	0.0	38.2	47.1	14.7	1.0	-	-	-	-	-	12,180

Form of Analysis: A, as received
C, moisture free

Note: To convert Btu/pound to kilojoules/kilogram, multiply by 2.326

Table 2. Coal Reserve Base data for surface mining methods for Federal coal lands (in short tons) in the Meadow Draw quadrangle, Uinta County, Wyoming.

Coal Bed or Zone	High Development Potential	Moderate Development Potential	Low Development Potential	Unknown Development Potential	Total
Adaville No. 3A	800,000	250,000	40,000	-	1,090,000
Adaville No. 2A	310,000	150,000	190,000	-	650,000
Adaville No. 1	2,150,000	210,000	350,000	-	2,710,000
Adaville No. 1A	-	-	10,000	-	10,000
Adaville No. 1B	20,000	-	-	-	20,000
Kemmerer	1,240,000	770,000	1,010,000	-	3,020,000
Spring Valley {1}	40,000	60,000	80,000	-	180,000
Isolated data points	-	-	-	90,000	90,000
Totals	4,650,000	1,440,000	1,680,000	90,000	7,830,000

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

Table 3. Coal Reserve Base data for conventional subsurface and in situ mining methods for Federal coal lands (in short tons) in the Meadow Draw quadrangle, Uinta County, Wyoming.

	Conventional Subsurface Mining Methods			In situ Mining Methods	
Coal Bed or Zone	High Development Potential	Moderate Development Potential	Development Potential	Development Potential	Total
Adaville No. 3A	1,990,000	-	-	3,120,000	5,110,000
Adaville No. 2A	970,000	1,650,000	-	1,860,000	4,480,000
Adaville No. 1B	10,000	-	-	10,000	20,000
Adaville No. 1A	-	-	-	-	-
Adaville No. 1	260,000	2,050,000	-	3,640,000	5,950,000
Kemmerer	-	-	2,260,000	1,400,000	3,660,000
Spring Valley {1}	-	-	-	340,000	340,000
Isolated data points	-	-	160,000	-	160,000
Totals	3,230,000	3,700,000	2,420,000	10,370,000	19,720,000

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

Table 4. -- Sources of data used on plate 1

Plate 1 Index Number	Source	Data Base
1	Veatch, 1907, U.S. Geological Survey Professional Paper 56, p. 128	Measured Section No. 114
2	Rocky Mountain Energy Co., (no date), unpublished data	Drill hole No. 4, line A
3	Schroeder, 1976, U.S. Geological Survey, unpublished data	Measured Section No. 5
4	Rocky Mountain Energy Co., (no date), unpublished data	Drill hole No. 3, line A
5	↓	Drill hole No. 2, line A
6	↓	Drill hole No. 1, line A
7	Veatch, 1907, U.S. Geological Survey Professional Paper 56, p. 128	Measured Section No. 115
8	↓	Measured Section No. 116
9	Schroeder, 1976, U.S. Geological Survey, unpublished data	Measured Section No. 4
10	Rocky Mountain Energy Co., (no date), unpublished data	Drill hole No. 3, line A
11	↓	Drill hole No. 2, line A
12	↓	Drill hole No. 1A, line A
13	↓	Drill hole No. 1, line A

Table 4. -- Continued

Plate 1 Index Number	Source	Data Base
14	Veatch, 1907, U.S. Geological Survey Professional Paper 56, p. 128	Measured Section No. 118
15	↓	Measured Section No. 117
16	Schroeder, 1976, U.S. Geological Survey, unpublished data	Measured Section No. 2
17	Rocky Mountain Energy Co., (no date), unpublished data	Drill hole No. 12
18	↓	Drill hole No. 11
19	↓	Drill hole No. 10
20	↓	Drill hole No. 9, line A
21	↓	Drill hole No. 8, line A
22	↓	Drill hole No. 7, line A
23	↓	Drill hole No. 6, line A
24	↓	Drill hole No. 5, line A
25	↓	Drill hole No. 4, line A
26	↓	Drill hole No. 3, line A
27	↓	Drill hole No. 2, line A
28	↓	Drill hole No. 1, line A

