UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

Geology and chemical analyses of coal and coal-associated rock samples, Williams Fork Formation (Upper Cretaceous), northwestern Colorado

by

Ricky T. Hildebrand, Robert S. Garrigues, Richard F. Meyer,

and Marith C. Reheis

Open-File Report 81-1348
1981

Table of Contents

Illustrations

Tables

Introduction

Remaining coal resources in excess of 33 billion short tons are present in a 1,275-square-mile area in northwestern Colorado (Landis, 1959), including parts of Garfield, Moffat, Pitkin, Rio Blanco, and Routt Counties (fig. 1). During the period between July 1975 and November 1978, 100 coal and 17 coal-associated rock samples were collected from mines and drill holes in this area by the Colorado Geological Survey and the U.S. Geological Survey in conjunction with coal exploration, resource assessment, and chemical characterization programs of the U.S. Geological Survey (see Swanson and others, 1976; Reheis, 1976, 1978a, 1978b; Boreck and others, 1977; and Khalsa and Ladwig, 1981).

All of the samples discussed in this report are from coal beds and associated strata in the Williams Fork Formation of Late Cretaceous age. This unit contains several coal beds of current and potential economic importance in the Danforth Hills, Grand Hogback, and Carbondale coal fields (Uinta region), and in the Yampa coal field (Green River region). Table 1 contains descriptions of the samples by coal field. Locations of the sample sites are included in figures 2 and 3.

Geologic setting

The geology of northwestern Colorado, particularly the stratigraphy and depositional history of the Cretaceous strata discussed in this report, and the coal resources, are documented by many authors, including Gale (1910), Hancock (1925), Bass and others (1955), Landis (1959), Weimer (1959), Masters (1967), Collins (1976), Hornbaker and others (1976), and Ryer (1977). The Upper Cretaceous Mesaverde Group is the principal coal-bearing sequence in northwestern Colorado. Regionally, the Mesaverde is divided into the Iles and Williams Fork Formations. The areal distribution of the Mesaverde Group and the major structural features in the region are shown in figures 2 and 3.

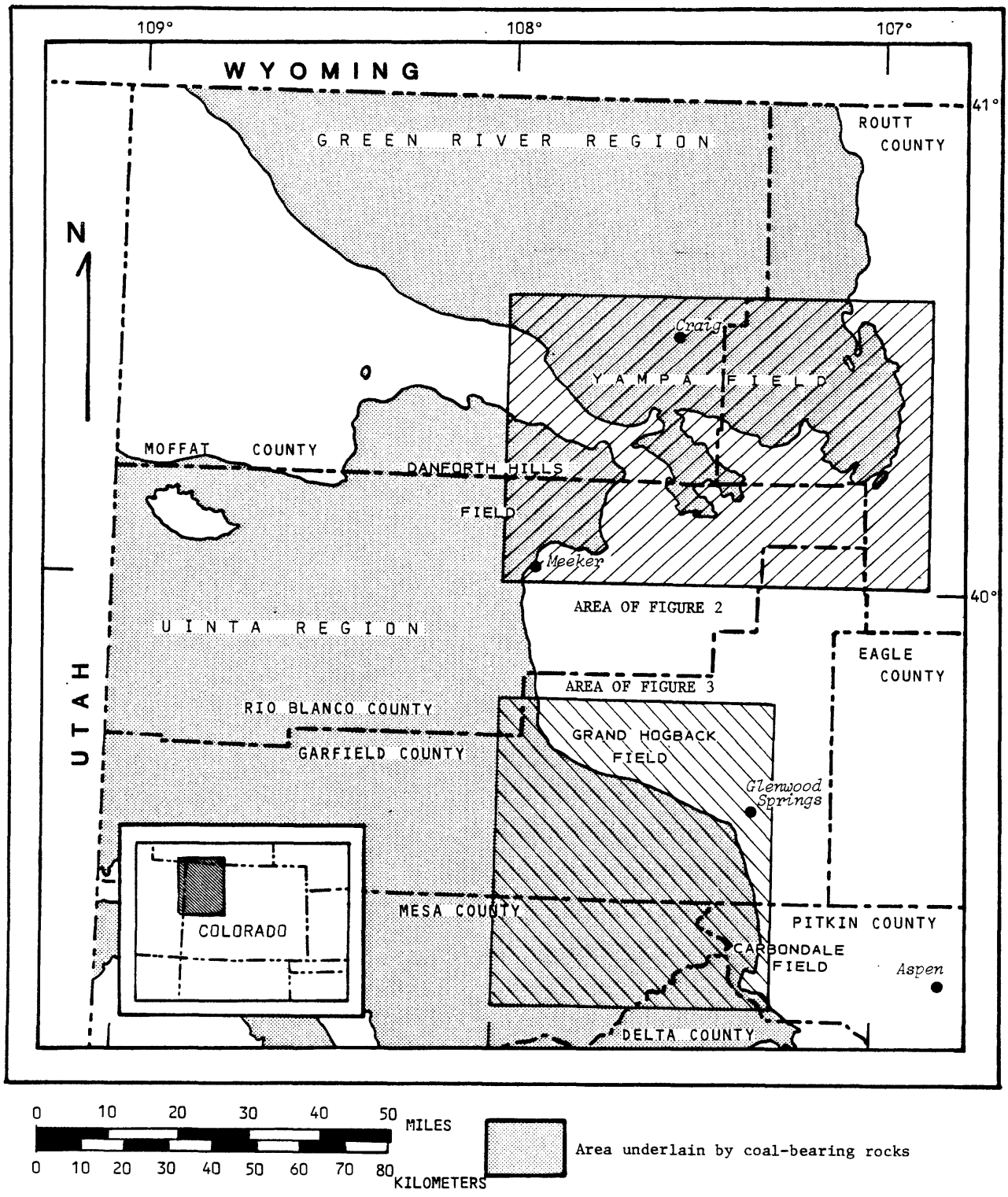


Figure 1.--Index map showing locations of the Yampa, Danforth Hills, Grand Hogback, and Carbondale coal fields, northwestern Colorado, and areas of figures 2 and 3 (modified from Jones, 1977).

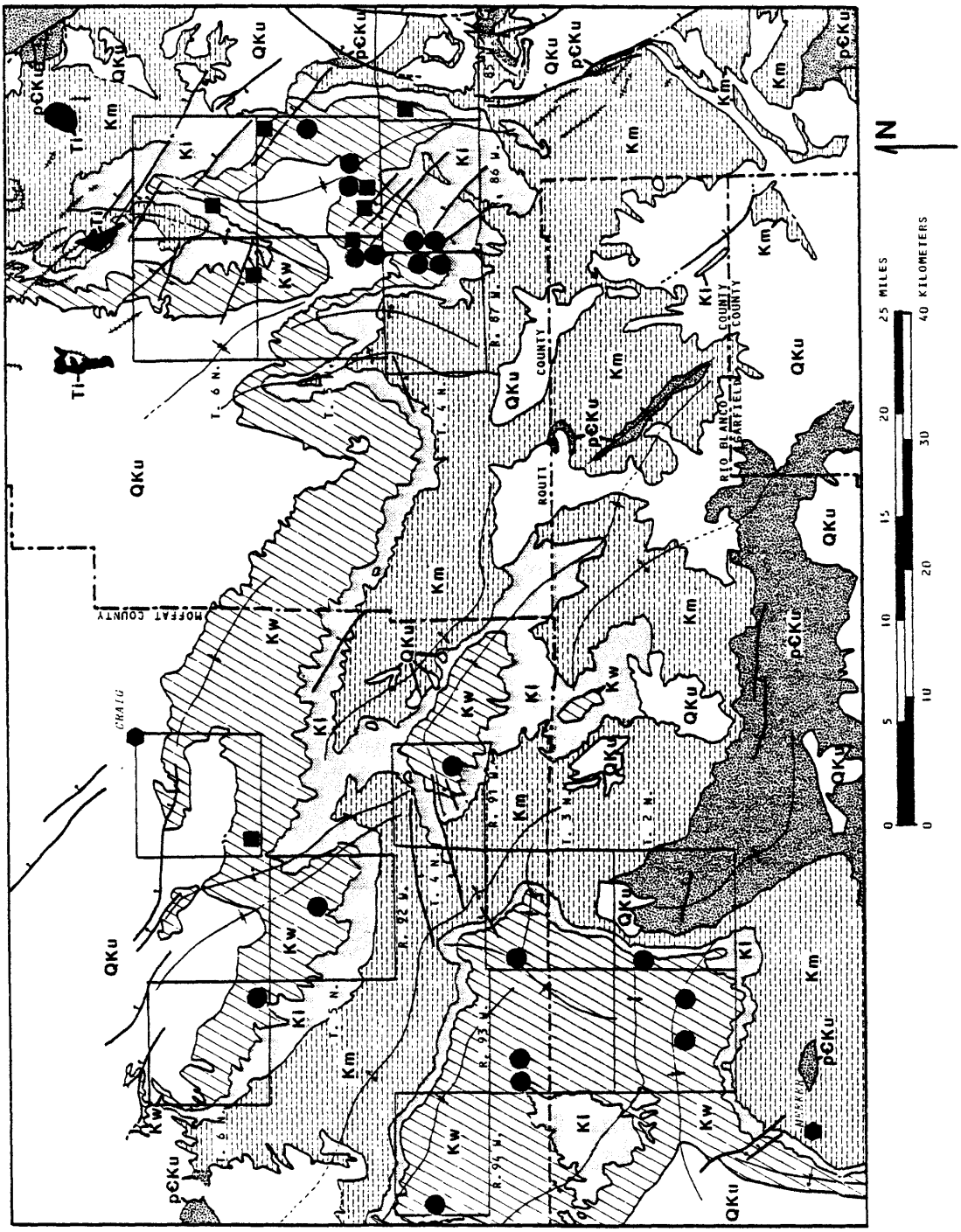


Figure 2.--Map showing general geology and sample localities, Yampa and Danforth Hills coal fields, northwestern Colorado (modified from Tweto, 1976). Explanation found on page 5.

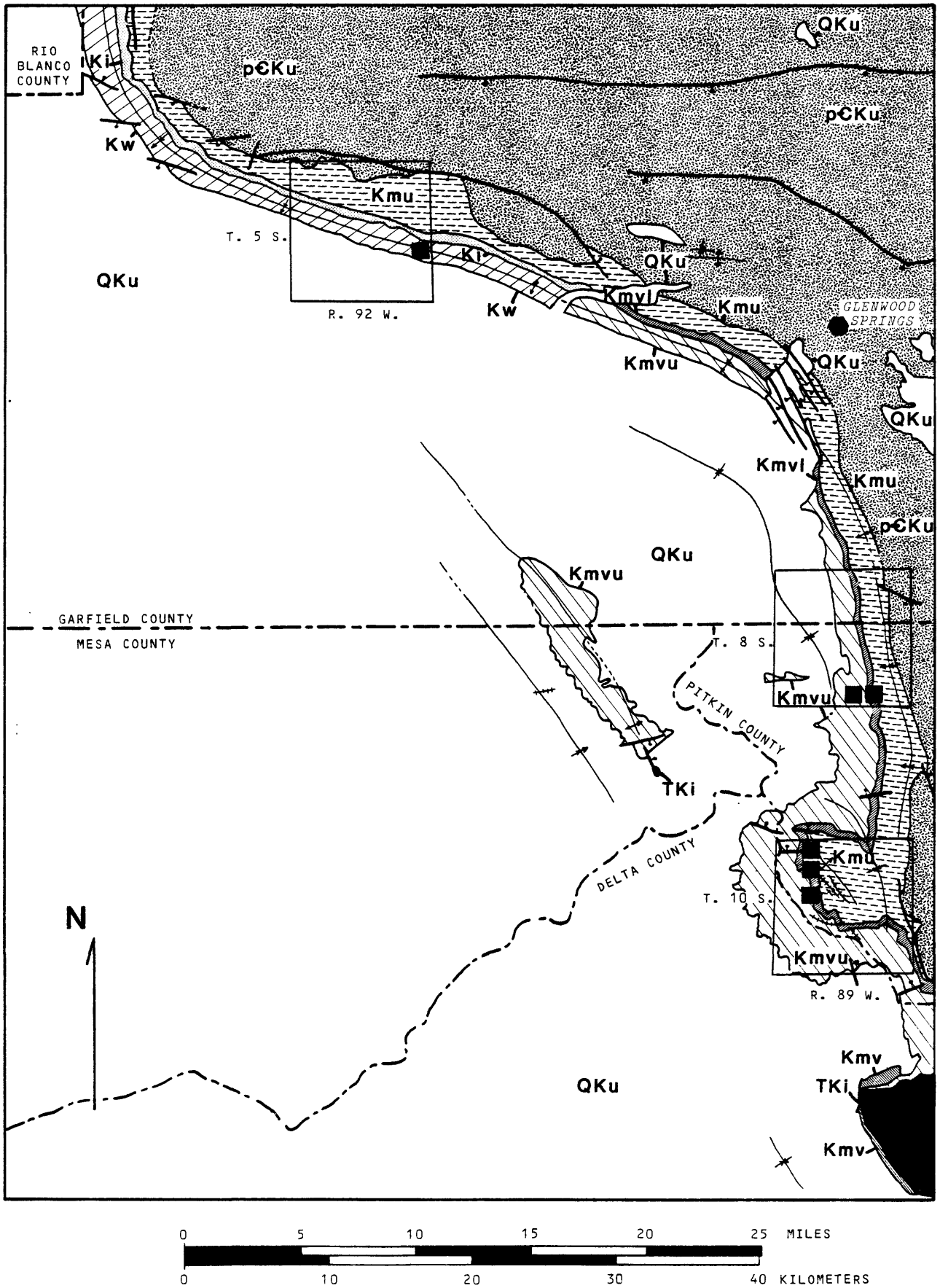


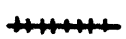
Figure 3.--Map showing general geology and sample localities, Grand Hogback and Carbondale coal fields, northwestern Colorado (modified from Tweto and others, 1978). Explanation found on page 5.

EXPLANATION OF FIGURES 2 AND 3

ROCK UNITS

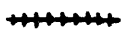
CRETACEOUS TO TERTIARY ROCKS, UNDIVIDED, AND QUATERNARY SURFICIAL UNITS (Lewis Shale and younger units)

TERTIARY INTRUSIVE ROCKS (fig. 2 only)



dike or sill

CRETACEOUS TO TERTIARY INTRUSIVE ROCKS (fig. 3 only)



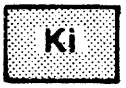
dike or sill

UPPER CRETACEOUS

MESAVERDE GROUP, UNDIVIDED (fig. 3 only)

Williams Fork Formation

Upper part of Mesaverde Formation (fig. 3 only)



Iles Formation

Lower part of Mesaverde Formation (fig. 3 only)

MANCOS SHALE (fig. 2 only)

Upper unit of Mancos Shale (fig. 3 only)

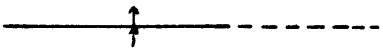
PRECAMBRIAN TO CRETACEOUS ROCKS, UNDIVIDED (Frontier Sandstone Member of Mancos Shale and older units)

CONTACT--dashed where approximately located or concealed

FAULT--dashed where approximately located or concealed. Bar and ball on downthrown side

CREST OF ANTICLINE--dashed where approximately located or concealed

TROUGH OF SYNCLINE--dashed where approximately located or concealed



LINE OF STEEP DIP IN MONOCLINE--dashed where approximately located or concealed

SAMPLE LOCALITIES

Mine

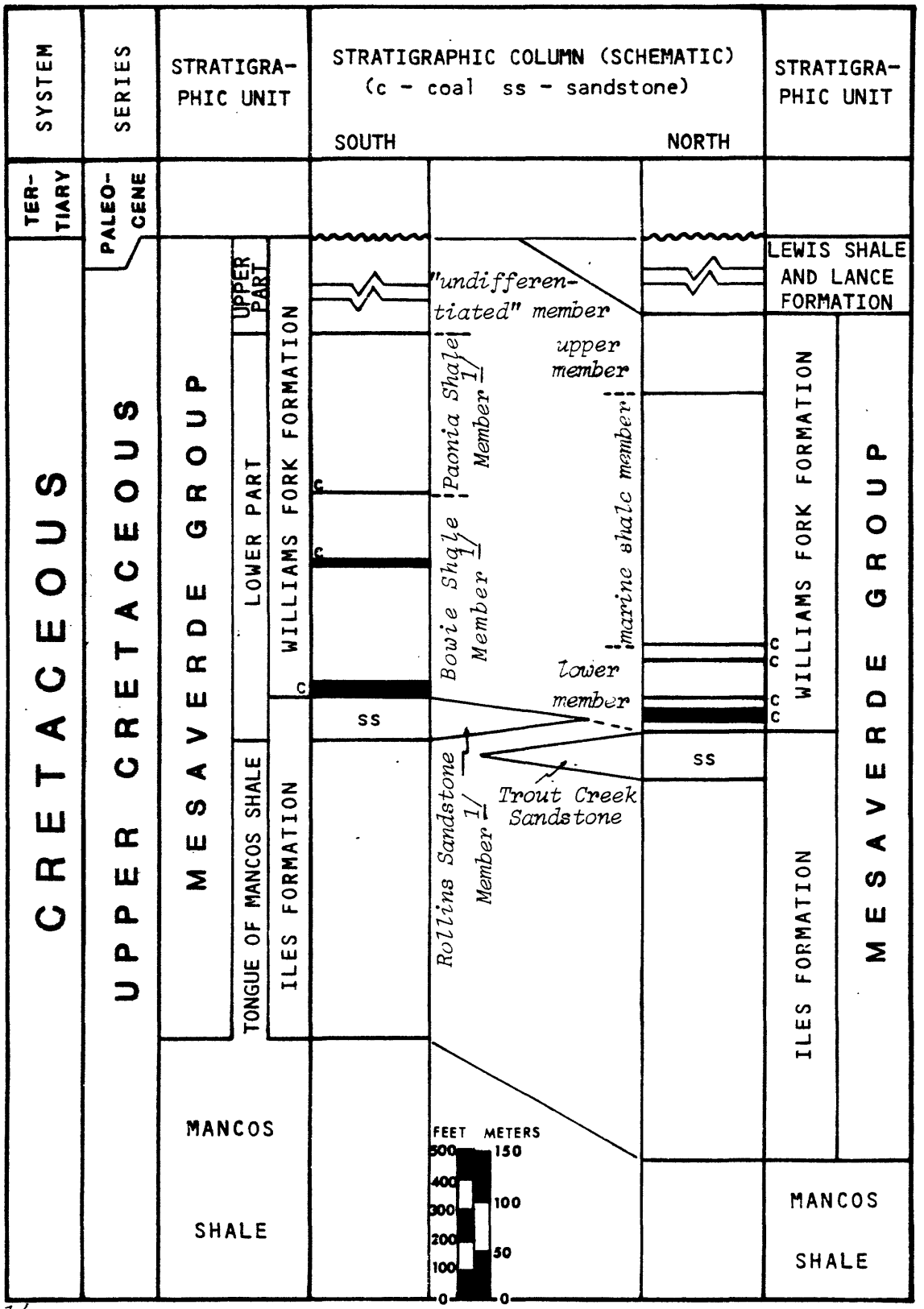
Drill hole

The Williams Fork Formation

The Williams Fork Formation comprises the upper portion of the Mesaverde Group. The unit lies conformably on the uppermost laterally persistent sandstone bed of the Iles Formation, variously called the Trout Creek Sandstone Member of the Iles Formation and the Rollins Sandstone Member of the Mesaverde Formation. The lithology of the Williams Fork Formation consists of alternating beds of sandstone, siltstone, shale and coal (Collins, 1976; Ryer, 1977). The general stratigraphic relationships of the coal-bearing strata and adjacent rocks are shown in figure 4.

Coal occurs in a number of laterally discontinuous beds in the lower member of the Williams Fork Formation; these beds are intercalated and interbedded with siltstone, silty sandstone, and carbonaceous shale. In the Uinta region, the coal beds are in three zones or "groups" in the lower member (Collins, 1976; Hornbaker and others, 1976). These zones are isolated from the correlative strata of the middle coal group in the Yampa field by erosion along the Axial Basin anticline (Hancock, 1925; Ryer, 1977).

Sediments of the Mesaverde Group accumulated in a series of marine, marginal-marine, and nonmarine depositional environments along the western edge of the Interior Cretaceous Seaway (Ryer, 1977; Berman and others, 1980). This vertical succession of sediments can be subdivided into three depositional cycles caused by alternative regressive and transgressive phases of the epeiric sea (Masters, 1967). The deposition of the lower coal-bearing member of the Williams Fork Formation occurred during the second regressive cycle, initiated by the underlying Trout Creek Sandstone Member of the Iles Formation.



1/ *As used by Collins (1976).*

Figure 4.--Generalized stratigraphic column of the Mesaverde Group and associated strata, northwestern Colorado (modified from Collins, 1976, Ryer, 1977, and Tweto and others, 1978).

The following is a short synopsis of the sequence of deposition of the lower Williams Fork Formation. The Trout Creek Sandstone Member of the Iles Formation was formed as a marine barrier-beach deposit along the receding shoreline of the epeiric sea during the second regressive cycle. As this barrier sand prograded seaward, poorly sorted, fine-grained terrigenous material accumulated in the lagoon behind the barrier sand. These shoreline and delta deposits followed the progradation of the barrier sand, forming brackish- to fresh-water swamps and marshes in the interdelta and interdistributary regions. Very fine grained materials and organic detritus accumulated in the shallow standing water, with periodic deposition of coarser, overbank material. This coal-forming sequence was ultimately covered by rapid sedimentation during the subsequent transgression, represented by the sediments of the overlying marine shale member of the Williams Fork Formation.

Explanation of data and summary tables

Significant to any complete coal resource appraisal is an estimate of the chemical composition of the coal. Four somewhat overlapping reasons for obtaining comprehensive and precise chemical analyses of coal are as follows: (1) to help assess the environmental implications of coal mining and utilization, (2) to help determine the most suitable use of the coal, (3) to assess possible by-product recovery, and (4) to help interpret the geological and geochemical history of the coal-bearing rocks.

Proximate and ultimate analyses and heat-of-combustion, air-dried-loss, forms-of-sulfur, free-swelling-index, and ash-fusion-temperature determinations for 67 single and nine composite coal samples from the Williams Fork Formation, northwestern Colorado, are given in tables 2a-2d. These analyses were provided by the Coal Analysis Section, U.S. Department of Energy (formerly U.S. Bureau of Mines), Pittsburgh, Pa. Analyses for ash content, contents of 35 major and minor oxides and trace elements in the laboratory ash (tables 3a-3d), and analyses of nine trace elements in whole coal or whole rock (tables 4a-4d) for 100 coal and 17 coal-associated rock samples from the Williams Fork Formation were provided by the U.S. Geological Survey in Denver, Colo. Tables 5a-5d contain the data listed in tables 3a-3d converted to a whole-coal or whole-rock basis and include the whole-coal and whole-rock analyses listed in tables 4a-4d. Twenty-three additional elements not listed in tables 3, 4, and 5 were looked for but not found in amounts greater than their lower limit of detection (table 6).

Unweighted statistical summaries, by coal field, of the analytical data for the coal samples in tables 2, 3, and 4 are given in tables 7, 8, and 9, respectively. Data summaries for P_2O_5 contents in ash are not included in tables 8b and 8c because P_2O_5 was detected in an insufficient number of samples to calculate meaningful statistics. For the same reason, the contents in whole coal of the following elements are not included in tables 9a-9d: Cd (9c,9d); Ce, Ge, and Nd (9a-9d); La (9a, 9b); and P (9b, 9c). For comparison, statistical summaries of the analytical data in tables 2, 3, and 4 for the coal samples from the Williams Fork Formation collectively are presented in tables 10, 11, and 12.

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 midpoint of the enclosing six-step brackets. (See headnote of table 3 or Swanson and Huffman, 1976, p. 6, for an explanation of six-step brackets.)

Most of the analytical procedures used by the U.S. Geological Survey are described in Swanson and Huffman (1976). Arsenic contents of samples included in this report were determined by three different analytical methods: samples D176362 - D176390 were analyzed spectrophotometrically (lower detection limit 1.0 ppm); samples D178117 - D178129, D188236 - D188246, and D196434 - D196438 were analyzed by the graphite furnace-atomic absorption method (lower detection limit 0.5 ppm); the remaining 68 samples were analyzed for arsenic by instrumental neutron activation analysis (lower detection limit 0.1 ppm).

Antimony, selenium, and thorium contents of samples D176362 - D178129, D188236 - D188246, and D196434 - D196438 were determined by the Rhodamine-B spectrophotometric method (lower detection limit 0.1 ppm), x-ray fluorescence analysis (lower detection limit 0.1 ppm), and delayed neutron activation analysis (lower detection limit 3.0 ppm), respectively. The remaining 68 samples were analyzed for antimony, selenium, and thorium by instrumental neutron activation analysis (lower detection limit 0.1 ppm).

Cobalt and chromium contents of samples D176362 - D178129, D188236 - D188246, and D196434 - D196438 were determined in ash by semiquantitative emission spectrography (lower detection limits 10 ppm and 2 ppm, respectively) and converted to a whole-coal or whole-rock basis (tables 4a-4d). The remaining 68 samples were analyzed for cobalt and chromium by instrumental neutron activation analysis (lower detection limit 0.1 ppm). The typical sequence of preparation and analysis of samples is presented in figure 5.

