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GEOLOGICAL SURVEY

Geology and coal resources of the Foidel Creek EMRIA site and surrounding area, Routt County, Colorado

By

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Statement on the use of metric and English units of measure in this report

Current policy calls for exclusive use of metric units in all reports of the U.S. Geological Survey; therefore, metric units are used throughout the text of this report. However, because the detailed coal resource data presented in the tables in this report are expected to be of interest primarily to the engineers and geologists of mining companies, and because mining companies in the United States principally employ the English system of measure, the data in the tables are presented in English units. English-to-metric conversion factors may be found in the headings of the tables.

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GEOLOGY AND COAL RESOURCES OF THE FOIDEL CREEK EMRIA SITE AND SURROUNDING AREA, ROUTT COUNTY, COLORADO

By THOMAS A. RYER

ABSTRACT

Terrigenous clastic sediments of the Upper Cretaceous Mesaverde Group (Campanian) in the southeastern part of the Yampa coal field in Routt County, northwestern Colorado, contain many beds of bituminous coal. Lower, middle, and upper coal groups are recognized. The middle coal group, in the lower coal-bearing member of the Williams Fork Formation, contains two thick, persistent coal beds in the Foidel Creek area. The Wadge coal bed, stratigraphically the higher of the two, reaches thicknesses of 3.7 meters, and is strippable beneath large areas on the south slope of Eckman Park. Coal resources of the Wadge bed in the Foidel Creek area--an area of 134 square kilometers, as defined in this study--are estimated to be 317 million metric tons. The Foidel Creek EMRIA reclamation study site--an area of 10.9 square kilometers--contains about 36.1 million metric tons of Wadge coal, as much as 28.1 million metric tons of which occur beneath overburden 61 meters or less in thickness. About 52 meters lower in the section, the Wolf Creek coal bed locally exceeds 6.1 meters in thickness. Coal resources of the Wolf Creek bed in the Foidel Creek area are estimated to be 434 million metric tons. The Foidel Creek EMRIA reclamation study site contains an estimated 49.7 million metric tons of Wolf Creek coal.

INTRODUCTION

This report describes the geology and coal resources of Upper Cretaceous rocks in a 134-square-kilometer area located near the southeastern margin of the Yampa coal field in south-central Routt County, Colorado. The mapped area (fig. 1) includes parts of the Rattlesnake Butte and Dunckley 7.5-minute quadrangles, and is located approximately 27 kilometers southwest of Steamboat Springs, the largest town in Routt County. Geologic study and mapping of the Foidel Creek area was undertaken in connection with the Bureau of Land Management's evaluation of the reclamation potential of the Foidel Creek Energy Minerals Rehabilitation Inventory and Analysis (EMRIA) site--an area of about 10.9 square kilometers located in the southwestern part of the Foidel Creek area. The Foidel Creek EMRIA reclamation study site is situated on the south slope of Eckman Park, which is developed upon gently northward-dipping strata of the lower coal-bearing member of the Williams Fork Formation. The Wadge coal bed may be stip mined beneath large areas of the south slope of Eckman Park, and is presently being mined at the Energy Fuels Corporation's Energy Strip No. 1 mine, the largest producing mine in the State of Colorado in 1975. The Foidel Creek area includes the entire south slope of Eckman Park and areas of more steeply-dipping strata to the east and west.

Particular attention has been focused in this study upon coal of the lower coal-bearing member of the Williams Fork Formation (middle coal group of the Yampa coal field). Drill and core hole data including data from the five EMRIA core holes and drill hole data kindly provided by W. T. Davis, Vice President of Exploration, Energy Fuels Corporation, have been used to estimate the coal resources of the Wadge and Wolf Creek coal beds in the Foidel Creek area. The coal resources of the lower and upper coal groups of the Yampa coal field, which are also present in the area, have not been determined.

PALEOGEOGRAPHY AND PALEOENVIRONMENTAL SETTING

Sediments of the Mesaverde Group of northwestern Colorado, the lithostratigraphic unit of primary interest in the Foidel Creek area, accumulated some 75 million years ago (Gill and Cobban, 1966, p. A35) in offshore-marine, shallow-marine, and marginal-marine depositional environments close to the western edge of an epeiric seaway which occupied the Western Interior of North America during latest Early Cretaceous and most of Late Cretaceous time (Reeside, 1957; McGookey, 1975). Deformation produced by the Laramide orogeny

and subsequent erosion have resulted in removal of Cretaceous rocks from much of the Rocky Mountain area. Cretaceous rocks are presently confined to a series of isolated structural basins. One such basin, the Washakie-Sand Wash basin of the Green River Region, contains the Yampa coal field and the Foidel Creek area.

STRUCTURAL SETTING

The Yampa coal field constitutes a southeastward, synclinal extension of the Washakie-Sand Wash structural basin of south-central Wyoming and northwestern Colorado (fig. 2), the major synclinal structure being highly modified by several lesser synclines and anticlines. The field is limited on the east by the Park Range uplift and on the southwest by the Axial Basin anticline.

The Foidel Creek EMRIA reclamation study site occupies the western part of a broad area in which the coal-bearing rocks dip gently to the north. West of this area, the dip steepens and the strike bends abruptly northward along the steeply dipping east flank of the north-south trending Fish Creek anticline. To the east, the dip steepens along the southward extension of the Twentymile Park syncline (figs. 2 and 3).

STRATIGRAPHIC TERMINOLOGY AND HISTORY OF STUDY

Table 1 presents, in general, the sequence of Cretaceous rocks of northwestern Colorado. Of the stratigraphic units described, only the Mancos Shale, the Mesaverde Group, and the Lewis Shale are exposed in the southeastern part of the Yampa coal field, in and near the area described here.

The history of previous work, introduction of stratigraphic terminology, and regional stratigraphic relations of Cretaceous rocks in northwestern Colorado are summarized by Bass, Eby, and Campbell (1955), Kucera (1959, 1962), Konishi (1959a, b), Masters (1959), Weimer (1959), and Collins (1976), among others. These topics will not be discussed at length here. The paper by Bass, Eby, and Campbell (1955) remains the most comprehensive work on stratigraphy and coal resources of the Yampa coal field.

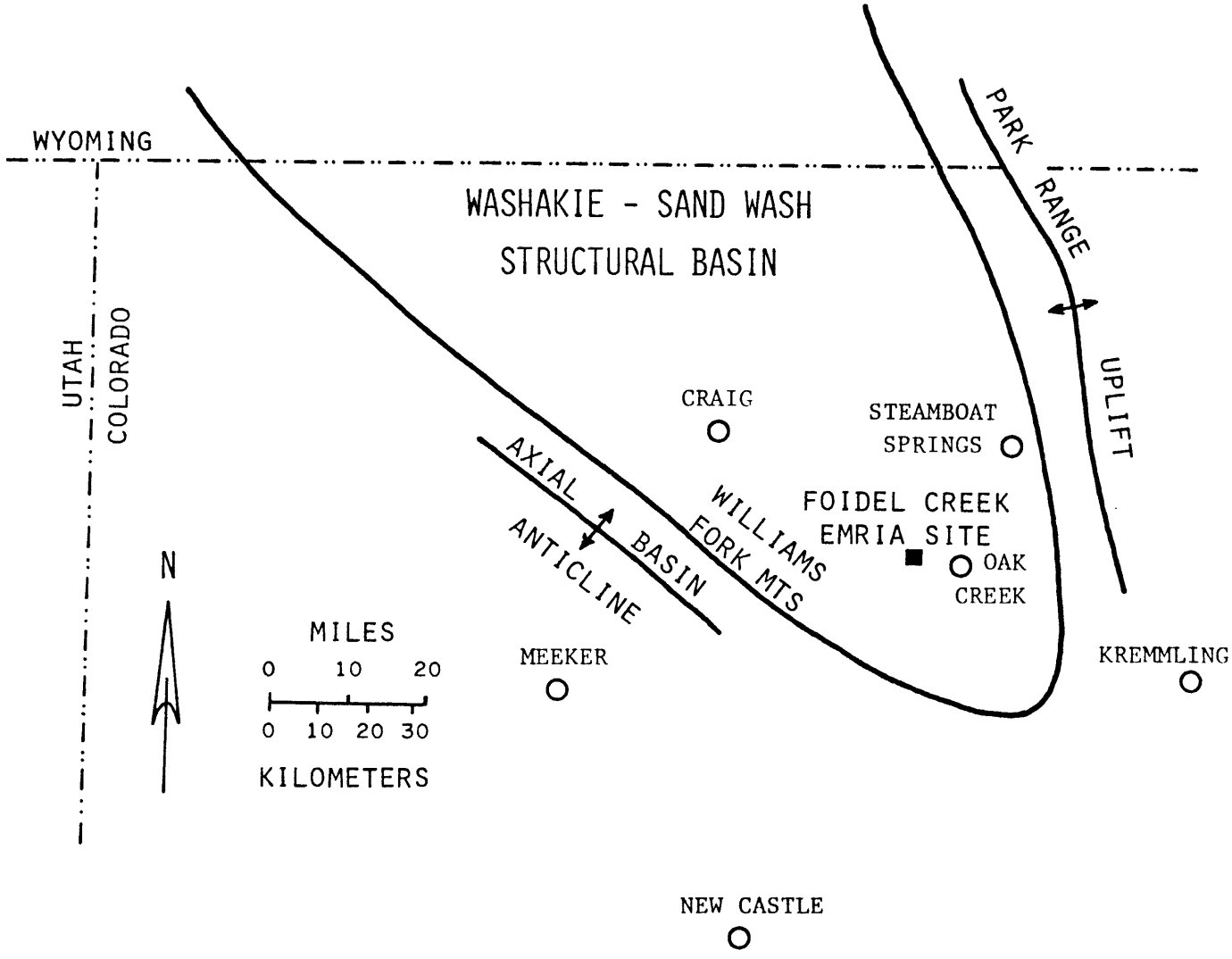

FIGURE 2.--INDEX MAP, NORTHWESTERN COLORADO.

