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UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

U.S. Geological Survey

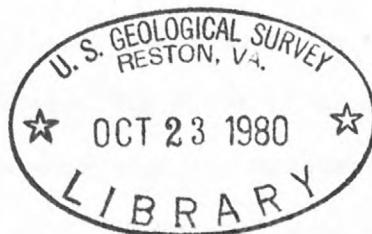
Reports-Open file Series

Chemical analyses of coal from the Mesaverde Formation,
Grand Mesa coal field, Delta and Mesa Counties, Colorado

TM
and
Swanson

by

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This report is preliminary and has not
been edited or reviewed for conformity
with U.S. Geological Survey Standards

INTRODUCTION

As part of a continuing program by the U.S. Geological Survey to collect and chemically analyze representative samples of U.S. coals, 45 coal samples were collected from the Upper Cretaceous Mesaverde Formation, Grand Mesa coal field, Delta and Mesa Counties, Colorado. These samples were collected from cores (30 samples, 11 locations), mines (11 face channel samples, 9 locations), and from drill cuttings (4 samples, 1 location).

U.S. Geological Survey sample numbers, index map locations, coal thickness or depth interval sampled, and brief descriptions for the 45 samples are listed in table 1. Sampling locations are shown in figure 1. Geophysical logs for all samples summarized in this report can be found in Eager (1978, 1979).

STRATIGRAPHY

The coals of the Grand Mesa coal field occur near the base of the Upper Cretaceous Mesaverde Formation (Lee, 1912), which is equivalent to the Mount Garfield Formation (Erdmann, 1934). The majority of coal beds sampled in this report occur in the Bowie Shale Member of the Mesaverde Formation also called the Cameo coal zone (Erdmann, 1934). This coal zone lies stratigraphically on the Rollins Sandstone Member, a regressive marine deposit. Near the Colorado River, the Palisade coal zone, which lies about 320 stratigraphic feet below the Rollins Sandstone Member was also sampled.

The lowest coals of the Cameo coal zone lie on and pinch-out into the Rollins Sandstone Member and were deposited in near-shore environments, possibly lagoons. Those coals stratigraphically higher and not directly associated with the beach sandstones, were probably deposited in interdistributary delta-plain environments.

Table 1.--U.S. Geological Survey sample numbers, index map location, location, coal thickness or depth interval and sample descriptions for 45 coal samples from the Mesaverde Formation, Grand Mesa coal field, Delta and Mesa Counties, Colorado

[1 foot = 0.305 meters]

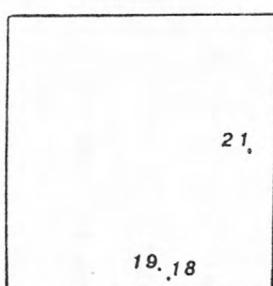
USGS sample no.	Index map locat- tion	Location	Thickness or depth interval (in feet)	Sample description
Delta County				
D191607	1	NW $\frac{1}{4}$ SW $\frac{1}{4}$ sec. 8, T. 13 S., R. 93 W.	4.8	Face channel sample unnamed bed
D194452	2	SE $\frac{1}{4}$ SW $\frac{1}{4}$ sec. 15, T. 13 S., R. 93 W.	5.5	Do.
D194453	3	SE $\frac{1}{4}$ NE $\frac{1}{4}$ sec. 22, T. 13 S., R. 93 W.	5.3	Do.
D194454	4	SE $\frac{1}{4}$ SW $\frac{1}{4}$ sec. 12, T. 13 S., R. 95 W.	5.7	Do.
D194455	5	NW $\frac{1}{4}$ NE $\frac{1}{4}$ sec. 13, T. 13 S., R. 95 W.	4.4	Do.
D194456	6	SE $\frac{1}{4}$ NE $\frac{1}{4}$ sec. 15, T. 13 S., R. 94 W.	1.8	Do.
D194457	7	NW $\frac{1}{4}$ SW $\frac{1}{4}$ sec. 27, T. 13 S., R. 92 W.	5.1	Do.
D203116	8	NE $\frac{1}{4}$ SE $\frac{1}{4}$ sec. 20, T. 13 S., R. 92 W.	1007.8-1011.3	Core Sample unnamed bed
D203117	8	-----do-----	1029.3-1038.3	Do.
D103118	8	-----do-----	1168.0-1173.7	Do.
D203119	8	-----do-----	1218.2-1228.0	Do.
D203113	10	SE $\frac{1}{4}$ SW $\frac{1}{4}$ sec. 19, T. 13 S., R. 92 W.	797.8- 804.1	Do.
D203114	10	-----do-----	881.7- 893.0	Do.
D203115	10	-----do-----	893.0- 900.1	Do.
D203120	11	NW $\frac{1}{4}$ SW $\frac{1}{4}$ sec. 24, T. 13 S., R. 93 W.	986.1- 998.9	Do.
D203109	12	NE $\frac{1}{4}$ NW $\frac{1}{4}$ sec. 8, T. 13 S., R. 93 W.	161.4- 168.2	Do.
D203110	12	-----do-----	192.7- 202.1	Do.
D203111	12	-----do-----	202.3- 206.4	Do.
D203112	12	-----do-----	237.3- 245.0	Do.
D203106	13	SW $\frac{1}{4}$ NE $\frac{1}{4}$ sec. 1, T. 13 S., R. 94 W.	838.0- 845.0	Do.
D203107	13	-----do-----	857.7- 865.1	Do.
D203108	13	-----do-----	883.2- 892.6	Do.
D203100	14	NE $\frac{1}{4}$ NE $\frac{1}{4}$ sec. 15, T. 13 S. R. 94 W.	82.0- 91.0	Drill cuttings unnamed bed
D203102	14	-----do-----	145.0- 155.0	Do.
D203103	14	-----do-----	169.0- 175.0	Do.
D203105	14	-----do-----	234.0- 240.0	Do.
D203095	15	NE $\frac{1}{4}$ NE $\frac{1}{4}$ sec. 8, T. 13 S., R. 95 W.	703.1- 714.2	Core sample unnamed bed
D203096	16	SW $\frac{1}{4}$ NW $\frac{1}{4}$ sec. 25, T. 13 S., R. 96 W.	178.7- 187.0	Do.
D203098	16	-----do-----	187.0- 190.2	Do.
D203099	16	-----do-----	210.0- 211.6	Do.
D203091	17	SE $\frac{1}{4}$ NW $\frac{1}{4}$ sec. 24, T. 13 S., R. 96 W.	505.5- 511.2	Do.
D203092	17	-----do-----	553.3- 564.3	Do.
D203093	17	-----do-----	564.8- 569.0	Do.
D203094	17	-----do-----	581.0- 584.0	Do.
D203089	22	SW $\frac{1}{4}$ NE $\frac{1}{4}$ sec. 32, T. 13 S., R. 96 W.	983.0- 986.5	Do.
D203090	22	-----do-----	1001.1-1007.0	Do.

Table 1.--U.S. Geological Survey sample numbers, index map location, location, coal thickness or depth interval and sample descriptions for 45 coal samples from the Mesaverde Formation, Grand Mesa coal field, Delta and Mesa Counties, Colorado--Continued

USGS sample no.	Index map loca- tion	Location	Thickness or depth interval (in feet)	Sample description
Mesa County				
D180095	22	SE $\frac{1}{4}$ SE $\frac{1}{4}$ sec. 34, T. 10 S., R. 98 W.	upper 4.0	Face channel sample unnamed bed
D180096	22	-----do-----	lower 3.75	Do.
D184655	19	NW $\frac{1}{4}$ SE $\frac{1}{4}$ sec. 34, T. 10 S., R. 98 W.	upper 3.0	Do.
D184656	19	-----do-----	lower 3.0	Do.
D203087	20	SE $\frac{1}{4}$ NW $\frac{1}{4}$ sec. 21, T. 12 S., R. 97 W.	528.8- 535.1	Core sample unnamed bed
D203088	20	-----do-----	540.9- 547.2	Do.
D203083	21	SW $\frac{1}{4}$ SE $\frac{1}{4}$ sec. 13, T. 10 S., R. 98 W.	868.4- 814.7	Do.
D203084	21	-----do-----	863.0- 862.0	Do.
D203086	21	-----do-----	1287.3-1290.8	Do.

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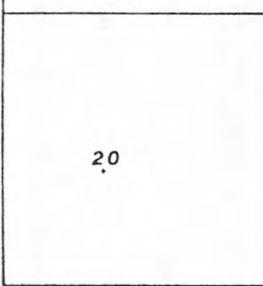


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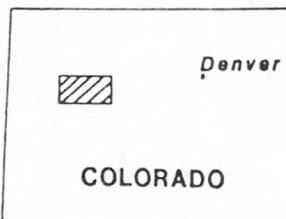
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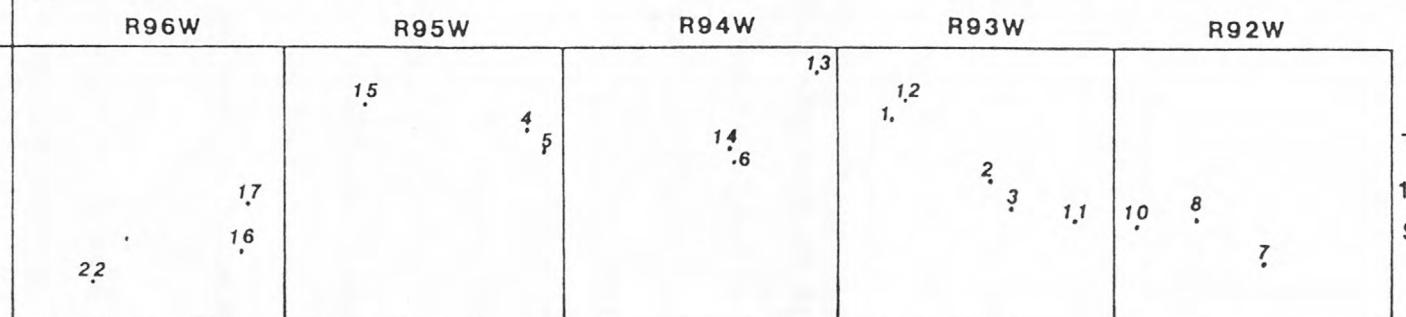
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COLORADO



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1 0 1 2 3 4 5 miles
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Fig. 1.--Index map showing the location of sample sites from the Grand Mesa coal field, Delta and Mesa

Counties, Colorado

EXPLANATION OF TABLES

Proximate and ultimate analyses, heat-of-combustion, air-dried-loss, forms-of-sulfur, free-swelling-index, and ash-fusion-temperature determinations on 43 samples from the Grand Mesa coal field are listed in table 2. These analyses were provided by the U.S. Department of Energy, Pittsburgh, Pa. Analyses for ash content and 39 major and minor oxides and trace elements in the laboratory ash (table 3) and analyses of nine trace elements in whole coal (table 4) for all 45 samples were provided by the U.S. Geological Survey, Denver, Colorado. Analytical procedures used by the U.S. Geological Survey are described in Swanson and Huffman (1976).

Table 5 contains the data listed in table 3 converted to a whole coal basis and the whole-coal analyses listed in table 4. Twenty-three additional elements not listed in tables 3, 4, and 5 were looked for but not found in amounts greater than their lower limits of detection (table 6). Unweighted statistical summaries of the analytical data for 45 coal samples from the Grand Mesa coal field in tables 2, 3, and 4 are listed in tables 7, 8, and 9. For comparison, data summaries for coal samples from the Rocky Mountain Province are included.

Arsenic contents of the samples summarized in this report have been determined by two different analytical methods. Samples D180095 and D180096 were analyzed by the graphite furnace-atomic absorption method (lower detection limit 0.5 ppm). The remaining 43 samples were analyzed by instrumental neutron activation analysis (lower detection limit 0.1 ppm).