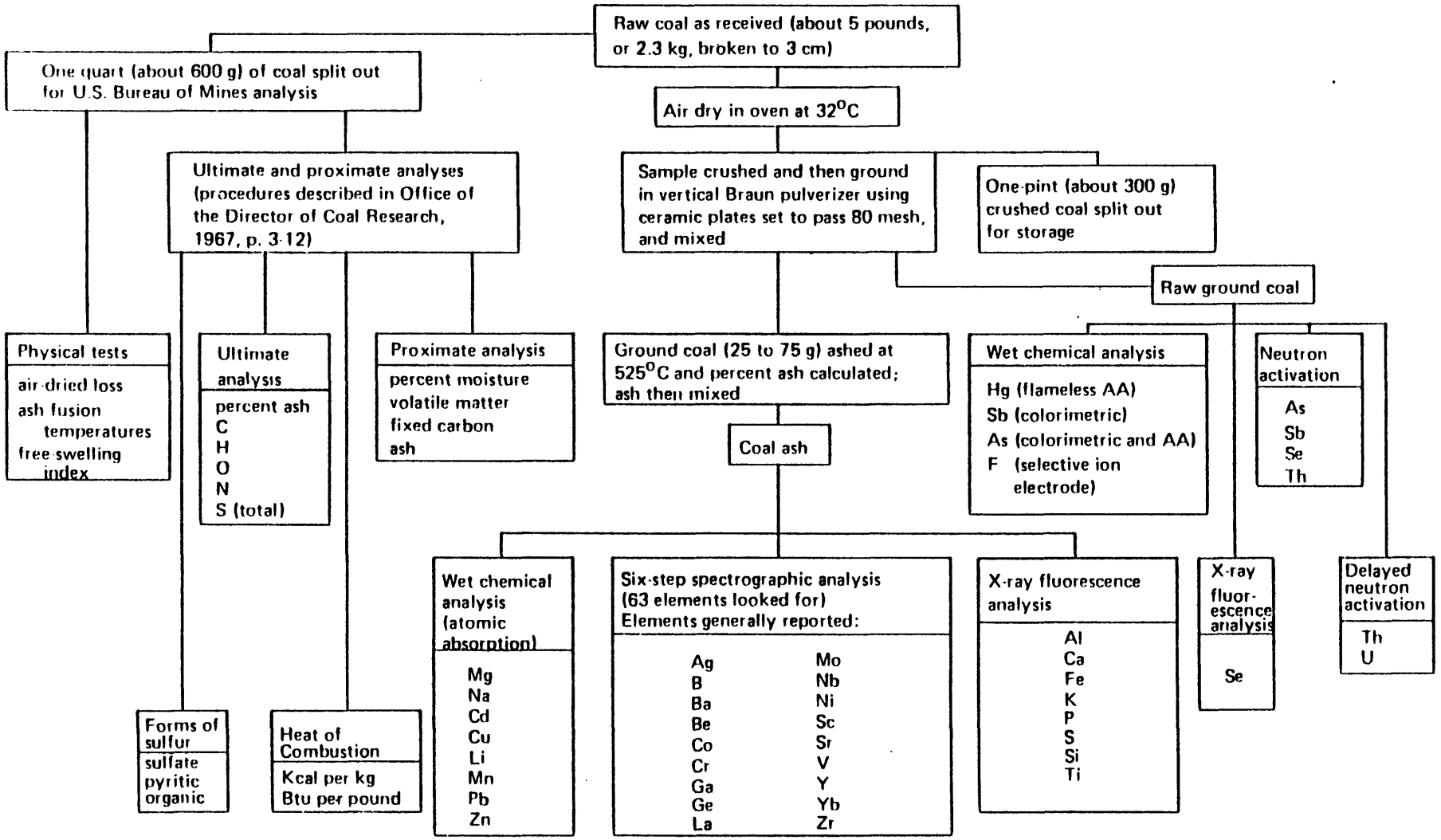


Figure 5.--Flow chart showing sequence of sample preparation and chemical analysis (modified from Swanson and Huffman, 1976).

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 GM 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 statistically analyzing and summarizing trace-element data on a logarithmic basis.

If the frequency distributions are lognormal, the GM 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 x 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 $GM \times (GD)^2$ (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 samples is below the limit of analytical detection. This results in a "censored" distribution. Procedures developed by Cohen (1959) are used to compute biased estimates of the GM, GD, and arithmetic mean when the data are censored.

Discussion

The heats of combustion (moist, mineral-matter-free basis) and apparent ranks for 76 coal samples from the Williams Fork Formation, northwestern Colorado, were calculated using the data in tables 2a-2d and the formulae in ASTM designation D-388-77 (American Society for Testing and Materials, 1978). The results are summarized below by coal field.

For 44 coal samples from the Yampa field, heats of combustion range from 5,810 kcal/kg (10,450 Btu/lb) to 7,200 kcal/kg (12,940 Btu/lb); the free-swelling index for the samples ranges from 0 to 0.5. The apparent ranks for the samples are distributed as follows: subbituminous B coal (2 samples), subbituminous A coal (29 samples), and high-volatile C bituminous coal (13 samples).

The heat-of-combustion values for 18 coal samples from the Danforth Hills field range from 5,240 kcal/kg (9,430 Btu/lb) to 6,580 kcal/kg (11,840 Btu/lb); the free-swelling index for all samples is 0. The apparent ranks for the samples are distributed as follows: subbituminous C coal (one sample), subbituminous B coal (11 samples), and subbituminous A coal (six samples). One high-ash sample was excluded from this summary because the results of the calculations were questionable.

Heats of combustion for five coal samples from the Grand Hogback field range from 7,500 kcal/kg (13,490 Btu/lb) to 7,630 kcal/kg (13,730 Btu/lb); the free-swelling index for the samples ranges from 1.0 to 1.5. The apparent rank for all five samples is high volatile B bituminous coal.

For eight samples from the Carbondale field, the heats of combustion range from 8,520 kcal/kg (15,330 Btu/lb) to 8,800 kcal/kg (15,820 Btu/lb), the free-swelling index ranges from 8.5 to 9.0, and the calculated fixed-carbon contents (dry, mineral-matter free) range from 64.7 percent to 76.8 percent. The apparent rank for two samples is high-volatile A bituminous coal; the apparent rank for the other six samples is medium-volatile bituminous coal.

Variations in coal rank within the coal fields are probably due to local variations in relative amounts of original constituents, depth of burial, or tectonic activity. The high coal rank in the southern fields (Grand Hogback and Carbondale) results primarily from intense metamorphism during the uplift of the White River Plateau and intrusion of several major igneous bodies into the coal-bearing rocks (Collins, 1976).

Statistical comparisons, using the "t" and "f" tests (95-percent confidence level) (Miller and Kahn, 1962), of the sample means and variances of the Department of Energy data for 76 coal samples from the Williams Fork Formation, northwestern Colorado, with 86 coal samples from the Rocky Mountain province (Swanson and others, 1976) show that the Williams Fork Formation samples collectively have significantly higher contents of fixed carbon, nitrogen, total sulfur, and organic sulfur; and significantly lower contents of volatile matter, hydrogen, oxygen, and sulfate sulfur. Heat of combustion and contents of moisture, ash, carbon, and pyritic sulfur are not significantly different.

Statistical comparisons of the sample means and variances of coal ash and contents of nine major and minor oxides in the ash for 100 Williams Fork Formation coal samples with 295 coal samples from the Rocky Mountain province (Hatch and Swanson, 1977) show that the Williams Fork Formation samples collectively have significantly higher contents of SiO_2, Al_2O_3, K_2O, and TiO_2; and significantly lower contents of MgO, Na_2O, and SO_3 in ash. Ash content and contents of CaO and Fe_2O_3 in ash are not significantly different.

Statistical comparisons of the sample means and variances of 35 elements (whole-coal basis) for 100 Williams Fork Formation coal samples with 295 coal samples from the Rocky Mountain province (Hatch and Swanson, 1977) show that the Williams Fork Formation samples collectively have significantly higher contents of K, Ti, Ba, F, and Nb; and significantly lower contents of Ca, Mg, Na, Fe, As, Co, Cr, Cu, Hg, Mn, Mo, and Se. The contents of Si Al, B, Be, Cd, Ga, Li, Ni, Pb, Sb, Sc, Sr, U, V, Y, Yb, Zn, and Zr are not significantly different.

Differences in the oxide composition of coal ash and the element contents of coal result from differences in the total and relative amounts of the various minerals in the coal, and the total and relative amounts of 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 geologic factors that influence element distributions includes chemical composition of original plants; amounts and compositions of various detrital, diagenetic, and epigenetic minerals; temperatures and pressures during burial; and extent of weathering. No evaluation of these factors has been made for any of the coal beds in the Williams Fork Formation.

Acknowledgments

Fundamental to this paper is the contribution of the team of chemical laboratory personnel in the U.S. Geological Survey under the direction of Claude Huffman, Jr., and Joseph H. Christi: James W. Baker, Ardith J. Bartel, Candy Bliss, Leon A. Bradley, Elaine L. Brandt, George T. Burrow, Nancy M. Conklin, M. F. Coughlin, James G. Crock, Celeste M. Ellis, Edward J. Fennelly, Johnnie M. Gardner, Patricia G. Guest, John C. Hamilton, Raymond G. Havens, Jay P. Hemming, Jesse O. Johnson, Roy J. Knight, Frederick E. Lichte, Cynthia McFee, Robert E. McGregor, Mollie Jane Malcolm, Violet M. Merritt, Hugh T. Millard, Jr., Harriet G. Neiman, Ralph L. Nelms, Jeffry O'Kelley, Farris D. Perez, Charles A. Ramsey, George O. Riddle, Michael N. Schneider, Caryl L. Shields, Gaylord D. Shipley, Vertie C. Smith, Merlyn W. Solt, Wenda R. Stang, James A. Thomas, Michele L. Tuttle, Richard E. Van Loenen, Robert B. Vaughn, Robin J. Vinnola, James S. Wahlberg, William J. Walz, Ralph J. White, and Robert J. Young. The invaluable contribution of the chemists in the Coal Analysis Section (Forrest E. Walker, Chermist-in-Charge, and John E. Puskas, Acting Chief), U.S. Department of Energy, Pittsburgh, Pa., is also gratefully appreciated.

Thanks are due to the following geologists who participated in the collection of the samples: Donna L. Boreck, David C. Jones, D. Keith Murray, Janet E. Schultz, and Daniel S. Walline, Colorado Geological Survey; Joseph R. Hatch, Edward A. Johnson, Anne E. Stevenson, and Thomas A. Ryer, U.S. Geological Survey; and Bruce A. Collins, Mid-Continent Coal and Coke Company.

References

American Society for Testing and Materials, 1978, Standard specifications for classification of coals by rank (ASTM designation D-388-77): 1978 Annual book of ASTM standards, pt. 26, p. 220-224.

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

Berman, A. E., Pooleschook, P., Jr., and Dimelow, T. E., 1980, Jurassic and Cretaceous Systems of Colorado, in Kent, H. C., and Porter, K. W., eds., Rocky Mountain Association of Geologists--1980 Symposium: p. 111-128.

Boreck, D. L., Jones, D. C., Murray, D. K., Schultz, J. E., and Suek, D. C., 1977, Colorado coal analyses, 1975: Colorado Geological Survey Information Series 7, 112 p.

Cohen, A. C., 1959, Simplified estimators for the normal distribution when samples are singly censored or truncated: Technometrics, v. 1, no. 3, p. 217-237.

Collins, B. A., 1976, Coal deposits of the Carbondale, Grand Hogback, and southern Danforth Hills coal fields, eastern Piceance basin, Colorado: Colorado School of Mines Quarterly, v. 71, no. 1, 138 p.

Conner, J. J., Keith, J. R., and Anderson, B. M., 1976, Trace-metal variation in soils and sagebrush in the Powder River basin, Wyoming and Montana: U.S. Geological Survey Journal of Research, v. 4, no. 1, p. 49-59.

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

Hancock, E. T., 1925, Geology and coal resources of the Axial and Monument Butte quadrangles, Moffat County, Colorado: U.S. Geological Survey Bulletin 757, 134 p.

Hatch, J. R., and Swanson, V. E., 1977, Trace elements in Rocky Mountain coals in Murray, D. K., ed., Geology of Rocky Mountain Coal--A symposium: Colorado Geological Survey Resource Series 1, p. 143-163.

Hornbacker, A. L., Holt, R. D., and Murray, D. K., 1976, 1975 summary of coal resources in Colorado: Colorado Geological Survey Special Publication 9, 17 p.

Jones, D. C., 1977, Licensed coal mines in Colorado: Colorado Geological Survey Map Series 8, scale 1:1,000,000.

Khalsa, N. S., and Ladwig, L. R., eds., 1981; Colorado coal analyses, 1976-1979: Colorado Geological Survey Information Series 10, 364 p.

Landis, E. R., 1959, Coal resources of Colorado: U.S. Geological Survey Bulletin 1072-C, p. 131-232.

Masters, C. D., 1967, Use of sedimentary structures in determination of depositional environments, Mesaverde Formation, Williams Fork Mountains, Colorado: American Association of Petroleum Geologists Bulletin, v. 51, no. 10, p. 2033-2043.

Miesch, A. T., 1967, Methods of computation for estimating geochemical abundances: U.S. Geological Survey, Professional Paper 574-B, 15 p.

Miller, R. L., and Kahn, J. S., 1962, Statistical analysis in the geological sciences: New York, John Wiley and Sons, 483 p.

Reheis, M. J., 1976, Reconnaissance drilling in the Danforth Hills coal field, Moffat and Rio Blanco Counties, Colorado, August-September, 1976: U.S. Geological Survey Open-file Report 76-870, 74 p.

_____, 1978a, Drilling during 1977 in the Danforth Hills coal field, Easton Gulch and Devils Hole quadrangles, Moffat County, Colorado: U.S. Geological Survey Open-file Report 78-272, 29 p.

Reheis, M. J., 1978b, Drilling during 1978 in the Danforth Hills coal field, Easton Gulch and Devils Hole Gulch, Axial, and Ninemile Gap quadrangles, Moffat and Rio Blanco Counties, Colorado: U.S. Geological Survey Open-file Report 78-1031, 38 p.

Ryer, T. A., 1977, Geology and coal resources of the Foidel Creek EMRIA site and surrounding area, Routt County, Colorado: U.S. Geological Survey Open-file Report 77-303, 31 p.

Staff, Office of the Director of Coal Research, 1967, Methods of analyzing and testing coal and coke: U.S. Bureau of Mines Bulletin 638, 85 p.

Swanson, V. E., and Huffman, Claude, Jr., 1976, Guidelines for sample collecting and analytical methods used in the U.S. Geological Survey for determining chemical composition of coal: U.S. Geological Survey Circular 735, 11 p.

Swanson, V. E., Medlin, J. H., Hatch, J. R., Coleman, S. L., Wood, G. H., Jr., Woodruff, S. D., and Hildebrand, R. T., 1976, Collection, chemical analysis, and evaluations of coal samples in 1975: U.S. Geological Survey Open-file Report 76-468, 503 p.

Tweto, Ogden, compiler, 1976, Geologic map of the Craig 1^{o} x 2^{o} quadrangle, northwestern Colorado: U.S. Geological Survey Miscellaneous Investigations Map I-972, scale 1:250,000.

Tweto, Ogden, Moench, R. H., and Reed, J. C., Jr., compilers, 1978, Geologic map of the Leadville 1^{o} x 2^{o} quadrangle, northwestern Colorado: U.S. Geological Survey Miscellaneous Investigations Map I-999, scale 1:250,000.

Weimer, R. J., 1959, Upper Cretaceous stratigraphy, Colorado, in Haun, J. D., and Weimer, R. J., eds., Rocky Mountain Association of Geologists Guidebook, 11th Annual Field Conference: p. 9-16.

TABLES 1-12

Table 1.--U.S. Geological Survey sample numbers, locations, sample types, sample thickness or depth interval represented, and brief descriptions for 100 coal and coal-associated rock samples from the Williams Fork Formation, northwestern Colorado

[For mine samples, U indicates underground operations; S indicates surface operation]

USGS sample number	Location			Sample type	Sample thickness or depth interval represented (feet)	Brief description (bed name)	Hole number or mine name (type)
	Section	Township	Range				
YAMPA COAL FIELD							
Mine samples--Moffat County							
D188245	31	6N	91W	Grab	No data	Floor rock	Wise Hill No. 5 (U)
D188256	31	6N	91W	Channel	Lower 3.0	Coal ("F")	Do.
D188255	31	6N	91W	--do--	Upper 3.0	----do----	Do.
D188246	31	6N	91W	Grab	No data	splay deposit	Do.
Mine samples--Routt County							
D176389	35	6N	87W	Channel	0.2	Floor rock	Seneca (S)
D176378	35	6N	87W	--do--	Lower 5.0	Coal (Wadge)	Do.
D176390	35	6N	87W	--do--	No data	Parting	Do.
D176377	35	6N	87W	--do--	Upper 4.0	Coal (Wadge)	Do.
D176388	35	6N	87W	--do--	.2	Roof rock	Do.
D188239	20	6N	86W	--do--	.5	Floor rock	Denton (S)
D184641	20	6N	86W	--do--	Lower 3.8	Coal (Wadge)	Do.
D184640	20	6N	86W	--do--	Middle 3.0	----do----	Do.
D184639	20	6N	86W	--do--	Upper 1.8	----do----	Do.
D188240	20	6N	86W	--do--	.3	Floor rock	Do.
D184643	20	6N	86W	--do--	Lower 2.0	Coal (Wadge)	Do.
D184642	20	6N	86W	--do--	Upper 5.9	----do----	Do.
D176387	1	5N	86W	Grab	No data	Floor rock	Energy No. 3 (S)
D176375	1	5N	86W	Channel	Lower 4.5	Coal (Wadge?)	Do.
D176376	1	5N	86W	--do--	Upper 4.0	----do----	Do.
D176383	25	5N	87W	Grab	No data	Floor rock	Energy No. 2 (S)
D176370	25	5N	87W	Channel	Lower 2.7	Coal (Fish Creek)	Do.
D176369	25	5N	87W	--do--	Upper 2.5	----do----	Do.
D176373	32	5N	86W	Channel	Lower 5.0	Coal (Wadge)	Energy No. 1 (S)
D176386	32	5N	86W	--do--	.8	Parting	Do.
D176374	32	5N	86W	--do--	Upper 4.0	Coal (Wadge)	Do.
D176385	33	5N	86W	Grab	No data	Floor rock	Energy No. 1A(S)
D176371	33	5N	86W	Channel	Lower 4.0	Coal (Wadge)	Do.
D176372	33	5N	86W	--do--	Upper 4.2	----do----	Do.
D176384	33	5N	86W	Grab	No data	Roof rock	Do.
D176380	7	4N	85W	Channel	.3	Floor rock	Edna (S)
D176363	7	4N	85W	--do--	Lower 2.8	Coal (Wadge)	Do.
D176362	7	4N	85W	--do--	Upper 2.5	----do----	Do.
D176379	7	4N	85W	--do--	.2	Roof rock	Do.
D176365	7	4N	85W	--do--	Lower 3.0	Coal (Wadge)	Do.
D176364	7	4N	85W	--do--	Upper 2.5	----do----	Do.

Table 1.--U.S. Geological Survey sample numbers, locations, sample types, sample thickness or depth interval represented, and brief descriptions for 100 coal and coal-associated rock samples from the Williams Fork Formation, northwestern Colorado--continued

USGS sample number	Location			Sample type	Sample thickness or depth interval represented (feet)	Brief description (bed name)	Hole number or mine name (type)
	Section	Township	Range				
Drill hole samples--Moffat County							
D186094	36	6N	93W	Core	220.0- 235.0	Coal	Y-20-HG
D208577	15	5N	92W	--do--	260.0- 274.0	-----do-----	C-4-RdB
D208564	23	4N	91W	--do--	176.8- 187.0	-----do-----	C-1C-H
D208565	23	4N	91W	--do--	187.0- 197.4	-----do-----	Do.
D208566	23	4N	91W	--do--	218.8- 222.1	-----do-----	Do.
D208567	23	4N	91W	--do--	646.2- 662.9	-----do-----	Do.
D208568	23	4N	91W	--do--	704.3- 705.7	-----do-----	Do.
D208569	23	4N	91W	--do--	722.5- 735.9	-----do-----	Do.
D208570	23	4N	91W	--do--	735.9- 746.5	-----do-----	Do.
D208571	23	4N	91W	--do--	746.5- 756.8	-----do-----	Do.
D208572	23	4N	91W	--do--	766.3- 766.7	-----do-----	Do.
D208573	23	4N	91W	--do--	785.2- 787.9	-----do-----	Do.
D208574	23	4N	91W	--do--	799.2- 811.0	-----do-----	Do.
D208575	23	4N	91W	--do--	854.4- 855.0	-----do-----	Do.
D208576	23	4N	91W	--do--	865.5- 872.0	-----do-----	Do.
Drill hole samples--Routt County							
D178117	24	4N	87W	Core	182.4- 191.2	Coal (Wadge)	DH-1
D178118	24	4N	87W	--do--	196.4- 198.8	Coal	Do.
D178119	24	4N	87W	--do--	253.9- 255.7	-----do-----	Do.
D178120	24	4N	87W	--do--	350.2- 352.5	Coal (Wolf Creek)	Do.
D178121	24	4N	87W	--do--	352.5- 362.5	-----do-----	Do.
D178122	24	4N	87W	--do--	362.5- 370.5	-----do-----	Do.
D178123	24	4N	87W	--do--	23.4- 32.2	Coal (Wadge)	DH-2
D178124	24	4N	87W	--do--	195.8- 214.9	Coal (Wolf Creek)	Do.
D178129	19	4N	86W	--do--	29.5- 32.7	Coal	DH-5A
D178128	18	4N	86W	--do--	88.3- 98.9	Coal (Wadge)	DH-4
D178125	13	4N	87W	--do--	32.4- 38.3	Coal	DH-3
D178126	13	4N	87W	--do--	106.7- 117.8	Coal (Wadge)	Do.
D178127	13	4N	87W	--do--	119.9- 121.9	Coal	Do.
D184645	35	5N	87W	--do--	1286.0-1295.0	Coal (Wadge)	W-36
D184646	26	5N	87W	--do--	1397.0-1403.0	-----do-----	W-35
D208579	28	5N	86W	--do--	74.5- 79.0	Coal (Fish Creek)	RB-23
D208578	28	5N	86W	--do--	20.0- 23.7	-----do-----	RB-16
D208580	27	5N	86W	--do--	10.0- 13.9	-----do-----	RB-24
D188237	13	5N	86W	Grab	No data	Roof rock	W-47
D188252	13	5N	86W	Core	1.3	Coal (Wolf Creek B)	Do.
D188236	13	5N	86W	Grab	No data	Floor rock	Do.
D188238	13	5N	86W	--do--	No data	Roof rock	Do.
D188254	13	5N	86W	Core	3.5	Coal (Wadge)	Do.
D188253	13	5N	86W	--do--	5.0	-----do-----	Do.
D188250	13	5N	86W	--do--	1113.0-1117.0	Coal (Wolf Creek A)	W-50
D188251	13	5N	86W	--do--	1131.0-1141.0	Coal(Wolf Creek A/B)	Do.

Table 1.--U.S. Geological Survey sample numbers, locations, sample types, sample thickness or depth interval represented, and brief descriptions for 100 coal and coal-associated rock samples from the Williams Fork Formation, northwestern Colorado--continued

USGS sample number	Location			Sample type	Sample thickness or depth interval represented (feet)	Brief description (bed name)	Hole number or mine name (type)
	Section	Township	Range				
DANFORTH HILLS COAL FIELD							
Drill hole samples--Moffat County							
D205272	18	4N	94W	Core	145.4-157.1	Coal	D-38-EG
D205273	18	4N	94W	--do--	165.4-179.2	-----do-----	Do.
D205274	18	4N	94W	--do--	179.2-180.7	-----do-----	Do.
D205275	18	4N	94W	--do--	180.7-184.9	-----do-----	Do.
D205276	18	4N	94W	--do--	196.4-198.7	Coal, carb. shale	Do.
D205277	18	4N	94W	--do--	222.5-225.0	Coal	Do.
D205278	18	4N	94W	--do--	287.5-291.6	-----do-----	Do.
D205279	18	4N	94W	--do--	295.3-315.6	-----do-----	Do.
D205280	18	4N	94W	--do--	351.7-359.7	-----do-----	Do.
D205281	18	4N	94W	--do--	367.8-370.0	-----do-----	Do.
D205282	18	4N	94W	--do--	391.6-395.6	-----do-----	Do.
D186091	7	3N	93W	Cuttings	52.8- 64.0	-----do-----	D-3-A
D186092	7	3N	93W	--do--	301.5-304.5	-----do-----	Do.
D186093	8	3N	93W	--do--	882.5-908.8	-----do-----	D-12-NG
D191603	7	3N	92W	Core	350.0-356.0	-----do-----	D-1-NG
D191604	7	3N	92W	--do--	456.0-465.0	-----do-----	Do.
D191605	7	3N	92W	--do--	465.0-472.0	-----do-----	Do.
D191606	7	3N	92W	--do--	639.0-642.0	-----do-----	Do.
Drill hole samples--Rio Blanco County							
D186095	7	2N	92W	Cuttings	60.0- 70.0	Coal	D-8-NG
D186096	7	2N	92W	--do--	145.0-150.0	-----do-----	Do.
D201454	23	2N	93W	Core	48.0- 59.5	-----do-----	M207A
D201455	21	2N	93W	--do--	502.6-515.2	-----do-----	M209A
GRAND HOGBACK COAL FIELD							
Mine samples--Garfield County							
D196217	24	5S	92W	Channel	Lower 3.0	Coal ("E")	Eastside (U)
D196216	24	5S	92W	--do--	Next 4.6	-----do-----	Do.
D196434	24	5S	92W	--do--	.7	Parting	Do.
D196215	24	5S	92W	--do--	Next 4.9	Coal ("E")	Do.
D196214	24	5S	92W	--do--	Upper 4.9	-----do-----	Do.
D196436	24	5S	92W	Grab	No data	Floor rock	Nu-Gap No. 3(U)
D196218	24	5S	92W	Channel	5.7	Coal (Sunnyridge)	Do.
D196435	24	5S	92W	Grab	No data	Roof rock	Do.