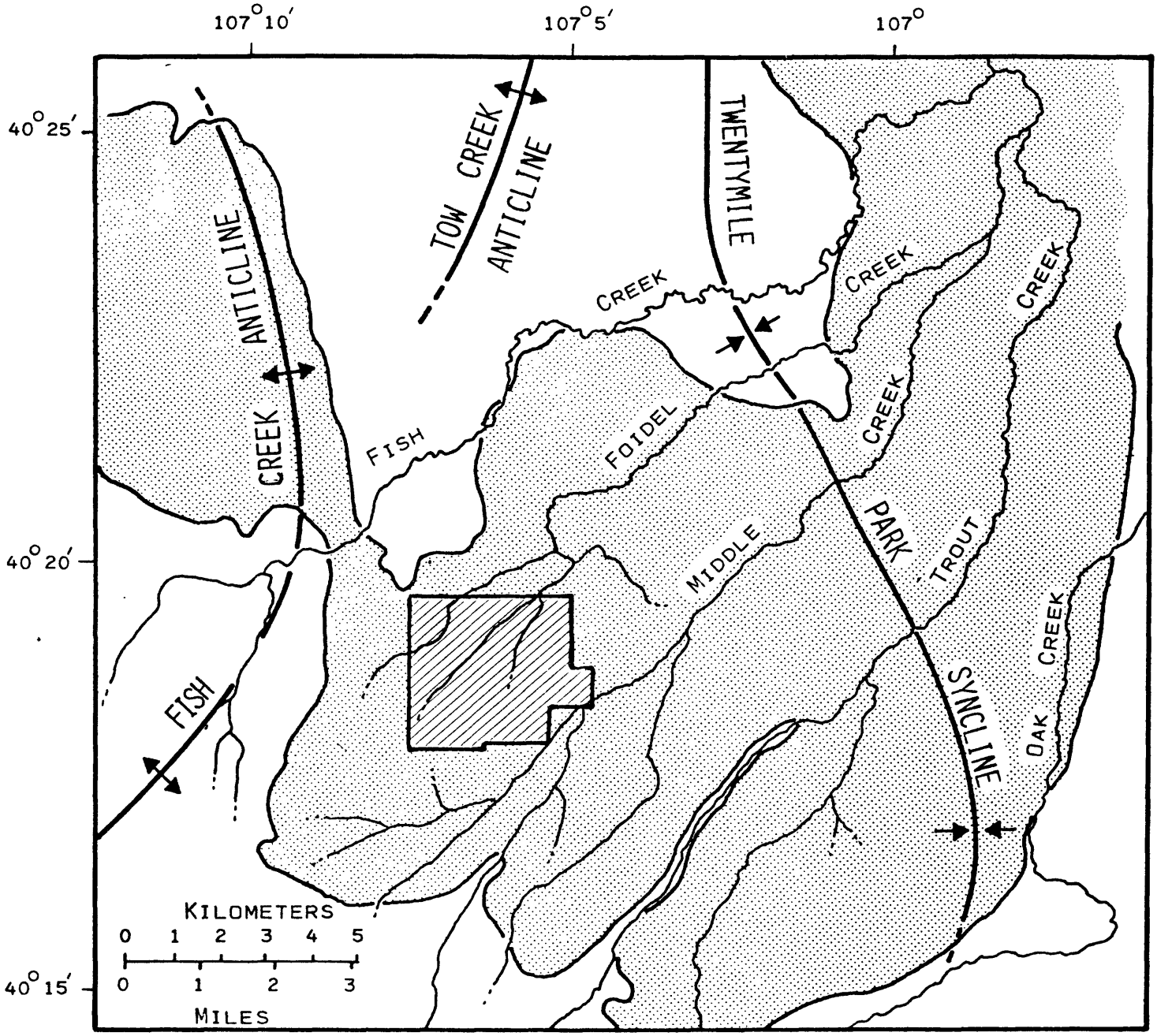

FIGURE 3.--STRUCTURAL SETTING OF THE FOIDEL CREEK EMRIA SITE (DIAGONAL RULING) AND ADJACENT AREAS. OUTCROP AREA OF THE MESAVERDE GROUP IS INDICATED BY STIPPLING.

Table 1.--Cretaceous stratigraphic units in northwestern Colorado

[Thicknesses after Bass, Eby, and Campbell (1955) and Kucera (1959)]

Upper Cretaceous	
Lance Formation.	Predominantly nonmarine sandstone, siltstone, and shale; some coal; a thick unit of marine sandstone (Fox Hills equivalent) at the base of the formation; conformably(?) overlain by the Fort Union Formation of Tertiary (Paleocene) age. Thickness 305 to 457 meters.
Lewis Shale.	Dark-gray marine shale. Thickness 579 meters.
Mesaverde Group (Williams Fork and Iles Formations).	Marine and marginal-marine sandstone, siltstone, and shale; numerous beds of coal; characterized by thick, laterally persistent, ledge-forming units of marine sandstone. Thickness 823 meters.
Mancos Shale.	Dark-gray marine shale with several units of resistant marine sandstone in the upper 213 to 274 meters. Thickness 914 meters.
Niobrara Formation.	Predominantly medium- to light-gray, calcareous marine shale with associated limestone, siltstone, gypsum, and bentonite. Thickness 183 to 274 meters.
Frontier Formation.	Dark-gray, silty marine shale with a thick unit of fossiliferous marine sandstone at the top. Thickness 82 to 113 meters.
Lower Cretaceous	
Mowry Shale.	Black, splintery, siliceous shale bearing teleost fish scales. Thickness 38 to 61 meters.
Dakota Sandstone.	Marine, marginal-marine, and nonmarine sandstone, siltstone, shale, and conglomerate; unconformably overlies the Morrison Formation of Jurassic age. Thickness 27 to 50 meters.

STRATIGRAPHY OF THE MESAVERDE GROUP IN THE FOIDEL CREEK AREA

The Foidel Creek EMRIA reclamation study site is situated entirely within the outcrop belt of the Mesaverde Group, which consists of two formations of approximately equal thickness--the Iles Formation below, and the Williams Fork Formation above. The top of the Trout Creek Sandstone Member of the Iles is a readily mapped datum used to define the contact between the two formations (Hancock, 1925, p. 14).

Iles Formation

The Iles Formation is approximately 427 meters thick and crops out in the southeastern and westernmost parts of the area mapped in this study. The formation may be conveniently divided into a lower and an upper part (fig. 4). The lower part of the formation is about 274 meters thick. It contains 4 or 5 prominently exposed, thick, cliff-forming units of marine sandstone which form flatiron-shaped ridges in the rugged country south of Fish Creek Canyon. These sandstones are well exposed along the north side of the valley of Trout Creek. They include, in ascending order, the Tow Creek Sandstone Member, the double ledge sandstone, and the Oak Creek Sandstone. The upper part of the formation, 152 meters thick, is composed primarily of nonresistant, gray siltstone rarely seen in natural exposures. This thick siltstone unit weathers to form a steep-sided valley both north and south of Fish Creek Canyon and underlies the floor and much of the north slope of the Middle Creek valley. At the top of the Iles Formation is the cliff-forming Trout Creek Sandstone Member.

Tow Creek Sandstone Member

The Tow Creek Sandstone Member of the Iles Formation was named by Crawford, Willson, and Perini (1920) for prominent exposures on the flanks of the Tow Creek anticline where it crosses Yampa River, approximately 18 kilometers north of the Foidel Creek area. The base of the member defines the boundary between the Mancos Shale and the Iles Formation. The contact is gradational; dark-gray shale and silty shale of the Mancos Shale grade upward to, and become interbedded with, silty sandstone and sandstone of the Tow Creek Sandstone Member. The member forms a high ridge along the western boundary of the mapped area. It is overlain by about 110 meters of marine shale and silty shale, which form very poor exposures between the prominently exposed Tow Creek Sandstone Member and the double ledge sandstone.