Table 4. -- Continued

Plate 1 Index Number	Source	Data Base
29	Schroeder, 1978, U.S. Geological Survey Open-File Report 78-658	Drill hole No. MD-6B
30	↓	Drill hole No. MD-6A
31	↓	Drill hole No. MD-7
32	↓	Drill hole No. MD-8B
33	Schroeder, 1976, U.S. Geological Survey, unpublished data	Measured Section No. 1
34	Rocky Mountain Energy Co., (no date), unpublished data	Drill hole No. 1A, line A
35	Schroeder, 1976, U.S. Geological Survey, unpublished data	Measured Section No. 10
36	↓	Measured Section No. 9
37	Rocky Mountain Energy Co., (no date), unpublished data	Drill hole No. 6, line A
38	↓	Drill hole No. 5
39	↓	Drill hole No. 4
40	Schroeder, 1976, U.S. Geological Survey, unpublished data	Measured Section No. 12
41	Rocky Mountain Energy Co., (no date), unpublished data	Drill hole No. 3
42	↓	Drill hole No. 2, line A
43	Schroeder, 1976, U.S. Geological Survey, unpublished data	Measured Section No. 8

Page 3 of 8

Table 4. -- Continued

Plate 1 Index Number	Source	Data Base
44	Rocky Mountain Energy Co., (no date), unpublished data	Drill hole No. 1
45	Veatch, 1907, U.S. Geological Survey Professional Paper 56, p. 127	Measured Section No. 102
46	Schroeder, 1978, U.S. Geological Survey Open-File Report 78-658	Drill hole No. MD-14
47	Schroeder, 1976, U.S. Geological Survey, unpublished data	Measured Section No. 11
48	↓	Drill hole No. SH-1023
49	Rocky Mountain Energy Co., (no date), unpublished data	Drill hole No. 1, line A
50	↓	Drill hole No. 2, Line A
51	Schroeder, 1976, U.S. Geological Survey, unpublished data	Drill hole No. SH-1068
52	Rocky Mountain Energy Co., (no date), unpublished data	Drill hole No. 3, line A
53	↓	Drill hole No. 6, line B
54	Schroeder, 1976, U.S. Geological Survey, unpublished data	Drill hole No. SH-1032
55	Rocky Mountain Energy Co., (no date), unpublished data	Drill hole No. 5, line B
56	Schroeder, 1976, U.S. Geological Survey, unpublished data	Drill hole No. SH-1021

Table 4. -- Continued

Plate 1 Index Number	Source	Data Base
57	Rocky Mountain Energy Co., (no date), unpublished data	Drill hole No. 4, line B
58	↓	Drill hole No. 3, line B
59	Schroeder, 1976, U.S. Geological Survey, unpublished data	Drill hole No. SH-1033
60	Rocky Mountain Energy Co., (no date), unpublished data	Drill hole No. 2, Line B
61	Schroeder, 1976, U.S. Geological Survey, unpublished data	Drill hole No. SH-1020
62	Rocky Mountain Energy Co., (no date), unpublished data	Drill hole No. 1, line B
63	↓	Drill hole No. 7
64	Schroeder, 1978, U.S. Geological Survey Open-File Report 78-658	Drill hole No. MD-15
65	Rocky Mountain Energy Co., (no date), unpublished data	Drill hole No. 1, line A
66	Schroeder, 1978, U.S. Geological Survey Open-File Report 78-658	Drill hole No. MD-1
67	Schroeder, 1976, U.S. Geological Survey, unpublished data	Drill hole No. SH-1040
68	↓	Drill hole No. SH-1043
69	↓	Drill hole No. SH-1037
70	↓	Drill hole No. SH-1036