Table 1.--U.S. Geological Survey sample numbers, locations, sample types, sample thickness or depth interval represented, and brief descriptions for 100 coal and coal-associated rock samples from the Williams Fork Formation, northwestern Colorado--continued

USGS sample number	Location			Sample type	Sample thickness or depth interval represented (feet)	Brief description (bed name)	Hole number or mine name (type)
	Section	Township	Range				
CARBONDALE COAL FIELD							
Mine samples--Pitkin County							
D208590	34	8S	89W	Channel	10.2	Coal(Anderson)	Thompson Creek No.3(U)
D208589	35	8S	89W	--do--	6.3	Coal ("A")	Thompson Creek No.1(U)
D196222	5	10S	89W	--do--	Lower 5.6	Coal ("B")	Coal Basin(U)
D196221	5	10S	89W	--do--	Upper 3.0	-----do-----	Do.
D196438	5	10S	89W	--do--	.5	Bone coal	Do.
D196223	8	10S	89W	--do--	Upper 7.9	Coal ("B")	L. S. Wood(U)
D196220	17	10S	89W	--do--	Lower 2.8	Coal (Dutch Creek)	Dutch Creek No.2(U)
D196437	17	10S	89W	--do--	1.5	Parting	Do.
D196219	17	10S	89W	--do--	Upper 2.3	Coal (Dutch Creek)	Do.
D184638	17	10S	89W	--do--	Lower 3.2	Coal ("B")	Dutch Creek No. 1(U)
D184637	17	10S	89W	--do--	Upper 3.2	-----do-----	Do.

Table 2a.--Proximate and ultimate analyses, and heat-of-combustion, forms-of-sulfur, free-swelling-index, and ash-fusion-temperature determinations for 44 coal samples from the Williams Fork Formation, Yampa coal field, northwestern Colorado

[All analyses except kcal/kg, Btu/lb, free-swelling index (FSI), and ash-fusion temperatures in percent. For each sample number, the analyses are reported three ways: first, as received; second, moisture free; third, moisture and ash free. Kcal/kg = 0.556 x (Btu/lb); °F = (°C x 1.8) + 32. L means less than the value shown. D188255* is a composite of samples D188255 and D188256; D176377* is a composite of D176377 and D176378; D184639* is a composite of D184639, D184640, and D184641; D184642* is a composite of D184642 and D184643; D176375* is a composite of D176375 and D176376; D176369* is a composite of D176369 and D176370; D176373* is a composite of D176373 and D176374; D176371* is a composite of D176371 and D176372; D176362* is a composite of D176362 and D176363; D176364* is a composite of D176364 and D176365; D188253* is a composite of D188253 and D188254]

Sample number	Proximate analysis				Ultimate analysis					Heat of combustion	
	Moisture	Volatile matter	Fixed carbon	Ash	Hydrogen	Carbon	Nitrogen	Oxygen	Sulfur	Kcal/kg	Btu/lb
D188255*	11.4	34.3	50.3	4.0	5.8	65.4	1.3	23.0	0.4	6,330	11,400
	---	38.7	56.8	4.5	5.1	73.8	1.5	14.5	.5	7,150	12,870
	---	40.5	59.5	---	5.4	77.3	1.5	15.2	.5	7,490	13,470
D176377*	8.0	36.6	46.0	9.4	5.4	63.4	1.6	19.7	.5	6,180	11,130
	---	39.8	50.0	10.2	4.9	68.9	1.7	13.7	.5	6,720	12,100
	---	44.3	55.7	---	5.5	76.8	1.9	15.2	.6	7,490	13,470
D184639*	12.0	34.7	43.6	9.7	5.5	59.9	1.5	22.6	.7	5,870	10,560
	---	39.4	49.5	11.0	4.7	68.1	1.7	13.6	.8	6,670	12,000
	---	44.3	55.7	---	5.3	76.5	1.9	15.2	.9	7,490	13,490
D184642*	12.7	33.1	45.0	9.2	5.4	58.9	1.5	24.5	.6	5,720	10,300
	---	37.9	51.5	10.5	4.6	67.5	1.7	15.1	.7	6,550	11,800
	---	42.4	57.6	---	5.1	75.4	1.9	16.9	.8	7,330	13,190
D176375*	10.9	36.7	45.2	7.2	5.6	61.9	1.5	23.3	.5	6,010	10,820
	---	41.2	50.7	8.1	4.9	69.5	1.7	15.3	.6	6,750	12,140
	---	44.8	55.2	---	5.4	75.6	1.8	16.6	.6	7,340	13,210
D176369*	10.4	39.0	46.5	4.1	5.6	66.5	1.9	21.4	.5	6,440	11,590
	---	43.5	51.9	4.6	5.0	74.2	2.1	13.6	.6	7,190	12,940
	---	45.6	54.4	---	5.2	77.8	2.2	14.2	.6	7,530	13,560
D176373*	5.7	35.2	41.3	17.8	4.9	59.2	1.5	16.0	.6	5,780	10,400
	---	37.3	43.8	18.9	4.5	62.8	1.6	11.6	.6	6,130	11,030
	---	46.0	54.0	---	5.6	77.4	2.0	14.3	.8	7,550	13,590
D176371*	7.0	38.1	47.3	7.6	5.4	66.1	1.7	18.6	.6	6,420	11,560
	---	41.0	50.9	8.2	5.0	71.1	1.8	13.3	.6	6,910	12,430
	---	44.6	55.4	---	5.4	77.4	2.0	14.5	.7	7,520	13,540
D176362*	6.4	38.3	52.3	3.0	5.5	71.0	1.6	18.3	.6	6,910	12,440
	---	40.9	55.9	3.2	5.1	75.9	1.7	13.5	.6	7,380	13,290
	---	42.3	57.7	---	5.3	78.4	1.8	13.9	.7	7,630	13,730
D176364*	7.7	37.6	44.8	9.9	5.3	61.8	1.5	20.8	.7	6,030	10,850
	---	40.7	48.5	10.7	4.8	67.0	1.6	15.1	.8	6,530	11,760
	---	45.6	54.4	---	5.4	75.0	1.8	16.9	.8	7,320	13,170
D186094	8.0	26.1	33.2	32.7	3.9	44.0	1.1	17.7	.6	4,170	7,500
	---	28.4	36.1	35.5	3.3	47.8	1.2	11.5	.7	4,530	8,150
	---	44.0	56.0	---	5.1	74.2	1.9	17.9	1.0	7,030	12,650

Table 2a.--Proximate and ultimate analyses, and heat-of-combustion, forms-of-sulfur, free-swelling-index, and ash-fusion-temperature determinations for 44 coal samples from the Williams Fork Formation, Yampa coal field, northwestern Colorado--continued

Sample number	Air-dried loss	Forms of sulfur			FSI	Ash-fusion temperature, °C		
		Sulfate	Pyritic	Organic		Initial deformation	Softening	Fluid
D188255*	3.8	0.01	0.13	0.30	0.0	1,255	1,320	1,375
	---	.01	.15	.34				
	---	.01	.15	.35				
D176377*	2.6	.03	.06	.45	.5	1,450	1,505	1,570
	---	.03	.07	.49				
	---	.04	.07	.54				
D184639*	5.8	.04	.10	.60	.0	1,540+	1,540+	1,540+
	---	.05	.11	.68				
	---	.05	.13	.77				
D184642*	6.3	.01	.07	.49	.0	1,540+	1,540+	1,540+
	---	.01	.08	.56				
	---	.01	.09	.63				
D176375*	4.0	.03	.03	.49	.0	1,500	1,525	1,590
	---	.03	.03	.55				
	---	.04	.04	.60				
D176369*	4.6	.01	.02	.43	.0	1,145	1,170	1,200
	---	.01	.02	.48				
	---	.01	.02	.50				
D176373*	1.6	.01	.01	.56	.5	1,295	1,350	1,425
	---	.01	.01	.59				
	---	.01	.01	.73				
D176371*	2.2	.01	.05	.53	.5	1,295	1,325	1,390
	---	.01	.05	.57				
	---	.01	.06	.62				
D176362*	2.0	.01	.01	.60	.5	1,170	1,200	1,240
	---	.01	.01	.64				
	---	.01	.01	.66				
D176364*	2.5	.02	.14	.53	.0	1,275	1,305	1,330
	---	.02	.15	.57				
	---	.02	.17	.64				
D186094	2.1	.01	.29	.26	.0	1,375	1,435	1,485
	---	.01	.32	.28				
	---	.02	.49	.44				

Table 2a.--Proximate and ultimate analyses, and heat-of-combustion, forms-of-sulfur, free-swelling-index, and ash-fusion-temperature determinations for 44 coal samples from the Williams Fork Formation, Yampa coal field, northwestern 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
D2 08577	16.3	36.2	43.4	4.1	6.5	60.8	1.4	26.8	0.4	5,800	10,430
	---	43.2	51.9	4.9	5.6	72.6	1.7	14.7	.5	6,920	12,460
	---	45.5	54.5	---	5.9	76.4	1.8	15.5	.5	7,280	13,110
D2 08564	16.3	34.9	44.9	3.9	6.0	61.2	1.6	26.9	.4	5,950	10,720
	---	41.7	53.6	4.7	5.0	73.1	1.9	14.8	.5	7,110	12,810
	---	43.7	56.3	---	5.2	76.7	2.0	15.6	.5	7,460	13,430
D2 08565	16.6	36.1	43.5	3.8	6.3	60.7	1.6	27.2	.4	5,890	10,600
	---	43.3	52.2	4.6	5.3	72.8	1.9	14.9	.5	7,060	12,710
	---	45.4	54.6	---	5.6	76.3	2.0	15.6	.5	7,400	13,320
D2 08566	16.4	35.7	42.4	5.5	6.1	59.3	1.6	26.8	.8	5,780	10,400
	---	42.7	50.7	6.6	5.1	70.9	1.9	14.6	1.0	6,910	12,440
	---	45.7	54.3	---	5.5	75.9	2.0	15.6	1.0	7,400	13,310
D2 08567	14.7	36.4	43.4	5.5	6.2	60.2	1.6	26.3	.3	5,920	10,650
	---	42.7	50.9	6.4	5.4	70.6	1.9	15.5	.4	6,940	12,490
	---	45.6	54.4	---	5.7	75.4	2.0	16.6	.4	7,420	13,350
D2 08568	15.7	35.5	43.4	5.4	6.0	60.2	1.5	26.5	.4	5,820	10,480
	---	42.1	51.5	6.4	5.0	71.4	1.8	14.9	.5	6,910	12,440
	---	45.0	55.0	---	5.4	76.3	1.9	15.9	.5	7,380	13,290
D2 08569	15.3	35.2	43.6	5.9	5.9	60.4	1.3	26.1	.4	5,870	10,560
	---	41.6	51.5	7.0	5.0	71.3	1.5	14.8	.5	6,930	12,470
	---	44.7	55.3	---	5.3	76.6	1.6	15.9	.5	7,450	13,400
D2 08570	12.8	35.6	42.1	9.5	5.3	59.2	1.2	24.2	.5	5,780	10,410
	---	40.8	48.3	10.9	4.4	67.9	1.4	14.7	.6	6,630	11,940
	---	45.8	54.2	---	5.0	76.2	1.5	16.5	.6	7,440	13,400
D2 08571	13.2	34.9	42.1	9.8	5.7	58.9	1.2	23.9	.5	5,720	10,300
	---	40.2	48.5	11.3	4.9	67.9	1.4	14.0	.6	6,590	11,870
	---	45.3	54.7	---	5.5	76.5	1.6	15.8	.6	7,430	13,380
D2 08572	12.2	35.9	43.7	8.2	5.7	60.5	1.3	23.9	.5	5,950	10,700
	---	40.9	49.8	9.3	4.9	68.9	1.5	14.9	.6	6,770	12,190
	---	45.1	54.9	---	5.5	76.0	1.6	16.4	.6	7,470	13,450
D2 08573	14.5	31.5	41.7	12.3	5.7	55.7	1.2	24.6	.5	5,410	9,740
	---	36.8	48.8	14.4	4.8	65.1	1.4	13.7	.6	6,330	11,390
	---	43.0	57.0	---	5.6	76.1	1.6	16.0	.7	7,390	13,300
D2 08574	14.5	34.5	39.7	11.3	5.9	55.4	1.3	25.3	.7	5,420	9,760
	---	40.4	46.4	13.2	5.0	64.8	1.5	14.5	.8	6,350	11,420
	---	46.5	53.5	---	5.8	74.7	1.8	16.7	.9	7,310	13,160

Table 2a.--Proximate and ultimate analyses, and heat-of-combustion, forms-of-sulfur, free-swelling-index, and ash-fusion-temperature determinations for 44 coal samples from the Williams Fork Formation, Yampa coal field, northwestern Colorado--continued

Sample number	Air-dried loss	Forms of sulfur			FSI	Ash-fusion temperature, °C		
		Sulfate	Pyritic	Organic		Initial deformation	Softening	Fluid
D208577	12.3	0.01	0.20	0.19	0.0	1,200	1,260	1,310
	---	.01	.24	.23				
	---	.01	.25	.24				
D208564	10.5	.01	.20	.16	.0	1,160	1,210	1,265
	---	.01	.24	.19				
	---	.01	.25	.20				
D208565	11.0	.01	.15	.20	.0	1,150	1,200	1,260
	---	.01	.18	.24				
	---	.01	.19	.25				
D208566	11.5	.01	.48	.35	.0	1,095	1,150	1,210
	---	.01	.57	.42				
	---	.01	.61	.45				
D208567	9.8	.01L	.15	.16	.0	1,350	1,405	1,455
	---	.01L	.18	.19				
	---	.01L	.19	.20				
D208568	10.7	.01	.20	.18	.0	1,205	1,265	1,325
	---	.01	.24	.21				
	---	.01	.25	.23				
D208569	10.7	.01	.23	.17	.0	1,430	1,495	1,540+
	---	.01	.27	.20				
	---	.01	.29	.22				
D208570	8.1	.01	.22	.31	.0	1,295	1,350	1,410
	---	.01	.25	.36				
	---	.01	.28	.40				
D208571	8.6	.01	.24	.25	.0	1,440	1,500	1,540+
	---	.01	.28	.29				
	---	.01	.31	.32				
D208572	7.0	.01	.19	.33	.0	1,370	1,430	1,480
	---	.01	.22	.38				
	---	.01	.24	.41				
D208573	10.1	.01	.15	.34	.0	1,440	1,490	1,540+
	---	.01	.18	.40				
	---	.01	.20	.46				
D208574	10.5	.01	.24	.45	.0	1,175	1,240	1,290
	---	.01	.28	.53				
	---	.01	.32	.61				

Table 2a.--Proximate and ultimate analyses, and heat-of-combustion, forms-of-sulfur, free-swelling-index, and ash-fusion-temperature determinations for 44 coal samples from the Williams Fork Formation, Yampa coal field, northwestern 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
D208575	15.8	34.9	43.8	5.5	7.1	60.5	1.4	24.8	0.7	5,870	10,570
	---	41.4	52.0	6.5	6.3	71.9	1.7	12.8	.8	6,970	12,550
	---	44.3	55.7	---	6.8	76.9	1.8	13.7	.9	7,460	13,430
D208576	12.5	34.8	45.5	7.2	5.6	62.5	1.5	22.8	.4	5,990	10,790
	---	39.8	52.0	8.2	4.8	71.4	1.7	13.4	.5	6,850	12,330
	---	43.3	56.7	---	5.2	77.8	1.9	14.6	.5	7,470	13,440
D178117	10.5	34.0	46.9	8.6	5.7	62.5	.9	21.8	.5	6,040	10,870
	---	38.0	52.4	9.6	5.1	69.8	1.0	13.9	.6	6,750	12,150
	---	42.0	58.0	---	5.6	77.3	1.1	15.4	.6	7,460	13,440
D178118	10.5	32.9	45.2	11.4	5.4	60.0	.7	21.9	.6	5,810	10,460
	---	36.8	50.5	12.7	4.7	67.0	.8	14.0	.7	6,490	11,690
	---	42.1	57.9	---	5.4	76.8	.9	16.1	.8	7,440	13,390
D178119	9.9	36.8	46.6	6.7	5.7	64.5	1.0	21.5	.6	6,240	11,240
	---	40.8	51.7	7.4	5.1	71.6	1.1	14.1	.7	6,930	12,480
	---	44.1	55.9	---	5.5	77.3	1.2	15.2	.7	7,490	13,480
D178120	8.8	34.7	46.3	10.2	5.5	62.8	.8	20.1	.6	6,080	10,940
	---	38.0	50.8	11.2	5.0	68.9	.9	13.5	.7	6,660	12,000
	---	42.8	57.2	---	5.6	77.5	1.0	15.2	.7	7,500	13,510
D178121	9.4	33.2	44.3	13.1	5.4	60.0	.8	20.3	.4	5,790	10,430
	---	36.6	48.9	14.5	4.8	66.2	.9	13.2	.4	6,400	11,510
	---	42.8	57.2	---	5.6	77.4	1.0	15.4	.5	7,480	13,460
D178122	9.5	34.5	43.6	12.4	5.3	60.5	1.0	20.2	.6	5,860	10,550
	---	38.1	48.2	13.7	4.7	66.9	1.1	13.0	.7	6,480	11,660
	---	44.2	55.8	---	5.4	77.5	1.3	15.1	.8	7,500	13,510
D178123	17.1	27.5	38.5	16.9	5.4	49.6	.8	26.9	.4	4,720	8,500
	---	33.2	46.4	20.4	4.2	59.8	1.0	14.1	.5	5,700	10,250
	---	41.7	58.3	---	5.3	75.2	1.2	17.7	.6	7,150	12,880
D178124	8.9	34.1	42.3	14.7	5.0	58.6	.7	20.4	.6	5,660	10,180
	---	37.4	46.4	16.1	4.4	64.3	.8	13.7	.7	6,210	11,170
	---	44.6	55.4	---	5.3	76.7	.9	16.3	.8	7,400	13,320
D178129	9.4	34.3	48.8	7.5	5.5	64.1	.8	21.6	.5	6,250	11,250
	---	37.9	53.9	8.3	4.9	70.8	.9	14.6	.6	6,900	12,420
	---	41.3	58.7	---	5.4	77.1	1.0	15.9	.6	7,520	13,540
D178128	7.5	34.5	35.0	23.0	4.9	51.3	1.1	16.6	3.1	5,140	9,250
	---	37.3	37.8	24.9	4.4	55.5	1.2	10.7	3.4	5,560	10,000
	---	49.6	50.4	---	5.9	73.8	1.6	14.3	4.5	7,390	13,310

Table 2a.--Proximate and ultimate analyses, and heat-of-combustion, forms-of-sulfur, free-swelling-index, and ash-fusion-temperature determinations for 44 coal samples from the Williams Fork Formation, Yampa coal field, northwestern Colorado--continued

Sample number	Air-dried loss	Forms of sulfur			FSI	Ash-fusion temperature, °C		
		Sulfate	Pyritic	Organic		Initial deformation	Softening	Fluid
D208575	11.7	0.01	0.14	0.54	0.0	1,265	1,315	1,375
	---	.01	.17	.64				
	---	.01	.18	.69				
D208576	7.6	.01	.05	.38	.0	1,295	1,350	1,400
	---	.01	.06	.43				
	---	.01	.06	.47				
D178117	1.0	.01	.07	.44	.5	1,390	1,415	1,470
	---	.01	.08	.49				
	---	.01	.09	.54				
D178118	.9	.01	.05	.57	.5	1,345	1,405	1,525
	---	.01	.06	.64				
	---	.01	.06	.73				
D178119	.8	.01	.06	.57	.5	1,555	1,580	1,600+
	---	.01	.07	.63				
	---	.01	.07	.68				
D178120	.6	.01	.03	.58	.0	1,600+	1,600+	1,600+
	---	.01	.03	.64				
	---	.01	.04	.72				
D178121	.7	.01	.02	.40	.0	1,320	1,350	1,525
	---	.01	.02	.44				
	---	.01	.03	.52				
D178122	.8	.01	.13	.46	.5	1,390	1,495	1,575
	---	.01	.14	.51				
	---	.01	.17	.59				
D178123	7.8	.01	.04	.37	.0	1,570	1,600+	1,600+
	---	.01	.05	.45				
	---	.02	.06	.56				
D178124	.6	.01	.12	.51	.0	1,230	1,290	1,345
	---	.01	.13	.56				
	---	.01	.16	.67				
D178129	.6	.01	.05	.41	.5	1,380	1,415	1,470
	---	.01	.06	.45				
	---	.01	.06	.49				
D178128	.5	.01	2.18	.92	.5	1,205	1,240	1,290
	---	.01	2.36	.99				
	---	.01	3.14	1.32				

Table 2a.--Proximate and ultimate analyses, and heat-of-combustion, forms-of-sulfur, free-swelling-index, and ash-fusion-temperature determinations for 44 coal samples from the Williams Fork Formation, Yampa coal field, northwestern 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
D178125	8.0	40.3	44.7	7.0	5.8	64.4	1.4	18.8	2.6	6,410	11,540
	---	43.8	48.6	7.6	5.3	70.0	1.5	12.7	2.8	6,970	12,540
	---	47.4	52.6	---	5.8	75.8	1.6	13.8	3.1	7,540	13,580
D178126	9.6	32.9	45.5	12.0	5.3	60.4	.5	21.3	.5	5,860	10,550
	---	36.4	50.3	13.3	4.7	66.8	.6	14.1	.6	6,480	11,670
	---	42.0	58.0	---	5.4	77.0	.6	16.3	.6	7,480	13,460
D178127	11.3	34.5	45.4	8.8	5.6	61.1	1.1	22.7	.7	5,970	10,750
	---	38.9	51.2	9.9	4.9	68.9	1.2	14.3	.8	6,730	12,120
	---	43.2	56.8	---	5.4	76.5	1.4	15.8	.9	7,470	13,450
D184645	8.2	34.2	50.1	7.5	5.4	66.9	1.7	18.1	.5	6,580	11,840
	---	37.3	54.6	8.2	4.9	72.9	1.9	11.8	.5	7,170	12,900
	---	40.6	59.4	---	5.3	79.4	2.0	12.8	.6	7,810	14,050
D184646	8.2	35.6	49.8	6.4	5.6	67.4	1.7	18.4	.4	6,670	12,010
	---	38.8	54.2	7.0	5.1	73.4	1.9	12.1	.4	7,270	13,080
	---	41.7	58.3	---	5.5	78.9	2.0	13.0	.5	7,810	14,060
D188252	9.6	35.2	50.1	5.1	5.8	66.6	1.6	20.3	.6	6,530	11,760
	---	38.9	55.4	5.6	5.2	73.7	1.8	13.0	.7	7,230	13,010
	---	41.3	58.7	---	5.5	78.1	1.9	13.8	.7	7,660	13,780
D188253*	8.8	33.9	49.5	7.8	5.6	65.1	1.6	19.4	.6	6,390	11,500
	---	37.2	54.3	8.6	5.1	71.4	1.8	12.7	.7	7,010	12,610
	---	40.6	59.4	---	5.5	78.1	1.9	13.9	.7	7,660	13,790
D188250	7.3	33.8	38.7	20.2	5.1	55.8	1.2	16.8	.9	5,480	9,870
	---	36.5	41.7	21.8	4.6	60.2	1.3	11.1	1.0	5,920	10,650
	---	46.6	53.4	---	5.9	77.0	1.7	14.2	1.2	7,560	13,620
D188251	8.7	36.5	44.2	10.6	5.6	63.1	1.5	18.9	.4	6,180	11,130
	---	40.0	48.4	11.6	5.1	69.1	1.6	12.2	.4	6,770	12,190
	---	45.2	54.8	---	5.7	78.2	1.9	13.8	.5	7,660	13,790

Table 2a.--Proximate and ultimate analyses, and heat-of-combustion, forms-of-sulfur, free-swelling-index, and ash-fusion-temperature determinations for 44 coal samples from the Williams Fork Formation, Yampa coal field, northwestern Colorado--continued

Sample number	Air-dried loss	Forms of sulfur			FSI	Ash-fusion temperature, °C		
		Sulfate	Pyritic	Organic		Initial deformation	Softening	Fluid
D178125	0.2	0.01	0.36	2.27	0.5	1,070	1,095	1,115
	---	.01	.39	2.47				
	---	.01	.42	2.67				
D178126	.7	.01	.05	.45	.5	1,525	1,580	1,600+
	---	.01	.06	.50				
	---	.01	.06	.57				
D178127	2.4	.01	.09	.60	.5	1,470	1,500	1,525
	---	.01	.10	.68				
	---	.01	.11	.75				
D184645	2.1	.01	.02	.43	.0	1,285	1,350	1,405
	---	.01	.02	.47				
	---	.01	.02	.51				
D184646	2.4	.02	.08	.35	.0	1,540+	1,540+	1,540+
	---	.02	.09	.38				
	---	.02	.09	.41				
D188252	2.6	.01	.19	.40	.0	1,325	1,380	1,430
	---	.01	.21	.44				
	---	.01	.22	.47				
D188253*	1.5	.01	.21	.34	.0	1,540+	1,540+	1,540+
	---	.01	.23	.37				
	---	.01	.25	.41				
D188250	1.6	.01	.27	.62	.0	1,540+	1,540+	1,540+
	---	.01	.29	.67				
	---	.01	.37	.86				
D188251	2.1	.01	.17	.24	.0	1,540+	1,540+	1,540+
	---	.01	.19	.26				
	---	.01	.21	.30				

Table 2b.--Proximate and ultimate analyses, and heat-of-combustion, forms-of-sulfur, free-swelling-index, and ash-fusion-temperature determinations for 19 coal samples from the Williams Fork Formation, Danforth Hills coal field, northwestern Colorado

[All analyses except kcal/kg, Btu/lb, free-swelling index (FSI), and ash-fusion temperatures in percent. For each sample number, the analyses are reported three ways: first, as received; second, moisture free; third, moisture and ash free. Kcal/kg = 0.556 x (Btu/lb); °F = (°C x 1.8) + 32. L means less than the value shown]