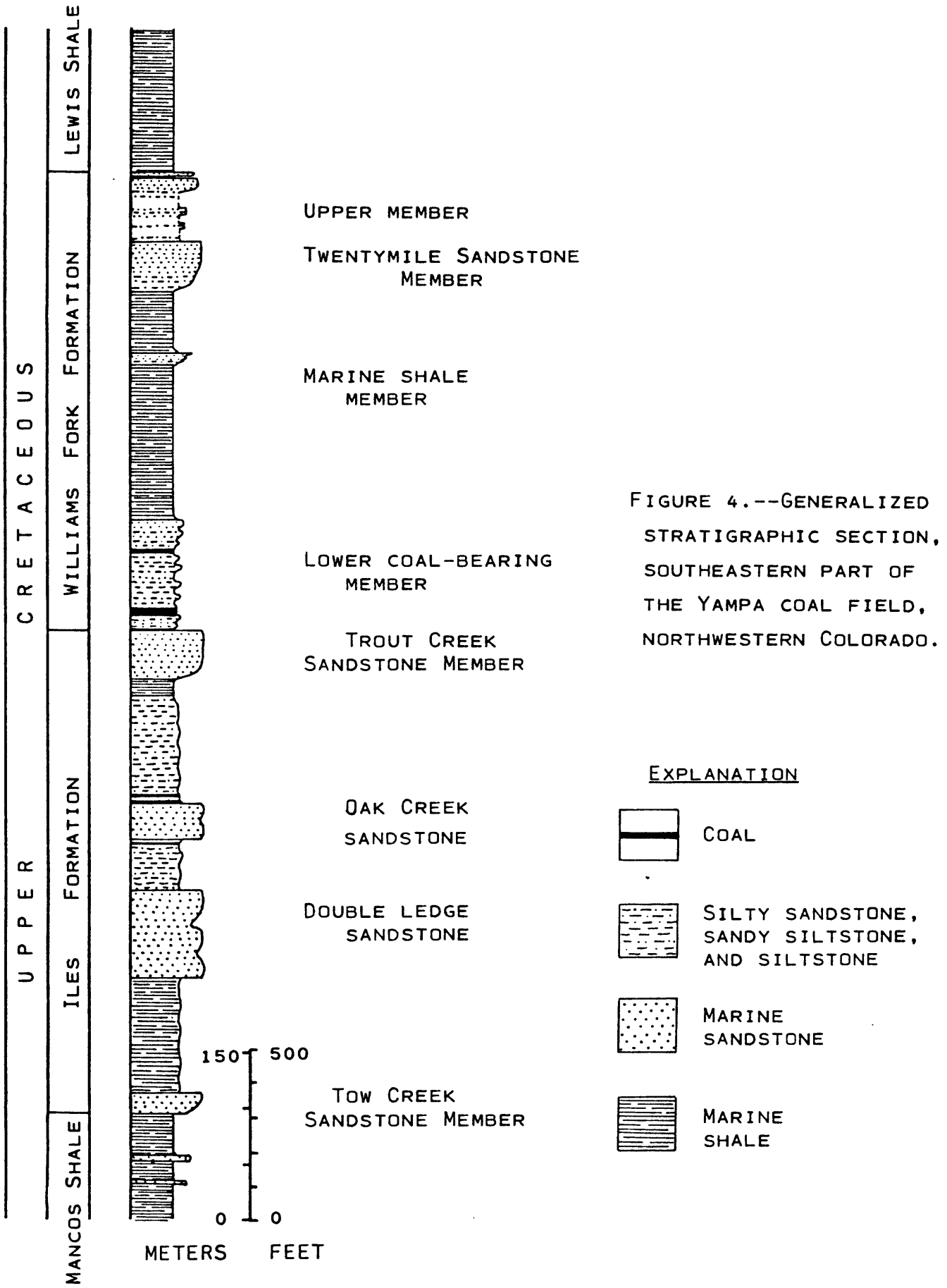

FIGURE 4.--GENERALIZED STRATIGRAPHIC SECTION, SOUTHEASTERN PART OF THE YAMPA COAL FIELD, NORTHWESTERN COLORADO.

Double ledge sandstone

The double ledge sandstone consists of one or more beds of marine sandstone at a level approximately 120 meters stratigraphically above the base of the Iles Formation in the southern part of the Yampa coal field. The unit is represented by a double ledge in the south-facing slopes of the Williams Fork Mountains, 26 kilometers west of the Foidel Creek area, where it was first described and informally named by Bass, Eby, and Campbell (1955, p. 156). Kucera (1959) extended the correlation of the unit to the area just west of the town of Oak Creek. The double ledge sandstone is well exposed on the north side of Fish Creek Canyon, where it is approximately 75 meters thick. Izett, Cobban, and Gill (1971, p. A3, A17) tentatively correlate the double ledge sandstone with the Hygiene Sandstone Member of the Pierre Shale near Kremmling, Colorado.

Oak Creek Sandstone of Kucera (1959)

Kucera (1959) applied the name Oak Creek Sandstone to a 30-meter-thick cliff-forming sandstone unit that crops out along the west side of Oak Creek near Haybro, 10 kilometers east of the Foidel Creek EMRIA site. The unit is associated with coal beds of the lower coal group throughout the southeastern part of the Yampa coal field (Bass, Eby, and Campbell, 1955).

The Oak Creek Sandstone is readily identified in the area mapped in this study. It forms a prominent hogback both north and south of Fish Creek Canyon, and is exposed on the north side of the North Fork of Middle Creek and along the west side of Little Middle Creek. The gentle slopes which dip northward into the valley of Middle Creek immediately overlie the top of the Oak Creek Sandstone.

Trout Creek Sandstone Member

The Trout Creek Sandstone Member, at the top of the Iles Formation, is a persistent unit throughout much of northwestern Colorado. It has been traced through the entire area of the Yampa coal field (Bass, Eby, and Campbell, 1955; Kucera, 1959; Konishi, 1959a) and is recognized as far south as Newcastle, in west-central Colorado (Gale, 1910; Hancock, 1925, p. 13-14; Cobban and Reeside, 1952, Cols. 45, 47; Collins, 1976, p. 24). The member was first named by Fenneman and Gale (1906, p. 26) for exposures along Trout Creek, 13 to 16 kilometers northeast of the Foidel Creek area. The Trout Creek Sandstone Member forms a nearly continuous cliff along the north side of the Middle Creek

valley (fig. 5). Outcrop thickness here reaches 25 to 30 meters. It is less well exposed along the eastern flank of the Fish Creek anticline. The structural contours on the geologic map (fig. 1) indicate the top of the Trout Creek Sandstone Member.

The Trout Creek Sandstone Member is composed of tan to white, moderately hard, fine-grained sandstone. It is easily distinguished from overlying marginal-marine sandstones of the lower coal-bearing member of the Williams Fork Formation in cores recovered from drill holes in the Foidel Creek area by its coarser texture and by the presence of sand-sized grains of dark chert in the Trout Creek. In several of the natural exposures, the member shows a tendency towards upward-coarsening of grain size. The trace fossil Ophiomorpha is locally abundant in the lower part of the member. Trough crossbedding and planar lamination are present, but these and other sedimentary structures are generally poorly displayed.

Izett, Cobban, and Gill (1971, p. A17) identified a sequence of marine shale beneath the Trout Creek Sandstone Member at a locality 10 kilometers southeast of the Foidel Creek area. No exposures of the marine shale could be found in the mapped area, but it is presumably present in the steep, debris-covered slopes beneath the cliff formed by the Trout Creek Sandstone Member.

Williams Fork Formation

The Williams Fork Formation is exposed in a broad belt which trends from southwest to northeast across the center of the mapped area. The formation is approximately 400 meters thick, and is here divided into four members: a lower coal-bearing member; a marine shale member composed of dark-gray shale, silty shale, and siltstone; the Twentymile Sandstone Member; and an upper member. The Williams Fork Formation contains only one thick unit of resistant marine sandstone--the Twentymile Sandstone Member--and therefore tends to form more subdued topography than does the generally more resistant Iles Formation.

Lower coal-bearing member

The Trout Creek Sandstone Member of the Iles Formation is conformably overlain by approximately 100 meters of strata deposited in a marginal-marine environment. The contact is sharp, the top of the Trout Creek Sandstone Member being overlain by about 0.3 meters of carbonaceous sandstone or coal at all exposures where it was examined and in EMRIA core holes nos. 1 and 2.

FIGURE 5.--EXPOSURES OF THE CLIFF-FORMING TROUT CREEK SANDSTONE MEMBER OF THE ILES FORMATION ALONG THE NORTH SIDE OF MIDDLE CREEK. THE STEEP SLOPE ABOVE THE TROUT CREEK SANDSTONE IS PRODUCED BY THE LOWER COAL-BEARING MEMBER OF THE WILLIAMS FORK FORMATION. THE DEBRIS COVERING PARTS OF THE SLOPE IS FROM THE ENERGY STRIP NO. 1 MINE. CLIFFS PRODUCED BY THE TWENTYMILE SANDSTONE MEMBER OF THE WILLIAMS FORK FORMATION IN DISTANCE AT RIGHT.

The lower coal-bearing member is moderately resistant and forms a steep slope above the cliff formed by the Trout Creek Sandstone Member in the north slope of the Middle Creek valley (fig. 5). The gentle slope which dips northward into Eckman Park, south of Foidel Creek, is formed upon resistant strata in the upper part of the member. Both the Foidel Creek EMRIA reclamation study site and the Energy Fuels Corporation's Energy Strip No. 1 mine are situated on this dip slope.

The predominant sediment type of the lower coal-bearing member is medium-gray to dark-gray siltstone. Very fine grained, tan to gray sandstone and silty sandstone are present at numerous levels, shale and carbonaceous shale being subordinate rock types. The member contains many beds of coal belonging to the middle coal group of the Yampa coal field. Of these, the Wolf Creek and Wadge coal beds are the thickest and laterally most persistent (fig. 6).

Sandstone, silty sandstone, and sandy siltstone of the lower coal-bearing member display symmetric, long-crested ripples and ripple-drift lamination at most exposures. Generally, however, the laminae are disrupted. Lamination planes, which are largely defined in this interval by concentrations of dark, carbonaceous material, are highly contorted and are penetrated by tubular structures, many of which probably represent infilling of cavities produced by the roots of plants. Others may record the burrowing activities of invertebrate organisms. Coarser sediments of the member frequently contain impressions of large fragments of deciduous plants. Fossils of the brackish-water bivalves Corbula perundata and Crassostrea sp. were encountered at several localities.

Marine shale member

The Williams Fork Formation contains a thick unit of marine shale in the southeastern part of the Yampa coal field. Because of poor exposure, the thickness of the marine shale member could not be measured directly. It is estimated, however, to be about 200 meters thick in the area northeast of the Foidel Creek EMRIA site. The member underlies much of the northern slope of Foidel Creek Canyon, where it forms rubble-strewn slopes beneath cliffs produced by the Twentymile Sandstone Member. It is best exposed in the eastern part of the mapped area, in a series of roadcuts along the county road between the crossings of Trout and Middle Creeks. The unit is also exposed in railroad cuts on the west slope of Pinnacle Peak and northeast of the old Foidel School.