Thorium contents of the samples were determined by two methods. Samples D180095 and D180096 were analyzed by delayed neutron activation analysis (lower detection limit 3.0 ppm). The remaining 43 samples were analyzed by instrumental neutron activation analysis (lower detection limit 0.1 ppm).

The P_2O_5 contents for all samples were determined by X-ray fluorescence spectroscopy. However, due to changes in technique, the lower detection limit for samples D180095-D180096, D184655-D184656, D191607, and D194452-D194457, was 1.0 percent in coal ash, and for the remaining 34 samples it was 0.01 percent in whole coal.

To be consistent with the precision of the semiquantitative emission spectrographic technique, arithmetic and geometric means of elements determined by this method are reported as the midpoints of the enclosing six step brackets (see subtitle of table 3, or Swanson and Huffman, 1976, p. 6 for an explanation of six step brackets).

Explanation of statistical terms used in summary tables

In this report the geometric mean (GM) is used as the estimate of the most probable concentration (mode); the geometric mean is calculated by taking the logarithm of each analytical value, summing the logarithms, dividing the sum by the total number of values, and obtaining the antilogarithm of the result. The measure of scatter about the mode used here is the geometric deviation (GD), which is the antilog of the standard deviation of the logarithms of the analytical values. These statistics are used because the quantities of trace elements in natural materials commonly exhibit positively skewed frequency distributions; such distributions are normalized by analyzing and summarizing trace-element data on a logarithmic basis.

If the frequency distributions are lognormal, the geometric mean is the best estimate of the mode, and the estimated range of the central two-thirds of the observed distribution has a lower limit equal to GM/GD and an upper limit equal to $GM \cdot GD$. The estimated range of the central 95 percent of the observed distribution has a lower limit equal to GM/GD^2 and an upper limit equal to $GM \cdot GD^2$ (Connor and others, 1976).

Although the geometric mean is, in general, an adequate estimate of the most common analytical value, it is, nevertheless, a biased estimate of the arithmetic mean. The estimates of the arithmetic means listed in the summary tables are Sichel's t statistic (Miesch, 1967).

A common problem in statistical summaries of trace-element data arises when the element content of one or more of the samples is below the limit of analytical detection. This results in a "censored" distribution. Procedures developed by Cohen (1959) were used to compute unbiased estimates of the geometric mean, geometric deviation, and arithmetic mean when the data are censored.

DISCUSSION

The apparent ranks of all 43 coal samples from the Grand Mesa coal field, Delta and Mesa Counties, Colorado were calculated using the data in table 2 and the formulas in ASTM designation D-388-77 (American Society for Testing and Materials, 1978). The apparent ranks range from subbituminous B coal to high-volatile A bituminous coal: eight samples have an apparent rank of subbituminous B coal; 8 samples, subbituminous A coal; 22 samples, high-volatile C bituminous coal, 2 samples, high-volatile B bituminous coal, and 3 samples, high volatile A bituminous coal.

STRUCTURE AND COAL RANK

The coal dips gently to north or northeast into the Piceance Creek basin. Apparent coal ranks of samples from the western part of the coal field varies linearly from subbituminous B to high-volatile A bituminous through the 7,700 foot (D203089) to 3,550 foot (D203086) elevation range sampled (fig. 2). The relationship of coal rank to elevation in the western Grand Mesa coal field is probably a reflection of original burial depth within the Piceance Creek basin. Freeman (1979) has shown similar trends in the deeper parts of the basin.

A statistical comparison (student's t-test, 95-percent confidence level) of the geometric mean contents of the U.S. Department of Energy's data for 43 coal samples from the Grand Mesa coal field with 86 coal samples from the Rocky Mountain Province shows that coal from the Grand Mesa coal field has significantly higher contents of ash, nitrogen, total sulfur, and organic sulfur and significantly lower contents of volatile matter and sulfate sulfur. The heat of combustion and the contents of moisture, fixed carbon, hydrogen, carbon, oxygen, and pyritic sulfur are not significantly different.

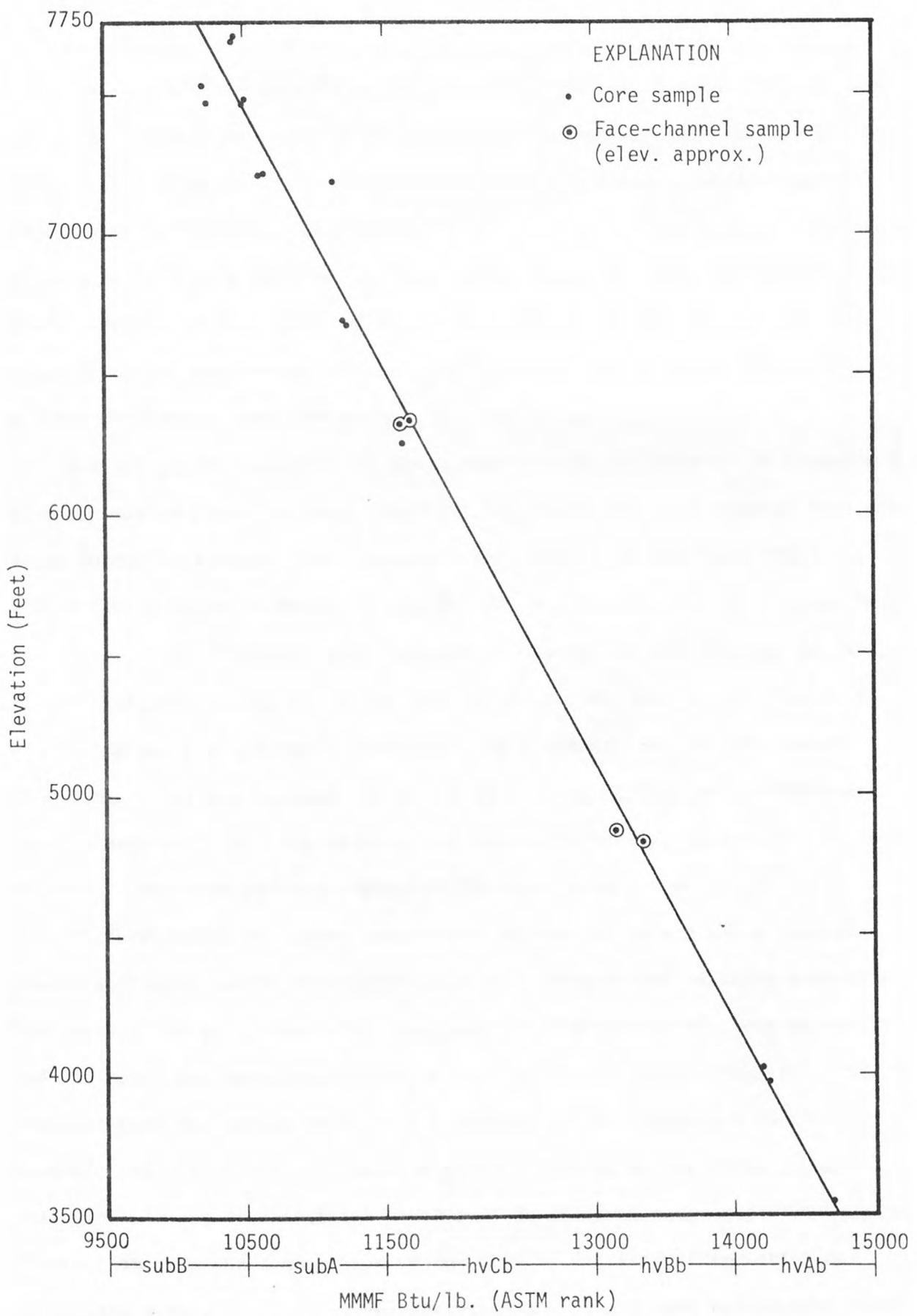


Figure 2.-- Relationship of coal elevation and coal rank in the western Grand Mesa coal field.

A statistical comparison of the geometric mean contents of coal ash and the geometric mean contents of nine major and minor oxides in the ash for 45 coal samples from the Grand Mesa coal field with 295 coal samples from the Rocky Mountain Province shows that coal ash from the Grand Mesa coal field has significantly higher contents of SiO_2 , Al_2O_3 , Na_2O , and TiO_2 , and significantly lower contents of CaO , MgO , and SO_3 . The contents of ash and K_2O and Fe_2O_3 contents in ash are not significantly different. When compared at the 99-percent confidence level the content of SiO_2 is not significantly different.

A statistical comparison of the geometric mean contents of 36 elements in 45 coal samples from the Grand Mesa coal field with 295 coal samples from the Rocky Mountain Province shows that coal from the Grand Mesa coal field has significantly higher contents of Al, Na, Ti, B, Be, Ga, Li, Nb, Pb, Sb, Zn, and Zr, and significantly lower contents of Ca, Mg, As, Cd, Cr, Hg, Mo, and V. The contents of Si, K, Fe, Ba, Co, Cu, F, Mn, Ni, Sc, Se, Sr, Th, U, Y, and Yb are not significantly different. When compared at the 99-percent confidence level the contents of Be and Sb are not significantly different. The contents of P, Ge, and La could not be statistically compared due to lack of this information for Rocky Mountain Province coals.

Differences in the oxide composition of coal ashes and the elemental contents of coal result from differences in the total and relative amounts of the various inorganic minerals, the elemental composition of these minerals, and the total and relative amounts of any organically bound elements. The chemical form and distribution of a given element are dependent on the geologic history of the coal bed. A partial listing of the factors that influence element distributions would include chemical composition of original plants; amounts and composition of the various detrital, diagenetic, and epigenetic minerals; chemical characteristics of the ground waters that come

in contact with the bed; temperatures and pressures during burial; and extent of weathering. No evaluation of these factors has been made for coal from the Grand Mesa coal field.

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Table 2.--Proximate and ultimate analyses, and heat-of-combustion, forms-of-sulfur, free-swelling-index and ash-fusion-temperature determinations for 43 coal samples from the Mesaverde Formation, Grand Mesa coal field, Delta and Mesa Counties, Colorado

[All analyses except heat of combustion, free-swelling index, and ash-fusion temperatures in percent. For each sample number, the analyses are reported three ways: first, as received; second, moisture free; and third, moisture and ash free. All analyses by Coal Analyses Section, U.S. Department of Energy, Pittsburgh, Pa. Kcal/kg = 0.556 (Btu/lb); °F = (°C x 1.8) + 32; L, less than the value shown, B, not determined.]