Sample number	Proximate analysis				Ultimate analysis					Heat of combustion	
	Moisture	Volatile matter	Fixed carbon	Ash	Hydrogen	Carbon	Nitrogen	Oxygen	Sulfur	Kcal/kg	Btu/lb
D205272	18.2	30.9	44.9	6.0	5.9	57.5	1.2	29.0	0.3	5,520	9,940
	---	37.8	54.9	7.3	4.7	70.3	1.5	15.7	.4	6,750	12,160
	---	40.8	59.2	---	5.1	75.9	1.6	16.9	.4	7,290	13,120
D205273	16.8	32.2	47.2	3.8	6.0	60.2	1.2	28.6	.3	5,810	10,460
	---	38.7	56.7	4.6	5.0	72.4	1.4	16.4	.4	6,990	12,580
	---	40.6	59.4	---	5.2	75.8	1.5	17.2	.4	7,320	13,180
D205274	16.3	28.1	38.7	16.9	5.4	49.4	.9	26.4	1.0	4,770	8,580
	---	33.6	46.2	20.2	4.3	59.0	1.1	14.2	1.2	5,690	10,250
	---	42.1	57.9	---	5.4	74.0	1.3	17.8	1.5	7,130	12,840
D205275	16.7	32.4	46.4	4.5	6.0	59.7	1.1	27.5	1.1	5,760	10,380
	---	38.9	55.7	5.4	5.0	71.7	1.3	15.2	1.3	6,920	12,460
	---	41.1	58.9	---	5.3	75.8	1.4	16.1	1.4	7,320	13,170
D205276	11.6	21.9	25.0	41.5	4.0	33.5	.7	19.2	1.0	3,210	5,780
	---	24.8	28.3	46.9	3.1	37.9	.8	10.1	1.1	3,630	6,530
	---	46.7	53.3	---	5.8	71.4	1.5	19.0	2.1	6,840	12,320
D205277	15.5	28.4	37.8	18.3	5.2	49.3	1.1	25.4	.7	4,780	8,600
	---	33.6	44.7	21.7	4.1	58.3	1.3	13.8	.8	5,660	10,180
	---	42.9	57.1	---	5.3	74.5	1.7	17.6	1.1	7,220	13,000
D205278	17.5	32.1	43.9	6.5	5.9	57.8	1.1	28.1	.6	5,490	9,880
	---	38.9	53.2	7.9	4.8	70.1	1.3	15.2	.7	6,660	11,980
	---	42.2	57.8	---	5.2	76.1	1.4	16.5	.8	7,220	13,000
D205279	15.7	32.6	45.9	5.8	5.9	59.9	1.1	26.9	.4	5,780	10,410
	---	38.7	54.4	6.9	4.9	71.1	1.3	15.4	.5	6,860	12,350
	---	41.5	58.5	---	5.3	76.3	1.4	16.5	.5	7,370	13,260
D205280	15.1	29.4	39.8	15.7	5.4	51.2	1.0	25.9	.8	5,040	9,070
	---	34.6	46.9	18.5	4.4	60.3	1.2	14.7	.9	5,940	10,680
	---	42.5	57.5	---	5.4	74.0	1.4	18.0	1.2	7,280	13,110
D205281	16.8	31.7	45.5	6.0	5.9	58.7	1.2	27.6	.7	5,680	10,220
	---	38.1	54.7	7.2	4.8	70.6	1.4	15.2	.8	6,820	12,280
	---	41.1	58.9	---	5.2	76.0	1.6	16.4	.9	7,360	13,240
D205282	15.0	28.2	39.8	17.0	5.2	51.2	1.0	24.9	.6	4,940	8,900
	---	33.2	46.8	20.0	4.2	60.2	1.2	13.6	.7	5,810	10,470
	---	41.5	58.5	---	5.2	75.3	1.5	17.0	.9	7,270	13,080

Table 2b.--Proximate and ultimate analyses, and heat-of-combustion, forms-of-sulfur, free-swelling-index, and ash-fusion-temperature determinations for 19 coal samples from the Williams Fork Formation, Danforth Hills coal field, northwestern Colorado--continued

Sample number	Air-dried loss	Forms of sulfur			FSI	Ash-fusion temperature, °C		
		Sulfate	Pyritic	Organic		Initial deformation	Softening	Fluid
D205272	14.2	0.01	0.13	0.20	0.0	1,345	1,405	1,460
	---	.01	.16	.24				
	---	.01	.17	.26				
D205273	12.7	.01	.13	.12	.0	1,290	1,350	1,405
	---	.01	.16	.14				
	---	.01	.16	.15				
D205274	12.4	.01	.41	.59	.0	1,495	1,600+	1,600+
	---	.01	.49	.70				
	---	.01	.61	.88				
D205275	12.9	.01	.38	.76	.0	1,160	1,210	1,270
	---	.01	.46	.91				
	---	.01	.48	.96				
D205276	9.1	.01	.25	.70	.0	1,600+	1,600+	1,600+
	---	.01	.28	.79				
	---	.02	.53	1.49				
D205277	11.8	.01	.13	.58	.0	1,505	1,600+	1,600+
	---	.01	.15	.69				
	---	.02	.20	.88				
D205278	13.4	.01	.10	.54	.0	1,290	1,350	1,405
	---	.01	.12	.65				
	---	.01	.13	.71				
D205279	11.6	.01	.07	.33	.0	1,295	1,345	1,405
	---	.01	.08	.39				
	---	.01	.09	.42				
D205280	11.4	.01	.23	.56	.0	1,455	1,515	1,600+
	---	.01	.27	.66				
	---	.01	.33	.81				
D205281	12.3	.01	.09	.58	.0	1,320	1,380	1,430
	---	.01	.11	.70				
	---	.01	.12	.75				
D205282	11.0	.01	.10	.54	.0	1,440	1,490	1,600+
	---	.01	.12	.64				
	---	.01	.15	.79				

Table 2b.--Proximate and ultimate analyses, and heat-of-combustion, forms-of-sulfur, free-swelling-index, and ash-fusion-temperature determinations for 19 coal samples from the Williams Fork Formation, Danforth Hills coal field, northwestern 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
D186091	15.2	30.2	42.5	12.1	5.4	55.6	1.3	25.3	0.3	5,320	9,570
	---	35.6	50.1	14.3	4.4	65.6	1.5	13.9	.4	6,270	11,290
	---	41.5	58.5	---	5.1	76.5	1.8	16.2	.4	7,320	13,170
D186092	2.9	11.3	40.0	45.8	2.5	43.6	1.0	6.4	.6	4,000	7,190
	---	11.6	41.2	47.2	2.2	44.9	1.0	3.9	.6	4,110	7,410
	---	22.0	78.0	---	4.2	85.0	1.9	7.5	1.2	7,790	14,020
D186093	17.1	23.2	22.5	37.2	4.6	34.3	.6	22.6	.6	3,280	5,910
	---	28.0	27.1	44.9	3.3	41.4	.7	8.9	.7	3,960	7,120
	---	50.8	49.2	---	5.9	75.1	1.3	16.2	1.3	7,180	12,920
D191603	11.5	32.7	50.7	5.1	5.3	62.9	1.5	24.5	.6	5,950	10,700
	---	36.9	57.3	5.8	4.5	71.1	1.7	16.1	.7	6,720	12,100
	---	39.2	60.8	---	4.8	75.4	1.8	17.1	.7	7,130	12,840
D191604	10.1	33.2	50.9	5.8	5.2	64.1	1.6	23.1	.3	6,020	10,830
	---	36.9	56.6	6.5	4.5	71.3	1.8	15.7	.3	6,690	12,050
	---	39.5	60.5	---	4.8	76.2	1.9	16.8	.4	7,150	12,880
D191605	8.1	32.2	45.7	14.0	4.7	57.6	1.4	22.0	.3	5,560	10,010
	---	35.0	49.7	15.2	4.1	62.7	1.5	16.1	.3	6,050	10,890
	---	41.3	58.7	---	4.9	73.9	1.8	19.0	.4	7,140	12,840
D191606	7.6	29.7	35.9	26.8	4.3	48.3	1.3	18.9	.5	4,550	8,190
	---	32.1	38.9	29.0	3.7	52.3	1.4	13.1	.5	4,920	8,860
	---	45.3	54.7	---	5.3	73.6	2.0	18.5	.8	6,930	12,480
D186096	23.8	24.7	31.2	20.3	5.6	42.0	.9	30.6	.5	4,070	7,320
	---	32.4	40.9	26.6	3.9	55.1	1.2	12.4	.7	5,340	9,600
	---	44.2	55.8	---	5.3	75.1	1.6	16.9	.9	7,270	13,090

Table 2b.--Proximate and ultimate analyses, and heat-of-combustion, forms-of-sulfur, free-swelling-index, and ash-fusion-temperature determinations for 19 coal samples from the Williams Fork Formation, Danforth Hills coal field, northwestern Colorado--continued

Sample number	Air-dried loss	Forms of sulfur			FSI	Ash-fusion temperature, °C		
		Sulfate	Pyritic	Organic		Initial deformation	Softening	Fluid
D186091	8.4	0.01	0.13	0.18	0.0	1,235	1,290	1,345
	---	.01	.15	.21				
	---	.01	.18	.25				
D186092	1.2	.01	.25	.39	.0	1,430	1,490	1,540+
	---	.01	.26	.40				
	---	.02	.49	.76				
D186093	13.9	.02	.16	.41	.0	1,325	1,375	1,435
	---	.02	.19	.49				
	---	.04	.35	.90				
D191603	2.3	.01	.32	.28	.0	1,115	1,145	1,170
	---	.01	.36	.32				
	---	.01	.38	.34				
D191604	.9	.01	.06	.23	.0	1,145	1,170	1,200
	---	.01	.07	.26				
	---	.01	.07	.27				
D191605	.7	.01L	.02	.23	.0	1,290	1,315	1,385
	---	.01L	.02	.25				
	---	.01L	.03	.30				
D191606	1.0	.01	.23	.26	.0	1,600+	1,600+	1,600+
	---	.01	.25	.28				
	---	.02	.35	.40				
D186096	19.8	.01	.11	.43	.0	1,430	1,490	1,540+
	---	.01	.14	.56				
	---	.02	.20	.77				

Table 2c.--Proximate and ultimate analyses, and heat-of-combustion, forms-of-sulfur, free-swelling-index, and ash-fusion-temperature determinations for five coal samples from the Williams Fork Formation, Grand Hogback coal field, northwestern Colorado

[All analyses except kcal/kg, Btu/lb, free-swelling index (FSI), and ash-fusion temperatures in percent. For each sample number, the analyses are reported three ways: first, as received; second, moisture free; third, moisture and ash free. Kcal/kg = 0.556 x (Btu/lb); °F = (°C x 1.8) + 32. L means less than the value shown]

Sample number	Proximate analysis				Ultimate analysis					Heat of combustion	
	Moisture	Volatile matter	Fixed carbon	Ash	Hydrogen	Carbon	Nitrogen	Oxygen	Sulfur	Kcal/kg	Btu/lb
D196217	4.3	39.2	46.1	10.4	5.5	68.0	1.4	14.1	0.6	6,750	12,150
	---	41.0	48.2	10.9	5.2	71.1	1.5	10.7	.6	7,050	12,690
	---	46.0	54.0	---	5.9	79.7	1.6	12.0	.7	7,910	14,240
D196216	4.5	37.2	48.3	10.0	5.4	68.2	1.4	14.3	.7	6,700	12,060
	---	39.0	50.6	10.5	5.1	71.4	1.5	10.8	.7	7,020	12,630
	---	43.5	56.5	---	5.7	79.8	1.6	12.0	.8	7,840	14,110
D196215	4.8	38.7	50.0	6.5	5.6	71.4	1.4	14.5	.6	6,980	12,560
	---	40.7	52.5	6.8	5.3	75.0	1.5	10.7	.6	7,330	13,190
	---	43.6	56.4	---	5.7	80.5	1.6	11.5	.7	7,870	14,160
D196214	4.7	39.4	49.8	6.1	5.5	71.0	1.4	15.3	.6	6,990	12,580
	---	41.3	52.3	6.4	5.2	74.5	1.5	11.7	.6	7,330	13,200
	---	44.2	55.8	---	5.6	79.6	1.6	12.5	.7	7,840	14,100
D196218	4.0	39.8	48.0	8.2	5.5	69.7	.9	15.3	.4	6,860	12,350
	---	41.5	50.0	8.5	5.3	72.6	.9	12.2	.4	7,150	12,860
	---	45.3	54.7	---	5.8	79.4	1.0	13.4	.5	7,810	14,070

Table 2c.--Proximate and ultimate analyses, and heat-of-combustion, forms-of-sulfur, free-swelling-index, and ash-fusion-temperature determinations for five coal samples from the Williams Fork Formation, Grand Hogback coal field, northwestern Colorado--continued

Sample number	Air-dried loss	Forms of sulfur			FSI	Ash-fusion temperature, °C		
		Sulfate	Pyritic	Organic		Initial deformation	Softening	Fluid
D196217	1.1	0.02	0.04	0.56	1.5	1,600+	1,600+	1,600+
	---	.02	.04	.59				
	---	.02	.05	.66				
D196216	.6	.02	.08	.55	1.0	1,600+	1,600+	1,600+
	---	.02	.08	.58				
	---	.02	.09	.64				
D196215	.9	.01	.09	.49	1.5	1,600+	1,600+	1,600+
	---	.01	.09	.51				
	---	.01	.10	.55				
D196214	.2	.01L	.07	.53	1.0	1,330	1,360	1,390
	---	.01L	.07	.56				
	---	.01L	.08	.59				
D196218	.1L	.01	.03	.38	1.0	1,220	1,250	1,315
	---	.01	.03	.40				
	---	.01	.03	.43				

Table 2d.--Proximate and ultimate analyses, and heat-of-combustion, forms-of-sulfur, free-swelling-index, and ash-fusion-temperature determinations for eight coal samples from the Williams Fork Formation, Carbondale coal field, northwestern Colorado

[All analyses except kcal/kg, Btu/lb, free-swelling index (FSI), and ash-fusion temperatures in percent. For each sample number, the analyses are reported three ways: first, as received; second, moisture free; third, moisture and ash free. Kcal/kg = 0.556 x (Btu/lb); °F = (°C x 1.8) + 32. D184637* is a composite of samples D184637 and D184638]

Sample number	Proximate analysis				Ultimate analysis					Heat of combustion	
	Moisture	Volatile matter	Fixed carbon	Ash	Hydrogen	Carbon	Nitrogen	Oxygen	Sulfur	Kcal/kg	Btu/lb
D208590	1.8	33.0	59.2	6.0	5.8	80.0	2.1	5.6	0.6	7,950	14,310
	---	33.6	60.3	6.1	5.7	81.5	2.1	4.1	.6	8,090	14,570
	---	35.8	64.2	---	6.1	86.8	2.3	4.3	.7	8,620	15,520
D208589	1.7	28.7	58.3	11.3	5.3	75.3	2.1	5.3	.6	7,470	13,450
	---	29.2	59.3	11.5	5.2	76.6	2.1	3.9	.6	7,600	13,680
	---	33.0	67.0	---	5.9	86.6	2.4	4.4	.7	8,590	15,460
D196222	1.0	23.9	68.6	6.5	5.0	82.8	1.9	3.5	.4	8,110	14,600
	---	24.1	69.3	6.6	4.9	83.6	1.9	2.6	.4	8,190	14,750
	---	25.8	74.2	---	5.3	89.5	2.1	2.8	.4	8,770	15,780
D196221	.8	25.9	69.4	3.9	5.3	85.7	1.9	2.6	.5	8,380	15,090
	---	26.1	70.0	3.9	5.3	86.4	1.9	1.9	.5	8,450	15,210
	---	27.2	72.8	---	5.5	89.9	2.0	2.0	.5	8,800	15,830
D196223	1.0	21.8	69.6	7.6	4.9	81.7	1.9	3.6	.4	8,050	14,490
	---	22.0	70.3	7.7	4.8	82.5	1.9	2.7	.4	8,130	14,630
	---	23.9	76.1	---	5.2	89.4	2.1	3.0	.4	8,810	15,850
D196220	.8	28.1	65.4	5.7	5.3	82.6	1.9	4.2	.3	8,150	14,670
	---	28.3	65.9	5.7	5.3	83.3	1.9	3.5	.3	8,210	14,790
	---	30.1	69.9	---	5.6	88.3	2.0	3.7	.3	8,710	15,690
D196219	1.0	27.3	63.2	8.5	5.0	79.7	1.7	3.8	1.3	7,810	14,070
	---	27.6	63.8	8.6	4.9	80.5	1.7	2.9	1.3	7,890	14,210
	---	30.2	69.8	---	5.4	88.1	1.9	3.2	1.4	8,630	15,540
D184637*	.8	22.7	69.0	7.5	4.8	81.9	1.9	3.3	.5	8,060	14,500
	---	22.9	69.6	7.6	4.7	82.6	1.9	2.6	.5	8,120	14,620
	---	24.8	75.2	---	5.1	89.3	2.1	2.8	.5	8,790	15,820

Table 2d.--Proximate and ultimate analyses, and heat-of-combustion, forms-of-sulfur, free-swelling-index, and ash-fusion-temperature determinations for eight coal samples from the Williams Fork Formation, Carbondale coal field, northwestern Colorado--continued

Sample number	Air-dried loss	Forms of sulfur			FSI	Ash-fusion temperature, °C		
		Sulfate	Pyritic	Organic		Initial deformation	Softening	Fluid
D208590	1.1	0.10	0.14	0.44	9.0	1,270	1,320	1,320
	---	.10	.14	.45				
	---	.11	.15	.48				
D208589	1.1	.01	.08	.54	9.0	1,320	1,370	1,430
	---	.01	.08	.55				
	---	.01	.09	.62				
D196222	.1L	.01	.01	.34	9.0	1,230	1,260	1,325
	---	.01	.01	.34				
	---	.01	.01	.37				
D196221	.1L	.02	.03	.50	9.0	1,200	1,230	1,345
	---	.02	.03	.50				
	---	.02	.03	.52				
D196223	.1L	.01	.03	.36	9.0	1,195	1,220	1,295
	---	.01	.03	.36				
	---	.01	.03	.39				
D196220	.1L	.02	.03	.28	8.5	1,170	1,200	1,310
	---	.02	.03	.28				
	---	.02	.03	.30				
D196219	.1L	.10	.60	.56	8.5	1,110	1,140	1,305
	---	.10	.61	.57				
	---	.11	.66	.62				
D184637*	.3	.01	.03	.48	9.0	1,280	1,330	1,375
	---	.01	.03	.48				
	---	.01	.03	.52				

Table 3a.--Major- and minor-oxide and trace-element composition of the laboratory ash of 63 coal and 13 coal-associated rock samples from the Williams Fork Formation, Yampa coal field, northwestern Colorado

[Coal ashed at 525°C. L means 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 are 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)	SiO2 (percent)	Al2O3 (percent)	CaO (percent)	MgO (percent)	Na2O (percent)	K2O (percent)	Fe2O3 (percent)	TiO2 (percent)	P2O5 (percent)	Sample number
D188245	94.8	70	20	2.0	0.73	0.77	2.4	1.3	0.84	1.0L	D188245
D188256	4.1	18	22	20	1.02	5.33	.22	4.1	1.8	11	D188256
D188255	5.1	37	26	11	.91	4.20	.43	3.4	1.4	2.1	D188255
D188246	94.5	66	15	8.9	.83	.39	1.7	1.9	.40	1.0L	D188246
D176389	67.2	83	13	.21	.50	.89	2.5	1.4	.69	1.0L	D176389
D176378	9.7	55	27	4.1	.71	.51	1.1	3.0	.92	1.2	D176378
D176390	48.9	57	36	.50	.52	.55	1.4	1.8	.77	1.0L	D176390
D176377	11.2	52	30	2.8	1.19	.35	1.0	3.1	1.0	1.0L	D176377
D176388	87.7	68	11	.28	.91	.50	2.0	2.1	.44	1.0L	D176388
D188239	29.9	65	19	2.3	1.19	.21	2.2	3.8	.81	1.0L	D188239
D184641	12.7	52	24	4.9	.75	.21	1.0	3.9	.89	1.0L	D184641
D184640	8.4	45	26	10	1.37	.16	.61	2.8	1.1	1.0L	D184640
D184639	10.5	49	26	7.5	1.61	.17	.55	3.0	.72	1.0L	D184639
D188240	91.1	72	14	.99	.81	.65	3.1	1.3	.73	1.0L	D188240
D184643	21.8	67	17	1.8	.57	.23	1.4	2.5	.69	1.0L	D184643
D184642	7.0	46	26	7.0	.94	.14	.59	3.8	1.0	1.0L	D184642
D176387	65.8	74	14	.33	.82	.50	2.6	1.6	.62	1.0L	D176387
D176375	11.9	48	31	3.2	.98	.15	.66	2.5	.79	1.0L	D176375
D176376	6.2	43	29	6.7	1.44	.18	.49	3.9	1.0	1.0L	D176376
D176383	65.4	85	7.4	.31	.29	.20	1.5	.86	.67	1.0L	D176383
D176370	3.9	31	18	14	3.10	.49	.28	10	.78	1.6	D176370
D176369	5.5	39	17	14	2.35	.49	.54	8.0	.88	3.2	D176369
D176373	10.1	52	21	5.7	1.53	1.46	.83	2.9	.84	1.3	D176373
D176386	30.0	82	12	.66	.40	.61	1.5	.94	.55	1.0L	D176386
D176374	28.2	71	14	2.4	.81	.84	1.5	1.8	.55	1.0L	D176374
D176385	78.3	83	11	.25	.44	.85	2.0	1.2	.63	1.0L	D176385
D176371	10.3	53	23	5.8	1.41	.57	.83	3.0	.86	1.0L	D176371
D176372	7.4	46	26	6.3	1.36	.26	.81	4.0	.99	1.0L	D176372
D176384	87.3	76	11	.96	1.12	.58	2.1	1.8	.59	1.0L	D176384
D176380	77.4	73	12	.49	.93	.45	1.8	8.3	.60	1.0L	D176380
D176363	12.0	53	23	4.2	1.16	.61	.85	2.7	.69	1.0L	D176363
D176362	8.2	41	21	7.1	1.87	.26	1.1	6.6	.98	2.1	D176362
D176379	67.1	83	13	.45	.70	.84	2.1	1.8	.76	1.0L	D176379
D176365	16.6	53	26	3.3	1.26	1.09	1.1	2.0	.67	1.0L	D176365
D176364	5.6	32	25	9.3	1.68	.23	.53	6.9	1.1	3.3	D176364
D186094	34.6	73	17	3.6	1.48	.72	2.5	3.2	.88	1.0L	D186094
D208577	4.7	28	23	15	.38	.24	.24	6.2	.94	2.3	D208577
D208564	4.7	28	21	18	.38	.20	.50	6.7	.85	1.3	D208564
D208565	4.1	21	21	22	.46	.23	.50	4.9	.84	.98	D208565
D208566	7.4	51	7.8	8.3	1.93	.09	.49	12	.55	.14L	D208566

Table 3a.--Major- and minor-oxide and trace-element composition of the laboratory ash of 63 coal and 13 coal-associated rock samples from the Williams Fork Formation, Yampa coal field, northwestern Colorado--continued

Sample number	SO3 (percent)	B-S (ppm)	Ba-S (ppm)	Be-S (ppm)	Cd (ppm)	Ce-S (ppm)	Cu (ppm)	Ga-S (ppm)	Ge-S (ppm)	La-S (ppm)	Sample number
D188245	0.91	150	700	7	2.0	N	67	30	20	70	D188245
D188256	13	1,500	10,000	3	1.0L	N	95	70	N	70	D188256
D188255	10	1,500	7,000	3	1.0	N	95	70	N	150	D188255
D188246	.20L	N	700	N	1.0L	200	20L	15	N	150	D188246
D176389	.20L	100	700	3	1.0L	500L	40	20	N	100L	D176389
D176378	3.0	700	1,500	7	1.0	500L	77	30	N	100L	D176378
D176390	.40	150	1,000	N	1.0L	N	31	50	N	100L	D176390
D176377	2.1	700	2,000	10	1.0L	500L	50	50	30	100	D176377
D176388	.26	70	700	3	1.0L	500L	43	15	N	100L	D176388
D188239	1.9	300	500	15	2.0	N	60	30	20	N	D188239
D184641	4.2	500	1,000	7	1.0L	500L	83	30	N	100L	D184641
D184640	7.2	1,000	1,500	5	1.0L	500L	67	30	N	150	D184640
D184639	5.7	700	700	7	1.0L	500L	50	30	N	100L	D184639
D188240	.48	50	700	N	1.0L	N	38	15	N	70	D188240
D184643	1.8	300	300	7	1.0L	N	43	20	N	100L	D184643
D184642	5.8	1,500	1,000	5	1.0L	500L	73	30	N	100	D184642
D176387	.35	150	700	7	1.0L	N	45	15	N	100L	D176387
D176375	3.1	700	700	7	1.0L	500L	57	50	N	100	D176375
D176376	6.5	2,000	1,500	7	1.0L	500L	77	30	N	100	D176376
D176383	.23	70	300	15	1.0L	N	20L	15	N	N	D176383
D176370	13	1,500	1,500	N	1.0L	500L	77	30	N	100L	D176370
D176369	9.9	2,000	1,500	N	1.0L	500L	77	30	N	100	D176369
D176373	4.0	1,500	3,000	7	1.0L	500L	57	30	N	100	D176373
D176386	.98	300	1,000	3	1.0L	N	40	15	N	N	D176386
D176374	1.4	1,000	3,000	3L	1.0	500L	36	30	N	100L	D176374
D176385	.26	70	700	N	1.0L	500L	24	20	N	100L	D176385
D176371	3.8	3,000	1,500	10	1.0L	500L	162	50	70	100L	D176371
D176372	4.6	700	2,000	3	1.0L	N	67	30	N	100L	D176372
D176384	.20L	70	500	N	1.0L	N	40	20	N	100L	D176384
D176380	2.2	70	300	3L	1.0L	N	33	15	N	N	D176380
D176363	3.3	700	1,000	3	1.0L	500L	57	30	N	100L	D176363
D176362	7.1	1,500	2,000	3	1.5	500L	74	30	N	100	D176362
D176379	.58	100	2,000	3	1.0L	N	22	15	N	100L	D176379
D176365	1.9	700	1,000	3	1.0L	500L	63	30	N	100L	D176365
D176364	10	1,500	3,000	10	1.0L	500L	91	50	N	100	D176364
D186094	2.3	200	1,000	3L	1.0L	N	49	15	N	100L	D186094
D208577	8.0	2,000	2,000	N	3.0	N	51	30	N	100L	D208577
D208564	10	1,500	2,000	N	1.0	N	73	30	N	100L	D208564
D208565	11	2,000	3,000	N	2.0	N	68	30	N	100L	D208565
D208566	14	700	15,000	10	1.0	N	31	15	20L	N	D208566

