Text to Accompany:

Open-File Report 79-823

1979

COAL RESOURCE OCCURRENCE AND COAL DEVELOPMENT POTENTIAL MAPS OF THE McINTURF MESA QUADRANGLE, MOFFAT COUNTY, COLORADO

[Report includes 9 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

TABLES

INTRODUCTION

Purpose

This text is to be used in conjunction with Coal Resource Occurrence and Coal Development Potential Maps of the McInturf Mesa quadrangle, Moffat County, Colorado. This report was compiled to support the land-planning work of the Bureau of Land Management (BLM) and 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 United States Geological Survey under contract number 14-08-0001-15789. 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 Published and unpublished public information available through October, 1978, was used as the data base for this study. No new drilling or field mapping was performed as part of this study, nor was any confidential data used.

Location

The McInturf Mesa quadrangle is located in east-central Moffat County in northwestern Colorado, approximately 31 airline miles (50 km) northwest of the town of Steamboat Springs and 9 miles (14 km) north-northeast of the town of Craig, Colorado along Colorado Highway 13 (also called Colorado Highway 789). The northeastern corner of the quadrangle lies in the Routt National Forest. With the exception of several ranches, the area within the quadrangle is unpopulated.

Accessibility

Colorado Highway 13 crosses from the south-central to the west-central edge of the quadrangle, connecting Craig and the town of Baggs, Wyoming, which are, respectively, approximately 9 miles (14 km) south-southwest and 24 miles (38 km) north-northwest of the quadrangle. The remainder of the quadrangle is accessible by several light-duty and unimproved dirt roads.

Railway service for the McInturf Mesa quadrangle is provided by the Denver and Rio Grande Western Railroad from Denver to the railhead at Craig. The rail line follows U.S. Highway 40, passing approximately 9 airline miles (14 km) south-southwest of the quadrangle. It is the major transportation route for coal shipped east from northwestern Colorado.

Physiography

The McInturf Mesa quadrangle lies in the southern part of the Wyoming Basin physiographic province, as defined by Howard and Williams (1972). The quadrangle is approximately 36 miles (58 km) west of the Continental Divide.

Approximately 2,440 feet (744 m) of relief is present in the McInturf Mesa quadrangle. Altitudes range from approximately 8,760 feet (2,670 m) in the valley of Fortification Creek on the southwestern edge of the quadrangle, to 7,000 feet (2,134 m) in the northeastern corner.

The landscape within the quadrangle is characterized by hill and valley topography. Broad gentle slopes and wide stream valleys are dominant in the southern portion of the quadrangle, while the topography is more pronounced with steeper slopes and narrower canyons in the northern portion of the quadrangle.

The McInturf Mesa area is drained by the Yampa River through Fortification Creek and its tributaries: Dry Cottonwood Creek, Little Bear Creek, and Dry Fork. These flow into Fortification Creek from the southeast. Fortification Creek flows southward across the southwestern part of the quadrangle and joins the Yampa River approximately 9 miles southwest of the quadrangle at Craig. There are numerous intermittent streams and creeks in the quadrangle, all of which flow mainly in response to snowmelt in the spring.

Climate and Vegetation

The climate of northwestern Colorado is semiarid. Clear, sunny days prevail in the McInturf Mesa area with large daily temperatures varying from 0° to 35° F (-18° to 2° C) in January to 42° to 80° F (6° to 27° C) in July. Annual precipitation in the area averages approximately 16 inches (41 cm). Snowfall during the winter months accounts for the major part of the precipitation in the area; however, rainfall from cloudbursts during the summer months also contributes to the total. Winds, averaging 3 miles per hour (5 km per hour), are generally from the west, but wind directions tend to vary greatly depending on the local terrain (U.S. Bureau of Land Management, 1977).

Vegetation in the northeastern half of the quadrangle is predominately mountain shrubs which range from 2 to 8 feet (0.6 to 2.4 m) high. Sagebrush is the dominant vegetative cover in the southwestern half of the quadrangle. The flatter areas along the valleys of Fortification Creek and Dry Fork are used as agricultural land (U.S. Bureau of Land Management (1977).

Land Status

The McInturf Mesa quadrangle lies on the north-central boundary of the Yampa Known Recoverable Coal Resource Area (KRCRA). The southern third of the quadrangle lies within the KRCRA boundary. The Federal government owns the coal rights for approximately 75 percent of that area. Two active coal leases are located within the KRCRA boundary in this quadrangle as shown on plate 2.