Table 4. -- Continued

Plate 1 Index Number	Source	Data Base
71	Schroeder, 1976, U.S. Geological Survey, unpublished data	Drill hole No. SH-B-1
72	↓	Drill hole No. SH-B-3
73	↓	Drill hole No. SH-1038
74	↓	Drill hole No. SH-1016
75	↓	Drill hole No. SH-1071
76	Rocky Mountain Energy Co., (no date), unpublished data	Drill hole No. 13
77	Schroeder, 1976, U.S. Geological Survey, unpublished data	Measured Section No. 3
78	↓	Drill hole No. SH-1044
79	Rocky Mountain Energy Co., (no date), unpublished data	Measured Section
80	Schroeder, 1976, U.S. Geological Survey, unpublished data	Drill hole No. SH-1013
81	↓	Drill hole No. SH-1006
82	↓	Drill hole No. SH-1011
83	↓	Drill hole No. SH-1005
84	Rocky Mountain Energy Co., (no date), unpublished data	Drill hole No. 12

Table 4. -- Continued

Plate 1 Index Number	Source	Data Base
85	Rocky Mountain Energy Co., (no date), unpublished data	Drill hole No. 11
86	↓	Drill hole No. 10
87	↓	Drill hole No. 9
88	↓	Drill hole No. 8
89	↓	Drill hole No. 7
90	↓	Drill hole No. 6
91	↓	Drill hole No. 4
92	↓	Drill hole No. 3
93	↓	Drill hole No. 2
94	↓	Drill hole No. 1
95	↓	Drill hole No. 5-A
96	↓	Measured Section No. 3
97	Schroeder, 1976, U.S. Geological Survey, unpublished data	Drill hole No. SH-1008
98	↓	Mine Section No. 7
99	↓	Measured Section No. 6
100	Veatch, 1907, U.S. Geological Survey Professional Paper 56, p. 128	Measured Section No. 111
101	Rocky Mountain Energy Co., (no date), unpublished data	Drill hole No. 3, line A

Table 4. -- Concluded

Plate 1 Index Number	Source	Data Base
102	Rocky Mountain Energy Co., (no date), unpublished data	Drill hole No. 2, line A
103	↓	Drill hole No. 1, line A
104		Drill hole No. 5, line A
105		Drill hole No. 4, line A
106		Drill hole No. 3, line A
107		Drill hole No. 2, line A
108		Drill hole No. 1, line A
109		Drill hole No. 4, line A
110		Drill hole No. 3, line A
111		Drill hole No. 2, line A
112		Drill hole No. 1, line A
113		Drill hole No. 4, line A
114	↓	Drill hole No. 5, line A

Page 8 of 8

REFERENCES

American Society for Testing and Materials, 1977, Standard specification for classification of coals by rank, in Gaseous fuels; coal and coke; atmospheric analysis: ASTM Standard Specification D 388-77, pt. 26, p. 214-218.

Cook, W. R., III, 1977, The structural geology of the Aspen Tunnel area, Uinta County, Wyoming, in Rocky Mountain and thrust belt geology and resources, Joint Wyoming, Montana and Utah Geological Association Guidebook, 29th Annual Field Conference, 1977: p. 397-405.

Eyer, J. A., 1969, Gannett Group of western Wyoming and southeastern Idaho: American Association of Petroleum Geologists Bulletin, v. 53, No. 7, p. 1368-1390, 8 figs.

Glass, G. B., 1975, Analyses and measured sections of 54 Wyoming coal samples (collected in 1974): Wyoming Geological Survey, Report of Investigations No. 11, 219 p.

______ 1977, Update on the Hams Fork coal region, in Rocky Mountain and thrust belt geology and resources, Joint Wyoming, Montana, and Utah Geological Association Guidebook, 29th Annual Field Conference, 1977: p. 689-706.

Hale, L. A., 1960, Frontier formation, Coalville, Utah, and nearby areas of Wyoming and Colorado, in Overthrust belt of southwestern Wyoming and adjacent areas, Wyoming Geological Association Guidebook, 15th Annual Field Conference, 1960: p. 136-146.

Hunter, W. S., Jr., 1950, The Kemmerer coal field, in Southwestern Wyoming, Wyoming Geological Association Guidebook, 5th Annual Field Conference, 1950: p. 123-132.