Table 3a.--Major- and minor-oxide and trace-element composition of the laboratory ash of 63 coal and 13 coal-associated rock samples from the Williams Fork Formation, Yampa coal field, northwestern Colorado--continued

Sample number	Li (ppm)	Mn (ppm)	Mo-S (ppm)	Nb-S (ppm)	Nd-S (ppm)	Ni-S (ppm)	Pb (ppm)	Sc-S (ppm)	Sr-S (ppm)	V-S (ppm)	Sample number
D188245	125	30	N	30	N	15	35	15	100	200	D188245
D188256	69	75	10	20	N	30	50	15	7,000	70	D188256
D188255	115	40	20	30	N	30	40	15	2,000	150	D188255
D188246	26	220	N	20	N	5	30	7	150	30	D188246
D176389	41	45	20	30	N	15	25L	10	150	100	D176389
D176378	108	70	7	20	150	20	50	15	1,000	70	D176378
D176390	106	65	7	20L	N	10L	40	N	150	30	D176390
D176377	82	75	10	50	150L	15	60	15	700	70	D176377
D176388	45	45	N	30	N	30	25L	15	70	70	D176388
D188239	69	135	N	50	N	30	65	30	150	150	D188239
D184641	99	285	10	30	N	20	40	15	300	70	D184641
D184640	87	415	10	30	N	20	55	15	700	70	D184640
D184639	95	230	10	30	N	15	70	10	300	30	D184639
D188240	28	65	N	20	N	30	25	7	70	70	D188240
D184643	61	50	7L	30	N	20	30	15	70	70	D184643
D184642	98	185	7	50	N	20	65	15	700	50	D184642
D176387	38	60	N	30	N	20	25L	15	100	150	D176387
D176375	97	95	N	20L	150L	10L	50	10	700	70	D176375
D176376	100	180	10	30	150	15	70	15	1,500	70	D176376
D176383	43	110	N	20	B	20	25L	30	100	300	D176383
D176370	90	1,140	N	20	N	30	40	15	2,000	70	D176370
D176369	87	830	N	20	N	30	40	15	1,500	70	D176369
D176373	51	95	7	30	150L	30	40	15	1,500	50	D176373
D176386	51	25	N	30	B	10L	30	10L	300	30	D176386
D176374	47	65	7	20	150	15	25	10L	1,500	50	D176374
D176385	38	35	30	20	N	15	25L	10L	150	70	D176385
D176371	75	90	7	30	150L	70	60	50	3,000	150	D176371
D176372	94	105	N	20	150L	15	60	10	1,000	70	D176372
D176384	38	60	N	20	N	30	25L	10	100	70	D176384
D176380	44	220	7	20	B	50	25L	10	150	70	D176380
D176363	78	110	7	20	150L	15	40	10	700	50	D176363
D176362	98	215	7	20	150L	30	35	15	3,000	70	D176362
D176379	39	50	N	20	N	30	25L	10L	150	70	D176379
D176365	76	55	N	20	N	15	30	10L	700	50	D176365
D176364	124	225	10	50	150L	15	45	30	5,000	100	D176364
D186094	45	220	N	30	N	30	40	15	300	150	D186094
D208577	106	1,070	7L	20	N	30	25L	15	2,000	70	D208577
D208564	62	310	7L	20L	N	20	34	15	2,000	70	D208564
D208565	75	64	N	20L	N	30	41	15	2,000	70	D208565
D208566	20	645	7	N	B	15	20	15	300	50	D208566

Table 3a.--Major- and minor-oxide and trace-element composition of the laboratory ash of 63 coal and 13 coal-associated rock samples from the Williams Fork Formation, Yampa coal field, northwestern Colorado--continued

Sample number	Y-S (ppm)	Yb-S (ppm)	Zn (ppm)	Zr-S (ppm)
D188245	30	5	303	150
D188256	70	5	44	150
D188255	70	7	32	200
D188246	30	3	112	150
D176389	30	3	57	300
D176378	30	3	58	300
D176390	20L	2L	30	300
D176377	50	7	44	300
D176388	30	3	109	200
D188239	70	7	342	700
D184641	50	5	82	200
D184640	70	7	43	300
D184639	70	7	49	200
D188240	30	3	113	200
D184643	30	3	106	200
D184642	70	7	47	200
D176387	30	3	61	300
D176375	30	3	35	200
D176376	70	7	37	300
D176383	30	5	42	300
D176370	30	3	37	200
D176369	30	3	38	200
D176373	70	5	48	300
D176386	30	3	29	200
D176374	30	3	39	200
D176385	30	3	40	200
D176371	70	7	56	200
D176372	30	3	38	200
D176384	30	3	122	200
D176380	30	3	89	200
D176363	30	3	85	200
D176362	50	5	83	200
D176379	30	3	104	200
D176365	30	2	74	200
D176364	70	7	56	300
D186094	50	5	145	150
D208577	30	3	42	300
D208564	30	3	76	300
D208565	50	5	61	200
D208566	30	5	77	700

Table 3a.--Major- and minor-oxide and trace-element composition of the laboratory ash of 63 coal and 13 coal-associated rock samples from the Williams Fork Formation, Yampa coal field, northwestern Colorado--continued

Sample number	Ash (percent)	SiO2 (percent)	Al2O3 (percent)	CaO (percent)	MgO (percent)	Na2O (percent)	K2O (percent)	Fe2O3 (percent)	TiO2 (percent)	P2O5 (percent)	Sample number
D208567	6.2	41	26	12	1.66	0.32	0.92	3.4	0.85	1.1	D208567
D208568	6.6	54	19	6.2	1.66	.51	1.6	4.9	.87	1.8	D208568
D208569	6.4	45	30	7.1	1.66	.46	.70	3.6	1.2	1.3	D208569
D208570	10.3	60	23	5.0	1.23	.36	.83	2.0	.87	.49	D208570
D208571	12.1	58	26	5.2	1.13	.38	.92	1.6	.94	.17	D208571
D208572	9.6	54	25	5.7	1.21	.49	1.4	1.6	.94	.73	D208572
D208573	12.4	68	16	3.5	.88	.34	.97	.94	.68	1.2	D208573
D208574	12.5	36	26	4.1	1.09	.24	.58	21	.90	.80	D208574
D208575	6.9	36	25	12	1.39	.42	.88	5.2	.97	1.9	D208575
D208576	8.8	47	28	6.0	1.64	.35	.83	5.9	1.1	2.4	D208576
D178117	10.7	55	23	3.6	.99	.47	.96	2.1	.79	1.0	D178117
D178118	12.9	67	16	2.3	.80	.58	1.1	1.7	.80	1.0L	D178118
D178119	6.8	47	23	4.6	.99	.46	.80	1.9	.98	2.4	D178119
D178120	10.4	45	31	3.9	.85	.67	.42	1.3	1.0	2.0	D178120
D178121	13.6	58	21	3.9	1.92	.79	.69	2.1	.73	1.0L	D178121
D178122	12.7	55	24	2.8	1.38	.98	.53	1.7	.84	1.0L	D178122
D178123	22.6	72	16	1.0	.80	.35	1.7	1.4	.65	1.0L	D178123
D178124	15.6	50	19	3.7	1.34	.26	.75	9.9	.68	1.0L	D178124
D178129	24.3	52	12	1.3	.70	.22	.81	9.4	.64	1.0L	D178129
D178128	8.6	48	25	5.8	2.01	.30	.52	2.3	.76	1.0L	D178128
D178125	8.1	25	13	6.6	1.38	.52	.31	29	.69	1.0	D178125
D178126	12.6	58	22	2.7	1.09	.76	1.1	1.7	.76	1.0L	D178126
D178127	10.3	64	16	1.2	.84	.31	.98	9.9	.80	1.0L	D178127
D184645	8.9	54	20	9.4	1.71	1.00	.85	2.6	.86	1.3	D184645
D184646	6.9	46	27	8.9	1.14	1.25	.74	3.0	1.1	1.1	D184646
D208579	5.0	32	21	13	1.99	2.70	.46	10	.87	4.6	D208579
D208578	6.6	34	18	11	1.64	.36	.40	19	.78	3.8	D208578
D208580	6.2	41	14	9.8	1.26	.24	.060	23	.75	3.4	D208580
D188237	24.0	51	40	2.8	.26	.45	.75	.40	1.1	1.0L	D188237
D188252	4.8	20	24	23	1.20	1.48	.29	4.0	1.4	9.7	D188252
D188236	79.5	84	8.5	.35	.39	.48	2.0	.60	.65	1.0L	D188236
D188238	91.9	71	15	2.2	1.58	.62	2.7	4.3	.79	1.0L	D188238
D188254	7.6	41	27	7.8	1.08	1.30	.86	7.3	1.0	1.1	D188254
D188253	9.1	46	33	6.7	1.05	1.28	.85	2.7	1.2	1.0L	D188253
D188250	21.4	64	23	1.9	.63	.83	1.5	2.1	.89	1.0L	D188250
D188251	10.5	47	24	8.6	1.19	1.50	.82	2.8	1.3	2.2	D188251

Table 3a.--Major- and minor-oxide and trace-element composition of the laboratory ash of 63 coal and 13 coal-associated rock samples from the Williams Fork Formation, Yampa coal field, northwestern Colorado--continued

Sample number	SO3 (percent)	B-S (ppm)	Ba-S (ppm)	Be-S (ppm)	Cd (ppm)	Ce-S (ppm)	Cu (ppm)	Ga-S (ppm)	Ge-S (ppm)	La-S (ppm)	Sample number
D208567	3.5	1,000	2,000	3	2.0	N	52	30	N	100L	D208567
D208568	4.5	700	3,000	10	2.0	N	49	30	N	100L	D208568
D208569	2.8	300	2,000	N	2.0	N	63	30	N	100L	D208569
D208570	2.5	200	1,000	N	2.0	N	47	30	N	100L	D208570
D208571	1.8	300	1,000	N	2.0	N	38	30	N	N	D208571
D208572	2.8	500	1,000	5	2.0	N	38	30	N	100L	D208572
D208573	2.5	300	2,000	7	2.0	N	33	20	N	100L	D208573
D208574	3.3	300	1,500	N	3.0	N	20	30	N	100L	D208574
D208575	4.8	700	3,000	10	2.0	N	45	30	20	100L	D208575
D208576	2.8	700	1,500	7	2.0	N	33	30	N	100L	D208576
D178117	3.0	700	2,000	15	1.0L	N	58	30	N	100L	D178117
D178118	2.6	700	2,000	15	1.0	500L	62	30	N	100L	D178118
D178119	5.1	1,000	5,000	30	1.0L	500L	62	50	30	100	D178119
D178120	2.8	700	3,000	15	1.0	500L	75	50	N	100L	D178120
D178121	2.6	700	3,000	7	1.0	N	43	30	N	100L	D178121
D178122	2.6	700	3,000	7	1.0	500L	47	30	N	100L	D178122
D178123	.97	500	1,000	5	1.0	N	44	30	N	100L	D178123
D178124	3.8	700	1,500	5	1.0L	500L	38	30	N	100L	D178124
D178129	1.1	300	1,500	7	1.0L	N	44	30	N	N	D178129
D178128	4.1	1,500	2,000	10	1.0L	500L	53	50	N	100L	D178128
D178125	11	1,500	3,000	5	1.0L	N	41	30	N	100L	D178125
D178126	1.7	1,000	1,500	7	1.0L	500L	47	30	N	100L	D178126
D178127	2.6	700	1,500	15	1.0	N	50	50	N	100L	D178127
D184645	2.9	700	3,000	5	1.0	500L	67	30	N	100L	D184645
D184646	3.8	1,000	3,000	7	1.0L	500L	73	30	N	100	D184646
D208579	8.0	2,000	2,000	7	2.0	N	67	30	50	100L	D208579
D208578	8.3	1,500	1,500	3	9.0	N	44	30	20	100L	D208578
D208580	7.8	1,500	1,000	3	1.0	N	47	30	30	100L	D208580
D188237	1.1	150	150	3	1.0L	N	57	50	N	70	D188237
D188252	8.9	1,500	7,000	7	2.0	200	99	50	N	150	D188252
D188236	.29	70	300	2	1.0L	N	20L	7	N	N	D188236
D188238	1.0	70	700	N	1.0L	N	29	15	N	N	D188238
D188254	5.3	1,500	1,500	7	1.0	200	66	70	N	150	D188254
D188253	4.0	1,500	1,500	7	1.0	N	71	70	N	70	D188253
D188250	1.0	300	700	7	2.0	200	50	30	N	150	D188250
D188251	3.7	700	3,000	3	2.0	N	87	50	N	150	D188251

Table 3a.--Major- and minor-oxide and trace-element composition of the laboratory ash of 63 coal and 13 coal-associated rock samples from the Williams Fork Formation, Yampa coal field, northwestern Colorado--continued

Sample number	Li (ppm)	Mn (ppm)	Mo-S (ppm)	Nb-S (ppm)	Nd-S (ppm)	Ni-S (ppm)	Pb (ppm)	Sc-S (ppm)	Sr-S (ppm)	V-S (ppm)	Sample number
D208567	72	436	7	30	N	20	43	15	1,000	70	D208567
D208568	63	251	10	30	N	70	23	20	1,500	150	D208568
D208569	90	228	10	30	N	30	25	15	1,000	70	D208569
D208570	55	260	7	30	N	20	46	10	300	70	D208570
D208571	68	283	7	20	B	30	40	15	200	70	D208571
D208572	68	317	7	20	N	30	40	15	500	70	D208572
D208573	62	193	7	30	N	15	33	15	500	70	D208573
D208574	109	1,660	N	20	N	20	29	10	500	30	D208574
D208575	93	1,820	7	30	N	30	25L	30	1,500	150	D208575
D208576	143	962	N	20	N	15	25L	15	2,000	70	D208576
D178117	111	50	N	30	N	15	45	15	1,500	70	D178117
D178118	90	65	N	30	N	15	40	15	700	100	D178118
D178119	126	155	7	50	150L	30	50	30	3,000	300	D178119
D178120	117	65	7	30	N	10	30	15	1,500	100	D178120
D178121	39	345	7	30	N	10L	40	15	1,000	70	D178121
D178122	70	75	7	30	N	10L	30	15	700	70	D178122
D178123	94	115	7	30	N	15	30	15	300	70	D178123
D178124	71	1,290	N	20	N	10	35	15	700	70	D178124
D178129	108	100	N	20	B	15	25L	15	1,000	150	D178129
D178128	71	125	7	30	N	10	45	15	500	70	D178128
D178125	38	160	7	20	N	15	25L	15	1,000	150	D178125
D178126	84	70	7	30	N	10	40	15	700	100	D178126
D178127	135	75	7	30	N	10	60	15	700	70	D178127
D184645	60	210	7	50	N	15	100	15	1,000	50	D184645
D184646	119	50	7	50	N	15	80	15	1,500	70	D184646
D208579	135	1,050	7	20	N	70	70	30	2,000	70	D208579
D208578	103	1,130	N	20	N	100	192	30	2,000	70	D208578
D208580	73	1,030	N	20L	N	70	144	20	2,000	70	D208580
D188237	186	30	N	20	N	5	65	10	150	70	D188237
D188252	161	145	5	30	150	30	70	15	7,000	70	D188252
D188236	27	25	N	30	N	7	25L	7	70	70	D188236
D188238	52	235	N	20	N	30	25	15	150	70	D188238
D188254	145	60	7	30	150	15	80	30	1,500	70	D188254
D188253	183	30	5	50	N	7	120	30	1,500	50	D188253
D188250	98	35	N	20	N	10	125	15	700	70	D188250
D188251	77	225	5	30	N	10	310	15	1,500	70	D188251

Table 3a.--Major- and minor-oxide and trace-element composition of the laboratory ash of 63 coal and 13 coal-associated rock samples from the Williams Fork Formation, Yampa coal field, northwestern Colorado--continued

Sample number	Y-S (ppm)	Yb-S (ppm)	Zn (ppm)	Zr-S (ppm)
D208567	30	3	609	300
D208568	50	5	233	300
D208569	30	3	317	300
D208570	30	3	368	300
D208571	30	3	270	300
D208572	30	3	89	300
D208573	50	5	83	300
D208574	30	B	122	200
D208575	70	7	114	500
D208576	50	5	81	300
D178117	70	5	53	200
D178118	70	7	101	200
D178119	100	10	44	300
D178120	50	5	44	200
D178121	50	5	44	150
D178122	70	5	29	200
D178123	30	5	88	150
D178124	50	5	59	150
D178129	70	7	95	150
D178128	70	5	45	200
D178125	50	B	32	150
D178126	70	5	102	200
D178127	70	5	41	300
D184645	70	7	202	300
D184646	70	7	91	300
D208579	70	5	76	200
D208578	50	B	50	200
D208580	50	B	64	200
D188237	30	2	44	200
D188252	150	7	65	200
D188236	50	5	66	700
D188238	50	5	134	150
D188254	100	10	96	300
D188253	70	7	59	300
D188250	70	7	224	300
D188251	70	7	159	300

Table 3b.--Major- and minor-oxide and trace-element composition of the laboratory ash of 22 coal samples from the Williams Fork Formation, Danforth Hills coal field, northwestern Colorado

[Coal ashed at 525°C. L means 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 are 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)	SiO2 (percent)	Al2O3 (percent)	CaO (percent)	MgO (percent)	Na2O (percent)	K2O (percent)	Fe2O3 (percent)	TiO2 (percent)	P2O5 (percent)	Sample number
D205272	6.9	47	30	6.6	1.76	0.11	0.32	2.7	1.1	0.60	D205272
D205273	4.5	41	27	9.2	1.74	.09	.43	4.0	1.1	1.1	D205273
D205274	20.2	66	23	1.7	.85	.08	1.4	3.7	.90	.050L	D205274
D205275	5.4	45	17	6.3	1.53	.11	.83	16	.82	.19L	D205275
D205276	43.9	71	18	1.8	.73	.08	1.4	3.3	.77	.16	D205276
D205277	18.9	69	21	2.2	1.03	.08	1.3	2.3	.90	.26	D205277
D205278	7.1	43	18	9.8	1.93	.09	.80	6.6	.77	3.0	D205278
D205279	5.4	45	25	9.5	2.08	.12	.30	3.6	.94	.56	D205279
D205280	22.3	66	21	2.2	.81	.12	1.3	2.4	.82	.040L	D205280
D205281	6.5	56	21	6.6	1.33	.12	.67	1.9	1.0	1.2	D205281
D205282	16.5	66	21	2.5	1.03	.11	1.4	1.9	.89	.61	D205282
D186091	11.2	51	12	13	2.34	.50	1.2	4.5	.95	2.2	D186091
D186092	43.4	72	12	2.8	1.03	.13	1.8	2.9	.69	1.0L	D186092
D186093	44.9	68	12	4.1	1.32	.70	1.5	3.3	.58	1.0L	D186093
D191603	5.7	28	10	16	.25	4.30	.54	12	.66	1.0L	D191603
D191604	5.7	31	20	16	2.30	3.70	.18	9.7	1.0	1.1	D191604
D191605	13.8	59	15	5.8	1.33	1.84	1.2	3.4	.81	1.0L	D191605
D191606	27.5	54	29	4.6	.79	.89	.76	2.3	.86	1.0L	D191606
D186095	26.1	59	11	12	1.96	.27	1.4	3.7	.57	1.0L	D186095
D186096	21.1	67	12	5.3	1.34	.17	1.4	3.3	.61	1.0L	D186096
D201454	3.4	B	B	B	3.42	.62	B	B	B	.29L	D201454
D201455	4.3	34	16	11	1.88	4.59	.50	12	.70	.23L	D201455

Table 3b.--Major- and minor-oxide and trace-element composition of the laboratory ash of 22 coal samples from the Williams Fork Formation, Danforth Hills coal field, northwestern Colorado--continued

Sample number	SO3 (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
D205272	3.0	1,000	2,000	5	1.0L	58	50	N	150	61	D205272
D205273	5.3	1,000	3,000	3L	1.0L	88	50	N	100	71	D205273
D205274	1.4	200	1,500	N	1.0L	78	30	N	N	52	D205274
D205275	9.3	1,500	3,000	20	1.0	104	30	N	100L	38	D205275
D205276	1.3	100	500	5	1.0	75	30	N	100L	144	D205276
D205277	2.3	300	1,000	15	2.0	84	30	20	N	95	D205277
D205278	9.8	700	5,000	15	1.0	81	30	50	100L	45	D205278
D205279	6.0	1,000	1,500	5	1.0	95	50	N	100L	69	D205279
D205280	2.1	200	1,000	10	2.0	79	50	20	100L	65	D205280
D205281	5.0	1,000	1,500	5	1.0	51	50	N	100	53	D205281
D205282	2.2	500	1,000	7	1.0L	74	30	N	100L	20	D205282
D186091	6.3	500	7,000	3L	1.0L	51	15	N	100L	28	D186091
D186092	2.2	100	700	3L	1.0L	35	15	N	100L	31	D186092
D186093	1.7	150	700	3L	1.0L	31	15	N	100L	37	D186093
D191603	19	700	5,000	10	1.0	79	20	N	100	29	D191603
D191604	11	700	3,000	3	3.0	61	30	N	70	130	D191604
D191605	3.8	200	2,000	10	2.0	88	30	N	70	62	D191605
D191606	2.3	100	700	15	1.0	61	50	20	70	140	D191606
D186095	3.5	200	700	N	1.0L	31	15	N	N	30	D186095
D186096	4.3	200	700	3L	1.0L	49	15	N	N	51	D186096
D201454	B	1,000	3,000	N	1.0L	86	20	N	N	20	D201454
D201455	12	700	5,000	15	1.0L	65	30	N	100L	32	D201455

Table 3b.--Major- and minor-oxide and trace-element composition of the laboratory ash of 22 coal samples from the Williams Fork Formation, Danforth Hills coal field, northwestern 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
D205272	457	7L	20L	30	43	20	500	150	70	3	D205272
D205273	266	7	20L	50	36	20	1,000	150	50	3	D205273
D205274	30L	7L	20L	50	40	20	100	200	30	3	D205274
D205275	81	10	20L	200	32	50	200	150	70	5	D205275
D205276	30L	5	20L	70	38	20	200	200	50	5	D205276
D205277	61	10	20L	150	36	30	200	200	70	5	D205277
D205278	221	10	20L	200	47	30	1,500	200	70	5	D205278
D205279	30L	10	20L	50	44	15	500	150	50	3	D205279
D205280	30L	10	20L	150	46	20	150	200	50	5	D205280
D205281	30L	15	20L	100	43	20	700	150	70	5	D205281
D205282	34	7	20L	70	25L	20	500	150	50	5	D205282
D186091	565	7	30	30	45	15	3,000	150	50	7	D186091
D186092	195	N	30	30	40	10	100	100	50	3	D186092
D186093	280	7	30	15	35	10	300	70	50	5	D186093
D191603	380	7	N	70	65	15	5,000	70	70	7	D191603
D191604	300	10	20	20	40	15	3,000	100	50	3	D191604
D191605	120	N	20	20	40	15	1,500	150	50	3	D191605
D191606	175	7	N	20	40	15	300	100	30	3	D191606
D186095	575	N	30	20	220	10L	200	70	70	3	D186095
D186096	330	7	30	30	25L	10L	700	100	30	3	D186096
D201454	420	N	20L	50	31	10	3,000	70	30	3	D201454
D201455	195	15	20L	70	32	30	5,000	150	150	10	D201455

Table 3b.--Major- and minor-oxide and trace-element composition of the laboratory ash of 22 coal samples from the Williams Fork Formation, Danforth Hills coal field, northwestern Colorado--continued

Sample number	Zn (ppm)	Zr-S (ppm)
D205272	198	300
D205273	352	300
D205274	127	200
D205275	286	200
D205276	231	200
D205277	255	500
D205278	358	300
D205279	194	300
D205280	185	500
D205281	174	300
D205282	172	200
D186091	107	150
D186092	110	150
D186093	101	200
D191603	83	70
D191604	55	200
D191605	49	150
D191606	99	200
D186095	331	150
D186096	117	150
D201454	80	70
D201455	77	150

Table 3c.--Major- and minor-oxide and trace-element composition of the laboratory ash of six coal and two coal-associated rock samples from the Williams Fork Formation, Grand Hogback coal field, northwestern Colorado

[Samples ashed at 525°C. L means less than the value shown; N, not detected. 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 are 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)	SiO2 (percent)	Al2O3 (percent)	CaO (percent)	MgO (percent)	Na2O (percent)	K2O (percent)	Fe2O3 (percent)	TiO2 (percent)	P2O5 (percent)	Sample number
D196217	12.2	56	31	2.7	0.39	0.50	0.70	0.60	1.2	0.080L	D196217
D196216	11.6	52	36	2.1	.37	.73	.40	1.4	1.2	.17	D196216
D196434	9.7	40	19	16	.73	.60	.60	1.9	.80	.10L	D196434
D196215	6.9	46	28	4.8	.67	1.19	.40	2.7	1.2	.58	D196215
D196214	6.7	42	28	6.7	.73	1.21	.40	2.1	1.1	1.5	D196214
D196436	60.4	82	18	.30	.76	.08	2.4	1.1	1.0	.020L	D196436
D196218	9.4	33	21	13	1.55	1.04	.30	5.2	1.0	.11L	D196218
D196435	90.8	62	18	2.4	2.55	.80	3.6	2.3	.80	.11	D196435