GENERAL GEOLOGY

Previous Work

The first geologic description of the general area in which the McInturf Mesa quadrangle is located was reported by Emmons (1877) as part of a Survey of the Fortieth Parallel. The decision to build a railroad into the region stimulated several investigations of coal between 1886 and 1905, including papers by Hewett (1889), Hills (1893), and Storrs (1902). Fenneman and Gale (1906) described the geology of the Yampa Coal Field, including a description of the geology and coal occurrence in most of the McInturf Mesa quadrangle. In 1955, Bass and others expanded Fenneman and Gale's work in their report on the geology and mineral fuels of parts of Routt and Moffat Counties and this is the most comprehensive work on the area. Tweto compiled a generalized regional geology map that included this quadrangle in 1976.

Stratigraphy

The rocks which crop out in the McInturf Mesa quadrangle are Tertiary in age and include the Fort Union and Wasatch Formations. These two formations unconformably overlie Upper Cretaceous sedimentary rocks that extend several thousand feet into the subsurface.

The Late Cretaceous-age Lewis Shale and the overlying Lance Formation, also Late Cretaceous in age, do not crop out in the McInturf Mesa quadrangle but have been identified in a drill hole in the southwestern corner of the quadrangle. No information is available on the thickness of the Lewis Shale in the McInturf Mesa quadrangle; however, according to Tweto (1976), it generally ranges from 1,500 to 1,900 feet (457 to 579 m). The available subsurface data indicate that the Lewis Shale is an interbedded dark-gray shale and fine-grained cross-bedded sandstone. The Lance Formation is a white and gray ledge-forming sandstone with thin shale lenses and tan to buff fine-grained soft sandstone interbedded with gray shale. It is approximately 1,350 feet (411 m) thick in the quadrangle.

The Fort Union Formation of Paleocene age unconformably overlies the Lance Formation and crops out in the southeastern third of the quadrangle. This formation is approximately 1,200 feet (366 m) thick and consists of a basal conglomerate overlain by a brown sandstone interbedded with gray shale, sandy shale and local coal beds. Several Fort Union coal beds, including the formally named Seymour coal bed, have been identified in the McInturf Mesa quadrangle.

The Eocene-age Wasatch Formation unconformably overlies the Fort Union Formation and crops out in the northwestern three quarters of the quadrangle. The Wasatch Formation consists of varicolored shale interbedded with brown coarse-grained thinly bedded sandstone. The thickness of the formation in this quadrangle could not be determined from drill-hole data or literature. The thickness shown in the generalized composite columnar section on Plate 3 is approximate and is for descriptive purposes only.

The Cretaceous sedimentary rocks in the McInturf Mesa quadrangle accumulated close to the western edge of a Late Cretaceous epeirogenic seaway which covered part of the western interior of North America. Several transgressive-regressive cycles caused the deposition of a series of marine, near-shore marine, and non-marine sediments in the McInturf Mesa area.

Deposition of the Lewis Shale marked a landward movement of the sea. The marine sediments of the Lewis Shale were deposited in water depths ranging from a few tens of feet to several hundred feet. Deposition of the Lewis Shale ended in the quadrangle with the regression of the sea.

Regional uplift west of the Yampa Basin area resulted in a regression of the Cretaceous sea and the close of Cretaceous time in the McInturf Mesa quadrangle. At this time, the carbonaceous shale, mudstone, and coal beds of the Lance Formation were deposited in broad areas of estuarine, marsh, lagoonal, and coastal swamp environments.

After the final withdrawal of the Cretaceous sea, thick sections of detrital material, eroded from older deposits, were deposited as the coarse conglomerate and sandstone in the Fort Union Formation. The sandstone, shale, and coal of the Fort Union Formation were deposited in stream, lake, and swamp environments.

Depositional environments fluctuated between fluvial and lacustrine during the Eocene Epoch; however, the varicolored shale and brown sandstone of the Wasatch Formation are predominately fluvial deposits (Picard and McGrew, 1955).

The Seymour coal bed, which has wide areal extent in the McInturf Mesa quadrangle, was deposited near the seaward margins of the non-marine environments, probably in large brackish-water lagoons or swamps. The slow migration of this depositional environment is responsible for the wide distribution of this coal bed. The remaining coal beds identified in the McInturf Mesa quadrangle are of limited areal extent and were generally deposited in environments associated with fluvial systems, such as back-levee and coastal-plain swamps, interchannel basin areas, and abandoned channels.