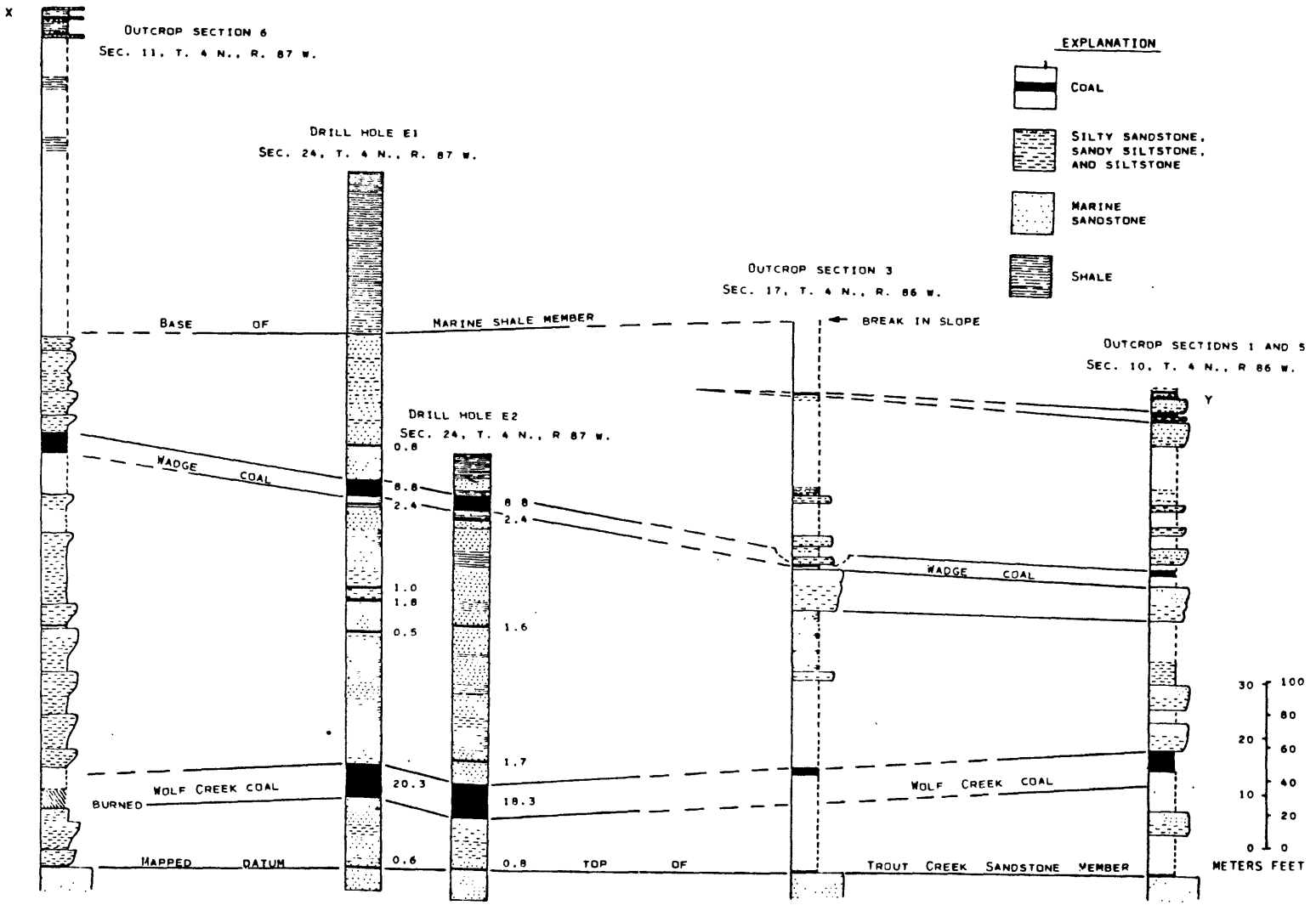

FIGURE 6.--EAST-WEST GEOLOGIC CROSS SECTION X-Y, LOWER COAL-BEARING MEMBER OF THE WILLIAMS FORK FORMATION, FOIDEL CREEK AREA. LOCATION OF THE CROSS SECTION IS SHOWN ON FIGURE 1. NUMBERS TO THE RIGHT OF THE CORE-HOLE SECTIONS ARE THICKNESSES OF COAL BEDS, IN FEET.

The marine shale member is composed of homogeneous, essentially non-fissile, dark-gray to dark-tan shale and silty shale with occasional interbeds of tan siltstone. Marine invertebrate fossils collected by J. R. Gill from this unit near the eastern edge of the mapped area (Sec. 14, T. 4 N., R. 86 W.) and identified by W. A. Cobban indicate that the unit is of Late Campanian age (Range Zone of Baculites reesidei).

The contact of the marine shale member with the overlying Twentymile Sandstone Member is gradational. The marine shale becomes increasingly silty upward, grading to silty shale and siltstone, which becomes interbedded with planar-laminated silty sandstone and sandstone. The beds of sandstone become thicker and more closely spaced as the base of the Twentymile Sandstone Member is approached. The contact is drawn at the level where sandstone beds predominate over those of siltstone and shale.

Twentymile Sandstone Member

The Twentymile Sandstone Member of the Williams Fork Formation was named by Fenneman and Gale (1906, p. 27) for exposures "in and around Twentymile Park," a part of which is included in the northeastern part of the mapped area. The outcrop thickness of the member is 36 meters in the area north of the old Foidel School. The lower 20 meters, as exposed here, consists of thoroughly bioturbated, tan, very fine grained sandstone which displays only very poorly defined, thick bedding. The upper 15 meters consists of very fine to fine-grained, light-tan sandstone with chert grains, and displays trough-crossbedding and planar lamination. Bioturbation of sediment comprising the upper part of the member was less intense than that of the lower part.

Upper member

The upper member of the Williams Fork Formation is approximately 60 meters thick in the area north of the old Foidel School. Exposures of the member in the Foidel Creek area are generally poor and a complete section could not be measured. The contact with the Twentymile Sandstone Member is sharp and is overlain by several centimeters of silty, sandy, carbonaceous shale and coal, which is, in turn, overlain by at least 4.5 meters of fine-grained tan sandstone irregularly interbedded with gray siltstone containing chips of dark-gray silty shale.

Most of the member is composed of light-gray to tan, silty, very fine grained, laminated sandstone interbedded with medium- to dark-gray, homogeneous

to laminated siltstone. Lamination planes in both the sandstone and siltstone are covered with very finely divided plant debris. A variety of trace fossils are present in the sandstones.

Near the top of the member is a unit of fine-grained, very light tan to white sandstone containing grains of chert and thus resembling, both in texture and composition, shallow-marine sandstone units found lower in the section. The base of the unit is not exposed. Outcrop thickness is 1.8 meters. The sandstone unit is overlain by a covered interval 3.0 meters thick, in which several prospect pits have been dug for coal of the Fish Creek coal bed. Bass, Eby, and Campbell (1955, pl. 23) indicate that the Fish Creek bed is approximately 1.2 meters thick in the area north of the old Foidel School. The coal-bearing interval is overlain by 1.8 meters of very fine grained, tan sandstone that contains casts of brackish-water bivalves. This unit is overlain by the Lewis Shale and thus marks the top of the Williams Fork Formation in this area.

COAL IN THE FOIDEL CREEK AREA

Stratigraphic distribution and production

Lower, middle, and upper coal groups are recognized in the Mesaverde Group of the Yampa coal field (Bass, Eby, and Campbell, 1955). Coal is presently being produced from each of the three coal groups within the area mapped in this study.

Lower coal group

The lower coal group includes coal beds in the upper part of the Iles Formation. These are best developed in the vicinity of the town of Oak Creek, 5.6 kilometers southeast of the mapped area. Mining of lower coal group coals in the Oak Creek area began in 1906, the year that the Moffat Road of the Denver and Rio Grande Western Railroad first provided a rail connection with Denver (Campbell, 1923). Within the mapped area, a coal bed belonging to the lower coal group is presently being mined underground at the Apex No. 2 mine, on the north side of Trout Creek (Sec. 22, T. 4 N., R. 86 W.). Coal from the Apex mine is sold for local consumption. Production in 1975 totalled 16,780 metric tons (Colorado Division of Mines, 1976).