Sample number	SO3 (percent)	B-S (ppm)	Ba-S (ppm)	Be-S (ppm)	Cd (ppm)	Cu (ppm)	Ga-S (ppm)	La-S (ppm)	Li (ppm)	Mn (ppm)	Sample number
D196217	1.2	1,000	2,000	10	1.0L	61	100	150	111	110	D196217
D196216	1.5	1,000	2,000	5	1.0	65	70	70	127	62	D196216
D196434	2.7	1,500	1,500	3	2.0	106	30	N	89	410	D196434
D196215	4.2	2,000	3,000	5	1.0L	85	70	N	139	155	D196215
D196214	3.5	2,000	3,000	7	1.0L	77	70	150	116	160	D196214
D196436	.080L	100	300	7	1.0L	29	30	70	41	54	D196436
D196218	6.5	700	3,000	5	1.0L	42	70	70	118	1,160	D196218
D196435	.080L	150	1,500	3	1.0	65	30	70	54	225	D196435

Table 3c.--Major- and minor-oxide and trace-element composition of the laboratory ash of six coal and two coal-associated rock samples from the Williams Fork Formation, Grand Hogback coal field, northwestern Colorado--continued

Sample number	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)	Zn (ppm)	Sample number
D196217	15	50	20	75	30	1,000	100	70	7	89	D196217
D196216	15	30	15	70	15	1,000	70	50	5	42	D196216
D196434	20	N	20	55	15	700	150	30	3	60	D196434
D196215	30	20	30	55	15	2,000	100	50	5	47	D196215
D196214	30	20	20	45	15	2,000	70	50	5	51	D196214
D196436	N	20	15	25	15	50	100	30	3	22	D196436
D196218	N	20	30	40	15	2,000	70	50	5	38	D196218
D196435	N	20L	50	25L	20	300	150	30	3	148	D196435

Sample number	Zr-S (ppm)
D196217	500
D196216	300
D196434	150
D196215	300
D196214	200
D196436	150
D196218	300
D196435	200

Table 3d.--Major- and minor-oxide and trace-element composition of the laboratory ash of nine coal and two coal-associated rock samples from the Williams Fork Formation, Carbondale coal field, northwestern Colorado

[Samples ashed at 525°C. L means less than the value shown; N, not detected. 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 are 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)	SiO2 (percent)	Al2O3 (percent)	CaO (percent)	MgO (percent)	Na2O (percent)	K2O (percent)	Fe2O3 (percent)	TiO2 (percent)	P2O5 (percent)	Sample number
D208590	6.2	36	23	10	2.49	0.03	0.43	12	0.87	0.65	D208590
D208589	11.7	45	34	5.2	.81	2.57	.49	3.6	1.0	1.4	D208589
D196222	7.5	45	22	6.8	2.16	4.40	.30	3.8	1.0	2.7	D196222
D196221	4.1	35	19	7.8	2.23	4.20	.30	7.0	1.1	1.2	D196221
D196438	71.2	61	25	.60	.44	1.00	2.0	2.6	1.0	.080	D196438
D196223	7.9	53	20	4.8	2.16	3.15	.30	3.5	.90	1.3	D196223
D196220	6.1	43	17	7.1	2.31	2.46	.60	9.3	1.0	.98	D196220
D196437	88.0	92	11	.30	.35	.88	1.9	.40	.70	.010L	D196437
D196219	10.2	61	15	2.2	.91	.95	.20	9.8	1.0	.78	D196219
D184638	7.9	43	24	8.5	1.91	3.33	.48	5.0	1.0	1.0L	D184638
D184637	9.2	43	23	9.4	1.59	3.70	.57	5.2	1.0	1.0L	D184637

Sample number	SO3 (percent)	B-S (ppm)	Ba-S (ppm)	Be-S (ppm)	Cd (ppm)	Cu (ppm)	Ga-S (ppm)	La-S (ppm)	Li (ppm)	Mn (ppm)	Sample number
D208590	4.5	500	3,000	3	1.0	59	30	100L	146	644	D208590
D208589	.50	700	3,000	3	1.0	51	70	100	174	122	D208589
D196222	4.8	1,000	5,000	7	1.0L	49	70	150	69	64	D196222
D196221	10	700	5,000	7	3.0	85	50	150	144	120	D196221
D196438	.40	150	2,000	3	1.0L	47	70	70	194	72	D196438
D196223	3.5	700	3,000	3	1.0L	54	50	70	75	205	D196223
D196220	9.8	500	5,000	3	1.0L	73	30	N	98	125	D196220
D196437	.080L	200	500	N	1.0L	20	20	70	41	44	D196437
D196219	3.5	200	2,000	10	1.0L	58	50	70	100	130	D196219
D184638	5.1	700	3,000	3	1.0L	67	30	100L	103	75	D184638
D184637	5.7	700	3,000	5	1.0L	53	30	100L	88	95	D184637

Table 3d.--Major- and minor-oxide and trace-element composition of the laboratory ash of nine coal and two coal-associated rock samples from the Williams Fork Formation, Carbondale coal field, northwestern Colorado--continued

Sample number	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)	Zn (ppm)	Sample number
D208590	7	20	30	25L	15	1,500	70	70	7	20L	D208590
D208589	7	20L	15	33	15	2,000	70	70	5	54	D208589
D196222	10	30	20	35	15	5,000	70	50	5	46	D196222
D196221	10	30	30	50	20	5,000	100	50	5	49	D196221
D196438	N	20L	20	50	10	150	100	30	3	127	D196438
D196223	7	20	15	35	10	2,000	70	30	3	67	D196223
D196220	10	20	30	35	15	3,000	70	30	3	41	D196220
D196437	N	20	10L	25L	N	70	70	20L	2	31	D196437
D196219	15	20	50	35	15	1,500	70	70	7	96	D196219
D184638	7L	30	10	60	10	1,000	50	50	5	55	D184638
D184637	7L	30	15	30	10	1,000	70	30	3	35	D184637

Sample number	Zr-S (ppm)
D208590	300
D208589	300
D196222	300
D196221	200
D196438	300
D196223	300
D196220	200
D196437	300
D196219	300
D184638	150
D184637	100

Table 4a.--Content of nine trace elements in 63 coal and 13 coal-associated rock samples from the Williams Fork Formation, Yampa coal field, northwestern Colorado

[Analyses on air-dried (32°C) sample unless otherwise noted. For samples D176362 - D178129 and D188236 - D188246, analysis for Co and Cr is on ash (525°C) by semiquantitative emission spectroscopy converted to whole-coal basis. 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
D188245	1.0	10	150	380	0.22	2.8	2.7	6.7	6.2	D188245
D188256	.4	1.7	11	150	.02	.7	2.1	7.0	.8	D188256
D188255	.6	1.0	2.9	55	.02	.3	1.4	1.5	1.5	D188255
D188246	2.5	7.0	15	450	.11	.5	2.3	11	3.5	D188246
D176389	2.0	7.0L	20	330	.06	1.9	.9	13	2.5	D176389
D176378	1.0L	1.5	1.5	140	.03	.3	.9	3.0L	.7	D176378
D176390	2.0	5.0L	1.5	208	.02	.3	1.3	15	4.1	D176390
D176377	1.0	1.5	1.5	115	.05	.5	1.3	8.7	1.3	D176377
D176388	8.0	15	50	755	.13	.7	1.4	16	4.6	D176388
D188239	1.5	7.0	30	250	.25	2.3	.6	8.5	3.6	D188239
D184641	1.0	1.8	4.6	75	.03	.2	1.2	3.1	1.3	D184641
D184640	.7	1.2	.1L	70	.01	.2	1.2	3.6	1.4	D184640
D184639	.8	1.1	1.8	80	.01	.2	1.4	4.2	1.9	D184639
D188240	6.5	15	70	670	.13	1.7	2.2	15	4.7	D188240
D184643	3.8	3.0	.1L	80	.07	.5	2.1	3.7	1.5	D184643
D184642	1.0	1.1	.1L	70	.02	.2	1.2	2.8	1.0	D184642
D176387	2.0	7.0L	30	330	.05	1.3	1.0	13	2.2	D176387
D176375	1.0L	1.0	1.0	50	.02	.2	1.0	3.0L	.6	D176375
D176376	1.0L	1.0	1.5	75	.02	.3	1.4	3.0L	1.1	D176376
D176383	3.0	10	100	115	.10	1.2	1.3	15	1.4	D176383
D176370	1.0L	.7	1.0	120	.01	.2	.9	3.0L	.4	D176370
D176369	1.0L	.7	1.5	190	.02	.3	.9	3.0L	.2L	D176369
D176373	1.0L	1.5	1.5	105	.04	.1	.9	3.0L	.7	D176373
D176386	2.0	3.0L	10	65	.02	.4	1.6	7.5	1.3	D176386
D176374	1.0L	3.0	5.0	150	.04	.3	1.4	9.7	1.5	D176374
D176385	2.0	7.0L	20	330	.06	.4	1.1	14	3.0	D176385
D176371	1.0L	5.0	7.0	80	.02	.2	.9	3.0L	.9	D176371
D176372	1.0L	1.0	1.0	100	.02	.1	.9	3.0L	.9	D176372
D176384	12	15	70	565	.23	1.1	1.8	20	4.4	D176384
D176380	30	10	20	455	.42	.8	2.5	21	7.2	D176380
D176363	1.0L	1.0L	1.5	105	.02	.1	.9	3.0L	.8	D176363
D176362	3.0	1.5	3.0	115	.10	.2	1.2	3.0L	.8	D176362
D176379	2.0	7.0L	20	275	.11	.3	1.5	19	3.0	D176379
D176365	1.0L	1.5	1.5	35	.03	.1L	.8	10	.8	D176365
D176364	1.0	1.0	1.0	75	.08	.2	1.0	3.0L	.9	D176364
D186094	3.7	5.5	22	200	.05	.8	.1L	6.0	3.4	D186094
D208577	.4	.7	2.4	45	.05	.1	.9	1.0	.5	D208577
D208564	.5	.1L	1.5	30	.09	.1L	.5	.8	.4	D208564
D208565	.3	.1L	1.3	20	.11	.1L	.7	.9	.4	D208565
D208566	1.9	.1L	2.9	20L	.09	.2	.6	.7	.9	D208566

Table 4a.--Content of nine trace elements in 63 coal and 13 coal-associated rock samples from the Williams Fork Formation, Yampa coal field, northwestern Colorado--continued

Sample number	As (ppm)	Co (ppm)	Cr (ppm)	F (ppm)	Hg (ppm)	Sb (ppm)	Se (ppm)	Th (ppm)	U (ppm)	Sample number
D208567	0.5	0.7	2.0	50	0.06	0.2	0.6	1.9	0.8	D208567
D208568	.7	1.2	4.0	60	.06	.2	.5	1.1	.6	D208568
D208569	.6	2.1	3.1	65	.04	.3	1.7	2.0	.8	D208569
D208570	.9	1.2	4.8	40	.04	.3	.1L	3.6	1.3	D208570
D208571	.6	1.2	4.4	60	.07	.1L	.1L	3.6	1.0	D208571
D208572	.4	1.1	2.1	70	.07	.3	.9	2.2	1.0	D208572
D208573	.5	1.7	2.2	90	.07	.5	.1L	1.6	1.0	D208573
D208574	2.0	.9	.1L	60	.13	.2	.9	2.7	1.0	D208574
D208575	.5	1.0	2.6	45	.07	.2	1.1	1.7	.7	D208575
D208576	.3	.9	3.6	120	.08	.2	1.0	2.6	.9	D208576
D178117	1.5	1.0L	3.0	145	.04	.2	1.0	3.0L	.8	D178117
D178118	.5	2.0	10	215	.04	.8	.9	4.3	.7	D178118
D178119	.5L	1.5	5.0	200	.02	.4	.9	4.2	.6	D178119
D178120	.5L	1.0	3.0	225	.08	.2	1.2	3.0L	.9	D178120
D178121	.5L	1.5L	5.0	75	.02	.2	.8	3.0L	1.2	D178121
D178122	1.5	1.5L	2.0	160	.06	.2	1.1	3.0L	1.6	D178122
D178123	.5	2.0L	15	440	.08	.5	1.1	5.8	1.5	D178123
D178124	.5L	1.5L	5.0	90	.05	.3	.8	5.6	1.1	D178124
D178129	6.0	2.0L	15	330	.29	.4	1.3	3.0L	1.5	D178129
D178128	.5L	1.0L	2.0	140	.02	.1	.7	3.0L	.8	D178128
D178125	1.5	.7L	2.0	70	.23	.2	1.2	3.0L	.4	D178125
D178126	.5	1.5L	3.0	240	.04	.3	.8	5.4	.8	D178126
D178127	1.5	1.0L	3.0	75	.02	.5	1.0	3.0L	.6	D178127
D184645	.4	.8	1.6	190	.01	.2	.6	2.1	1.1	D184645
D184646	.5	.8	1.4	75	.01	.1	.1L	2.5	.9	D184646
D208579	.4	2.2	2.3	740	.06	.2	.7	1.0	.3	D208579
D208578	1.8	4.1	3.1	200	.18	.4	1.1	1.2	.5	D208578
D208580	2.6	3.6	2.6	180	.14	.5	1.1	1.0	.6	D208580
D188237	.5	1.5	7.0	60	.03	.5	6.4	3.0L	4.9	D188237
D188252	.2	1.2	1.6	150	.03	.1	.7	.9	1.2	D188252
D188236	1.5	5.0	50	220	.05	.7	.9	9.0	3.7	D188236
D188238	4.5	15	70	860	.24	1.1	2.2	9.4	4.4	D188238
D188254	1.2	1.1	3.0	60	.15	.2	1.2	3.5	1.5	D188254
D188253	.3	.7	1.8	20	.02	.2	1.1	3.8	1.8	D188253
D188250	1.5	2.5	10	120	.05	.3	.1L	6.1	2.5	D188250
D188251	.4	1.0	2.8	55	.02	.3	1.1	3.4	1.7	D188251

Table 4b.--Content of nine trace elements in 22 coal samples from the Williams Fork Formation, Danforth Hills coal field, northwestern Colorado

[Analyses on 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
D205272	0.5	0.9	2.4	85	0.02	0.3	0.7	2.5	1.3	D205272
D205273	.4	.8	2.6	65	.02	.1	.7	1.7	.7	D205273
D205274	1.1	3.0	20	190	.12	.7	1.2	3.6	2.8	D205274
D205275	6.2	2.0	3.9	60	.39	.2	1.0	.9	.7	D205275
D205276	11	6.2	47	330	.34	1.5	1.9	6.8	5.2	D205276
D205277	2.1	4.2	18	150	.07	1.5	1.4	3.3	6.3	D205277
D205278	.8	2.3	4.4	120	.07	.6	.7	1.3	1.7	D205278
D205279	.4	.8	2.4	50	.03	.2	.7	1.5	.7	D205279
D205280	1.7	3.0	9.2	95	.09	.8	1.0	3.3	2.7	D205280
D205281	.6	1.4	3.0	35	.03	.3	.6	1.1	.9	D205281
D205282	1.2	2.8	13	150	.06	.6	.8	2.8	1.6	D205282
D186091	1.5	1.3	6.1	210	.06	.2	.6	1.9	.5	D186091
D186092	5.0	4.4	26	235	.02	.7	.1L	5.2	2.4	D186092
D186093	5.1	3.6	23	230	.09	.5	1.4	6.4	2.7	D186093
D191603	.7	1.8	.1L	20	.05	.2	.6	.7	.7	D191603
D191604	.6	.7	.1L	55	.05	.1	.6	1.4	.9	D191604
D191605	1.0	1.6	8.6	90	.03	.9	.8	2.2	1.1	D191605
D191606	2.0	5.5	.1L	170	.06	3.3	1.1	10	3.7	D191606
D186095	2.9	2.2	9.7	130	.05	.3	.7	3.5	1.5	D186095
D186096	2.0	2.1	12	175	.04	.5	.9	3.0	2.2	D186096
D201454	.4	.5	1.1	20L	.01	.1L	.4	.3	.2L	D201454
D201455	.4	1.7	.1L	20L	.02	.1	.5	.7	.6	D201455

Table 4c.--Content of nine trace elements in six coal and two coal-associated rock samples from the Williams Fork Formation, Grand Hogback coal field, northwestern Colorado

[Analyses on air-dried (32°C) coal unless otherwise noted. * indicates analysis for Co and Cr on ash (525°C) by semi-quantitative emission spectroscopy converted to whole-coal basis. L, less than the value shown; N, not detected]

Sample number	As (ppm)	Co (ppm)	Cr (ppm)	F (ppm)	Hg (ppm)	Sb (ppm)	Se (ppm)	Th (ppm)	U (ppm)	Sample number
D196217	1.4	2.3	3.5	55	0.03	0.3	1.9	3.4	1.2	D196217
D196216	.4	1.3	2.1	35	.10	.2	.8	2.6	.4	D196216
D196434*	1.6	1	3	25	.01L	1.1	1.5	3.0L	2.3	D196434*
D196215	2.1	1.6	2.3	40	.03	.2	.9	1.3	.7	D196215
D196214	1.7	1.3	1.5	85	.02	.1	.8	1.0	.4	D196214
D196436*	1.4	N	30	300	.01L	4.5	1.4	10	2.2	D196436*
D196218	.9	1.4	2.4	25	.03	.3	1.5	4.6	1.1	D196218
D196435*	6.7	15	70	900	.05	1.9	2.1	14	4.5	D196435*

Table 4d.--Content of nine trace elements in nine coal and two coal-associated rock samples from the Williams Fork Formation, Carbondale coal field, northwestern Colorado

[Analyses on air-dried (32°C) sample unless otherwise noted. * indicates analysis for Co and Cr on ash (525°C) by semiquantitative emission spectroscopy converted to whole-coal basis. L, less than the value shown; N, not detected]

Sample number	As (ppm)	Co (ppm)	Cr (ppm)	F (ppm)	Hg (ppm)	Sb (ppm)	Se (ppm)	Th (ppm)	U (ppm)	Sample number
D208590	0.7	1.0	3.1	40	0.10	0.3	0.1L	2.0	1.2	D208590
D208589	.3	1.3	.1L	100	.07	.3	1.5	3.8	1.1	D208589
D196222	.1	.9	1.6	200	.01	.2	.8	2.0	.2L	D196222
D196221	.4	.8	1.5	55	.01	.1L	.6	.7	.2L	D196221
D196438*	25	7L	15	285	.17	4.4	3.7	12	3.0	D196438*
D196223	.5	1.0	1.8	130	.02	.2	1.1	2.1	.2	D196223
D196220	.2	1.3	2.1	45	.31	.1	.6	1.0	.2L	D196220
D196437*	2.0	N	30	135	.04	.9	1.1	6.8	2.9	D196437*
D196219	2.5	1.4	3.8	70	.02	.2	1.2	1.4	.2L	D196219
D184638	.1L	.8	1.8	65	.01	.2	1.1	2.9	.9	D184638
D184637	1.4	.8	1.6	90	.01	.1	1.0	1.7	.7	D184637

Table 5a.--Major-, minor-, and trace-element composition of 63 coal and 13 coal-associated rock samples from the Williams Fork Formation, Yampa coal field, northwestern Colorado

[As, Co, Cr, F, Hg, Sb, Se, Th, and U values (unless otherwise noted) are from direct determinations on air-dried (32°C) sample; all other values calculated from analyses of ash. S means analysis by semiquantitative emission spectroscopy. L, less than the value shown; N, not detected, B, not determined. For samples D176362 - D178129 and D188236 - D188246, analysis for Co and Cr is by semiquantitative emission spectroscopy]

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
D188245	31	10	1.4	0.42	0.54	1.9	0.86	0.48	1.0	150	D188245
D188256	.34	.48	.59	.025	.16	.008	.12	.044	.4	70	D188256
D188255	.88	.70	.40	.028	.16	.018	.12	.043	.6	70	D188255
D188246	29	7.5	6.0	.47	.27	1.3	1.3	.23	2.5	N	D188246
D176389	26	4.6	.10	.20	.44	1.4	.66	.28	2.0	70	D176389
D176378	2.5	1.4	.28	.041	.037	.091	.20	.053	1.0L	70	D176378
D176390	13	9.3	.17	.15	.20	.57	.62	.23	2.0	70	D176390
D176377	2.7	1.8	.22	.080	.029	.097	.25	.068	1.0	70	D176377
D176388	28	5.1	.18	.48	.32	1.5	1.3	.23	8.0	70	D176388
D188239	9.1	3.0	.49	.21	.047	.55	.79	.15	1.5	100	D188239
D184641	3.1	1.6	.44	.057	.020	.11	.35	.068	1.0	70	D184641
D184640	1.8	1.2	.60	.069	.010	.043	.16	.055	.7	100	D184640
D184639	2.4	1.4	.56	.10	.013	.048	.22	.045	.8	70	D184639
D188240	31	6.7	.64	.44	.44	2.4	.83	.40	6.5	50	D188240
D184643	6.8	2.0	.28	.075	.037	.25	.38	.090	3.8	70	D184643
D184642	1.5	.96	.35	.040	.007	.034	.19	.042	1.0	100	D184642
D176387	23	4.9	.16	.32	.24	1.4	.74	.24	2.0	100	D176387
D176375	2.7	2.0	.27	.070	.013	.065	.21	.056	1.0L	100	D176375
D176376	1.2	.95	.30	.054	.008	.025	.17	.038	1.0L	150	D176376
D176383	26	2.6	.14	.11	.097	.82	.39	.26	3.0	50	D176383
D176370	.57	.36	.39	.073	.014	.009	.27	.018	1.0L	70	D176370
D176369	1.0	.50	.55	.078	.020	.025	.31	.029	1.0L	100	D176369
D176373	2.4	1.1	.41	.093	.11	.070	.21	.051	1.0L	150	D176373
D176386	11	1.9	.14	.072	.14	.37	.20	.099	2.0	100	D176386
D176374	9.3	2.0	.48	.14	.18	.35	.36	.093	1.0L	300	D176374
D176385	30	4.6	.14	.21	.49	1.3	.66	.30	2.0	50	D176385
D176371	2.5	1.3	.43	.087	.044	.071	.21	.053	1.0L	300	D176371
D176372	1.6	1.0	.33	.061	.014	.050	.21	.044	1.0L	50	D176372
D176384	31	5.1	.60	.59	.38	1.5	1.1	.31	12	70	D176384
D176380	26	4.9	.27	.43	.26	1.2	4.5	.28	30	50	D176380
D176363	3.0	1.5	.36	.084	.054	.085	.22	.050	1.0L	100	D176363
D176362	1.6	.90	.42	.092	.016	.074	.38	.048	3.0	150	D176362
D176379	26	4.6	.22	.28	.42	1.2	.84	.31	2.0	70	D176379
D176365	4.1	2.3	.39	.13	.13	.15	.23	.067	1.0L	100	D176365
D176364	.84	.74	.37	.057	.010	.025	.27	.038	1.0	100	D176364
D186094	12	3.1	.89	.31	.18	.72	.77	.18	3.7	70	D186094
D208577	.61	.56	.52	.011	.008	.009	.20	.026	.4	100	D208577
D208564	.61	.52	.61	.011	.007	.020	.22	.024	.5	70	D208564
D208565	.41	.45	.66	.011	.007	.017	.14	.021	.3	70	D208565
D208566	1.8	.30	.44	.086	.005	.030	.60	.024	1.9	50	D208566

Table 5a.--Major-, minor-, and trace-element composition of 63 coal and 13 coal-associated rock samples from the Williams Fork Formation, Yampa coal field, northwestern Colorado--continued

Sample number	Ba-S (ppm)	Be-S (ppm)	Cd (ppm)	Ce-S (ppm)	Co (ppm)	Cr (ppm)	Cu (ppm)	F (ppm)	Ga-S (ppm)	Ge-S (ppm)	Sample number
D188245	700	7	1.9	N	10	150	64	380	30	20	D188245
D188256	500	.15	.04L	N	1.7	11	3.9	150	3	N	D188256
D188255	300	.15	.05	N	1.0	2.9	4.8	55	3	N	D188255
D188246	700	N	.95L	200	7.0	15	19L	450	15	N	D188246
D176389	500	2	.67L	300L	7.0L	20	27	330	15	N	D176389
D176378	150	.7	.10	50L	1.5	1.5	7.5	140	3	N	D176378
D176390	500	N	.49L	N	5.0L	1.5	15	208	20	N	D176390
D176377	200	1	.11L	50L	1.5	1.5	5.6	115	5	3	D176377
D176388	700	3	.88L	500L	15	50	38	755	15	N	D176388
D188239	150	5	.60	N	7.0	30	18	250	10	7	D188239
D184641	150	1	.13L	70L	1.8	4.6	11	75	3	N	D184641
D184640	150	.5	.08L	50L	1.2	.1L	5.6	70	2	N	D184640
D184639	70	.7	.11L	50L	1.1	1.8	5.3	80	3	N	D184639
D188240	700	N	.91L	N	15	70	35	670	15	N	D188240
D184643	70	1.5	.22L	N	3.0	.1L	9.4	80	5	N	D184643
D184642	70	.3	.07L	30L	1.1	.1L	5.1	70	2	N	D184642
D176387	500	5	.66L	N	7.0L	30	30	330	10	N	D176387
D176375	100	1	.12L	70L	1.0	1.0	6.8	50	7	N	D176375
D176376	100	.5	.06L	30L	1.0	1.5	4.8	75	2	N	D176376
D176383	200	10	.65L	N	10	100	13L	115	10	N	D176383
D176370	70	N	.04L	20L	.7	1.0	3.0	120	1	N	D176370
D176369	70	N	.06L	30L	.7	1.5	4.2	190	1.5	N	D176369
D176373	300	.7	.10L	50L	1.5	1.5	5.8	105	3	N	D176373
D176386	300	1	.30L	N	3.0L	10	12	65	5	N	D176386
D176374	1,000	1L	.28	150L	3.0	5.0	10	150	10	N	D176374
D176385	500	N	.78L	500L	7.0L	20	19	330	15	N	D176385
D176371	150	1	.10L	50L	5.0	7.0	17	80	5	7	D176371
D176372	150	.2	.07L	N	1.0	1.0	5.0	100	2	N	D176372
D176384	500	N	.87L	N	15	70	35	565	15	N	D176384
D176380	200	2L	.77L	N	10	20	26	455	10	N	D176380
D176363	100	.3	.12L	70L	1.0L	1.5	6.8	105	3	N	D176363
D176362	150	.2	.12	50L	1.5	3.0	6.1	115	2	N	D176362
D176379	1,500	2	.67L	N	7.0L	20	15	275	10	N	D176379
D176365	150	.5	.17L	100L	1.5	1.5	10	35	5	N	D176365
D176364	150	.5	.06L	30L	1.0	1.0	5.1	75	3	N	D176364
D186094	300	1L	.35L	N	5.5	22	17	200	5	N	D186094
D208577	100	N	.14	N	.7	2.4	2.4	45	1.5	N	D208577
D208564	100	N	.05	N	.1L	1.5	3.4	30	1.5	N	D208564
D208565	150	N	.08	N	.1L	1.3	2.8	20	1.5	N	D208565
D208566	1,000	.7	.07	N	.1L	2.9	2.3	20L	1	1.5L	D208566