Intrusive Rocks

The Tertiary-age Wasatch Formation in the McInturf Mesa quadrangle has been intruded by Upper Tertiary-age rocks of intermediate and basaltic composition. These intrusions occur in the northwestern part of the quadrangle in secs. 15 and 22, T. 9 N., R. 90 W. (Little Buck Mountain), in sec. 23, T. 9 N., R. 90 W., and in secs. 12 and 13, T. 9 N., R. 90 W. (Bass and others, 1955).

Structure

The Yampa KRCRA lies in the southern extension of the Washakie/ Sand Wash structural basin of south-central Wyoming. The basin is bordered on the east by the Park Range, approximately 27 miles (43 km) northeast of the McInturf Mesa quadrangle, and on the southwest by the Axial Basin Anticline, approximately 24 miles (38 km) southwest of the quadrangle.

Structure contours of the coal beds have been projected into this quadrangle (plate 5) from the south and east, and are based on the general trend of a regional structure map constructed by Bass and others (1955).

COAL GEOLOGY

Several coal beds in the Fort Union Formation have been identified in the McInturf Mesa quadrangle (plate 1). Coal beds which are not formally named have been numbered with bracketed numbers for identification purposes in this quadrangle only. Coal beds in this quadrangle include the Fort Union [2] (FU[2]) and Seymour coal beds which are located approximately 390 and 930 feet (119 and 283 m), respectively, above the base of the Fort Union Formation.

Chemical analyses of coal.--Chemical analyses are not available for the FU[2] coal bed in the McInturf Mesa quadrangle, but it is believed to be similar to other Fort Union coal beds and to range in rank from subbituminous B to subbituminous A on a moist, mineral-matter free basis (American Society for Testing and Materials, 1977), as is the coal from the Seymour bed. Analyses for the Seymour coal bed are shown in table 1. Samples of the Seymour coal bed were taken from the Little Bear (Richards) Mine in sec. 18, T. 8 N., R. 89 W.; the Seymour Mine in sec. 7, T. 8 N., R. 89 W.; the Bridges Mine in sec. 18, T. 8 N., R. 89 W.; and the Star Mine in sec. 17, T. 8 N., R. 89 W. All of these mines are located in the McInturf Mesa quadrangle.

Fort Union Formation Coal Beds

The Fort Union Formation contains two known coal beds greater than the Reserve Base thickness of 5.0 feet (1.5 m) in the McInturf Mesa quadrangle. The FU[2] coal bed is located in the subsurface in the southwestern part of the quadrangle and the Seymour coal bed crops out in the southeastern corner of the quadrangle.

FU[2] Coal Bed

The FU[2] coal bed does not crop out in the McInturf Mesa quadrangle but has been penetrated in the oil and gas test hole drilled in sec. 28, T. 8 N., R. 90 W., where the coal bed has been measured to be 5 feet (1.5 m) thick. This coal bed has been correlated with a Fort Union coal bed penetrated in two oil and gas wells drilled in sections 8 and 16, T. 8 N., R. 90 W., in the adjacent Craig NE quadrangle to the west where it measures 4.0 and 11.0 feet (1.2 and 3.4 m) respectively. Based on the structural trend of the FU[2] coal bed projected from the adjacent Craig NE quadrangle, and the elevation of penetration in this quadrangle, the coal bed appears to dip approximately 3° to the northeast.

Seymour Coal Bed

The Seymour coal bed, which is located approximately 930 feet (283 m) stratigraphically above the base of the Fort Union Formation, has been identified in numerous outcrops in the southeastern part of the quadrangle. This coal bed ranges from 4.0 to 17.7 feet (1.2 to 5.4 m) in thickness, reaching a maximum measured thickness in sec. 17, T. 8 N., R. 89 W. Only a few thin partings ranging in thickness from 0.25 to 0.7 feet (0.1 to 0.2 m) were measured in this coal bed in this quadrangle. To the east in the Slide Mountain quadrangle, the Seymour coal bed attains a maximum reported thickness of 13.8 feet (4.2 m) in secs. 16 and 21, T. 8 N., R. 89 W. Numerous thin partings are common in the Slide Mountain quadrangle and attain a maximum measured cumulative thickness of 4.3 feet (1.3 m) in sec. 15., T. 8 N., R. 90 W. In general, the Seymour coal bed appears to thin rapidly to the south and east of the McInturf Mesa quadrangle. Dips average approximately 2° to the northwest as calculated from plate 5.