Sample number	Proximate analysis				Ultimate analysis					Heat of Combustion	
	Moisture	Volatile matter	Fixed carbon	Ash	Hydrogen	Carbon	Nitrogen	Oxygen	Sulfur	Kcal/kg	Btu/lb
D191607	11.2	31.1	39.0	18.7	5.1	52.9	1.2	21.5	0.6	5,170	9,310
	--	35.0	43.9	21.1	4.3	59.6	1.4	13.0	.7	5,820	10,480
	--	44.4	55.6	--	5.5	75.5	1.7	16.5	.9	7,380	13,280
D194452	13.5	34.0	42.0	10.5	5.8	59.0	1.4	22.6	.7	5,700	10,260
	--	39.3	48.6	12.1	5.0	68.2	1.6	12.3	.8	6,590	11,860
	--	44.7	55.3	--	5.7	77.6	1.8	13.9	.9	7,500	13,500
D194453	12.6	33.1	42.6	11.7	5.4	56.3	1.4	24.5	.8	5,450	9,820
	--	37.9	48.7	13.4	4.6	64.4	1.6	15.2	.9	6,240	11,230
	--	43.7	56.3	--	5.3	74.4	1.8	17.6	1.1	7,210	12,970
D194454	11.9	34.9	44.8	8.4	5.7	61.1	1.4	22.1	1.4	5,900	10,620
	--	39.6	50.9	9.5	5.0	69.4	1.6	13.1	1.6	6,700	12,060
	--	43.8	56.2	--	5.5	76.7	1.8	14.5	1.8	7,400	13,330
D194455	11.2	34.3	45.8	8.7	5.6	60.0	.8	23.8	1.1	5,850	10,520
	--	38.6	51.6	9.8	4.9	67.6	.9	15.6	1.2	6,580	11,850
	--	42.8	57.2	--	5.4	74.9	1.0	17.3	1.4	7,300	13,140
D194456	8.9	35.6	40.9	14.6	5.3	56.5	1.3	21.1	1.1	5,490	9,880
	--	39.1	44.9	16.0	4.7	62.0	1.4	14.5	1.2	6,030	10,850
	--	46.5	53.5	--	5.6	73.9	1.7	17.2	1.4	7,180	12,920
D194457	10.5	35.6	44.5	9.4	5.6	60.9	1.4	21.9	.8	6,030	10,850
	--	39.8	49.7	10.5	5.0	68.0	1.6	14.0	.9	6,740	12,130
	--	44.4	55.6	--	5.5	76.0	1.7	15.7	1.0	7,530	13,550
D203116	13.6	34.6	48.6	3.2	6.1	64.6	1.6	24.1	.5	6,300	11,340
	--	40.0	56.2	3.7	5.3	74.8	1.9	13.9	.6	7,290	13,120
	--	41.6	58.4	--	5.5	77.6	1.9	14.4	.6	7,570	13,620
D203117	13.3	36.8	43.7	6.2	5.8	62.3	1.5	23.8	.4	6,100	10,990
	--	42.4	50.4	7.2	5.0	71.9	1.7	13.8	.5	7,040	12,670
	--	45.7	54.3	--	5.4	77.4	1.9	14.9	.5	7,580	13,650
D203118	10.4	35.2	45.6	8.8	5.9	62.7	1.5	20.7	.6	6,150	11,070
	--	39.3	50.9	9.8	5.3	70.0	1.7	12.8	.7	6,860	12,360
	--	43.6	56.4	--	5.9	77.6	1.9	14.2	.7	7,610	13,700
D203119	11.0	33.1	46.2	9.7	5.7	61.6	1.4	21.1	.6	6,050	10,890
	--	37.2	51.9	10.9	5.0	69.2	1.6	12.7	.7	6,800	12,230
	--	41.7	58.3	--	5.6	77.7	1.8	14.3	.8	7,630	13,730

Table 2.--Proximate and ultimate analyses, and heat-of-combustion, forms-of-sulfur, free-swelling-index and ash-fusion-temperature determinations for 43 coal samples from the Mesa Verde Formation, Grand Mesa coal field, Delta and Mesa Counties, Colorado
--continued

Sample number	Air-dried loss	Forms of sulfur			Free swelling	Ash fusion temperature, °C		
		Sulfate	Pyritic	Organic		Initial deformation	Softening	Fluid
D191607	2.6	0.03	0.02	0.55	0.0	1,600	1,600	1,600
	--	.03	.02	.62				
	--	.04	.03	.78				
D194452	7.6	.02	.13	.52	.0	1,490	1,540	1,540
	--	.02	.15	.60				
	--	.03	.17	.68				
D194453	6.2	.02	.28	.47	.0	1,540	1,540	1,540
	--	.02	.32	.54				
	--	.03	.37	.62				
D194454	5.8	.02	.09	1.26	.0	1,540	1,540	1,540
	--	.02	.10	1.43				
	--	.03	.11	1.58				
D194455	5.2	.02	.11	.94	.0	1,540	1,540	1,540
	--	.02	.12	1.06				
	--	.02	.14	1.17				
D194456	3.6	.01	.20	.91	.0	1,540	1,540	1,540
	--	.01	.22	1.00				
	--	.01	.26	1.19				
D194457	4.7	.01	.08	.67	.0	1,540	1,540	1,540
	--	.01	.09	.75				
	--	.01	.10	.84				
D203116	8.8	.01	.03	.42	.0	1,150	1,210	1,260
	--	.01	.03	.49				
	--	.01	.04	.50				
D203117	9.0	.01	.05	.38	.0	1,375	1,440	1,490
	--	.01	.06	.44				
	--	.01	.06	.47				
D203118	6.6	.01	.05	.53	.0	1,600+	1,600+	1,600+
	--	.01	.06	.59				
	--	.01	.06	.66				
D203119	7.0	.01	.09	.54	.0	1,600+	1,600+	1,600+
	--	.01	.10	.61				
	--	.01	.11	.68				

Table 2.--Proximate and ultimate analyses, and heat-of-combustion, forms-of-sulfur, free-swelling-index and ash-fusion-temperature determinations for 43 coal samples from the Mesaverde Formation, Grand Mesa coal field, Delta and Mesa Counties, Colorado
--continued

Sample number	Proximate analysis				Ultimate analysis					Heat of Combustion	
	Moisture	Volatile matter	Fixed carbon	Ash	Hydrogen	Carbon	Nitrogen	Oxygen	Sulfur	Kcal/kg	Btu/lb
D203113	15.1	35.3	46.1	3.5	6.2	62.9	1.5	25.5	0.5	6,180	11,130
	--	41.6	54.3	4.1	5.3	74.1	1.8	14.2	.6	7,280	13,100
	--	43.4	56.6	--	5.6	77.3	1.8	14.8	.6	7,590	13,670
D203114	14.1	32.5	43.9	9.5	5.9	58.8	1.3	23.9	.5	5,750	10,360
	--	37.8	51.1	11.1	5.0	68.5	1.5	13.2	.6	6,700	12,060
	--	42.5	57.5	--	5.7	77.0	1.7	14.9	.7	7,530	13,550
D203115	13.9	32.3	42.6	11.2	5.8	57.6	1.3	23.7	.4	5,610	10,110
	--	37.5	49.5	13.0	4.9	66.9	1.5	13.2	.5	6,520	11,740
	--	43.1	56.9	--	5.7	76.9	1.7	15.1	.5	7,500	13,490
D203120	10.1	33.6	44.9	11.4	5.5	59.7	1.4	21.5	.5	5,830	10,490
	--	37.4	49.9	12.7	4.9	66.4	1.6	13.9	.6	6,480	11,660
	--	42.8	57.2	--	5.6	76.1	1.8	16.0	.6	7,420	13,360
D203109	13.1	36.4	44.8	5.7	6.0	63.5	1.5	22.8	.6	6,230	11,210
	--	41.9	51.6	6.6	5.2	73.1	1.7	12.8	.7	7,160	12,900
	--	44.8	55.2	--	5.6	78.2	1.8	13.7	.7	7,670	13,800
D203110	12.8	37.7	44.0	5.5	6.1	64.0	1.3	22.8	.4	6,320	11,370
	--	43.2	50.5	6.3	5.4	73.4	1.5	13.1	.5	7,240	13,040
	--	46.1	53.9	--	5.7	78.3	1.6	14.0	.5	7,730	13,920
D203111	12.2	35.8	43.0	9.0	5.8	61.6	1.4	21.7	.5	6,060	10,920
	--	40.8	49.0	10.3	5.1	70.2	1.6	12.4	.6	6,910	12,430
	--	45.4	54.6	--	5.6	78.2	1.8	13.8	.6	7,700	13,850
D203112	11.8	36.3	42.6	9.3	5.7	61.5	1.4	21.5	.6	6,060	10,910
	--	41.2	48.3	10.5	5.0	69.7	1.6	12.5	.7	6,870	12,370
	--	46.0	54.0	--	5.6	77.9	1.8	14.0	.8	7,680	13,830
D203106	12.1	34.3	47.9	5.7	6.1	64.4	1.5	21.8	.5	6,340	11,410
	--	39.0	54.5	6.5	5.4	73.3	1.7	12.6	.6	7,210	12,990
	--	41.7	58.3	--	5.8	78.3	1.8	13.4	.6	7,710	13,890
D203107	12.4	37.2	43.0	7.4	5.8	62.7	1.4	22.1	.6	6,120	11,020
	--	42.5	49.1	8.4	5.0	71.6	1.6	12.6	.7	6,990	12,580
	--	46.4	53.6	--	5.5	78.2	1.7	13.8	.7	7,630	13,740
D203108	11.5	37.0	42.0	9.5	5.8	61.6	1.4	21.2	.6	6,090	10,970
	--	41.8	47.5	10.7	5.1	69.6	1.6	12.4	.7	6,890	12,390
	--	46.8	53.2	--	5.7	78.0	1.8	13.9	.8	7,710	13,880
D203100	14.2	31.5	39.5	14.8	5.5	54.2	1.2	23.6	.6	5,300	9,540
	--	36.7	46.0	17.2	4.6	63.2	1.4	12.8	.7	6,180	11,120
	--	44.4	55.6	--	5.5	76.3	1.7	15.5	.8	7,460	13,430

Table 2.--Proximate and ultimate analyses, and heat-of-combustion, forms-of-sulfur, free-swelling-index and ash-fusion-temperature determinations for 43 coal samples from the Mesaverde Formation, Grand Mesa coal field, Delta and Mesa Counties, Colorado
--continued

Sample number	Air-dried loss	Forms of sulfur			Free swelling	Ash fusion temperature, °C		
		Sulfate	Pyritic	Organic		Initial deformation	Softening	Fluid
D203113	11.0	0.01	0.04	0.42	0.0	1,155	1,205	1,265
	--	.01	.05	.49				
	--	.01	.05	.52				
D203114	10.3	.01	.04	.49	.0	1,515	1,600+	1,600+
	--	.01	.05	.57				
	--	.01	.05	.64				
D203115	10.2	.01	.04	.40	.0	1,600+	1,600+	1,600+
	--	.01	.05	.46				
	--	.01	.05	.53				
D203120	6.3	.01	.05	.42	.0	1,600+	1,600+	1,600+
	--	.01	.06	.47				
	--	.01	.06	.54				
D203109	9.0	.01	.10	.45	.0	1,270	1,320	1,380
	--	.01	.12	.52				
	--	.01	.12	.55				
D203110	8.7	.01	.04	.35	1.0	1,600+	1,600+	1,600+
	--	.01	.05	.40				
	--	.01	.05	.43				
D203111	8.1	.01	.04	.48	.0	1,600+	1,600+	1,600+
	--	.01	.05	.55				
	--	.01	.05	.61				
D203112	7.6	.01	.05	.51	.0	1,600+	1,600+	1,600+
	--	.01	.06	.58				
	--	.01	.06	.65				
D203106	7.9	.01	.06	.42	.0	1,600+	1,600+	1,600+
	--	.01	.07	.48				
	--	.01	.07	.51				
D203107	8.2	.01	.05	.53	.0	1,600+	1,600+	1,600+
	--	.01	.06	.61				
	--	.01	.06	.66				
D203108	6.9	.01	.04	.54	1.0	1,600+	1,600+	1,600+
	--	.01	.05	.61				
	--	.01	.05	.68				
D203100	8.1	.01	.03	.65	.0	1,345	1,400	1,455
	--	.01	.03	.76				
	--	.01	.04	.92				

Table 2.--Proximate and ultimate analyses, and heat-of-combustion, forms-of-sulfur, free-swelling-index and ash-fusion-temperature determinations for 43 coal samples from the Mesaverde Formation, Grand Mesa coal field, Delta and Mesa Counties, Colorado
 --continued