Middle coal group

The middle coal group includes coal beds that occur between the Trout

Table 2.--Elevation, depth, and thickness, in feet, of Lennox, Wadge, and Wolf Creek coal beds in 44 drill holes in the Foidel Creek area. Location of drill holes is shown on fig. 1

[Metric conversion: 1 foot = 0.305 meter]

Drill hole number	Surface elevation	Lennox coal 1/			Wadge coal			Wolf Creek coal		
		Elevation	Depth	Thickness	Elevation	Depth	Thickness	Elevation	Depth	Thickness
1	7350	-	-	-	7272	78	8.5	-	-	-
2	7650	7635	15	0.5	7550	100	8.0	-	-	-
3	7680	-	-	-	7604	76	12.0	-	-	-
4	7220	-	-	-	7140	80	0.5	-	-	-
5	7097	7087	10	2.9	6997	100	10.0	-	-	-
6	7218	-	-	0	7115	103	10.6	-	-	-
7	7180	7093	87	2.7	-	-	-	-	-	-
8	7580	-	-	-	7500	80	11.5	-	-	-
9	7178	-	-	0	7081	97	10.6	-	-	-
10	7290	-	-	-	7227	63	10.3	-	-	-
11	7608	7573	35	1.8	7498	110	10.7	-	-	-
12	7600	-	-	-	7535	66	10.3	-	-	-
13	7292	-	-	-	7252	40	10.9	-	-	-
14	7439	-	-	-	-	-	0	-	-	-
15	7326	-	-	-	7286	40	- 2/	-	-	-
16	7229	-	-	-	7173	56	10.1	6859	238	6.5
17	7368	-	-	-	7311	57	10.6	-	-	-
18	7190	7179	11	2.0	7110	80	13.0	-	-	-
19	7324	-	-	0	7242	82	10.4	-	-	-
20	7486	-	-	-	7427	59	10.3	7292	194	4.0
21	7635	-	-	-	7568	67	10.5	-	-	-
22	7709	-	-	-	7659	50	10.3	-	-	-
23	7236	7230	6	5.4	7155	81	10.6	-	-	-
24	7376	-	-	-	7318	58	10.2	-	-	-
25	7513	-	-	-	7466	47	10.3	-	-	-
26	7666	-	-	0	7591	75	10.0	-	-	-
27	7289	-	-	-	7222	67	11.0	-	-	-
28	7431	-	-	-	7369	62	9.4	-	-	-
29	7654	-	-	-	7595	59	9.4	-	-	-
30	7681	-	-	-	7628	53	10.0	-	-	-
31	7372	-	-	0	7290	82	10.3	-	-	-
32	7486	-	-	0	7412	74	10.2	-	-	-
33	7615	-	-	-	7561	54	7.3	-	-	-
34	7510	-	-	-	7480	30	10.3	-	-	-
35	6840	6713	127	2.5	6652	188	10.0	-	-	-
36	6840	6785	55	1.3	6726	114	9.5	-	-	-
37	6960	-	-	-	6930	30	8.1	-	-	-
38	7280	-	-	-	7245	35	7.3	-	-	-
39	7460	-	-	-	7418	42	6.8	-	-	-
E1	7520	-	-	0	7338	182	8.8	7170	350	20.3
E2	7890	-	-	-	7867	23	8.8	7694	196	18.3
E3	7117	7085	32	5.9	7010	107	9.1	-	-	-
E4	7160	-	-	-	7072	88	10.6	-	-	-
E5	7515	-	-	-	7485	30	3.0	-	-	-

1/ The Lennox coal is not a laterally continuous seam, as are the Wadge and Wolf Creek coals. Rather, it is a series of lenticular beds that rise stratigraphically from east to west within the mapped area.

2/ Only the upper part of the coal bed was drilled--thickness undetermined.

Creek Sandstone Member of the Iles Formation and the Twentymile Sandstone Member of the Williams Fork Formation. In the southeastern part of the Yampa coal field, coal beds are restricted to the lowermost 90 meters of this interval. The Wadge and Wolf Creek beds are the thickest and most continuous of the coal beds. The stratigraphic positions of these beds are shown in geologic cross section X-Y (fig. 6).

Wolf Creek bed.--The base of the Wolf Creek coal bed is situated approximately 6 to 15 meters stratigraphically above the top of the Trout Creek Sandstone Member. Though it locally reaches thicknesses of 6.1 meters, the Wolf Creek bed is highly irregular in thickness and locally contains thick partings of claystone. It was penetrated by EMRIA core holes 1 and 2, and by two holes drilled by the Energy Fuels Corporation in the area just east of the Foidel Creek EMRIA site. The maximum (6.2 meters) and minimum (1.2 meters) thicknesses encountered occur in EMRIA core hole no. 1 and drill hole no. 20, respectively. These two holes are only 3.9 kilometers apart. Marked variation in thickness over relatively short distances is characteristic of the Wolf Creek bed elsewhere in the Yampa coal field (Bass, Eby, and Campbell, 1955). The Wolf Creek bed is not now being mined in the Foidel Creek area.

Wadge bed.--The Wadge coal bed, which occurs approximately 60 meters stratigraphically above the top of the Trout Creek Sandstone Member, is the most uniform in thickness of the coal beds in the middle coal group, and has been mined and prospected at numerous localities (Bass, Eby, and Campbell, 1955). The Wadge coal bed has an average thickness of 2.8 meters in the drill holes shown on the geologic map (fig. 1), and attains a maximum reported thickness of 4.0 meters (table 2). It is presently being mined at the Energy Fuels Corporation's Energy Strip No. 1 mine (thickness 2.7 meters), just east of the Foidel Creek EMRIA site, and at the Pittsburgh and Midway Coal Mining Company's Edna strip mine (thickness 1.8 meters), near the east margin of the mapped area (Colorado Division of Mines, 1976). Total production for 1975 from the Energy Strip No. 1 mine was 1.12 million metric tons. Cumulative production to January 1, 1976, totalled 7.38 million metric tons (Jones and Murray, 1976; Colorado Division of Mines, 1976).

Lennox bed.--The Lennox coal bed occurs near the top of the lower coal-bearing member of the Williams Fork Formation. According to Bass, Eby, and Campbell (1955, p. 173), it is 0.9 to 1.2 meters thick at most places. It is 1.2 to 1.5 meters thick at the Edna strip mine, where it has been mined along

with the Wadge bed (Hayes, 1966). The Lennox bed cannot be recognized with certainty in drill holes within the mapped area. A number of lenticular coal beds ranging from 0.5 to about 1.8 meters in thickness have been encountered at approximately the stratigraphic level of the Lennox bed.

Upper coal group

The upper coal group of the Yampa coal field consists of coal beds overlying the Twentymile Sandstone Member. The upper coal group contains only one economically important coal bed--the Fish Creek bed--in the Foidel Creek area. The Fish Creek bed is presently being mined in the Energy Strip No. 2 mine, where the bed is 1.4 meters thick (Jones and Murray, 1976). The mine is operated by the Energy Fuels Corporation and is located in Secs. 19, 25, and 30, T. 5 N., R. 87 W. (mine not shown on the geologic map, fig. 1). Total production in 1975 was 0.76 million metric tons. Cumulative production to January 1, 1976, amounts to 1.47 million metric tons.

Coal resources of the Foidel Creek area

Coal resources of the Wolf Creek and Wadge beds have been calculated for the Foidel Creek EMRIA reclamation study site and for the entire mapped area (fig. 1). These data are presented in tables 3 and 4. Because of their lenticularity, coal beds at the stratigraphic level of the Lennox bed have not been considered in the analysis of coal resources. Resource calculations were performed for each section whose entire coal-bearing area falls within the boundaries of the geologic map. Sections along the margins of the map were lumped for resource analysis. Coal has been separated into five overburden categories (0-30 meters; 30-61 meters; 61-305 meters; 305-610 meters; >610 meters) and, within these categories, into "demonstrated" and "inferred" coal resources. "Demonstrated" coal occurs within a distance of 1.21 kilometers from points of observation (drill and core holes, mines, outcrops). "Inferred" coal occurs in a belt extending 3.62 kilometers beyond the outer edge of the demonstrated coal (1.21 to 4.83 kilometers from points of observation) (U.S. Bureau of Mines and U.S. Geological Survey, 1976).

Wolf Creek bed

The Foidel Creek EMRIA reclamation study site is estimated to contain 49.7 million metric tons of Wolf Creek coal. Of this amount, only about 11.8 million metric tons occur beneath overburden of 61 meters or less. Overburden thickness is less than 30 meters only beneath the steep slopes immediately above the cliff formed by the Trout Creek Sandstone Member. The mapped area is

Table 3.--Estimated coal resources, in short tons, of the Wolf Creek coal bed in the Foidel Creek area, recorded by section, overburden thickness, and degree of geologic assurance.

[D=demonstrated; I=inferred; !=very small amount, included in 100-200 feet overburden thickness category; *=very small amount, included in 200-1,000 feet overburden thickness category; metric conversions: 1 foot = 0.305 meter; 1 short ton = 0.907 metric ton; [EMRIA] indicates areas that are included in the Foidel Creek EMRIA reclamation study site.]

Township and range	Section	Thickness of overburden, in feet										Total
		0-100		100-200		200-1000		1000-2000		2000		
		D	I	D	I	D	I	D	I	D	I	
T. 5 N. R. 86 W.	27	-	-	-	-	-	-	-	16.9	-	0.9	17.8
	28	-	-	-	-	-	4.9	-	13.2	-	0.5	18.6
	29	-	-	-	-	-	6.3	-	8.5	-	-	14.8
	30	-	-	-	-	-	-	-	13.3	-	-	13.3
	31	-	-	-	-	-	9.2	-	3.7	-	-	12.9
	32	-	-	-	5.3	-	11.0	-	-	-	-	16.3
	33	!	!	4.3	5.8	2.1	8.1	-	1.1	-	-	21.4
	34	!	-	1.0	-	3.8	-	7.2	9.5	-	-	21.5
T. 5 N. R. 87 W.	25	-	-	-	-	-	-	-	10.9	-	1.1	12.0
	26	-	-	-	-	-	-	-	1.1	-	10.5	11.6
	27	-	*	-	*	-	0.5	-	2.1	-	10.1	12.7
	28	-	*	-	*	-	1.9	-	0.8	-	-	2.7
	34	-	*	-	*	-	2.9	-	7.0	-	3.7	13.6
	35	-	-	-	-	-	-	-	12.0	-	1.4	13.4
	36	-	-	-	-	-	0.5	-	12.4	-	-	12.9
T. 4 N. R. 87 W.	11	-	*	-	*	-	2.1	-	5.7	-	-	7.8
	12	-	-	-	-	-	1.0	-	8.2	-	-	9.2
[EMRIA]	13	-	-	-	-	5.3	9.3	-	1.2	-	-	15.8
	14	-	*	-	*	3.1	6.6	-	3.3	-	-	13.0
	23	-	!	0.5	3.8	11.4	3.5	-	-	-	-	19.2
[EMRIA]	24	-	-	5.2	-	16.5	-	-	-	-	-	21.7
	25	!	!	4.8	0.7	-	-	-	-	-	-	5.5
	26	-	!	-	2.5	-	-	-	-	-	-	2.5
T. 4 N. R. 86 W.	7	-	-	-	-	4.3	4.1	-	1.3	-	-	9.7
	8	-	-	-	3.3	0.8	4.8	-	-	-	-	8.9
	9	!	!	0.3	5.9	-	-	-	-	-	-	6.2
	10	!	!	3.1	0.7	5.3	0.9	-	-	-	-	10.0
	15	-	!	-	3.2	-	0.3	-	-	-	-	3.5
	16	-	-	-	-	-	0.5	-	-	-	-	0.5
	17	!	!	5.2	0.3	1.6	1.5	-	-	-	-	8.6
	18	-	-	1.4	-	8.4	0.3	-	-	-	-	10.1
[EMRIA]	18(part)	-	-	(0.4)	-	(6.9)	(0.3)	-	-	-	-	(7.6)
[EMRIA]	19	!	!	4.2	3.1	0.8	1.6	-	-	-	-	9.7
	30	!	-	0.6	-	-	-	-	-	-	-	0.6
Total		-	-	30.6	34.6	63.4	81.8	7.2	132.2	0	28.2	