COAL RESOURCES

Data from the one drill hole in the McInturf Mesa quadrangle and the data projected into the McInturf Mesa quadrangle from the Craig NE quadrangle were used to construct the isopach and structure contour maps of the FU[2] coal bed. Data from drill holes, mine measured sections and outcrop measurements were used to construct outcrop, isopach, and structure contour maps of the Seymour coal bed. 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 (plate 4) and the areal distribution and identified resources (ADIR) maps (plate 7). The coal-bed acreage (measured by planimeter), multiplied by the average thickness of the coal bed times a conversion factor of 1,770 short tons of coal per acre-foot (13,018 metric tons per hectare-meter) for subbituminous coal yields the coal resources in short tons (metric tons) of coal for each coal bed.

Reserve Base and Reserve tonnages for the FU[2] and Seymour coal beds are shown on plate 7, and are rounded to the nearest 10,000 short tons (9,072 metric tons). Reserve Base and Reserve tonnages are calculated for coal beds thicker than 5.0 feet (1.5 m) that lie less than 3,000 feet (914 m) below the ground surface. These criteria differ from those stated in U.S. Geological Survey Bulletin 1450-B which calls for a maximum depth of 1,000 feet (305 m) for subbituminous coal.

Coal Reserve Base tonnages per Federal section are shown on plate 2 and total approximately 13.35 million short tons (12.11 million metric tons) for the entire quadrangle. Reserve Base tonnages in the various development potential categories for surface and subsurface mining methods are shown in tables 2 and 3.

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 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 portion 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 surface mining and can be 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 as follows:

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

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 less than 200 feet (61 m) of overburden and 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.

The coal development potential for surface mining methods is shown on plate 8. Of those Federal land areas having a known development potential for surface mining, 70 percent are rated high and 30 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 coal beds of Reserve Base thickness are between 200 and 3,000 feet (61 and 914 m) below the ground surface and have dips of 15° or less. 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 development potential for in-situ mining methods..

Areas of high, moderate, and low development potential for conventional subsurface mining are defined as areas underlain by coal beds of Reserve Base thickness at depths ranging from 200 to 1,000 feet (61 to 305 m), 1,000 feet to 2,000 feet (305 to 610 m), and 2,000 to 3,000 feet (610 to 914 m), below the ground surface, respectively.

The coal development potential for conventional subsurface mining methods is shown on plate 9. Of those Federal land areas having a known development potential for conventional subsurface mining methods, 70 percent are rated as high and 30 percent are rated as moderate. The remaining Federal land is classified as having unknown development potential for conventional subsurface mining methods.

Because the coal beds in this quadrangle have dips less than 15°, all Federal land areas within the KRCRA boundary have been rated as having an unknown development potential for in-situ mining methods.

Table 1 -- Chemical analyses of coals in the McInturf Mesa quadrangle, Moffat County, Colorado

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
NE¼ SE¼ sec. 18, T. 8 N., R. 89 W., Little Bear (Richards) Mine (Fieldner and others, 1937)	Seymour bed	A	19.4	31.8	43.6	5.2	0.2	--	--	--	--	5,378	9,680
		B	--	39.4	54.2	6.4	0.2	--	--	--	--	6,672	12,010
SE¼ sec. 17, T. 8 N., R. 89 W., Seymour Mine (Bass and others, 1955)	Seymour bed	A	17.9	33.4	44.4	4.3	0.2	--	--	--	--	5,540	9,970
		B	14.9	34.7	46.0	4.4	0.2	--	--	--	--	5.744	10,340
		C	--	40.7	54.1	5.2	0.3	--	--	--	--	6,745	12,140
SW¼ sec. 18, T. 8 N., R. 89 W., Bridges Mine (Bass and others, 1955)	Seymour bed	A	18.4	31.2	46.5	3.9	0.2	--	--	--	--	5,560	10,010
		B	15.4	32.3	48.3	4.0	0.3	--	--	--	--	5,760	10,370
		C	--	38.2	57.1	4.7	0.3	--	--	--	--	6,810	12,260
SE¼ sec. 17, T. 8 N., R. 89 W., Star Mine (Bass and others, 1955)	Seymour bed	A	17.1	32.2	42.9	7.8	0.4	--	--	--	--	5,360	9,650
		B	14.7	33.1	44.2	8.0	0.4	--	--	--	--	5,510	9,920
		C	--	38.8	51.8	9.4	0.4	--	--	--	--	6,460	11,630

Form of Analysis: A, as received
B, air dried
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 McInturf Mesa quadrangle, Moffat County, Colorado.