Sample number	Proximate analysis				Ultimate analysis				Heat of Combustion		
	Moisture	Volatile matter	Fixed carbon	Ash	Hydrogen	Carbon	Nitrogen	Oxygen	Sulfur	Kcal/kg	Btu/lb
D203102	14.8	30.2	38.3	16.7	5.3	52.6	1.2	23.9	0.4	5,120	9,220
	--	35.4	45.0	19.6	4.3	61.7	1.4	12.6	.5	6,010	10,820
	--	44.1	55.9	--	5.3	76.8	1.8	15.7	.6	7,470	13,450
D203103	11.1	22.9	24.6	41.4	4.1	35.7	.8	17.5	.5	3,440	6,200
	--	25.8	27.7	46.6	3.2	40.2	.9	8.6	.6	3,870	6,970
	--	48.2	51.8	--	6.0	75.2	1.7	16.1	1.1	7,250	13,040
D203105	14.7	28.7	38.6	18.0	5.4	51.2	1.1	23.6	.6	4,990	8,990
	--	33.6	45.3	21.1	4.4	60.0	1.3	12.3	.7	5,850	10,530
	--	42.6	57.4	--	5.6	76.1	1.6	15.7	.9	7,420	13,350
D203095	13.8	31.4	45.1	9.7	5.5	59.1	1.4	23.7	.6	5,790	10,420
	--	36.4	52.3	11.3	4.6	68.6	1.6	13.3	.7	6,710	12,080
	--	41.0	59.0	--	5.2	77.3	1.8	14.9	.8	7,560	13,620
D203096	19.2	31.3	41.0	8.5	6.1	55.2	1.3	28.3	.6	5,380	9,680
	--	38.7	50.7	10.5	4.9	68.3	1.6	13.9	.7	6,660	11,990
	--	43.3	56.7	--	5.5	76.3	1.8	15.5	.8	7,440	13,400
D203098	18.9	32.3	37.9	10.9	6.0	53.3	1.3	27.7	.8	5,200	9,370
	--	39.8	46.7	13.4	4.8	65.7	1.6	13.4	1.0	6,420	11,550
	--	46.0	54.0	--	5.6	75.9	1.9	15.5	1.1	7,410	13,340
D203099	16.6	33.8	41.3	8.3	5.9	57.2	1.3	25.6	1.6	5,630	10,140
	--	40.5	49.5	10.0	4.9	68.6	1.6	13.0	1.9	6,750	12,160
	--	45.0	55.0	--	5.4	76.2	1.7	14.4	2.1	7,500	13,500
D203091	18.8	30.4	33.5	17.3	5.4	47.8	1.1	27.4	1.0	4,610	8,300
	--	37.4	41.3	21.3	4.1	58.9	1.4	13.2	1.2	5,680	10,220
	--	47.6	52.4	--	5.2	74.8	1.7	16.7	1.6	7,210	12,990
D203092	19.5	31.6	38.5	10.4	6.0	53.1	1.2	28.3	1.0	5,180	9,320
	--	39.3	47.8	12.9	4.8	66.0	1.5	13.6	1.2	6,430	11,580
	--	45.1	54.9	--	5.5	75.7	1.7	15.6	1.4	7,390	13,290
D203093	19.6	31.2	34.0	15.2	5.7	48.8	1.1	28.7	.6	4,750	8,550
	--	38.8	42.3	18.9	4.4	60.7	1.4	14.0	.7	5,910	10,640
	--	47.9	52.1	--	5.4	74.8	1.7	17.3	.9	7,290	13,120
D203094	20.2	30.7	39.7	9.4	6.1	53.3	1.1	28.9	1.2	5,240	9,420
	--	38.5	49.7	11.8	4.8	66.8	1.4	13.7	1.5	6,560	11,810
	--	43.6	56.4	--	5.5	75.7	1.6	15.5	1.7	7,440	13,390
D203089	19.1	30.4	39.7	10.8	5.8	53.0	1.2	28.7	.5	5,120	9,220
	--	37.6	49.1	13.3	4.5	65.5	1.5	14.5	.6	6,330	11,400
	--	43.4	56.6	--	5.2	75.6	1.7	16.7	.7	7,310	13,150

Table 2.--Proximate and ultimate analyses, and heat-of-combustion, forms-of-sulfur, free-swelling-index and ash-fusion-temperature determinations for 43 coal samples from the Mesaverde Formation, Grand Mesa coal field, Delta and Mesa Counties, Colorado
 --continued

Sample number	Air-dried loss	Forms of sulfur			Free swelling	Ash fusion temperature, °C		
		Sulfate	Pyritic	Organic		Initial deformation	Softening	Fluid
D203102	8.8	0.01	0.03	0.35	0.0	1,290	1,345	1,400
	--	.01	.04	.41				
	--	.01	.04	.51				
D203103	8.9	.01	.14	.38	.0	1,375	1,440	1,495
	--	.01	.16	.43				
	--	.02	.29	.80				
D203105	11.8	.01	.12	.44	.0	1,600+	1,600+	1,600+
	--	.01	.14	.52				
	--	.01	.18	.65				
D203095	7.6	.01	.03	.58	.0	1,600+	1,600+	1,600+
	--	.01	.03	.67				
	--	.01	.04	.76				
D203096	11.5	.01	.04	.51	.0	1,600+	1,600+	1,600+
	--	.01	.05	.63				
	--	.01	.06	.71				
D203098	11.6	.01	.03	.75	.0	1,600+	1,600+	1,600+
	--	.01	.04	.92				
	--	.01	.04	1.07				
D203099	9.5	.01	.94	.62	.0	1,125	1,180	1,230
	--	.01	1.13	.74				
	--	.01	1.25	.83				
D203091	10.9	.01	.03	.94	.0	1,320	1,380	1,435
	--	.01	.04	1.16				
	--	.02	.05	1.47				
D203092	11.6	.01	.09	.91	.0	1,235	1,290	1,345
	--	.01	.11	1.13				
	--	.01	.13	1.30				
D203093	12.2	.01	.05	.54	.0	1,600+	1,600+	1,600+
	--	.01	.06	.67				
	--	.02	.08	.83				
D203094	13.5	.01	.05	1.12	.0	1,205	1,265	1,325
	--	.01	.06	1.40				
	--	.01	.07	1.59				
D203089	11.2	.01	.04	.49	.0	1,345	1,400	1,450
	--	.01	.05	.61				
	--	.01	.06	.70				

Table 2.--Proximate and ultimate analyses, and heat-of-combustion, forms-of-sulfur, free-swelling-index and ash-fusion-temperature determinations for 43 coal samples from the Mesaverde Formation, Grand Mesa coal field, Delta and Mesa Counties, Colorado
--continued

Sample number	Proximate analysis				Ultimate analysis					Heat of Combustion	
	Moisture	Volatile matter	Fixed carbon	Ash	Hydrogen	Carbon	Nitrogen	Oxygen	Sulfur	Kcal/kg	Btu/lb
D203090	19.4	31.2	38.3	11.1	5.9	52.3	1.3	28.7	0.8	5,090	9,160
	--	38.7	47.5	13.8	4.6	64.9	1.6	14.2	1.0	6,320	11,370
	--	44.9	55.1	--	5.4	75.3	1.9	16.5	1.2	7,330	13,190
D180095	5.1	29.8	41.8	23.3	4.5	56.0	1.2	13.9	1.2	5,460	9,830
	--	31.4	44.0	24.6	4.1	59.0	1.3	9.9	1.3	5,760	10,360
	--	41.6	58.4	--	5.5	78.2	1.7	13.1	1.7	7,630	13,730
D184655	5.5	35.4	47.3	11.8	5.0	66.1	1.5	15.0	.6	6,470	11,650
	--	37.5	50.1	12.5	4.6	69.9	1.6	10.7	.6	6,850	12,330
	--	42.8	57.2	--	5.3	79.9	1.8	12.2	.7	7,830	14,090
D203087	15.3	35.9	38.6	10.2	5.9	57.8	1.2	24.3	.5	5,540	9,970
	--	42.4	45.6	12.0	5.0	68.2	1.4	12.6	.6	6,540	11,780
	--	48.2	51.8	--	5.6	77.6	1.6	14.4	.7	7,440	13,390
D203088	14.2	31.7	36.2	17.9	5.6	51.9	1.2	22.8	.6	5,030	9,060
	--	36.9	42.2	20.9	4.7	60.5	1.4	11.9	.7	5,870	10,560
	--	46.7	53.3	--	5.9	76.4	1.8	15.0	.9	7,410	13,340
D203083	3.5	35.4	46.4	14.7	5.4	66.6	1.5	11.1	.8	6,630	11,930
	--	36.7	48.1	15.2	5.2	69.0	1.6	8.3	.8	6,870	12,360
	--	43.3	56.7	--	6.1	81.4	1.8	9.8	1.0	8,100	14,590
D203084	3.0	34.5	47.5	15.0	5.4	66.8	1.4	10.5	.9	6,630	11,940
	--	35.6	49.0	15.5	5.2	68.9	1.4	8.1	.9	6,840	12,310
	--	42.1	57.9	--	6.2	81.5	1.7	9.6	1.1	8,090	14,560
D203086	2.5	38.7	51.5	7.3	5.7	74.2	1.8	8.7	2.2	7,490	13,490
	--	39.7	52.8	7.5	5.6	76.1	1.8	6.6	2.3	7,690	13,830
	--	42.9	57.1	--	6.0	82.3	2.0	7.2	2.4	8,310	14,950

Table 2.--Proximate and ultimate analyses, and heat-of-combustion, forms-of-sulfur, free-swelling-index and ash-fusion-temperature determinations for 43 coal samples from the Mesaverde Formation, Grand Mesa coal field, Delta and Mesa Counties, Colorado
--continued

Sample number	Air-dried loss	Forms of sulfur			Free swelling	Ash fusion temperature, °C		
		Sulfate	Pyritic	Organic		Initial deformation	Softening	Fluid
D203090	11.7	0.01	0.05	0.71	0.0	1,235	1,290	1,345
	--	.01	.06	.88				
	--	.01	.07	1.02				
D180095	1.6	.06	.57	.53	1.0	1,400	1,445	1,495
	--	.06	.60	.56				
	--	.08	.80	.74				
D184655	1.6	.01L	.04	.54	1.0	1,350	1,405	1,465
	--	.01L	.04	.57				
	--	.01L	.05	.65				
D203087	9.2	.01	.15	.34	.0	1,180	1,235	1,290
	--	.01	.18	.40				
	--	.01	.20	.46				
D203088	8.3	.01	.29	.34	.0	1,375	1,435	1,490
	--	.01	.34	.40				
	--	.01	.43	.50				
D203083	.9	.01	.15	.60	3.0	1,480	1,540	1,595
	--	.01	.16	.62				
	--	.01	.18	.73				
D203084	.6	.01	.39	.52	2.5	1,600+	1,600+	1,600+
	--	.01	.40	.54				
	--	.01	.48	.63				
D203086	.4	.02	1.55	.59	5.0	1,155	1,205	1,270
	--	.02	1.59	.61				
	--	.02	1.72	.65				

Table 3.--Major- and minor-oxide and trace element composition of the laboratory ash of 45 coal samples from the Mesaverde Formation, Grand Mesa coal field, Delta and Mesa Counties, Colorado

[Values in percent or parts per million. Coal ashed at 525° C. L, less than the value shown; N not detected; B, not determined. S after element title indicates determinations by semiquantitative emission spectrography. The spectrographic results are to be identified with geometric brackets whose boundaries are part of the ascending series 0.12, 0.18, 0.26, 0.38, 0.56, 0.83, 1.2, etc. but reported as midpoints of the brackets, 0.1, 0.15, 0.2, 0.3, 0.5, 0.7, 1.0, etc. Precision of the spectrographic data is plus-or-minus one bracket at 68 percent or plus-or-minus two brackets at 95 percent confidence level]