Total Wolf Creek coal in sections included in analysis = 378.0 x 10^6 tons

Wolf Creek coal in sections at margins of map = 100 x 10^6 tons

Total Wolf Creek coal in mapped area = 478 x 10^6 tons

Table 4.--Estimated coal resources, in short tons, of the Wadge coal bed in the Foidel Creek area, recorded by section, overburden thickness, and degree of geologic assurance.

[D=demonstrated; I=inferred; *=very small amount, included in 200-1,000 feet overburden thickness category; metric conversion: 1 foot = 0.305 meter; 1 short ton = 0.907 metric tons] [EMRIA] indicates areas that are included in the Foidel Creek EMRIA reclamation study site.]

Township and range	Section	Thickness of overburden, in feet										Total
		0-100		100-200		200-1000		1000-2000		2000		
		D	I	D	I	D	I	D	I	D	I	
T. 5 N. R. 86 W.	27	-	-	-	-	-	-	-	9.5	-	-	9.5
	28	-	-	0.1	-	4.2	1.5	-	5.5	-	-	11.3
	29	-	-	0.5	-	5.2	-	2.6	2.4	-	-	10.7
	30	-	-	-	-	-	-	2.3	8.8	-	-	11.1
	31	-	-	0.8	-	3.0	4.6	0.2	1.8	-	-	10.4
	32	2.6	-	1.9	-	0.6	-	-	-	-	-	5.1
	33	4.2	-	0.8	-	1.6	0.4	-	-	-	-	7.0
	34	0.2	0.3	0.1	0.3	0.1	1.7	-	5.7	-	-	8.4
T. 5 N. R. 87 W.	25	-	-	-	-	-	-	-	11.6	-	0.3	11.9
	26	-	-	-	-	-	-	-	2.3	-	10.1	12.4
	27	-	*	-	*	-	0.7	-	2.1	-	11.4	14.2
	28	-	*	-	*	-	2.1	-	0.9	-	-	3.0
	34	*	*	*	*	2.1	1.4	6.7	1.5	0.2	3.6	15.5
	35	-	-	-	-	-	-	1.0	13.0	-	0.7	14.7
	36	-	-	-	-	-	1.4	-	12.6	-	-	14.0
T. 4 N. R. 87 W.	11	*	*	*	*	1.9	0.2	4.0	2.0	-	-	8.1
	12	-	-	-	-	0.6	1.4	-	7.4	-	-	9.4
[EMRIA]	13	0.8	-	0.9	-	6.8	1.1	-	0.2	-	-	9.8
	14	-	*	-	*	2.0	5.1	-	1.9	-	-	9.0
	23	2.0	2.9	1.1	0.1	2.1	0.4	-	-	-	-	8.6
[EMRIA]	24	8.1	-	1.2	-	0.7	-	-	-	-	-	10.0
	25	2.2	0.3	-	-	-	-	-	-	-	-	2.5
	26	-	1.1	-	-	-	-	-	-	-	-	1.1
T. 4 N. R. 86 W.	7	0.1	-	1.1	-	6.2	3.8	-	0.8	-	-	12.0
	8	4.0	-	2.4	-	1.6	-	-	-	-	-	8.0
	9	1.2	-	-	-	-	-	-	-	-	-	1.2
	10	-	1.5	-	1.5	-	0.7	-	-	-	-	3.7
	15	-	1.4	-	-	-	-	-	-	-	-	1.4
	16	0.04	-	-	-	-	-	-	-	-	-	0.04
	17	8.4	-	-	-	-	-	-	-	-	-	8.4
	18	11.3	-	2.7	-	2.2	-	-	-	-	-	16.2
[EMRIA]	18(part)	(7.2)	-	(2.7)	-	(2.2)	-	-	-	-	-	(12.1)
[EMRIA]	19	7.9	-	-	-	-	-	-	-	-	-	7.9
	30	0.3	-	-	-	-	-	-	-	-	-	0.3
Total		53.3	7.5	13.6	1.9	40.9	26.5	16.8	90.0	0.2	26.0	

Total Wadge coal in sections included in analysis = 276.8 x 10^6 tons
Wadge coal in sections at margins of map = 72 x 10^6 tons
Total Wadge coal in mapped area = 349 x 10^6 tons

estimated to contain a total of 434 million metric tons of Wolf Creek coal.

Wadge bed

The Wadge bed in the Foidel Creek EMRIA site contains approximately 36.1 million metric tons of coal. Of this amount 28.1 million metric tons occurs beneath overburden thicknesses of 61 meters or less, and all but 2.0 million metric tons is classified as demonstrated. Total Wadge coal within the mapped area is estimated to be 317 million metric tons.

ANALYSES OF COAL FROM THE FOIDEL CREEK AREA

Thirteen coal samples from the core holes in the Foidel Creek EMRIA reclamation study site were submitted to the U.S. Bureau of Mines, Pittsburgh, Pa., for proximate, ultimate, Btu, and forms-of-sulfur analyses, and to the U.S. Geological Survey, Denver, Colo., for minor and trace element analyses. The complete analyses of these samples and information relating the samples to the EMRIA core holes are presented in tables 5, 6, 7, and 8. One sample is from a coal bed tentatively identified as Lennox, five of the samples are from the Wadge bed, and four are from the Wolf Creek bed. The Wolf Creek, Wadge, and Lennox coal beds of the middle coal group in the Foidel Creek area are all classified as high-volatile C bituminous in rank (American Society for Testing and Materials, 1974), based on the analyses presented in table 6.

Four analyses of Wolf Creek coal from the Foidel Creek EMRIA site, on an as-received basis, averaged 9.2 percent moisture, 34.1 percent volatile matter, 44.1 percent fixed carbon, 12.6 percent ash, with 0.6 percent sulfur, and had a heating value of 10,530 Btu. By comparison, twelve analyses of Wolf Creek coal from the southeastern part of the Yampa coal field reported by Bass, Eby, and Campbell (1955, p. 184-207) averaged, on an as-received basis, 10.1 percent moisture, 36.6 percent volatile matter, 43.1 percent fixed carbon, and 9.9 percent ash, with 0.5 percent sulfur, and had a heating value of 10,990 Btu.

The five analyses of Wadge coal from the Foidel Creek EMRIA site, on an as-received basis, averaged 10.8 percent moisture, 32.6 percent volatile matter, 43.0 percent fixed carbon, and 13.6 percent ash, with 1.0 percent sulfur, and had a heating value of 10,080 Btu. These average values of ash, sulfur, and heating value differ appreciably from the values in analyses reported by Bass, Eby, and Campbell (1955, p. 184-207) from the southeastern part of the Yampa coal field. Thirty-three analyses of Wadge coal reported by those authors averaged 10.7 percent moisture, 37.0 percent volatile matter, 46.3 percent

Table 5.--EMRIA core hole number, location, name of coal bed, and depth interval of coal samples, the analyses of which are presented in Tables 6, 7, and 8.

[Metric conversion: 1.0 foot = 0.305 meter]

Test No.	EMRIA Core Hole No.	Location Sec.	T.	R.	Name of coal bed (if named)	Depth interval
D178117	1	24	4N	87W	Wadge	182.4-191.2
D178118	1	24	4N	87W	-----	196.4-198.8
D178119	1	24	4N	87W	-----	253.9-255.7
D178120	1	24	4N	87W	Wolf Creek (upper part)	350.2-352.5
D178121	1	24	4N	87W	Wolf Creek (middle part)	352.5-362.5
D178122	1	24	4N	87W	Wolf Creek (lower part)	362.5-370.5
D178123	2	24	4N	87W	Wadge	23.4- 32.2
D178124	2	24	4N	87W	Wolf Creek	195.8-214.7
D178125	3	13	4N	87W	Lennox?	32.4- 38.3
D178126	3	13	4N	87W	Wadge	106.7-117.8
D178127	3	13	4N	87W	-----	119.9-121.9
D178128	4	18	4N	86W	Wadge	88.3- 98.9
D178129	5	19	4N	86W	Wadge?	29.5- 32.7

Table 6.--Proximate, ultimate, Btu, and forms-of-sulfur analyses of 13 coal samples from the Foidel Creek EMRIA site, Routt County, Colo.