Coal Bed or Zone	High Development Potential	Moderate Development Potential	Low Development Potential	Unknown Development Potential	Total
Seymour	890,000	330,000	320,000	--	1,540,000
Totals	890,000	330,000	320,000	--	1,540,000

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

Table 3. Coal Reserve Base data for subsurface mining methods for Federal coal lands (in short tons) in the McInturf Mesa quadrangle, Moffat County, Colorado.

Coal Bed or Zone	High Development Potential	Moderate Development Potential	Low Development Potential	Unknown Development Potential	Total
Seymour	2,530,000	--	--	--	2,530,000
FU [2]	3,590,000	5,690,000	--	--	9,280,000
Totals	6,120,000	5,690,000	--	--	11,810,000

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	Bass and others, 1955, U.S. Geological Survey Bulletin 1027-D, pl. 24	Measured Section No. 351
2	↓	Measured Section No. 352
3	↓	Measured Section No. 353
4	↓	Measured Section No. 357
5	↓	Measured Section No. 354
6	↓	Measured Section No. 356
7	↓	Measured Section No. 358
8	↓	Measured Section No. 355
9	↓	Measured Section No. 359
10	↓	Measured Section No. 361
11	↓	Measured Section No. 360
12	U.S. Geological Survey, 1936, Inactive Coal Prospecting Permit No. Denver 039641, John Zato	Mine-Measured Section
13	U.S. Geological Survey, 1930, Inactive Coal Prospecting Permit No. Denver 038581, Charles H. Taylor	Measured Section
14	Bass and others, 1955, U.S. Geological Survey Bulletin 1027-D, pl. 24	Measured Section No. 362
15	U.S. Geological Survey, 1935, Inactive Coal Prospecting Permit No. Denver 032924, Clinton Richards	Measured Section

Page 1 of 2

Table 4. -- Continued

Plate 1 Index Number	Source	Data Base
16	Bass and others, 1955, U.S. Geological Survey Bulletin 1027-D, pl. 24	Measured Section No. 363
17	↓	Measured Section No. 364
18		Measured Section No. 367
19		Measured Section No. 365
20		Measured Section No. 366
21		Measured Section No. 369
22		Measured Section No. 425
23	U.S. Smelting	Drill hole No. 1-28 Gov't-McWm.

Page 2 of 2

SELECTED 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.

Bass, N. W., Eby, J. B., and Campbell, M. R., 1955, Geology and mineral fuels of parts of Routt and Moffat Counties, Colorado: U.S. Geological Survey Bulletin 1027-D, p. 143-250.

Emmons, S. F., 1877, Valleys of the Upper Yampa and Little Snake Rivers, in Hague, Arnold and Emmons, S. F., Descriptive Geology: U.S. Geological Exploration of the Fortieth Parallel, Section IX, p. 181-189.

Fenneman, N. M., and Gale, H. S., 1906, The Yampa coal field, Routt County, Colorado: U.S. Geological Survey Bulletin 297, 96 p.

Fieldner, A. C., Cooper, H. M., and Abernethy, R. F., 1937, Analyses of Colorado coals: U.S. Bureau of Mines Technical Paper 574, p. 118-119, 124-125, 287, and 297.

Gale, H. S., 1910, Coal fields of northwestern Colorado and northeastern Utah: U.S. Geological Survey Bulletin 415, 265 p.

Hewett, G. C., 1889, The northwestern Colorado coal region: American Institute of Mining Engineers Transactions, v. 17, p. 375-380.

Hills, R. C., 1893, Coal fields of Colorado, in Mineral resources of the United States, calendar year 1892: U.S. Geological Survey, p. 319-365.

Hornbaker, A. L., Holt, R. D., and Murray, K. D., 1975, Summary of coal resources in Colorado: Colorado Geological Survey Special Publication No. 9, 17 p.

Howard, A. D., and Williams, J. W., 1972, Physiography, in Geologic Atlas of the Rocky Mountain Region (W. W. Mallory, ed.): Rocky Mountain Association of Geologists, p. 30.

Konishe, Kenji, 1959, Upper Cretaceous surface stratigraphy, Axial Basin and Williams Fork area, Moffat and Routt Counties, Colorado; in Washakie, Sand Wash, and Piceance Basins, Symposium on Cretaceous rocks of Colorado and adjacent areas, Rocky Mountain Association of Geologists Guidebook, 11th Annual Field Conference: p. 67-73.

Kucera, R. E., 1959, Cretaceous stratigraphy of the Yampa district, northwest Colorado, in Washakie, Sand Wash, and Piceance Basins, Symposium on Cretaceous rocks of Colorado and adjacent areas, Rocky Mountain Association of Geologists Guidebook, 11th Annual Field Conference: p. 37-45.