Sample number	Ash (percent)	SiO ₂ (percent)	Al ₂ O ₃ (percent)	CaO (percent)	MgO (percent)	Na ₂ O (percent)	K ₂ O (percent)	Fe ₂ O ₃ (percent)	TiO ₂ (percent)	P ₂ O ₅ (percent)	Sample number
D191607	19.8	55	34	2.2	0.63	0.86	0.89	0.60	1.1	1.0L	D191607
D194452	12.2	51	30	2.3	2.86	.30	.40	5.8	1.2	1.0L	D194452
D194453	13.6	49	30	1.9	3.00	.70	.50	7.1	1.0	1.0L	D194453
D194454	9.8	52	35	1.9	1.89	.36	.30	1.5	1.3	1.0L	D194454
D194455	9.7	50	34	1.5	2.17	.46	.40	3.2	1.3	1.0L	D194455
D194456	16.4	51	33	1.5	1.32	.27	.30	3.3	1.1	1.0L	D194456
D194457	10.8	53	31	1.9	1.38	.28	.50	1.6	1.3	1.0L	D194457
D203116	3.8	43	21	5.2	.94	6.61	.36	6.1	.96	1.3	D203116
D203117	6.5	51	28	3.1	.75	4.19	.41	3.6	.99	1.1	D203117
D203118	9.8	58	25	2.1	.55	1.95	.77	2.4	1.1	1.4	D203118
D203119	11.2	60	26	1.4	.61	1.81	.96	3.3	1.1	.45	D203119
D203113	3.7	36	25	6.6	1.10	6.75	.12	5.1	1.2	2.9	D203113
D203114	10.7	49	30	2.5	.75	2.17	.64	5.9	1.2	.65	D203114
D203115	12.9	49	34	1.4	.56	2.02	.37	2.9	1.1	.080L	D203115
D203120	13.1	49	30	2.8	1.10	.85	.47	8.2	1.1	.080	D203120
D203109	6.7	47	25	3.9	.76	2.66	.36	8.0	1.0	1.8	D203109
D203110	6.5	51	36	1.8	.35	2.38	.24	1.9	1.3	.46	D203110
D203111	10.8	64	28	.84	.25	1.84	.79	.84	1.2	.090L	D203111
D203112	9.9	54	36	1.3	.30	2.03	.30	1.9	1.3	.20	D203112
D203106	6.7	49	34	2.9	.31	2.70	.24	2.6	1.2	.90	D203106
D203107	8.5	51	36	1.1	.25	2.38	.24	1.8	1.4	.11L	D203107
D203108	10.8	54	34	1.0	.28	1.93	.39	1.1	1.2	.090L	D203108
D203100	16.6	64	21	2.4	1.34	.53	2.2	4.4	.92	.060	D203100
D203102	18.5	64	21	2.8	1.34	.68	1.8	4.3	.88	.32	D203102
D203103	43.3	71	17	2.2	1.25	1.26	1.9	2.1	.68	.070	D203103
D203105	19.7	62	25	2.0	1.21	.55	1.6	3.2	.93	.050L	D203105
D203095	11.1	54	34	1.2	.33	1.90	.37	1.4	1.1	.090L	D203095
D203096	10.5	45	32	4.8	1.31	2.10	.24	1.6	1.1	.59	D203096
D203098	14.3	54	26	3.8	1.00	1.15	.84	2.6	.91	.070	D203098
D203099	8.9	36	19	6.7	1.49	.62	.060	22	.73	.11	D203099
D203091	19.1	51	26	2.8	.85	2.60	.54	5.0	.87	.050L	D203091
D203092	12.5	45	26	8.3	.86	2.38	.43	4.0	.89	.48	D203092
D203093	18.5	51	32	3.4	.75	1.65	.84	3.1	.84	.050L	D203093
D203094	12.8	60	14	4.6	1.00	2.35	.46	8.2	.65	.23	D203094
D203089	12.4	49	26	5.6	1.10	3.78	.37	2.9	.77	.080L	D203089
D203090	12.2	49	23	5.6	1.18	2.66	.90	5.6	.90	.080L	D203090
D180095	20.1	36	23	13	2.70	.58	.23	2.5	.72	1.0L	D180095
D180096	34.7	51	28	2.9	1.19	.49	.87	4.1	.78	1.0L	D180096
D184655	7.2	48	31	3.4	.83	.91	.29	4.6	1.6	1.0L	D184655
D184656	20.2	29	20	27	3.55	.64	.17	3.4	.73	1.0L	D184656

Table 3.--Major- and minor-oxide and trace element composition of the laboratory ash of 45 coal samples from the Mesaverde Formation, Grand Mesa coal field, Delta and Mesa Counties, Colorado--continued

Sample number	SO ₃ (percent)	B-S (ppm)	Ba-S (ppm)	Be-S (ppm)	Cd (ppm)	Cu (ppm)	Ga-S (ppm)	Ge-S (ppm)	La-S (ppm)	Li (ppm)	Sample number
D191607	1.1	700	2,000	.10	1.0L	63	70	N	70	121	D191607
D194452	1.7	1,500	3,000	3	1.0L	80	70	N	150	89	D194452
D194453	1.7	1,500	3,000	3	1.0L	65	50	N	100	112	D194453
D194454	1.1	1,500	2,000	5	1.0L	83	70	N	100	127	D194454
D194455	1.4	1,500	5,000	5	1.0L	75	70	N	70	144	D194455
D194456	1.1	1,000	2,000	5	1.0L	53	70	N	100	195	D194456
D194457	.90	1,500	1,500	5	1.0L	90	70	N	70	119	D194457
D203116	8.0	5,000	10,000	3	1.0	114	50	N	100L	59	D203116
D203117	2.2	2,000	7,000	15	1.0L	66	70	N	100L	100	D203117
D203118	1.7	1,500	5,000	7	1.0	76	70	N	100L	133	D203118
D203119	1.3	1,000	3,000	3	1.0	82	50	N	100L	101	D203119
D203113	7.3	3,000	10,000	15	2.0	100	70	70	100L	125	D203113
D203114	1.7	1,500	3,000	3	1.0	76	70	N	100	125	D203114
D203115	.50	1,000	3,000	3	1.0L	61	70	N	100	147	D203115
D203120	1.8	1,000	5,000	7	1.0	66	50	N	100L	110	D203120
D203109	2.5	1,500	2,000	3	1.0	88	30	N	100L	94	D203109
D203110	.50	2,000	2,000	3	2.0	87	70	N	150	139	D203110
D203111	.50	1,000	1,500	7	1.0	73	50	N	100L	129	D203111
D203112	.54	1,000	2,000	7	1.0	87	50	N	100L	186	D203112
D203106	.75	1,500	1,500	10	1.0	83	70	N	100	137	D203106
D203107	.50	1,500	1,000	15	1.0L	104	50	20L	100L	194	D203107
D203108	.30	1,000	1,000	10	1.0	84	70	20	100L	168	D203108
D203100	1.9	700	1,500	10	1.0L	66	30	N	500	53	D203100
D203102	1.9	700	1,000	3	1.0L	60	30	N	N	63	D203102
D203103	1.3	150	1,500	N	1.0L	35	30	N	100L	46	D203103
D203105	1.5	500	1,000	3	1.0L	68	30	N	100L	88	D203105
D203095	.75	700	5,000	7	1.0L	80	70	20L	100L	152	D203095
D203096	2.4	1,000	5,000	3	1.0	76	50	N	100L	294	D203096
D203098	2.5	700	3,000	10	1.0L	86	70	N	100L	86	D203098
D203099	7.0	1,500	1,000	15	1.0L	50	50	30	100L	85	D203099
D203091	2.5	700	2,000	7	1.0	61	50	N	100L	93	D203091
D203092	4.3	1,000	7,000	7	1.0	73	70	N	100L	135	D203092
D203093	1.4	700	2,000	7	1.0L	46	50	N	100L	90	D203093
D203094	7.5	1,000	2,000	7	1.0L	43	30	N	N	100	D203094
D203089	3.8	1,500	2,000	5	1.0L	51	50	N	100L	79	D203089
D203090	5.3	1,000	1,500	7	1.0L	83	50	N	100L	108	D203090
D180095	3.2	300	1,000	5	1.0L	37	30	N	100L	137	D180095
D180096	2.3	150	700	5	1.0L	37	30	N	100	156	D180096
D184655	2.4	1,000	1,000	15	1.0L	116	30	20	100L	180	D184655
D184656	4.4	300	1,000	3	1.0L	33	20	N	100L	120	D184656

Table 3.--Major- and minor-oxide and trace element composition of the laboratory ash of 45 coal samples from the Mesaverde Formation, Grand Mesa coal field, Delta and Mesa Counties, Colorado--continued

Sample number	Mn (ppm)	Mo-S (ppm)	Nb-S (ppm)	Ni-S (ppm)	Pb (ppm)	Sc-S (ppm)	Sr-S (ppm)	V-S (ppm)	Y-S (ppm)	Yb-S (ppm)	Sample number
D191607	40	N	20	15	65	10	300	70	30	3	D191607
D194452	440	7	30	15	55	20	700	100	70	5	D194452
D194453	480	7	30	15	60	15	700	70	50	5	D194453
D194454	210	7	30	15	65	20	700	100	50	5	D194454
D194455	160	7	20	20	55	20	700	150	70	5	D194455
D194456	70	7L	30	10L	70	20	500	70	70	5	D194456
D194457	185	10	30	30	50	20	500	150	50	5	D194457
D203116	140	30	N	50	44	15	3,000	150	50	5	D203116
D203117	63	20	30	30	61	15	2,000	150	50	5	D203117
D203118	85	15	N	50	50	15	2,000	150	30	3	D203118
D203119	67	15	30	30	51	20	2,000	150	30	3	D203119
D203113	220	10	20	100	51	20	5,000	150	50	5	D203113
D203114	440	7	20	15	109	15	2,000	150	50	5	D203114
D203115	115	7	30	20	51	15	1,000	100	30	3	D203115
D203120	1,120	7	30	20	45	15	1,500	70	30	3	D203120
D203109	110	30	N	30	50	10	1,000	100	30	3	D203109
D203110	27	N	N	15	85	10	1,000	100	50	3	D203110
D203111	22	N	N	30	71	15	300	70	30	3	D203111
D203112	31	7	30	30	67	15	700	150	50	5	D203112
D203106	45	7	20	20	90	15	700	70	50	3	D203106
D203107	36	7	30	30	71	15	500	150	30	3	D203107
D203108	36	7	30	30	282	15	300	100	50	3	D203108
D203100	155	7	20	30	47	15	300	150	30	3	D203100
D203102	215	N	N	15	49	10	200	70	30	3	D203102
D203103	220	N	20	15	26	10L	150	70	30	3	D203103
D203105	180	7L	20	30	49	15	200	150	30	3	D203105
D203095	67	7	30	30	82	15	500	100	30	3	D203095
D203096	140	7	20	20	101	15	2,000	70	30	3	D203096
D203098	105	7	30	20	55	15	1,000	150	50	5	D203098
D203099	470	N	20	20	29	20	1,000	70	70	7	D203099
D203091	105	10	20	30	51	15	700	100	50	5	D203091
D203092	295	15	20	30	48	15	2,000	100	50	5	D203092
D203093	155	7	30	15	45	15	700	70	70	7	D203093
D203094	420	7	20	15	33	15	1,000	70	30	3	D203094
D203089	190	10	20	20	58	15	1,000	70	50	5	D203089
D203090	220	10	20	30	73	15	1,000	100	50	5	D203090
D180095	95	7	30	10L	50	10	500	70	70	7	D180095
D180096	50	7	30	15	75	10	300	100	50	5	D180096
D184655	120	7	70	20	70	20	150	150	100	10	D184655
D184656	80	7	30	10L	35	15	700	50	70	7	D184656