Myers, R. C., 1977, Stratigraphy of the Frontier Formation (Upper Cretaceous), Kemmerer area, Lincoln County, Wyoming, in Rocky Mountain and thrust belt geology and resources, Joint Wyoming, Montana and Utah Geological Association Guidebook, 29th Annual Field Conference, 1977: p. 271-311.

Oriel, S. S., and Tracey, J. I., Jr., 1970, Uppermost Cretaceous and Tertiary stratigraphy of Fossil Basin, southwestern Wyoming: U.S. Geological Survey Professional Paper 635, 53 p.

Rocky Mountain Energy Company, (no date), Unpublished drill-hole data from the Union Pacific coal inventory of 1968-1969.

References--Continued

Roehler, H. W., Swanson, V. E., and Sanchez, J. D., 1977, Summary report of the geology, mineral resources, engineering geology and environmental geochemistry of the Sweetwater-Kemmerer area, Wyoming, part A, geology and mineral resources: U.S. Geological Survey Open-File Report 77-360, 80 p.

Rubey, W. W., Oriel, S. S., and Tracey, J. I., Jr., 1975, Geology of the Sage and Kemmerer 15-minute quadrangles, Lincoln County, Wyoming: U.S. Geological Survey Professional Paper 855, 18 p.

Schroeder, M. L., 1976, Preliminary geologic map and coal resources of the Meadow Draw quadrangle, Uinta County, Wyoming: U.S. Geological Survey, unpublished report and maps, scale 1:24,000.

_______ 1978, Geophysical logs of 15 coal test holes drilled in the Kemmerer coal field, Uinta County, Wyoming: U.S. Geological Survey Open-File Report 78-658, 30 p.

Schultz, A. R., 1914, Geology and geography of a portion of Lincoln County, Wyoming: U.S. Geological Survey Bulletin 543, 141 p.

Townsend, D. H., 1960, Economic report on the Kemmerer coal field, in Overthrust belt of southwestern Wyoming and adjacent areas, Wyoming Geological Association Guidebook, 15th Annual Field Conference, 1960: p. 252-255.

U.S. Bureau of Land Management, 1971, BLM public lands guide, Rock Springs district, Wyoming: Ogden, Utah, scale 1:337,920.

______ 1978, Draft environmental statement, proposed development of coal resources in southwestern Wyoming: U.S. Department of the Interior, v. 1 to 3.

U.S. Bureau of Mines, 1931, Analyses of Wyoming coals: U.S. Bureau of Mines Technical Paper 484, pp. 54-57, 115-121.

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 Bulletin 1450-B, 7 p.

Veatch, A. C., 1907, Geography and geology of a portion of southwestern Wyoming with special reference to coal and oil: U.S. Geological Survey Professional Paper 56, 178 p.

References--Continued

Walker, C. L., 1943, Geology of the Cumberland Reservoir, Little Muddy Creek area, Lincoln and Uinta Counties, Wyoming: University of Wyoming, Laramie, unpublished M.S. thesis.

Weimer, R. J., 1960, Upper Cretaceous stratigraphy, Rocky Mountain area: American Association of Petroleum Geologists Bulletin, v. 44, no. 1, p. 1-20.

______ 1961, Uppermost Cretaceous rocks in central and southern Wyoming, and northwest Colorado, in Symposium on the Late Cretaceous rocks in Wyoming and adjacent areas: Wyoming Geological Association Guidebook, 16th Annual Field Conference, 1961: p. 17-28.

Worral, D. M., 1977, Structural development of the Round Mountain area, Uinta County, Wyoming, in Rocky Mountain and thrust belt geology and resources, Joint Wyoming, Montana and Utah Geological Association Guidebook, 29th Annual Field Conference, 1977: p. 537-541.

Wyoming Natural Resources Board, 1966, Wyoming weather facts: Cheyenne, p. 30-31.

Wyoming State Highway Commission, 1978, Wyoming official highway map: Cheyenne, Wyoming, approximate scale 1:140,000.