[All analyses except Btu are in percent. Original moisture content may be slightly more than shown because samples were collected and transported in plastic bags to avoid metal contamination. Form of analyses: 1, as received; 2, moisture free; 3, moisture and ash free. All analyses by Coal Analysis Section, U.S. Bureau of Mines, Pittsburg, Pa. Vol.Mtr. = volatile matter; A.d. = air-dried.]

		Proximate analysis				Ultimate analysis				
Sample	Form of analysis	Moisture	Vol.Mtr.	Fixed C	Ash	Hydrogen	Carbon	Nitrogen	Oxygen	Sulfur
D178117	1	10.5	34.0	46.9	8.6	5.7	62.5	0.9	21.8	0.5
	2	-	38.0	52.4	9.6	5.1	69.8	1.0	13.9	.6
	3	-	42.0	58.0	-	5.6	77.3	1.1	15.4	.6
D178118	1	10.5	32.9	45.2	11.4	5.4	60.0	.7	21.9	.6
	2	-	36.8	50.5	12.7	4.7	67.0	.8	14.0	.7
	3	-	42.1	57.9	-	5.4	76.8	.9	16.1	.8
D178119	1	9.9	36.8	46.6	6.7	5.7	64.5	1.0	21.5	.6
	2	-	40.8	51.7	7.4	5.1	71.6	1.1	14.1	.7
	3	-	44.1	55.9	-	5.5	77.3	1.2	15.2	.7
D178120	1	8.8	34.7	46.3	10.2	5.5	62.8	.8	20.1	.6
	2	-	38.0	50.8	11.2	5.0	68.9	.9	13.5	.7
	3	-	42.8	57.2	-	5.6	77.5	1.0	15.2	.7
D178121	1	9.4	33.2	44.3	13.1	5.4	60.0	.8	20.3	.4
	2	-	36.6	48.9	14.5	4.8	66.2	.9	13.2	.4
	3	-	42.8	57.2	-	5.6	77.4	1.0	15.4	.5
D178122	1	9.5	34.5	43.6	12.4	5.3	60.5	1.0	20.2	.6
	2	-	38.1	48.2	13.7	4.7	66.9	1.1	13.0	.7
	3	-	44.2	55.8	-	5.4	77.5	1.3	15.1	.8
D178123	1	17.1	27.5	38.5	16.9	5.4	49.6	.8	26.9	.4
	2	-	33.2	46.4	20.4	4.2	59.8	1.0	14.1	.5
	3	-	41.7	58.3	-	5.3	75.2	1.2	17.7	.6
D178124	1	8.9	34.1	42.3	14.7	5.0	58.6	.7	20.4	.6
	2	-	37.4	46.4	16.1	4.4	64.3	.8	13.7	.7
	3	-	44.6	55.4	-	5.3	76.7	.9	16.3	.8
D178125	1	8.0	40.3	44.7	7.0	5.8	64.4	1.4	18.8	2.6
	2	-	43.8	48.6	7.6	5.3	70.0	1.5	12.7	2.8
	3	-	47.4	52.6	-	5.8	75.8	1.6	13.8	3.1
D178126	1	9.6	32.9	45.5	12.0	5.3	60.4	.5	21.3	.5
	2	-	36.4	50.3	13.3	4.7	66.8	.6	14.1	.6
	3	-	42.0	58.0	-	5.4	77.0	.6	16.3	.6
D178127	1	11.3	34.5	45.4	8.8	5.6	61.1	1.1	22.7	.7
	2	-	38.9	51.2	9.9	4.9	68.9	1.2	14.3	.8
	3	-	43.2	56.8	-	5.4	76.5	1.4	15.8	.9
D178128	1	7.5	34.5	35.0	23.0	4.9	51.3	1.1	16.6	3.1
	2	-	37.3	37.8	24.9	4.4	55.5	1.2	10.7	3.4
	3	-	49.6	50.4	-	5.9	73.8	1.6	14.3	4.5
D178129	1	9.4	34.3	48.8	7.5	5.5	64.1	0.8	21.6	0.5
	2	-	37.9	53.9	8.3	4.9	70.8	.9	14.6	.6
	3	-	41.3	58.7	-	5.4	77.1	1.0	15.9	.6

Table 6.--Proximate, ultimate, Btu, and forms-of-sulfur analyses of 13 coal samples from the Foidel Creek EMRIA site, Routt County, .--Continued

Sample	Form of analysis	Btu	A.d.loss	Forms of sulfur		
				Sulfate	Pyritic	Organic
D178117	1	10870	1.0	0.01	0.07	0.44
	2	12150	-	.01	.08	.49
	3	13440	-	.01	.09	.54
D178118	1	10460	1.1	.01	.05	.57
	2	11690	-	.01	.06	.64
	3	13390	-	.01	.06	.73
D178119	1	11240	.8	.01	.06	.57
	2	12480	-	.01	.07	.63
	3	13480	-	.01	.07	.68
D178120	1	10940	.6	.01	.03	.58
	2	12000	-	.01	.03	.64
	3	13510	-	.01	.04	.72
D178121	1	10430	.7	.01	.02	.40
	2	11510	-	.01	.02	.44
	3	13460	-	.01	.03	.52
D178122	1	10550	.8	.01	.13	.46
	2	11660	-	.01	.14	.51
	3	13510	-	.01	.17	.59
D178123	1	8500	7.8	.01	.04	.37
	2	10250	-	.01	.05	.45
	3	12880	-	.02	.06	.56
D178124	1	10180	.6	.01	.12	.51
	2	11170	-	.01	.13	.56
	3	13320	-	.01	.16	.67
D178125	1	11540	.2	.01	.36	2.27
	2	12540	-	.01	.39	2.47
	3	13580	-	.01	.42	2.67
D178126	1	10550	.7	.01	.05	.45
	2	11670	-	.01	.06	.50
	3	13460	-	.01	.06	.57
D178127	1	10750	2.4	.01	.09	.60
	2	12120	-	.01	.10	.68
	3	13450	-	.01	.11	.75
D178128	1	9250	.5	.01	2.18	.92
	2	10000	-	.01	2.36	.99
	3	13310	-	.01	3.14	1.32
D178129	1	11250	0.6	0.01	0.05	0.41
	2	12420	-	.01	.06	.45
	3	13540	-	.01	.06	.49

Table 7.--Major, minor, and trace element composition of 13 coal samples from the Foidel Creek EMRIA site, Routt County, Colo., reported on whole-coal basis

[Values are in either percent or parts per million. Si, Al, Ca, Mg, Na, K, Fe, Mn, Ti, P, Cl, Cd, Cu, Li, Pb, and Zn values were calculated from analysis of ash. As, F, Hg, Sb, Se, Th, and U values are from direct determinations on air-dried (32°C) coal. The remaining analyses were calculated from spectrographic determinations on ash. L after a value means less than the value shown, N means not detected, and B means not determined. S after element titles means that the values listed were determined by semiquantitative spectrographic analysis.]

Sample	Si %	Al %	Ca %	Mg %	Na %	K %	Fe %	Mn ppm	Ti %	P ppm
D178117	2.7	1.3	0.27	0.064	0.037	0.086	0.15	5.3	0.051	480
D178118	4.0	1.1	.21	.062	.055	.12	.15	8.4	.062	560 L
D178119	1.5	.83	.22	.041	.023	.045	.088	11	.040	710
D178120	2.2	1.7	.29	.053	.052	.037	.097	6.8	.065	910
D178121	3.7	1.5	.37	.158	.080	.077	.20	47	.060	590 L
D178122	3.3	1.6	.25	.105	.093	.056	.15	9.5	.064	550 L
D178123	7.6	1.9	.16	.108	.059	.32	.22	26	.088	990 L
D178124	3.6	1.5	.41	.126	.030	.097	1.1	200	.064	680 L
D178125	.94	.57	.38	.067	.032	.021	1.6	31 L	.033	360
D178126	3.4	1.5	.24	.083	.071	.12	.15	8.8	.057	550 L
D178127	3.1	.86	.090	.053	.024	.084	.71	40 L	.050	450 L
D178128	1.9	1.1	.36	.104	.019	.037	.14	11	.039	380 L
D178129	5.9	1.5	.22	.102	.039	.16	1.6	24	.093	1000 L

Sample	Cl %	As ppm	Cd ppm	Cu ppm	F ppm	Hg ppm	Li ppm	Pb ppm	Sb ppm	Se ppm
D178117	0.021L	2	0.11L	6.2	145	0.04	11.9	4.8	0.2	1.0
D178118	.026L	1	.13	8.0	215	.04	11.6	5.2	.8	.9
D178119	.014L	1 L	.07L	4.2	200	.02	8.6	3.4	.4	.9
D178120	.021L	1 L	.10	7.8	225	.08	12.2	3.1	.2	1.2
D178121	.027L	1 L	.14	5.8	75	.02	5.3	5.4	.2	.8
D178122	.025L	2	.13	6.0	160	.06	8.9	3.8	.2	1.1
D178123	.045L	1	.23	9.9	440	.08	21.2	6.8	.5	1.1
D178124	.031L	1 L	.16L	5.9	90	.05	11.1	5.5	.3	.8
D178125	.016L	2	.08L	3.3	70	.23	3.1	2.0L	.2	1.1
D178126	.025L	1	.13L	5.9	240	.04	10.6	5.0	.3	.8
D178127	.021L	2	.10	5.1	75	.02	13.9	6.2	.5	1.0
D178128	.017L	1 L	.09L	4.6	140	.02	6.1	3.9	.1	.7
D178129	.049L	6	.24L	10.7	330	.29	26.2	6.1L	.4	1.3