Table 3.--Major- and minor-oxide and trace element composition of the laboratory ash of 45 coal samples from the Mesa Verde Formation, Grand Mesa coal field, Delta and Mesa Counties, Colorado--continued

Sample number	Zn (ppm)	Zr-S (ppm)
D191607	80	300
D194452	89	200
D194453	58	200
D194454	79	300
D194455	66	300
D194456	55	300
D194457	92	300
D203116	72	200
D203117	54	200
D203118	55	200
D203119	75	300
D203113	59	300
D203114	254	300
D203115	75	300
D203120	88	300
D203109	81	150
D203110	73	300
D203111	73	300
D203112	76	300
D203106	125	300
D203107	93	300
D203108	182	300
D203100	163	300
D203102	102	300
D203103	91	200
D203105	116	200
D203095	102	300
D203096	66	300
D203098	63	300
D203099	230	300
D203091	137	300
D203092	111	300
D203093	72	300
D203094	175	300
D203089	108	300
D203090	179	300
D180095	46	200
D180096	115	200
D184655	98	500
D184656	59	200

Table 3.--Major- and minor-oxide and trace element composition of the laboratory ash of 45 coal samples from the Mesaverde Formation, Grand Mesa coal field, Delta and Mesa Counties, Colorado--continued

Sample number	Ash (percent)	SiO ₂ (percent)	Al ₂ O ₃ (percent)	CaO (percent)	MgO (percent)	Na ₂ O (percent)	K ₂ O (percent)	Fe ₂ O ₃ (percent)	TiO ₂ (percent)	P ₂ O ₅ (percent)	Sample number
D203087	13.7	21	12	35	1.25	0.68	0.020L	5.4	0.62	1.0	D203087
D203088	20.2	43	26	8.4	1.52	.30	.41	6.9	.85	.050L	D203088
D203083	15.0	56	25	5.7	1.39	.70	.37	3.2	.80	.13	D203083
D203084	15.2	56	34	1.2	.15	.45	.32	3.1	1.0	.72	D203084
D203086	7.9	43	21	1.4	.25	.93	.24	23	.89	.38	D203086

Sample number	S ₀ (percent)	B-S (ppm)	Ba-S (ppm)	Be-S (ppm)	Cd (ppm)	Cu (ppm)	Ga-S (ppm)	Ge-S (ppm)	La-S (ppm)	Li (ppm)	Sample number
D203087	7.0	1,000	3,000	3	1.0L	46	30	N	N	42	D203087
D203088	2.2	500	1,000		1.0L	46	50	N	N	108	D203088
D203083	1.6	300	700	3	1.0L	65	30	N	100L	105	D203083
D203084	.20	300	700	5	1.0L	56	50	N	100L	195	D203084
D203086	.80	700	300	7	1.0L	66	50	30	100L	133	D203086

Sample number	Mn (ppm)	Mo-S (ppm)	Nb-S (ppm)	Ni-S (ppm)	Pb (ppm)	Sc-S (ppm)	Sr-S (ppm)	V-S (ppm)	Y-S (ppm)	Yb-S (ppm)	Sample number
D203087	310	7	N	10	40	10	2,000	70	30	3	D203087
D203088	1,830	7L	N	10L	56	15	300	70	30	3	D203088
D203083	71	10	30	15	57	10	500	70	30	3	D203083
D203084	31	7	30	20	70	15	700	70	50	3	D203084
D203086	175	15	30	30	65	15	700	70	70	5	D203086

Sample number	Zn (ppm)	Zr-S (ppm)
D203087	68	150
D203088	58	300
D203083	117	200
D203084	54	300
D203086	95	200

Table 4.--Contents of nine trace elements in 45 coal samples from the Mesaverde Formation, Grand Mesa coal field,
Delta and Mesa Counties, Colorado

[Analyses in air-dried (32°C) coal. L, less than the value shown]

Sample number	As (ppm)	Co (ppm)	Cr (ppm)	F (ppm)	Hg (ppm)	Sb (ppm)	Se (ppm)	Th (ppm)	U (ppm)	Sample number
D191607	0.1L	1.7	3.5	100	0.06	0.8	1.7	7.5	3.0	D191607
D194452	.9	1.0	3.1	60	.06	.3	1.4	3.3	2.2	D194452
D194453	2.1	1.4	2.5	55	.12	.3	1.4	4.1	2.1	D194453
D194454	.7	1.4	1.9	80	.02	.2	.9	2.2	1.2	D194454
D194455	1.3	1.2	2.7	55	.06	.5	1.1	2.7	1.7	D194455
D194456	1.2	1.1	2.4	25	.14	.2	1.3	5.4	2.1	D194456
D194457	.6	2.1	3.0	45	.04	.2	1.9	2.2	1.1	D194457
D203116	.8	.6	1.3	30	.01	.2	.4	.6	.6	D203116
D203117	.2	.9	.1L	60	.01	.5	.6	1.7	.7	D203117
D203118	.3	1.6	4.2	60	.02	.5	1.1	1.8	1.4	D203118
D203119	.3	1.3	4.2	60	.04	.3	1.1	1.7	.9	D203119
D203113	.3	1.8	1.4	30	.01	.6	.6	.7	.3	D203113
D203114	.4	1.3	2.9	60	.02	.3	1.0	2.4	.9	D203114
D203115	.2	1.6	2.8	50	.01	.1	1.1	2.9	.9	D203115
D203120	.5	1.4	.1L	65	.01L	.3	1.2	2.9	1.0	D203120
D203109	.6	1.0	1.8	120	.02	.3	.5	1.2	1.0	D203109
D203110	.2	1.0	1.8	35	.01	.2	.8	1.9	.6	D203110
D203111	.5	2.1	3.3	35	.04	1.3	1.1	1.8	.6	D203111
D203112	.4	1.5	3.0	40	.02	.8	1.3	2.9	1.2	D203112
D203106	.2	.9	1.7	70	.02	.5	.8	2.2	.8	D203106
D203107	.1L	1.4	2.0	30	.02	.8	1.0	1.6	.8	D203107
D203108	.4	1.7	3.0	45	.03	1.2	1.3	2.8	1.3	D203108
D203100	.8	2.0	.1L	135	.03	1.3	.7	2.8	2.3	D203100
D203102	1.3	2.3	8.9	155	.02	.5	1.0	3.2	1.2	D203102
D203103	3.3	3.7	13	190	.04	.8	1.0	6.3	2.7	D203103
D203105	3.8	2.6	7.6	100	.04	.7	1.2	3.9	2.1	D203105
D203095	.8	1.5	3.8	25	.03	1.1	1.5	3.5	1.6	D203095
D203096	.5	1.3	2.8	50	.02	.3	1.4	2.9	1.3	D203096
D203098	1.7	1.7	5.6	50	.06	1.1	2.0	5.6	3.1	D203098
D203099	.9	1.3	3.1	20	.07	.1	1.0	1.4	.5	D203099
D203091	5.9	2.6	7.2	100	.14	.9	.1L	4.8	2.3	D203091
D203092	1.9	1.7	4.1	40	.05	.7	1.3	3.2	1.7	D203092
D203093	3.6	1.8	5.2	65	.05	.5	1.3	6.8	2.8	D203093
D203094	1.4	.9	4.7	20L	.11	.1	1.1	1.3	.9	D203094
D203089	.9	1.5	2.8	50	.03	.4	.9	3.2	1.5	D203089
D203090	2.9	1.6	5.2	40	.07	1.0	1.6	2.2	1.7	D203090
D180095	.5	2.0L	4.0	40	.06	.4	1.6	6.4	2.3	D180095
D180096	7.0	3.7L	11	150	.27	.6	3.1	7.2	5.4	D180096
D184655	.4	.9	.1L	40	.01	.9	1.1	2.6	1.0	D184655
D184656	.4	.8	2.8	70	.01	.1L	1.2	4.9	1.8	D184656

Table 4.--Contents of nine trace elements in 45 coal samples from the Mesaverde Formation, Grand Mesa coal field, Delta and Mesa Counties, Colorado--continued

Sample number	As (ppm)	Co (ppm)	Cr (ppm)	F (ppm)	Hg (ppm)	Sb (ppm)	Se (ppm)	Th (ppm)	U (ppm)	Sample number
D203087	0.3	1.0	3.0	130	0.02	0.3	1.0	1.6	1.0	D203087
D203088	2.7	1.2	4.0	50	.04	.5	1.5	5.0	1.9	D203088
D203083	2.4	1.7	3.9	85	.07	.7	1.4	3.7	1.9	D203083
D203084	5.0	1.5	4.5	105	.10	.4	1.8	4.8	2.1	D203084
D203086	4.4	1.0	3.7	35	.20	.3	1.8	1.8	.8	D203086

Table 5.--Major-, minor-, and trace-element composition of 45 coal samples from the Mesaverde Formation, Grand Mesa coal field, Delta and Mesa Counties, Colorado

[Values in percent or parts per million. As, Co, Cr, F, Hg, Sb, Se, Th, and U values are from direct determinations on air-dried (32°C) coal; all other values calculated from analyses of coal ash. S means analysis by emission spectrography; L, less than the value shown; N, not detected; B, not determined.]

Sample number	Si (percent)	Al (percent)	Ca (percent)	Mg (percent)	Na (percent)	K (percent)	Fe (percent)	Ti (percent)	As (ppm)	B-S (ppm)	Sample number
D191607	5.1	3.6	0.31	0.075	0.13	0.15	0.083	0.13	0.1L	150	D191607
D194452	2.9	1.9	.20	.21	.027	.041	.49	.088	.9	200	D194452
D194453	3.1	2.2	.18	.25	.071	.057	.67	.081	2.1	200	D194453
D194454	2.4	1.8	.13	.11	.026	.024	.10	.076	.7	150	D194454
D194455	2.3	1.7	.10	.13	.033	.032	.22	.076	1.3	150	D194455
D194456	3.9	2.9	.18	.13	.033	.041	.38	.11	1.2	150	D194456
D194457	2.7	1.8	.15	.090	.022	.045	.12	.084	.6	150	D194457
D203116	.76	.42	.14	.022	.19	.011	.16	.022	.8	200	D203116
D203117	1.5	.96	.14	.029	.20	.022	.16	.039	.2	150	D203117
D203118	2.7	1.3	.15	.032	.14	.063	.16	.065	.3	150	D203118
D203119	3.1	1.5	.11	.041	.15	.090	.26	.074	.3	100	D203119
D203113	.62	.49	.17	.025	.19	.004	.13	.027	.3	100	D203113
D203114	2.4	1.7	.19	.048	.17	.057	.44	.077	.4	150	D203114
D203115	3.0	2.3	.13	.043	.19	.040	.26	.085	.2	150	D203115
D203120	3.0	2.1	.26	.087	.083	.051	.75	.086	.5	150	D203120
D203109	1.5	.89	.19	.031	.13	.020	.37	.040	.6	100	D203109
D203110	1.5	1.2	.084	.014	.11	.013	.086	.051	.2	150	D203110
D203111	3.2	1.6	.065	.016	.15	.071	.063	.078	.5	100	D203111
D203112	2.5	1.9	.092	.018	.15	.025	.13	.077	.4	100	D203112
D203106	1.5	1.2	.14	.013	.13	.013	.12	.048	.2	100	D203106
D203107	2.0	1.6	.067	.013	.15	.017	.11	.071	.1L	150	D203107
D203108	2.7	1.9	.077	.018	.15	.035	.083	.078	.4	100	D203108
D203100	5.0	1.8	.28	.13	.065	.30	.51	.091	.8	100	D203100
D203102	5.5	2.1	.37	.15	.093	.28	.56	.098	1.3	150	D203102
D203103	14	3.9	.68	.33	.40	.69	.64	.18	3.3	70	D203103
D203105	5.7	2.6	.28	.14	.080	.26	.44	.11	3.8	100	D203105
D203095	2.8	2.0	.095	.022	.16	.034	.11	.073	.8	70	D203095
D203096	2.2	1.8	.36	.083	.16	.021	.12	.069	.5	100	D203096
D203098	3.6	2.0	.39	.086	.12	.10	.26	.078	1.7	100	D203098
D203099	1.5	.89	.43	.080	.041	.004	1.4	.039	.9	150	D203099
D203091	4.5	2.6	.38	.098	.37	.086	.67	.10	5.9	150	D203091
D203092	2.6	1.7	.74	.065	.22	.045	.35	.067	1.9	150	D203092
D203093	4.4	3.1	.45	.084	.23	.13	.40	.093	3.6	150	D203093
D203094	3.6	.95	.42	.077	.22	.049	.73	.050	1.4	150	D203094
D203089	2.8	1.7	.50	.082	.35	.038	.25	.057	.9	200	D203089
D203090	2.8	1.5	.49	.087	.24	.091	.48	.066	2.9	150	D203090
D180095	3.4	2.5	1.9	.33	.086	.039	.35	.087	.5	70	D180095
D180096	8.2	5.1	.71	.25	.13	.25	1.0	.16	7.0	50	D180096
D184655	1.6	1.2	.17	.036	.049	.017	.23	.069	.4	70	D184655
D184656	2.7	2.1	3.9	.43	.096	.029	.48	.088	.4	70	D184656