Table 5a.--Major-, minor-, and trace-element composition of 63 coal and 13 coal-associated rock samples from the Williams Fork Formation, Yampa coal field, northwestern Colorado--continued

Sample number	Hg (ppm)	La-S (ppm)	Li (ppm)	Mn (ppm)	Mo-S (ppm)	Nb-S (ppm)	Nd-S (ppm)	Ni-S (ppm)	P (ppm)	Pb (ppm)	Sample number
D188245	0.22	70	120	28	N	30	N	15	4,100L	33	D188245
D188256	.02	3	2.8	3.1	.5	.7	N	1.5	2,000	2.1	D188256
D188255	.02	7	5.9	2.0	1	1.5	N	1.5	470	2.0	D188255
D188246	.11	150	25	210	N	20	N	5	4,100L	28	D188246
D176389	.06	70L	28	30	15	20	N	10	2,900L	17L	D176389
D176378	.03	10L	10	6.8	.7	2	15	2	490	4.9	D176378
D176390	.02	50L	52	32	3	10L	N	5L	2,100L	20	D176390
D176377	.05	10	9.2	8.4	1	5	15L	1.5	490L	6.7	D176377
D176388	.13	100L	39	39	N	30	N	30	3,800L	22L	D176388
D188239	.25	N	21	40	N	15	N	10	1,300L	19	D188239
D184641	.03	15L	13	36	1.5	3	N	2	550L	5.1	D184641
D184640	.01	15	7.3	35	1	2	N	1.5	370L	4.6	D184640
D184639	.01	10L	10	24	1	3	N	1.5	460L	7.4	D184639
D188240	.13	70	26	59	N	20	N	30	4,000L	23	D188240
D184643	.07	20L	13	11	1.5L	7	N	5	950L	6.5	D184643
D184642	.02	7	6.9	13	.5	3	N	1.5	310L	4.6	D184642
D176387	.05	70L	25	39	N	20	N	15	2,900L	16L	D176387
D176375	.02	10	12	11	N	2L	20L	1L	520L	6.0	D176375
D176376	.02	7	6.2	11	.7	2	10	1	270L	4.3	D176376
D176383	.10	N	28	72	N	15	B	15	2,900L	16L	D176383
D176370	.01	5L	3.5	44	N	.7	N	1	270	1.6	D176370
D176369	.02	5	4.8	46	N	1	N	1.5	760	2.2	D176369
D176373	.04	10	5.2	9.6	.7	3	15L	3	570	4.0	D176373
D176386	.02	N	15	7.5	N	10	B	3L	1,300L	9.0	D176386
D176374	.04	30L	13	18	2	7	50	5	1,200L	7.1	D176374
D176385	.06	70L	30	27	20	15	N	10	3,400L	20L	D176385
D176371	.02	10L	7.7	9.3	.7	3	15L	7	450L	6.2	D176371
D176372	.02	7L	7.0	7.8	N	1.5	10L	1	320L	4.4	D176372
D176384	.23	100L	33	52	N	15	N	30	3,800L	22L	D176384
D176380	.42	N	34	170	5	15	B	50	3,400L	19L	D176380
D176363	.02	10L	9.4	13	1	2	20L	2	520L	4.8	D176363
D176362	.10	7	8.0	18	.7	1.5	15L	2	770	2.9	D176362
D176379	.11	70L	26	34	N	15	N	20	2,900L	17L	D176379
D176365	.03	15L	13	9.1	N	3	N	2	730L	5.0	D176365
D176364	.08	5	6.9	13	.5	3	10L	1	810	2.5	D176364
D186094	.05	30L	16	76	N	10	N	10	1,500L	14	D186094
D208577	.05	5L	5.0	51	.3L	1	N	1.5	480	1.2L	D208577
D208564	.09	5L	2.9	15	.3L	1L	N	1	260	1.6	D208564
D208565	.11	5L	3.1	2.6	N	.7L	N	1.5	180	1.7	D208565
D208566	.09	N	1.5	48	.5	N	B	1	45L	1.5	D208566

Table 5a.--Major-, minor-, and trace-element composition of 63 coal and 13 coal-associated rock samples from the Williams Fork Formation, Yampa coal field, northwestern Colorado--continued

Sample number	Sb (ppm)	Sc-S (ppm)	Se (ppm)	Sr-S (ppm)	Th (ppm)	U (ppm)	V-S (ppm)	Y-S (ppm)	Yb-S (ppm)	Zn (ppm)	Sample number
D188245	2.8	15	2.7	100	6.7	6.2	200	30	5	290	D188245
D188256	.7	.7	2.1	300	7.0	.8	3	3	.2	1.8	D188256
D188255	.3	.7	1.4	100	1.5	1.5	7	3	.3	1.6	D188255
D188246	.5	7	2.3	150	11.0	3.5	30	30	3	110	D188246
D176389	1.9	7	.9	100	13.0	2.5	70	20	2	38	D176389
D176378	.3	1.5	.9	100	3.0L	.7	7	3	.3	5.6	D176378
D176390	.3	N	1.3	70	15.1	4.1	15	10L	1L	15	D176390
D176377	.5	1.5	1.3	70	8.7	1.3	7	5	.7	4.9	D176377
D176388	.7	15	1.4	70	16.2	4.6	70	30	3	96	D176388
D188239	2.3	10	.6	50	8.5	3.6	50	20	2	100	D188239
D184641	.2	2	1.2	30	3.1	1.3	10	7	.7	10	D184641
D184640	.2	1.5	1.2	70	3.6	1.4	7	7	.7	3.6	D184640
D184639	.2	1	1.4	30	4.2	1.9	3	7	.7	5.1	D184639
D188240	1.7	7	2.2	70	15.0	4.7	70	30	3	100	D188240
D184643	.5	3	2.1	15	3.7	1.5	15	7	.7	23	D184643
D184642	.2	1	1.2	50	2.8	1.0	3	5	.5	3.3	D184642
D176387	1.3	10	1.0	70	13.3	2.2	100	20	2	40	D176387
D176375	.2	1	1.0	100	3.0L	.6	10	3	.3	4.2	D176375
D176376	.3	1	1.4	100	3.0L	1.1	5	5	.5	2.3	D176376
D176383	1.2	20	1.3	70	14.5	1.4	200	20	3	27	D176383
D176370	.2	.7	.9	70	3.0L	.4	3	1	.1	1.4	D176370
D176369	.3	.7	.9	70	3.0L	.2L	5	1.5	.15	2.1	D176369
D176373	.1	1.5	.9	150	3.0L	.7	5	7	.5	4.8	D176373
D176386	.4	3L	1.6	100	7.5	1.3	10	10	1	8.7	D176386
D176374	.3	3L	1.4	500	9.7	1.5	15	10	1	11	D176374
D176385	.4	7L	1.1	100	14.4	3.0	50	20	2	31	D176385
D176371	.2	5	.9	300	3.0L	.9	15	7	.7	5.8	D176371
D176372	.1	.7	.9	70	3.0L	.9	5	2	.2	2.8	D176372
D176384	1.1	10	1.8	100	19.9	4.4	70	30	3	110	D176384
D176380	.8	7	2.5	100	21.1	7.2	50	20	2	69	D176380
D176363	.1	1	.9	100	3.0L	.8	7	3	.3	10	D176363
D176362	.2	1.5	1.2	200	3.0L	.8	7	5	.5	6.8	D176362
D176379	.3	7L	1.5	100	18.8	3.0	50	20	2	70	D176379
D176365	.1L	1.5L	.8	100	10.2	.8	10	5	.3	12	D176365
D176364	.2	1.5	1.0	300	3.0L	.9	5	5	.5	3.1	D176364
D186094	.8	5	.1L	100	6.0	3.4	50	15	1.5	50	D186094
D208577	.1	.7	.9	100	1.0	.5	3	1.5	.15	2.0	D208577
D208564	.1L	.7	.5	100	.8	.4	3	1.5	.15	3.6	D208564
D208565	.1L	.7	.7	70	.9	.4	3	2	.2	2.5	D208565
D208566	.2	1	.6	20	.7	.9	3	2	.3	5.7	D208566

Table 5a.--Major-, minor-, and trace-element composition of 63 coal and 13 coal-associated rock samples from the Williams Fork Formation, Yampa coal field, northwestern Colorado--continued

Sample number	Zr-S (ppm)
D188245	150
D188256	7
D188255	10
D188246	150
D176389	200
D176378	30
D176390	150
D176377	30
D176388	150
D188239	200
D184641	20
D184640	20
D184639	20
D188240	200
D184643	50
D184642	15
D176387	200
D176375	20
D176376	20
D176383	200
D176370	7
D176369	10
D176373	30
D176386	70
D176374	70
D176385	150
D176371	20
D176372	15
D176384	150
D176380	150
D176363	20
D176362	15
D176379	150
D176365	30
D176364	15
D186094	50
D208577	15
D208564	15
D208565	7
D208566	50

Table 5a.--Major-, minor-, and trace-element composition of 63 coal and 13 coal-associated rock samples from the Williams Fork Formation, Yampa coal field, northwestern 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
D208567	1.2	0.87	0.54	0.062	0.015	0.048	0.15	0.032	0.5	70	D208567
D208568	1.6	.66	.29	.066	.025	.086	.22	.034	.7	50	D208568
D208569	1.3	1.0	.33	.064	.022	.037	.16	.045	.6	20	D208569
D208570	2.9	1.2	.37	.076	.027	.071	.14	.054	.9	20	D208570
D208571	3.3	1.7	.45	.082	.034	.093	.13	.068	.6	30	D208571
D208572	2.4	1.2	.39	.070	.035	.12	.11	.054	.4	50	D208572
D208573	4.0	1.0	.31	.066	.031	.10	.081	.051	.5	30	D208573
D208574	2.1	1.7	.36	.082	.022	.060	1.9	.067	2.0	30	D208574
D208575	1.2	.90	.59	.058	.021	.051	.25	.040	.5	50	D208575
D208576	1.9	1.3	.38	.087	.023	.061	.36	.056	.3	70	D208576
D178117	2.7	1.3	.27	.064	.037	.086	.15	.051	1.5	70	D178117
D178118	4.0	1.1	.21	.062	.055	.12	.15	.062	.5	100	D178118
D178119	1.5	.83	.22	.041	.023	.045	.088	.040	.5L	70	D178119
D178120	2.2	1.7	.29	.053	.052	.036	.097	.065	.5L	70	D178120
D178121	3.7	1.5	.37	.16	.080	.078	.20	.059	.5L	100	D178121
D178122	3.3	1.6	.25	.11	.092	.056	.15	.064	1.5	100	D178122
D178123	7.6	1.9	.16	.11	.059	.32	.22	.088	.5	100	D178123
D178124	3.6	1.5	.41	.13	.030	.097	1.1	.064	.5L	100	D178124
D178129	5.9	1.5	.22	.10	.040	.16	1.6	.093	6.0	70	D178129
D178128	1.9	1.1	.36	.10	.019	.037	.14	.039	.5L	150	D178128
D178125	.96	.56	.38	.067	.031	.021	1.6	.033	1.5	150	D178125
D178126	3.4	1.5	.24	.083	.071	.12	.15	.057	.5	150	D178126
D178127	3.1	.87	.088	.052	.024	.084	.71	.049	1.5	70	D178127
D184645	2.2	.94	.60	.092	.066	.063	.16	.046	.4	70	D184645
D184646	1.5	.99	.44	.047	.064	.043	.14	.045	.5	70	D184646
D208579	.75	.55	.47	.060	.10	.019	.35	.026	.4	100	D208579
D208578	1.1	.62	.53	.065	.018	.022	.86	.031	1.8	100	D208578
D208580	1.2	.46	.43	.047	.011	.003	.99	.028	2.6	100	D208580
D188237	5.7	5.1	.48	.038	.080	.15	.067	.16	.5	30	D188237
D188252	.45	.61	.79	.035	.053	.012	.13	.040	.2	70	D188252
D188236	31	3.6	.20	.19	.28	1.3	.33	.31	1.5	50	D188236
D188238	30	7.3	1.4	.87	.42	2.1	2.8	.43	4.5	70	D188238
D188254	1.5	1.1	.42	.049	.073	.054	.39	.046	1.2	100	D188254
D188253	2.0	1.6	.44	.058	.086	.064	.17	.065	.3	150	D188253
D188250	6.4	2.6	.29	.081	.13	.27	.31	.11	1.5	70	D188250
D188251	2.3	1.3	.64	.075	.12	.072	.21	.082	.4	70	D188251

Table 5a.--Major-, minor-, and trace-element composition of 63 coal and 13 coal-associated rock samples from the Williams Fork Formation, Yampa coal field, northwestern Colorado--continued

Sample number	Ba-S (ppm)	Be-S (ppm)	Cd (ppm)	Ce-S (ppm)	Co (ppm)	Cr (ppm)	Cu (ppm)	F (ppm)	Ga-S (ppm)	Ge-S (ppm)	Sample number
D208567	150	0.2	0.12	N	0.7	2.0	3.2	50	2	N	D208567
D208568	200	.7	.13	N	1.2	4.0	3.2	60	2	N	D208568
D208569	150	N	.13	N	2.1	3.1	4.0	65	2	N	D208569
D208570	100	N	.21	N	1.2	4.8	4.8	40	3	N	D208570
D208571	100	N	.24	N	1.2	4.4	4.6	60	3	N	D208571
D208572	100	.5	.19	N	1.1	2.1	3.6	70	3	N	D208572
D208573	200	1	.25	N	1.7	2.2	4.1	90	2	N	D208573
D208574	200	N	.38	N	.9	.1L	2.5	60	3	N	D208574
D208575	200	.7	.14	N	1.0	2.6	3.1	45	2	1.5	D208575
D208576	150	.7	.18	N	.9	3.6	2.9	120	3	N	D208576
D178117	200	1.5	.11L	N	1.0L	3.0	6.2	145	3	N	D178117
D178118	200	2	.13	70L	2.0	10	8.0	215	5	N	D178118
D178119	300	2	.07L	30L	1.5	5.0	4.2	200	3	2	D178119
D178120	300	1.5	.10	50L	1.0	3.0	7.8	225	5	N	D178120
D178121	500	1	.14	N	1.5L	5.0	5.8	75	5	N	D178121
D178122	300	1	.13	70L	1.5L	2.0	6.0	160	3	N	D178122
D178123	200	1	.23	N	2.0L	15	9.9	440	7	N	D178123
D178124	200	.7	.16L	70L	1.5L	5.0	5.9	90	5	N	D178124
D178129	300	1.5	.24L	N	2.0L	15	11	330	7	N	D178129
D178128	150	1	.09L	50L	1.0L	2.0	4.6	140	5	N	D178128
D178125	200	.5	.08L	N	.7L	2.0	3.3	70	2	N	D178125
D178126	200	1	.13L	70L	1.5L	3.0	5.9	240	3	N	D178126
D178127	150	1.5	.10	N	1.0L	3.0	5.2	75	5	N	D178127
D184645	300	.5	.09	50L	.8	1.6	6.0	190	3	N	D184645
D184646	200	.5	.07L	30L	.8	1.4	5.0	75	2	N	D184646
D208579	100	.3	.10	N	2.2	2.3	3.4	740	1.5	2	D208579
D208578	100	.2	.59	N	4.1	3.1	2.9	200	2	1.5	D208578
D208580	70	.2	.06	N	3.6	2.6	2.9	180	2	2	D208580
D188237	30	.7	.24L	N	1.5	7.0	14	60	10	N	D188237
D188252	300	.3	.10	10	1.2	1.6	4.8	150	2	N	D188252
D188236	200	1.5	.80L	N	5.0	50	16L	220	5	N	D188236
D188238	700	N	.92L	N	15	70	27	860	15	N	D188238
D188254	100	.5	.08	15	1.1	3.0	5.0	60	5	N	D188254
D188253	150	.7	.09	N	.7	1.8	6.5	20	7	N	D188253
D188250	150	1.5	.43	50	2.5	10	11	120	7	N	D188250
D188251	300	.3	.21	N	1.0	2.8	9.1	55	5	N	D188251

Table 5a.--Major-, minor-, and trace-element composition of 63 coal and 13 coal-associated rock samples from the Williams Fork Formation, Yampa coal field, northwestern Colorado--continued

Sample number	Hg (ppm)	La-S (ppm)	Li (ppm)	Mn (ppm)	Mo-S (ppm)	Nb-S (ppm)	Nd-S (ppm)	Ni-S (ppm)	P (ppm)	Pb (ppm)	Sample number
D208567	0.06	7L	4.5	27	0.5	2	N	1.5	310	2.7	D208567
D208568	.06	7L	4.2	17	.7	2	N	5	520	1.5	D208568
D208569	.04	7L	5.8	15	.7	2	N	2	350	1.6	D208569
D208570	.04	10L	5.7	27	.7	3	N	2	220	4.7	D208570
D208571	.07	N	8.2	34	1	2	B	3	90	4.8	D208571
D208572	.07	10L	6.5	30	.7	2	N	3	310	3.8	D208572
D208573	.07	15L	7.7	24	1	3	N	2	660	4.1	D208573
D208574	.13	15L	14	210	N	2	N	2	440	3.6	D208574
D208575	.07	7L	6.4	130	.5	2	N	2	570	1.7L	D208575
D208576	.08	10L	13	85	N	1.5	N	1.5	920	2.2L	D208576
D178117	.04	10L	12	5.4	N	3	N	1.5	480	4.8	D178117
D178118	.04	15L	12	8.4	N	5	N	2	560L	5.2	D178118
D178119	.02	7	8.6	11	.5	3	10L	2	710	3.4	D178119
D178120	.08	10L	12	6.8	.7	3	N	1	910	3.1	D178120
D178121	.02	15L	5.3	47	1	5	N	1.5L	590L	5.4	D178121
D178122	.06	15L	8.9	9.5	1	3	N	1.5L	550L	3.8	D178122
D178123	.08	20L	21	26	1.5	7	N	3	990L	6.8	D178123
D178124	.05	15L	11	200	N	3	N	1.5	680L	5.5	D178124
D178129	.29	N	26	24	N	5	B	3	1,100L	6.1L	D178129
D178128	.02	10L	6.1	11	.7	2	N	1	380L	3.9	D178128
D178125	.23	7L	3.1	13	.7	1.5	N	1.5	350	2.0L	D178125
D178126	.04	15L	11	8.8	1	3	N	1.5	550L	5.0	D178126
D178127	.02	10L	14	7.7	.7	3	N	1	450L	6.2	D178127
D184645	.01	10L	5.3	19	.7	5	N	1.5	510	8.9	D184645
D184646	.01	7	8.2	3.5	.5	3	N	1	330	5.5	D184646
D208579	.06	5L	6.8	52	.3	1	N	3	1,000	3.5	D208579
D208578	.18	7L	6.8	75	N	1.5	N	7	1,100	13	D208578
D208580	.14	7L	4.5	64	N	1.5L	N	5	920	8.9	D208580
D188237	.03	15	45	7.2	N	5	N	1	1,000L	16	D188237
D188252	.03	7	7.7	7.0	.2	1.5	7	1.5	2,000	3.4	D188252
D188236	.05	N	21	20	N	20	N	5	3,500L	20L	D188236
D188238	.24	N	48	220	N	20	N	30	4,000L	23	D188238
D188254	.15	10	11	4.6	.5	2	10	1	370	6.1	D188254
D188253	.02	7	17	2.7	.5	5	N	.7	400L	11	D188253
D188250	.05	30	21	7.5	N	5	N	2	940L	27	D188250
D188251	.02	15	8.1	24	.5	3	N	1	1,000	33	D188251

Table 5a.--Major-, minor-, and trace-element composition of 63 coal and 13 coal-associated rock samples from the Williams Fork Formation, Yampa coal field, northwestern Colorado--continued

Sample number	Sb (ppm)	Sc-S (ppm)	Se (ppm)	Sr-S (ppm)	Th (ppm)	U (ppm)	V-S (ppm)	Y-S (ppm)	Yb-S (ppm)	Zn (ppm)	Sample number
D208567	0.2	1	0.6	70	1.9	0.8	5	2	0.2	38	D208567
D208568	.2	1.5	.5	100	1.1	.6	10	3	.3	15	D208568
D208569	.3	1	1.7	70	2.0	.8	5	2	.2	20	D208569
D208570	.3	1	.1L	30	3.6	1.3	7	3	.3	38	D208570
D208571	.1L	2	.1L	20	3.6	1.0	10	3	.3	33	D208571
D208572	.3	1.5	.9	50	2.2	1.0	7	3	.3	8.5	D208572
D208573	.5	2	.1L	70	1.6	1.0	10	7	.7	10	D208573
D208574	.2	1.5	.9	70	2.7	1.0	3	3	B	15	D208574
D208575	.2	2	1.1	100	1.7	.7	10	5	.5	7.9	D208575
D208576	.2	1.5	1.0	150	2.6	.9	7	5	.5	7.1	D208576
D178117	.2	1.5	1.0	150	3.0L	.8	7	7	.5	5.7	D178117
D178118	.8	2	.9	100	4.3	.7	15	10	1	13	D178118
D178119	.4	2	.9	200	4.2	.6	20	7	.7	3.0	D178119
D178120	.2	1.5	1.2	150	3.0L	.9	10	5	.5	4.6	D178120
D178121	.2	2	.8	150	3.0L	1.2	10	7	.7	6.0	D178121
D178122	.2	2	1.1	100	3.0L	1.6	10	10	.7	3.7	D178122
D178123	.5	3	1.1	70	5.8	1.5	15	7	1	20	D178123
D178124	.3	2	.8	100	5.6	1.1	10	7	.7	9.2	D178124
D178129	.4	3	1.3	200	3.0L	1.5	30	15	1.5	23	D178129
D178128	.1	1.5	.7	50	3.0L	.8	7	7	.5	3.9	D178128
D178125	.2	1.5	1.2	70	3.0L	.4	15	5	B	2.6	D178125
D178126	.3	2	.8	100	5.4	.8	15	10	.7	13	D178126
D178127	.5	1.5	1.0	70	3.0L	.6	7	7	.5	4.2	D178127
D184645	.2	1.5	.6	100	2.1	1.1	5	7	.7	18	D184645
D184646	.1	1	.1L	100	2.5	.9	5	5	.5	6.3	D184646
D208579	.2	1.5	.7	100	1.0	.3	3	3	.2	3.8	D208579
D208578	.4	2	1.1	150	1.2	.5	5	3	B	3.3	D208578
D208580	.5	1.5	1.1	150	1.0	.6	5	3	B	4.0	D208580
D188237	.5	2	6.4	30	3.0L	4.9	15	7	.5	11	D188237
D188252	.1	.7	.7	300	.9	1.2	3	7	.3	3.1	D188252
D188236	.7	5	.9	50	9.0	3.7	50	50	5	52	D188236
D188238	1.1	15	2.2	150	9.4	4.4	70	50	5	120	D188238
D188254	.2	2	1.2	100	3.5	1.5	5	7	.7	7.3	D188254
D188253	.2	3	1.1	150	3.8	1.8	5	7	.7	5.4	D188253
D188250	.3	3	.1L	150	6.1	2.5	15	15	1.5	48	D188250
D188251	.3	1.5	1.1	150	3.4	1.7	7	7	.7	17	D188251

Table 5a.--Major-, minor-, and trace-element composition of 63 coal and 13 coal-associated rock samples from the Williams Fork Formation, Yampa coal field, northwestern Colorado--continued

Sample number	Zr-S (ppm)
D208567	20
D208568	20
D208569	20
D208570	30
D208571	30
D208572	30
D208573	30
D208574	20
D208575	30
D208576	30
D178117	20
D178118	20
D178119	20
D178120	20
D178121	20
D178122	20
D178123	30
D178124	20
D178129	30
D178128	15
D178125	15
D178126	20
D178127	30
D184645	30
D184646	20
D208579	10
D208578	15
D208580	15
D188237	50
D188252	10
D188236	500
D188238	150
D188254	20
D188253	30
D188250	70
D188251	30

Table 5b.--Major-, minor-, and trace-element composition of 22 coal samples from the Williams Fork Formation, Danforth Hills coal field, northwestern Colorado

[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 ash. S means analysis by semiquantitative emission spectroscopy. 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
D205272	1.5	1.1	0.32	0.073	0.006	0.018	0.13	0.045	0.5	70	D205272
D205273	.86	.64	.30	.047	.003	.016	.13	.030	.4	50	D205273
D205274	6.2	2.5	.25	.10	.012	.24	.52	.11	1.1	50	D205274
D205275	1.1	.49	.24	.050	.004	.037	.60	.027	6.2	70	D205275
D205276	15	4.2	.56	.19	.026	.51	1.0	.20	11	50	D205276
D205277	6.1	2.1	.30	.12	.011	.20	.30	.10	2.1	70	D205277
D205278	1.4	.68	.50	.082	.005	.047	.33	.033	.8	50	D205278
D205279	1.1	.71	.37	.068	.005	.013	.14	.030	.4	50	D205279
D205280	6.9	2.5	.35	.11	.020	.24	.37	.11	1.7	50	D205280
D205281	1.7	.72	.31	.052	.006	.036	.086	.039	.6	70	D205281
D205282	5.1	1.8	.29	.10	.013	.19	.22	.088	1.2	70	D205282
D186091	2.7	.71	1.0	.16	.042	.11	.35	.064	1.5	50	D186091
D186092	15	2.8	.87	.27	.042	.65	.88	.18	5.0	50	D186092
D186093	14	2.9	1.3	.36	.23	.56	1.0	.16	5.1	70	D186093
D191603	.75	.30	.65	.009	.18	.026	.48	.023	.7	50	D191603
D191604	.83	.60	.65	.079	.16	.009	.39	.034	.6	50	D191604
D191605	3.8	1.1	.57	.11	.19	.14	.33	.067	1.0	30	D191605
D191606	6.9	4.2	.90	.13	.18	.17	.44	.14	2.0	30	D191606
D186095	7.2	1.5	2.2	.31	.052	.30	.68	.089	2.9	50	D186095
D186096	6.6	1.3	.80	.17	.027	.25	.49	.077	2.0	50	D186096
D201454	B	B	B	.070	.016	B	B	B	.4	30	D201454
D201455	.69	.37	.33	.049	.15	.018	.37	.018	.4	30	D201455