Sample	Th ppm	U ppm	Zn ppm	B ppm-S	Ba ppm-S	Be ppm-S	Ce ppm-S	Co ppm-S	Cr ppm-S	Ga ppm-S
D178117	3.0L	0.8	5.7	70	200	1.5	N	1 L	3	3
D178118	4.3	.7	13.0	100	200	2	70 L	2	10	5
D178119	4.2	.6	3.0	70	300	2	30 L	1.5	5	3
D178120	3.0L	.9	4.6	70	300	1.5	50 L	1	3	5
D178121	3.0L	1.2	6.0	100	500	1	N	1.5 L	5	5
D178122	3.0L	1.5	3.7	100	300	1	70 L	1.5 L	2	3
D178123	5.8	1.4	19.9	100	200	1	N	2 L	15	7
D178124	5.6	1.1	9.2	100	200	.7	70 L	1.5 L	5	5
D178125	3.0L	.4	2.6	150	200	.5	N	.7 L	2	2
D178126	5.4	.8	12.9	150	200	1	70 L	1.5 L	3	3
D178127	3.0L	.6	4.2	70	150	1.5	N	1 L	3	5
D178128	3.0L	.8	3.9	150	150	1	50 L	1 L	2	5
D178129	3.0L	1.5	23.1	70	300	1.5	N	2 L	15	7

Table 7.--Major, minor, and trace element composition of 13 coal samples from the Foidel Creek EMRIA site, Routt County, Colo., reported on whole-coal basis--Continued

Sample	Ge ppm-S	La ppm-S	Mo ppm-S	Nb ppm-S	Nd ppm-S	Ni ppm-S	Sc ppm-S	Sr ppm-S	V ppm-S	Y ppm-S
D178117	N	10 L	N	3	N	1.5	1.5	150	7	7
D178118	N	15 L	N	5	N	2	2	100	15	10
D178119	2	7	.5	3	10 L	2	2	200	20	7
D178120	N	10 L	.7	3	N	1	1.5	150	10	5
D178121	N	15 L	1	5	N	1.5 L	2	150	10	7
D178122	N	15 L	1	3	N	1.5 L	2	100	10	10
D178123	N	20 L	1.5	7	N	3	3	70	15	7
D178124	N	15 L	N	3	N	1.5	2	100	10	7
D178125	N	7 L	.7	1.5	N	1.5	1.5	70	15	5
D178126	N	15 L	1	3	N	1.5	2	100	15	10
D178127	N	10 L	.7	3	N	1	1.5	70	7	7
D178128	N	10 L	.7	2	N	1	1.5	50	7	7
D178129	N	N	N	5	B	3	3	200	30	15

Sample	Yb ppm-S	Zr ppm-S
D178117	0.5	20
D178118	1	20
D178119	.7	20
D178120	.5	20
D178121	.7	20
D178122	.7	20
D178123	1	30
D178124	.7	20
D178125	B	15
D178126	.7	20
D178127	.5	30
D178128	.5	15
D178129	1.5	30

Table 8.--Major and minor oxide and trace element composition of the laboratory ash of 13 coal samples from the Foidel Creek EMRIA site, Routt County, Colo.

[Values are in either percent or parts per million. The coals were ashed at 525°C. L after a value means less than the value shown, N means not detected, and B means not determined. S after the element title means that the values listed were determined by semiquantitative spectrographic analysis. The spectrographic results are to be identified with geometric brackets whose boundaries are 1.2, 0.83, 0.56, 0.38, 0.26, 0.18, 0.12, etc., but are reported arbitrarily as mid-points of those brackets, 1.0, 0.7, 0.5, 0.3, 0.2, 0.15, 0.1, etc. The precision of the spectrographic data is approximately one bracket at 68 percent, or two brackets at 95 percent confidence.]

Sample	Ash %	SiO2 %	Al2O3 %	CaO %	MgO %	Na2O %	K2O %	Fe2O3 %	MnO %	TiO2 %
D178117	10.7	55	23	3.6	1.00	0.47	0.96	2.1	0.006	0.79
D178118	12.9	67	16	2.3	.80	.58	1.1	1.7	.008	.80
D178119	6.8	47	23	4.6	1.00	.46	.79	1.9	.020	.98
D178120	10.4	45	31	3.9	.85	.67	.42	1.3	.008	1.0
D178121	13.6	58	21	3.8	1.93	.80	.68	2.1	.045	.73
D178122	12.7	55	24	2.8	1.38	.99	.53	1.7	.010	.84
D178123	22.6	72	16	1.0	.80	.35	1.7	1.4	.015	.65
D178124	15.6	50	19	3.7	1.34	.26	.75	9.9	.17	.68
D178125	8.1	25	13	6.7	1.38	.53	.31	29	.050L	.69
D178126	12.6	58	22	2.7	1.10	.76	1.1	1.7	.009	.76
D178127	10.3	64	16	1.2	.85	.31	.97	9.9	.050L	.80
D178128	8.6	48	25	5.8	2.01	.30	.52	2.3	.016	.77
D178129	24.3	52	12	1.2	.70	.22	.80	9.4	.013	.64

Sample	P2O5 %	SO3 %	Cl %	Cd ppm	Cu ppm	Li ppm	Pb ppm	Zn ppm	B ppm-S	Ba ppm-S
D178117	1.0	3.0	0.20 L	1.0L	58	111	45	53	700	2000
D178118	1.0 L	2.6	.20 L	1.0	62	90	40	101	700	2000
D178119	2.4	5.1	.20 L	1.0L	62	126	50	44	1000	5000
D178120	2.0	2.8	.20 L	1.0	75	117	30	44	700	3000
D178121	1.0 L	2.6	.20 L	1.0	43	39	40	44	700	3000
D178122	1.0 L	2.6	.20 L	1.0	47	70	30	29	700	3000
D178123	1.0 L	.97	.20 L	1.0	44	94	30	88	500	1000
D178124	1.0 L	3.7	.20 L	1.0L	38	71	35	59	700	1500
D178125	1.0	11	.20 L	1.0L	41	38	25 L	32	1500	3000
D178126	1.0 L	1.7	.20 L	1.0L	47	84	40	102	1000	1500
D178127	1.0 L	2.6	.20 L	1.0	50	135	60	41	700	1500
D178128	1.0 L	4.1	.20 L	1.0L	53	71	45	45	1500	2000
D178129	1.0 L	1.1	.20 L	1.0L	44	108	25 L	95	300	1500

Table 8.--Major and minor oxide and trace element composition of the laboratory ash of 13 coal samples from the Foidel Creek EMRIA site, Routt County, Colo.--Continued

Sample	Be ppm-S	Ce ppm-S	Co ppm-S	Cr ppm-S	Ga ppm-S	Ge ppm-S	La ppm-S	Mo ppm-S	Nb ppm-S	Nd ppm-S
D178117	15	N	10 L	30	30	N	100 L	N	30	N
D178118	15	500 L	15	70	30	N	100 L	N	30	N
D178119	30	500 L	20	70	50	30	100	7	50	150 L
D178120	15	500 L	10	30	50	N	100 L	7	30	N
D178121	7	N	10 L	30	30	N	100 L	7	30	N
D178122	7	500 L	10 L	20	30	N	100 L	7	30	N
D178123	5	N	10 L	70	30	N	100 L	7	30	N
D178124	5	500 L	10 L	30	30	N	100 L	N	20	N
D178125	5	N	10 L	30	30	N	100 L	7	20	N
D178126	7	500 L	10 L	30	30	N	100 L	7	30	N
D178127	15	N	10 L	30	50	N	100 L	7	30	N
D178128	10	500 L	10 L	30	50	N	100 L	7	30	N
D178129	7	N	10 L	70	30	N	N	N	20	B

Sample	Ni ppm-S	Sc ppm-S	Sr ppm-S	V ppm-S	Y ppm-S	Yb ppm-S	Zr ppm-S
D178117	15	15	1500	70	70	5	200
D178118	15	15	700	100	70	7	200
D178119	30	30	3000	300	100	10	300
D178120	10	15	1500	100	50	5	200
D178121	10 L	15	1000	70	50	5	150
D178122	10 L	15	700	70	70	5	200
D178123	15	15	300	70	30	5	150
D178124	10	15	700	70	50	5	150
D178125	15	15	1000	150	50	B	150
D178126	10	15	700	100	70	5	200
D178127	10	15	700	70	70	5	300
D178128	10	15	500	70	70	5	200
D178129	15	15	1000	150	70	7	150

fixed carbon, and 5.9 percent ash, with 0.5 percent sulfur, and had a heating value of 11,430 Btu.

The average value of 1.0 percent sulfur in samples of Wadge coal collected from core holes in the Foidel Creek EMRIA site is not representative of the Wadge coal bed in this area, but reflects the high sulfur content (3.1 percent) of one of the samples (D178128). The other four samples contained 0.5 percent or less of sulfur.

The average ash content of samples of Wadge coal from the Foidel Creek EMRIA site, on an as-received basis, is relatively high--13.6 percent--as compared to an average of 5.9 percent for analyses reported by Bass, Eby, and Campbell. Five of the analyses reported by those authors were of samples collected within or very near the Foidel Creek area. They averaged 6.3 percent ash, and ranged from 4.8 to 8.0 percent ash. The relatively high ash content of the samples of Wadge coal from the Foidel Creek EMRIA site cannot, therefore, be considered representative of the Wadge coal elsewhere in the Foidel Creek area.

The major, minor, and trace element composition of the 13 coal samples from the Foidel Creek EMRIA site are presented in tables 7 and 8. Comparisons of these values with those presented by Hatch and Swanson (1977) indicate that the elemental compositions of the Foidel Creek area samples are typical of coal in the Rocky Mountain province, all values falling well within the ranges of values reported for the province.

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