Table. 5--Major-, minor-, and trace-element composition of 45 coal samples from the Mesaverde Formation, Grand Mesa coal field, Delta and Mesa Counties, Colorado--continued

Sample number	Ba-S (ppm)	Be-S (ppm)	Cd (ppm)	Co (ppm)	Cr (ppm)	Cu (ppm)	P (ppm)	Ga-S (ppm)	Ge-S (ppm)	Hg (ppm)	Sample number
D191607	500	2	0.20L	1.7	3.5	12	100	15	N	0.06	D191607
D194452	300	.3	.12L	1.0	3.1	9.8	60	10	N	.06	D194452
D194453	500	.5	.14L	1.4	2.5	8.8	55	7	N	.12	D194453
D194454	200	.5	.10L	1.4	1.9	8.1	80	7	N	.02	D194454
D194455	500	.5	.10L	1.2	2.7	7.3	55	7	N	.06	D194455
D194456	300	.7	.16L	1.1	2.4	8.7	25	10	N	.14	D194456
D194457	150	.5	.11L	2.1	3.0	9.7	45	7	N	.04	D194457
D203116	300	1	.04	.6	1.3	4.3	30	2	N	.01	D203116
D203117	500	1	.07L	.9	.1L	4.3	60	5	N	.01	D203117
D203118	500	.7	.10	1.6	4.2	7.4	60	7	N	.02	D203118
D203119	300	.3	.11	1.3	4.2	9.2	60	5	N	.04	D203119
D203113	300	.5	.07	1.8	1.4	3.7	30	2	2	.01	D203113
D203114	300	.3	.11	1.3	2.9	8.1	60	7	N	.02	D203114
D203115	500	.5	.13L	1.6	2.8	7.9	50	10	N	.01	D203115
D203120	700	1	.13	1.4	.1L	8.6	65	7	N	.01L	D203120
D203109	150	.2	.07	1.0	1.8	5.9	120	2	N	.02	D203109
D203110	150	.2	.13	1.0	1.8	5.7	35	5	N	.01	D203110
D203111	150	.7	.11	2.1	3.3	7.9	35	5	N	.04	D203111
D203112	200	.7	.10	1.5	3.0	8.6	40	5	N	.02	D203112
D203106	100	.7	.07	.9	1.7	5.6	70	5	N	.02	D203106
D203107	100	1.5	.09L	1.4	2.0	8.8	30	5	1.5L	.02	D203107
D203108	100	1	.11	1.7	3.0	9.1	45	7	2	.03	D203108
D203100	200	1.5	.17L	2.0	.1L	11	135	5	N	.03	D203100
D203102	200	.5	.19L	2.3	8.9	11	155	5	N	.02	D203102
D203103	700	N	.43L	3.7	13	15	190	15	N	.04	D203103
D203105	200	.7	.20L	2.6	7.6	13	100	7	N	.04	D203105
D203095	500	.7	.11L	1.5	3.8	8.9	25	7	2L	.03	D203095
D203096	500	.3	.11	1.3	2.8	8.0	50	5	N	.02	D203096
D203098	500	1.5	.14L	1.7	5.6	12	50	10	N	.06	D203098
D203099	100	1.5	.09L	1.3	3.1	4.5	20	5	3	.07	D203099
D203091	300	1.5	.19	2.6	7.2	12	100	10	N	.14	D203091
D203092	1,000	1	.13	1.7	4.1	9.1	40	10	N	.05	D203092
D203093	300	1.5	.19L	1.8	5.2	8.5	65	10	N	.05	D203093
D203094	200	1	.13L	.9	4.7	5.5	20L	5	N	.11	D203094
D203089	200	.7	.12L	1.5	2.8	6.3	50	7	N	.03	D203089
D203090	200	1	.12L	1.6	5.2	10	40	7	N	.07	D203090
D180095	200	1	.20L	2.0L	4.0	7.4	40	7	N	.06	D180095
D180096	200	1.5	.35L	3.7L	11	13	150	10	N	.27	D180096
D184655	70	1	.07L	.9	.1L	8.4	40	2	1.5	.01	D184655
D184656	200	.7	.20L	.8	2.8	6.7	70	5	N	.01	D184656

Table 5.--Major-, minor-, and trace-element composition of 45 coal samples from the Mesaverde Formation, Grand Mesa
coal field, Delta and Mesa Counties, Colorado--continued

Sample number	La-S (ppm)	Li (ppm)	Mn (ppm)	Mo-S (ppm)	Nb-S (ppm)	Ni-S (ppm)	P (ppm)	Pb (ppm)	Sb (ppm)	Sc-S (ppm)	Sample number
D191607	15	24	7.9	N	5	3	870L	13	0.8	2	D191607
D194452	20	11	54	1	3	2	530L	6.7	.3	2	D194452
D194453	15	15	65	1	5	2	590L	8.2	.3	2	D194453
D194454	10	12	21	.7	3	1.5	430L	6.4	.2	2	D194454
D194455	7	14	16	.7	2	2	420L	5.3	.5	2	D194455
D194456	15	32	11	1L	5	1.5L	720L	11	.2	3	D194456
D194457	7	13	20	1	3	3	470L	5.4	.2	2	D194457
D203116	3L	2.2	5.3	N	2	220	1.7	.2	.7	D203116	
D203117	7L	6.5	4.1	1.5	2	2	310	4.0	.5	1	D203117
D203118	10L	13	8.3	1.5	N	5	600	4.9	.5	1.5	D203118
D203119	10L	11	7.5	1.5	3	3	220	5.7	.3	2	D203119
D203113	3L	4.6	8.1	.3	.7	3	470	1.9	.6	.7	D203113
D203114	10	13	47	.7	2	1.5	300	12	.3	1.5	D203114
D203115	15	19	15	1	5	2	45L	6.6	.1	2	D203115
D203120	15L	14	150	1	5	3	46	5.9	.3	2	D203120
D203109	7L	6.3	7.4	2	N	2	530	3.4	.3	.7	D203109
D203110	10	9.0	1.8	N	N	1	130	5.5	.2	.7	D203110
D203111	10L	14	2.4	N	N	3	42L	7.7	1.3	1.5	D203111
D203112	10L	18	3.1	.7	3	3	87	6.6	.8	1.5	D203112
D203106	7	9.2	3.0	.5	1.5	1.5	260	6.0	.5	1	D203106
D203107	10L	16	3.1	.7	2	2	41L	6.0	.8	1.5	D203107
D203108	10L	18	3.9	.7	3	3	42L	30	1.2	1.5	D203108
D203100	100*	8.8	26	1	3	5	44	7.8	1.3	2	D203100
D203102	N	12	40	N	N	3	260	9.1	.5	2	D203102
D203103	50L	20	95	N	10	7	130	11	.8	5L	D203103
D203105	20L	17	35	1.5L	5	7	43L	9.7	.7	3	D203105
D203095	10L	17	7.4	.7	3	3	44L	9.1	1.1	1.5	D203095
D203096	10L	31	15	.7	2	2	270	11	.3	1.5	D203096
D203098	15L	12	15	1	5	3	44	7.9	1.1	2	D203098
D203099	10L	7.6	42	N	2	2	43	2.6	.1	2	D203099
D203091	20L	18	20	2	3	7	42L	9.7	.9	3	D203091
D203092	15L	17	37	2	2	3	260	6.0	.7	2	D203092
D203093	20L	17	29	1.5	5	3	40L	8.3	.5	3	D203093
D203094	N	13	54	1	2	2	130	4.2	.1	2	D203094
D203089	15L	9.8	24	1.5	2	2	43L	7.2	.4	2	D203089
D203090	15L	13	27	1.5	2	3	43L	8.9	1.0	2	D203090
D180095	20L	28	19	1.5	7	2L	880L	10	.4	2	D180095
D180096	30	54	17	2	10	5	1,500L	26	.6	3	D180096
D184655	7L	13	8.6	.5	5	1.5	310L	5.0	.9	1.5	D184655
D184656	20L	24	16	1.5	7	2L	880L	7.1	.1L	3	D184656

Table. 5--Major-, minor-, and trace-element composition of 45 coal samples from the Mesaverde Formation, Grand Mesa coal field, Delta and Mesa Counties, Colorado--continued

Sample number	Se (ppm)	Sr-S (ppm)	Th (ppm)	U (ppm)	V-S (ppm)	Y-S (ppm)	Yb-S (ppm)	Zn (ppm)	Zr-S (ppm)	Sample number
D191607	1.7	70	7.5	3.0	15	7	0.7	16	70	D191607
D194452	1.4	100	3.3	2.2	15	10	.7	11	20	D194452
D194453	1.4	100	4.1	2.1	10	7	.7	7.9	30	D194453
D194454	.9	70	2.2	1.2	10	5	.5	7.7	30	D194454
D194455	1.1	70	2.7	1.7	15	7	.5	6.4	30	D194455
D194456	1.3	70	5.4	2.1	10	10	.7	9.0	50	D194456
D194457	1.9	50	2.2	1.1	15	5	.5	9.9	30	D194457
D203116	.4	100	.6	.6	7	2	.2	2.7	7	D203116
D203117	.6	150	1.7	.7	10	3	.3	3.5	15	D203117
D203118	1.1	200	1.8	1.4	15	3	.3	5.4	20	D203118
D203119	1.1	200	1.7	.9	15	3	.3	8.4	30	D203119
D203113	.6	200	.7	.3	5	2	.2	2.2	10	D203113
D203114	1.0	200	2.4	.9	15	5	.5	27	30	D203114
D203115	1.1	150	2.9	.9	15	5	.5	9.7	50	D203115
D203120	1.2	200	2.9	1.0	10	5	.5	12	50	D203120
D203109	.5	70	1.2	1.0	7	2	.2	5.4	10	D203109
D203110	.8	70	1.9	.6	7	3	.2	4.7	20	D203110
D203111	1.1	30	1.8	.6	7	3	.3	7.9	30	D203111
D203112	1.3	70	2.9	1.2	15	5	.5	7.5	30	D203112
D203106	.8	50	2.2	.8	5	3	.2	8.4	20	D203106
D203107	1.0	50	1.6	.8	15	2	.2	7.9	20	D203107
D203108	1.3	30	2.8	1.3	10	5	.3	20	30	D203108
D203100	.7	50	2.8	2.3	20	5	.5	27	50	D203100
D203102	1.0	30	3.2	1.2	15	5	.5	19	50	D203102
D203103	1.0	70	6.3	2.7	30	15	1.5	39	100	D203103
D203105	1.2	50	3.9	2.1	30	7	.7	23	50	D203105
D203095	1.5	50	3.5	1.6	10	3	.3	11	30	D203095
D203096	1.4	200	2.9	1.3	7	3	.3	6.9	30	D203096
D203098	2.0	150	5.6	3.1	20	7	.7	9.0	50	D203098
D203099	1.0	100	1.4	.5	7	7	.7	20	30	D203099
D203091	.11	150	4.8	2.3	20	10	1	26	70	D203091
D203092	1.3	200	3.2	1.7	15	7	.7	14	30	D203092
D203093	1.3	150	6.8	2.8	15	15	1.5	13	50	D203093
D203094	1.1	150	1.3	.9	10	5	.5	22	50	D203094
D203089	.9	150	3.2	1.5	10	7	.7	13	30	D203089
D203090	1.6	150	2.2	1.7	15	7	.7	22	30	D203090
D180095	1.6	100	6.4	2.3	15	15	1.5	9.2	50	D180095
D180096	3.1	100	7.2	5.4	30	15	1.5	40	70	D180096
D184655	1.1	10	2.6	1.0	10	7	.7	7.1	30	D184655
D184656	1.2	150	4.9	1.8	10	15	1.5	12	50	D184656

Table 5.--Major-, minor-, and trace-element composition of 45 coal samples from the Mesaverde Formation, Grand Mesa coal field, Delta and Mesa Counties, Colorado--continued

Sample number	Si (percent)	Al (percent)	Ca (percent)	Mg (percent)	Na (percent)	K (percent)	Fe (percent)	Ti (percent)	As (ppm)	B-S (ppm)	Sample number
D203087	1.3	0.87	3.4	0.10	0.069	0.002L	0.52	0.051	0.3	150	D203087
D203088	4.1	2.8	1.2	.18	.045	.069	.97	.10	2.7	100	D203088
D203083	3.9	2.0	.61	.13	.078	.046	.34	.072	2.4	50	D203083
D203084	4.0	2.7	.13	.014	.051	.041	.33	.091	5.0	50	D203084
D203086	1.6	.88	.079	.012	.054	.016	1.3	.042	4.4	50	D203086

Sample number	Ba-S (ppm)	Be-S (ppm)	Cd (ppm)	Co (ppm)	Cr (ppm)	Cu (ppm)	F (ppm)	Ga-S (ppm)	Ge-S (ppm)	Hg (ppm)	Sample number
D203087	500	0.5	0.14L	1.0	3.0	6.3	130	5	N	0.02	D203087
D203088	200	.7	.20L	1.2	4.0	9.3	50	10	N	.04	D203088
D203083	100	.5	.15L	1.7	3.9	9.8	85	5	N	.07	D203083
D203084	100	.7	.15L	1.5	4.5	8.5	105	7	N	.10	D203084
D203086	20	.5	.08L	1.0	3.7	5.2	35	5	2	.20	D203086

Sample number	La-S (ppm)	Li (ppm)	Mn (ppm)	Mo-S (ppm)	Nb-S (ppm)	Ni-S (ppm)	P (ppm)	Pb (ppm)	Sb (ppm)	Sc-S (ppm)	Sample number
D203087	N	5.8	42	1	N	1.5	600	5.5	0.3	1.5	D203087
D203088	N	22	370	1.5L	N	2L	44L	11	.5	3	D203088
D203083	15L	16	11	1.5	5	2	85	8.6	.7	1.5	D203083
D203084	15L	30	4.7	1	5	3	480	11	.4	2	D203084
D203086	7L	11	14	1	2	2	130	5.1	.3	1	D203086

Sample number	Se (ppm)	Sr-S (ppm)	Th (ppm)	U (ppm)	V-S (ppm)	Y-S (ppm)	Yb-S (ppm)	Zn (ppm)	Zr-S (ppm)	Sample number
D203087	1.0	300	1.6	1.0	10	5	0.5	9.3	20	D203087
D203088	1.5	70	5.0	1.9	15	7	.7	12	70	D203088
D203083	1.4	70	3.7	1.9	10	5	.5	18	30	D203083
D203084	1.8	100	4.8	2.1	10	7	.5	8.2	50	D203084
D203086	1.8	50	1.8	.8	5	5	.5	7.5	15	D203086

Table 6.--Elements looked for, but not detected in 45 coal samples from the Mesaverde Formation, Grand Mesa coal field, Delta and Mesa Counties, Colorado

[Approximate lower detection limits for these elements in ash, by the six-step spectrographic method of the U.S. Geological Survey, are included]

Element name	Symbol	Lower limit of detection (ppm) in ash
Silver	Ag	1
Gold	Au	50
Bismuth	Bi	20
Dysprosium	Dy	100
Erbium	Er	100
Europium	Eu	200
Gadolinium	Gd	100
Hafnium	Hf	200
Holmium	Ho	50
Indium	In	20
Lutetium	Lu	70
Palladium	Pd	5
Praseodymium	Pr	200
Platinum	Pt	100
Rhenium	Re	100
Samarium	Sm	200
Tin	Sn	20
Tantalum	Ta	1,000
Terbium	Tb	700
Tellurium	Te	5,000
Thallium	Tl	100
Thulium	Tm	50
Tungsten	W	200

Table 7.--Arithmetic mean, observed range, geometric mean, and geometric deviation of proximate and ultimate analyses, heat of combustion, forms of sulfur, and ash-fusion temperatures of 43 coal samples from the Mesaverde Formation, Grand Mesa coal field, Delta and Mesa Counties, Colorado

[For comparison, geometric means for 86 Rocky Mountain Province coal samples are included (Swanson and others, 1976, Table 33a). All values are in percent except Kcal/kg, Btu/lb, ash-fusion temperatures, and geometric deviations, and are reported on the as-received basis. L, less than the value shown. G, greater than the value shown. Leaders (---) indicate no data. Kcal/kg = 0.556(Btu/lb). $^{\circ}\text{F} = (^{\circ}\text{C} \times 1.8) + 32$]

Arithmetic mean	Observed range		Geometric mean	Geometric deviation	Rocky Mountain Province geometric mean
	Minimum	Maximum			
Proximate and ultimate analyses					
Moisture	13.3	2.5	20.2	11.9	1.6
Volatile matter	33.3	22.9	38.7	33.3	1.1
Fixed carbon	42.1	24.6	51.5	41.7	1.1
Ash	11.6	3.2	41.4	10.4	1.6
Hydrogen	5.7	4.1	6.2	5.6	1.1
Carbon	58.2	35.7	74.2	57.8	1.1
Nitrogen	1.3	.8	1.8	1.3	1.2
Oxygen	22.6	8.7	28.9	21.8	1.3
Sulfur	.7	.4	2.2	.7	1.5
Heat of combustion					
Kcal/kg	5,700	3,450	7,500	5,660	1.1
Btu/lb	10,260	6,200	13,490	10,180	1.1
Forms of sulfur					
Sulfate	0.01	0.01L	0.06	0.01	1.5
Pyritic	.12	.02	1.55	.08	2.7
Organic	.57	.34	1.26	.54	1.4
Ash-fusion temperatures, $^{\circ}\text{C}$					
Initial deformation	1,360	1,125	1,600G	1,350	1.1
Softening temperature	1,390	1,180	1,600G	1,390	1.1
Fluid temperature	1,435	1,230	1,600G	1,430	1.1

Table 8.--Arithmetic mean, observed range, geometric mean, and geometric deviation of ash content and contents of 10 major and minor oxides in the laboratory ash of 45 coal samples from the Mesaverde Formation, Grand Mesa coal field, Delta and Mesa Counties, Colorado

[For comparison, geometric means for 295 Rocky Mountain Province coal samples are included (Hatch and Swanson, 1977, Table 3a). All samples were ashed at 525°C; all analyses except geometric deviation are in percent. L, less than the value shown. Leaders (---) indicate no data.]

Oxide	Arithmetic mean	Observed range		Geometric mean	Geometric deviation	Rocky Mountain Province geometric mean
		Minimum	Maximum			
(Ash)	13.5	3.7	43.3	12.1	1.6	10.9
SiO ₂	50.	21.	71.	49.	1.2	44.
Al ₂ O ₃	28.	12.	36.	27.	1.3	19.
CaO	4.2	.84	35.	3.0	2.2	6.2
MgO	1.2	.15	3.6	.87	2.1	1.4
Na ₂ O	1.7	.27	6.8	1.2	2.3	.68
K ₂ O	.58	.06L	2.2	.42	2.2	.45
Fe ₂ O ₃	4.5	.60	23.	3.5	2.1	4.5
TiO ₂	1.0	.62	1.6	1.0	1.2	.81
SO ₃	2.5	.20	8.0	1.7	2.4	5.1
P ₂ O ₅	.58	.06L	2.9	.07	8.4	---

Table 9.--Arithmetic mean, observed range, geometric mean, and geometric deviation of 39 elements in 45 coal samples from the Mesaverde Formation, Grand Mesa coal field, Delta and Mesa Counties, Colorado

[For comparison, geometric means for 295 Rocky Mountain Province coal samples are included (Hatch and Swanson, 1977, Table 3b). All analyses except geometric deviation are in percent or parts per million and are reported on a whole coal basis. As, Co, Cr, F, Hg, Sb, Se, Th, and U values used to calculate the statistics were determined directly on whole coal. All other values used were calculated from determinations made on coal ash. L, less than the value shown. Leaders (---) indicate no data.]

Element	Arithmetic mean	Observed range		Geometric mean	Geometric deviation	Rocky Mountain Province geometric mean
		Minimum	Maximum			
Percent						
Si	3.3	0.62	14	2.7	1.8	2.3
Al	1.9	.42	5.1	1.7	1.6	1.1
Ca	.41	.065	3.9	.26	2.7	.48
Mg	.10	.012	.43	.063	2.7	.089
Na	.14	.022	.40	.11	2.1	.055
K	.079	.004L	.69	.042	3.1	.041
Fe	.40	.063	1.4	.29	2.2	.34
Ti	.078	.022	.18	.072	1.5	.047
P	.017	.004L	.059	.005	5.1	---
Parts per million						
As	1.5	0.2L	7	0.8	3.0	2
B	150	50	200	100	1.5	70
Ba	300	20	1000	200	2.1	150
Be	.7	.1L	2	.7	2.0	.5
Cd	.05	.03L	.19	.02	3.3	.05
Co	1.4	.6	3.7	1.3	1.4	1.5
Cr	3.8	1.3	13	3.2	1.8	5
Cu	8.5	3.7	15	8	1.4	8.4
F	65	20L	190	56	1.8	69
Ga	7	2	15	7	1.6	3
Ge	1	1.5L	3	.7	1.9	---
Hg	.05	.01L	.27	.03	2.4	.05
La	7	7L	30	5	2.4	---
Li	16	2.2	54	14	1.7	8
Mn	30	1.8	370	16	3.1	20
Mo	1	.3L	2	.7	2.2	1.5
Nb	3	.7L	10	2	2.5	.5
Ni	3	1L	7	2	1.7	2
Pb	8.1	1.7	30	7	1.7	4.7
Sb	.6	.09L	1.3	.4	2.1	.3
Sc	2	.7L	3	1.5	1.5	1.5
Se	1.2	.4L	3.1	1.1	1.5	1.2
Sr	100	10	300	100	2.0	100
Th	3.3	.6	7.5	2.8	1.8	2.9
U	1.6	.3	5.4	1.3	1.8	1.1
V	15	5	30	10	1.6	100
Y	7	2	15	5	1.8	5
Yb	.7	.2	1.5	.5	1.8	.5
Zn	13	2.2	40	11	1.9	6.8
Zr	30	7	100	30	1.7	20

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