Table 5b.--Major-, minor-, and trace-element composition of 22 coal samples from the Williams Fork Formation, Danforth Hills coal field, northwestern Colorado--continued

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
D205272	150	0.3	0.07L	0.9	2.4	4.0	85	3	N	0.02	D205272
D205273	150	.15L	.05L	.8	2.6	4.0	65	2	N	.02	D205273
D205274	300	N	.20L	3.0	20	16	190	7	N	.12	D205274
D205275	150	1	.05	2.0	3.9	5.6	60	1.5	N	.39	D205275
D205276	200	2	.44	6.2	47	33	330	15	N	.34	D205276
D205277	200	3	.38	4.2	18	16	150	7	3	.07	D205277
D205278	300	1	.07	2.3	4.4	5.8	120	2	3	.07	D205278
D205279	70	.3	.05	.8	2.4	5.1	50	3	N	.03	D205279
D205280	200	2	.45	3.0	9.2	18	95	10	5	.09	D205280
D205281	100	.3	.07	1.4	3.0	3.3	35	3	N	.03	D205281
D205282	150	1	.17L	2.8	13	12	150	5	N	.06	D205282
D186091	700	.3L	.11L	1.3	6.1	5.7	210	1.5	N	.06	D186091
D186092	300	1.5L	.43L	4.4	26	15	235	7	N	.02	D186092
D186093	300	1.5L	.45L	3.6	23	14	230	7	N	.09	D186093
D191603	300	.7	.06	1.8	.1L	4.5	20	1	N	.05	D191603
D191604	150	.15	.17	.7	.1L	3.5	55	1.5	N	.05	D191604
D191605	300	1.5	.28	1.6	8.6	12	90	5	N	.03	D191605
D191606	200	5	.28	5.5	.1L	17	170	15	5	.06	D191606
D186095	200	N	.26L	2.2	9.7	8.1	130	5	N	.05	D186095
D186096	150	.7L	.21L	2.1	12	10	175	3	N	.04	D186096
D201454	100	N	.03L	.5	1.1	2.9	20L	.7	N	.01	D201454
D201455	200	.7	.04L	1.7	.1L	2.8	20L	1.5	N	.02	D201455

Table 5b.--Major-, minor-, and trace-element composition of 22 coal samples from the Williams Fork Formation, Danforth Hills coal field, northwestern 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
D205272	10	4.2	32	0.5L	1.5L	2	180	3.0	0.3	1.5	D205272
D205273	5	3.2	12	.3	1L	2	220	1.6	.1	1	D205273
D205274	N	11	6.1L	1.5L	5L	10	44L	8.1	.7	5	D205274
D205275	5L	2.1	4.4	.5	1L	10	45L	1.7	.2	3	D205275
D205276	50L	63	13L	2	10L	30	310	17	1.5	10	D205276
D205277	N	18	12	2	3L	30	210	6.8	1.5	7	D205277
D205278	7L	3.2	16	.7	1.5L	15	930	3.3	.6	2	D205278
D205279	5L	3.7	1.6L	.5	1L	3	130	2.4	.2	.7	D205279
D205280	20L	14	6.7L	2	5L	30	39L	10	.8	5	D205280
D205281	7	3.4	2.0L	1	1.5L	7	340	2.8	.3	1.5	D205281
D205282	15L	3.3	5.6	1	3L	10	440	4.1L	.6	3	D205282
D186091	10L	3.1	63	.7	3	3	1,100	5.0	.2	1.5	D186091
D186092	50L	13	85	N	15	15	1,900L	17	.7	5	D186092
D186093	50L	17	130	3	15	7	2,000L	16	.5	5	D186093
D191603	7	1.7	22	.5	N	5	250L	3.7	.2	1	D191603
D191604	5	7.4	17	.7	1	1	270	2.3	.1	1	D191604
D191605	10	8.6	17	N	3	3	600L	5.5	.9	2	D191605
D191606	20	39	48	2	N	5	1,200L	11	3.3	5	D191606
D186095	N	7.8	150	N	7	5	1,100L	57	.3	2L	D186095
D186096	N	11	70	1.5	7	7	920L	5.3L	.5	2L	D186096
D201454	N	.7	14	N	.7L	1.5	43L	1.1	.1L	.3	D201454
D201455	5L	1.4	8.4	.7	1L	3	43L	1.4	.1	1.5	D201455

Table 5b.--Major-, minor-, and trace-element composition of 22 coal samples from the Williams Fork Formation, Danforth Hills coal field, northwestern 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
D205272	0.7	30	2.5	1.3	10	5	0.2	14	20	D205272
D205273	.7	50	1.7	.7	7	2	.15	16	15	D205273
D205274	1.2	20	3.6	2.8	50	7	.7	26	50	D205274
D205275	1.0	10	.9	.7	7	3	.3	15	10	D205275
D205276	1.9	100	6.8	5.2	100	20	2	100	100	D205276
D205277	1.4	30	3.3	6.3	30	15	1	48	100	D205277
D205278	.7	100	1.3	1.7	15	5	.3	25	20	D205278
D205279	.7	30	1.5	.7	7	3	.15	10	15	D205279
D205280	1.0	30	3.3	2.7	50	10	1	41	100	D205280
D205281	.6	50	1.1	.9	10	5	.3	11	20	D205281
D205282	.8	70	2.8	1.6	20	7	.7	28	30	D205282
D186091	.6	300	1.9	.5	15	5	.7	12	15	D186091
D186092	.1L	50	5.2	2.4	50	20	1.5	48	70	D186092
D186093	1.4	150	6.4	2.7	30	20	2	45	100	D186093
D191603	.6	300	.7	.7	5	5	.5	4.7	5	D191603
D191604	.6	150	1.4	.9	7	3	.15	3.1	10	D191604
D191605	.8	200	2.2	1.1	20	7	.5	6.8	20	D191605
D191606	1.1	70	10.1	3.7	30	7	.7	27	50	D191606
D186095	.7	50	3.5	1.5	20	20	.7	86	50	D186095
D186096	.9	150	3.0	2.2	20	7	.7	25	30	D186096
D201454	.4	100	.3	.2L	2	1	.1	2.7	2	D201454
D201455	.5	200	.7	.6	7	7	.5	3.3	7	D201455

Table 5c.--Major-, minor-, and trace-element composition of six coal and two coal-associated rock samples from the Williams Fork Formation, Grand Hogback coal field, northwestern Colorado

[As, Co, Cr, F, Hg, Sb, Se, Th, and U values (unless otherwise noted by *) are from direct determinations on air-dried (32°C) sample; all other values calculated from analyses of ash. S means analysis by semiquantitative emission spectroscopy. L, less than the value shown; N, not detected]

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
D196217	3.2	2.0	0.24	0.029	0.045	0.071	0.051	0.088	1.4	150	D196217
D196216	2.8	2.2	.17	.026	.063	.039	.11	.083	.4	100	D196216
D196434	1.8	.97	1.1	.043	.043	.048	.13	.046	1.6	150	D196434
D196215	1.5	1.0	.24	.028	.061	.023	.13	.050	2.1	150	D196215
D196214	1.3	.99	.32	.029	.060	.022	.098	.044	1.7	150	D196214
D196436	23	5.8	.13	.28	.036	1.2	.46	.36	1.4	70	D196436
D196218	1.4	1.0	.87	.088	.072	.023	.34	.056	.9	70	D196218
D196435	26	8.6	1.6	1.4	.54	2.7	1.5	.44	6.7	150	D196435

Sample number	Ba-S (ppm)	Be-S (ppm)	Cd (ppm)	Co (ppm)	Cr (ppm)	Cu (ppm)	F (ppm)	Ga-S (ppm)	Hg (ppm)	La-S (ppm)	Sample number
D196217	200	1.5	0.12L	2.3	3.5	7.4	55	15	0.03	20	D196217
D196216	200	.7	.12	1.3	2.1	7.5	35	7	.10	7	D196216
D196434	150	.3	.19	1 *	3 *	10	25	3	.01L	N	D196434
D196215	200	.3	.07L	1.6	2.3	5.9	40	5	.03	N	D196215
D196214	200	.5	.07L	1.3	1.5	5.2	85	5	.02	10	D196214
D196436	200	5	.60L	N *	50 *	18	300	20	.01L	50	D196436
D196218	300	.5	.09L	1.4	2.4	3.9	25	7	.03	7	D196218
D196435	1,500	3	.91	15 *	70 *	59	900	30	.05	70	D196435

Table 5c.--Major-, minor-, and trace-element composition of six coal and two coal-associated rock samples from the Williams Fork Formation, Grand Hogback coal field, northwestern Colorado--continued

Sample number	Li (ppm)	Mn (ppm)	Mo-S (ppm)	Nb-S (ppm)	Ni-S (ppm)	P (ppm)	Pb (ppm)	Sb (ppm)	Sc-S (ppm)	Se (ppm)	Sample number
D196217	14	13	2	7	2	43L	9.2	0.3	3	1.9	D196217
D196216	15	7.2	1.5	3	1.5	86	8.1	.2	1.5	.8	D196216
D196434	8.6	40	2	N	2	42L	5.3	1.1	1.5	1.5	D196434
D196215	9.6	11	2	1.5	2	170	3.8	.2	1	.9	D196215
D196214	7.8	11	2	1.5	1.5	440	3.0	.1	1	.8	D196214
D196436	25	33	N	10	10	53L	15	4.5	10	1.4	D196436
D196218	11	110	N	2	3	45L	3.8	.3	1.5	1.5	D196218
D196435	49	200	N	20L	50	440	23L	1.9	20	2.1	D196435

Sample number	Sr-S (ppm)	Th (ppm)	U (ppm)	V-S (ppm)	Y-S (ppm)	Yb-S (ppm)	Zn (ppm)	Zr-S (ppm)	Sample number
D196217	150	3.4	1.2	15	10	1	11	70	D196217
D196216	100	2.6	.4	7	7	.7	4.9	30	D196216
D196434	70	3.0L	2.3	15	3	.3	5.8	15	D196434
D196215	150	1.3	.7	7	3	.3	3.2	20	D196215
D196214	150	1.0	.4	5	3	.3	3.4	15	D196214
D196436	30	10.0	2.2	70	20	2	13	100	D196436
D196218	200	4.6	1.1	7	5	.5	3.6	30	D196218
D196435	300	14.0	4.5	150	30	3	130	200	D196435

Table 5d.--Major-, minor-, and trace-element composition of nine coal and two coal-associated rock samples from the Williams Fork Formation, Carbondale coal field, northwestern Colorado

[As, Co, Cr, F, Hg, Sb, Se, Th, and U values (unless otherwise noted by *) are from direct determinations on air-dried (32°C) sample; all other values calculated from analyses of ash. S means analysis by semiquantitative emission spectroscopy. L, less than the value shown; N, not detected]

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
D208590	1.1	0.74	0.45	0.093	0.001	0.022	0.52	0.032	0.7	30	D208590
D208589	2.5	2.1	.43	.057	.22	.048	.29	.070	.3	70	D208589
D196222	1.6	.87	.36	.098	.24	.019	.20	.045	.1	70	D196222
D196221	.67	.41	.23	.055	.13	.010	.20	.027	.4	30	D196221
D196438	20	9.4	.31	.19	.53	1.2	1.3	.43	25	100	D196438
D196223	2.0	.84	.27	.10	.18	.020	.19	.043	.5	50	D196223
D196220	1.2	.55	.31	.085	.11	.030	.40	.037	.2	30	D196220
D196437	38	5.1	.19	.19	.57	1.4	.25	.37	2.0	150	D196437
D196219	2.9	.81	.16	.056	.072	.017	.70	.061	2.5	20	D196219
D184638	1.6	1.0	.48	.091	.19	.032	.28	.047	.1L	50	D184638
D184637	1.8	1.1	.62	.088	.25	.044	.33	.055	1.4	70	D184637

Sample number	Ba-S (ppm)	Be-S (ppm)	Cd (ppm)	Co (ppm)	Cr (ppm)	Cu (ppm)	F (ppm)	Ga-S (ppm)	Hg (ppm)	La-S (ppm)	Sample number
D208590	200	0.2	0.06	1.0	3.1	3.7	40	2	0.10	7L	D208590
D208589	300	.3	.12	1.3	.1L	6.0	100	7	.07	10	D208589
D196222	300	.5	.08L	.9	1.6	3.7	200	5	.01	10	D196222
D196221	200	.3	.12	.8	1.5	3.5	55	2	.01	7	D196221
D196438	1,500	2	.71L	7L *	15 *	33	285	50	.17	50	D196438
D196223	200	.2	.08L	1.0	1.8	4.3	130	5	.02	5	D196223
D196220	300	.2	.06L	1.3	2.1	4.5	45	2	.31	N	D196220
D196437	500	N	.88L	N *	30 *	18	135	15	.04	70	D196437
D196219	200	1	.10L	1.4	3.8	5.9	70	5	.02	7	D196219
D184638	200	.2	.08L	.8	1.8	5.3	65	2	.01	7L	D184638
D184637	300	.5	.09L	.8	1.6	4.9	90	3	.01	10L	D184637

Table 5d.--Major-, minor-, and trace-element composition of nine coal and two coal-associated rock samples from the Williams Fork Formation, Carbondale coal field, northwestern Colorado--continued

Sample number	Li (ppm)	Mn (ppm)	Mo-S (ppm)	Nb-S (ppm)	Ni-S (ppm)	P (ppm)	Pb (ppm)	Sb (ppm)	Sc-S (ppm)	Se (ppm)	Sample number
D208590	9.1	40	0.5	1.5	2	180	1.6L	0.3	1	0.1L	D208590
D208589	20	14	.7	2L	1.5	700	3.9	.3	1.5	1.5	D208589
D196222	5.2	4.8	.7	2	1.5	880	2.6	.2	1	.8	D196222
D196221	5.9	4.9	.5	1.5	1.5	220	2.1	.1L	.7	.6	D196221
D196438	140	51	N	15L	15	250	36	4.4	7	3.7	D196438
D196223	5.9	16	.5	1.5	1	450	2.8	.2	.7	1.1	D196223
D196220	6.0	7.6	.7	1.5	2	260	2.1	.1	1	.6	D196220
D196437	36	39	N	15	10L	38L	22L	.9	N	1.1	D196437
D196219	10	13	1.5	2	5	350	3.6	.2	1.5	1.2	D196219
D184638	8.1	5.9	.5L	2	.7	350L	4.7	.2	.7	1.1	D184638
D184637	8.1	8.7	.7L	3	1.5	400L	2.8	.1	1	1.0	D184637

Sample number	Sr-S (ppm)	Th (ppm)	U (ppm)	V-S (ppm)	Y-S (ppm)	Yb-S (ppm)	Zn (ppm)	Zr-S (ppm)	Sample number
D208590	100	2.0	1.2	5	5	0.5	1.2L	20	D208590
D208589	200	3.8	1.1	7	7	.7	6.3	30	D208589
D196222	300	2.0	.2L	5	3	.3	3.5	20	D196222
D196221	200	.7	.2L	5	2	.2	2.0	7	D196221
D196438	100	12.0	3.0	70	20	2	90	200	D196438
D196223	150	2.1	.2	5	2	.2	5.3	20	D196223
D196220	200	1.0	.2L	5	2	.2	2.5	15	D196220
D196437	70	6.8	2.9	70	15L	1.5	27	300	D196437
D196219	150	1.4	.2L	7	7	.7	9.8	30	D196219
D184638	70	2.9	.9	5	5	.5	4.3	10	D184638
D184637	100	1.7	.7	7	3	.3	3.2	10	D184637

Table 6.--Elements looked for but not detected in samples from the Williams Fork Formation, northwestern Colorado

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

Element name	Symbol	Lower limit of detection in ash (ppm)
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
Tellerium	Te	5,000
Thallium	Tl	100
Thulium	Tm	50
Tungsten	W	200

Table 7a.--Arithmetic mean, observed range, geometric mean, and geometric deviation of proximate and ultimate analyses, and heat of combustion, forms of sulfur, and ash-fusion temperatures of 44 coal samples from the Williams Fork Formation, Yampa coal field, northwestern Colorado

[All values are in percent except kcal/kg, Btu/lb, and ash-fusion temperatures, and are reported on the as-received basis. °F = (°C x 1.8) + 32; kcal/kg = 0.556 x (Btu/lb). L, less than the value shown]

	Arithmetic mean	Observed range		Geometric mean	Geometric deviation
		Minimum	Maximum		
Proximate and ultimate analyses					
Moisture	11.1	5.7	17.1	10.6	1.3
Volatile matter	34.9	26.1	40.3	34.8	1.1
Fixed carbon	44.4	33.2	52.3	44.2	1.1
Ash	9.6	3.0	32.7	8.4	1.7
Hydrogen	5.6	3.9	7.1	5.6	1.1
Carbon	60.9	44.0	71.0	60.7	1.1
Nitrogen	1.3	.5	1.9	1.2	1.4
Oxygen	22.0	16.0	27.2	21.8	1.2
Sulfur	.6	.3	3.1	.6	1.5
Heat of combustion					
Kcal/kg	5,930	4,170	6,920	5,910	1.1
Btu/lb	10,670	7,500	12,440	10,630	1.1
Forms of sulfur					
Sulfate	0.01	0.01L	0.04	0.01	1.4
Pyritic	.18	.01	2.18	.10	2.9
Organic	.45	.16	2.27	.40	1.6
Ash-fusion temperatures, °C					
Initial deformation	1,315	1,070	1,600+	1,310	1.1
Softening temperature	1,360	1,095	1,600+	1,350	1.1
Fluid temperature	1,390	1,115	1,600+	1,385	1.1

Table 7b.--Arithmetic mean, observed range, geometric mean, and geometric deviation of proximate and ultimate analyses, and heat of combustion, forms of sulfur, and ash-fusion temperatures of 19 coal samples from the Williams Fork Formation, Danforth Hills coal field, northwestern Colorado

[All values are in percent except kcal/kg, Btu/lb, and ash-fusion temperatures, and are reported on the as-received basis. °F = (°C x 1.8) + 32; kcal/kg = 0.556 x (Btu/lb). L, less than the value shown]

	Arithmetic mean	Observed range		Geometric mean	Geometric deviation
		Minimum	Maximum		
Proximate and ultimate analyses					
Moisture	14.7	2.9	23.8	13.2	1.6
Volatile matter	28.9	11.3	33.2	28.0	1.3
Fixed carbon	40.9	22.5	50.9	39.9	1.2
Ash	16.5	3.8	45.8	12.1	2.2
Hydrogen	5.2	2.5	6.0	5.1	1.2
Carbon	52.6	33.5	64.1	51.6	1.2
Nitrogen	1.1	.6	1.6	1.1	1.3
Oxygen	24.8	6.4	30.6	23.4	1.4
Sulfur	.6	.3	1.1	.5	1.6
Heat of combustion					
Kcal/kg	5,040	3,210	6,020	4,950	1.2
Btu/lb	9,070	5,780	10,830	8,900	1.2
Forms of sulfur					
Sulfate	0.01	0.01L	0.02	0.01	1.2
Pyritic	.18	.02	.41	.14	2.1
Organic	.42	.12	.76	.37	1.7
Ash-fusion temperatures, °C					
Initial deformation	1,325	1,115	1,600+	1,320	1.1
Softening temperature	1,370	1,145	1,600+	1,365	1.1
Fluid temperature	1,355	1,170	1,600+	1,350	1.1

Table 7c.--Arithmetic mean, observed range, geometric mean, and geometric deviation of proximate and ultimate analyses, and heat of combustion, forms of sulfur, and ash-fusion temperatures of five coal samples from the Williams Fork Formation, Grand Hogback coal field, northwestern Colorado

[All values are in percent except kcal/kg, Btu/lb, and ash-fusion temperatures, and are reported on the as-received basis. °F = (°C x 1.8) + 32; kcal/kg = 0.556 x (Btu/lb). L, less than the value shown]

	Arithmetic mean	Observed range		Geometric mean	Geometric deviation
		Minimum	Maximum		
Proximate and ultimate analyses					
Moisture	4.5	4.0	4.8	4.4	1.1
Volatile matter	38.9	37.2	39.8	38.8	1.0
Fixed carbon	48.4	46.1	50.0	48.4	1.0
Ash	8.3	6.1	10.4	8.0	1.3
Hydrogen	5.5	5.4	5.6	5.5	1.0
Carbon	69.7	68.0	71.4	69.6	1.0
Nitrogen	1.3	.9	1.4	1.3	1.2
Oxygen	14.7	14.1	15.3	14.7	1.0
Sulfur	.6	.4	.7	.6	1.2
Heat of combustion					
Kcal/kg	6,860	6,700	6,990	6,860	1.0
Btu/lb	12,340	12,060	12,580	12,340	1.0
Forms of sulfur					
Sulfate	0.02	0.01L	0.02	0.01	1.5
Pyritic	.06	.03	.09	.06	1.6
Organic	.50	.38	.56	.50	1.2
Ash-fusion temperatures, °C					
Initial deformation	1,280	1,220	1,600+	1,275	1.0
Softening temperature	1,305	1,250	1,600+	1,305	1.0
Fluid temperature	1,350	1,315	1,600+	1,350	1.0

Table 7d.--Arithmetic mean, observed range, geometric mean, and geometric deviation of proximate and ultimate analyses, and heat of combustion, forms of sulfur, and ash-fusion temperatures of eight coal samples from the Williams Fork Formation, Carbondale coal field, northwestern Colorado

[All values are in percent except kcal/kg, Btu/lb, and ash-fusion temperatures, and are reported on the as-received basis. °F = (°C x 1.8) + 32; kcal/kg = 0.556 x (Btu/lb)]

	Arithmetic mean	Observed range		Geometric mean	Geometric deviation
		Minimum	Maximum		
Proximate and ultimate analyses					
Moisture	1.1	0.8	1.8	1.1	1.4
Volatile matter	26.4	21.8	33.0	26.2	1.2
Fixed carbon	65.4	58.3	69.6	65.2	1.1
Ash	7.2	3.9	11.3	6.8	1.4
Hydrogen	5.2	4.8	5.8	5.2	1.1
Carbon	81.2	75.3	85.7	81.2	1.0
Nitrogen	1.9	1.7	2.1	1.9	1.1
Oxygen	4.0	2.6	5.6	3.9	1.3
Sulfur	.6	.3	1.3	.5	1.5
Heat of combustion					
Kcal/kg	8,000	7,470	8,380	8,000	1.0
Btu/lb	14,400	13,450	15,090	14,390	1.0
Forms of sulfur					
Sulfate	0.03	0.01	0.10	0.02	2.7
Pyritic	.11	.01	.60	.05	3.5
Organic	.44	.28	.56	.43	1.3
Ash-fusion temperatures, °C					
Initial deformation	1,225	1,110	1,320	1,220	1.1
Softening temperature	1,260	1,140	1,370	1,255	1.1
Fluid temperature	1,340	1,295	1,430	1,340	1.0

Table 8a.--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 63 coal samples from the Williams Fork Formation, Yampa coal field, northwestern Colorado

[All samples were ashed at 525°C; all values except geometric deviation are in percent. L, less than the value shown]

Oxide	Arithmetic mean	Observed range		Geometric mean	Geometric deviation
		Minimum	Maximum		
(Ash)	11.8	3.9	48.9	10.0	1.8
SiO2	49	18	82	46	1.4
Al2O3	23	7.8	40	22	1.3
CaO	7.3	.50	23	5.2	2.3
MgO	1.23	.26	3.10	1.10	1.6
Na2O	.65	.090	5.33	.47	2.2
K2O	.88	.060	2.5	.73	1.8
Fe2O3	5.0	.40	29	3.6	2.2
TiO2	.90	.55	1.8	.88	1.2
P2O5	2.6	.14L	11	.26	9.1
SO3	4.9	.20L	14	3.7	2.1

Table 8b.--Arithmetic mean, observed range, geometric mean, and geometric deviation of ash content and contents of nine major and minor oxides in the laboratory ash of 22 coal samples from the Williams Fork Formation, Danforth Hills coal field, northwestern Colorado

[All samples were ashed at 525°C; all values except geometric deviation are in percent]

Oxide	Arithmetic mean	Observed range		Geometric mean	Geometric deviation
		Minimum	Maximum		
(Ash)	16.9	3.4	44.9	12.0	2.3
SiO2	54	28	72	52	1.3
Al2O3	19	10	30	18	1.4
CaO	7.3	1.8	16	5.6	2.1
MgO	1.53	.25	3.42	1.32	1.7
Na2O	.75	.08	4.59	.29	4.1
K2O	1.0	.18	1.8	.84	1.9
Fe2O3	4.9	1.9	16	1.4	1.9
TiO2	.83	.57	1.1	.82	1.2
SO3	5.4	1.3	19	4.1	2.1

Table 8c.--Arithmetic mean, observed range, geometric mean, and geometric deviation of ash content and contents of nine major and minor oxides in the laboratory ash of six coal samples from the Williams Fork Formation, Grand Hogback coal field, northwestern Colorado

[All samples were ashed at 525°C; all values except geometric deviation are in percent. L, less than the value shown]

Oxide	Arithmetic mean	Observed range		Geometric mean	Geometric deviation
		Minimum	Maximum		
(Ash)	9.5	6.7	12.2	9.2	1.3
SiO2	45	33	56	44	1.2
Al2O3	27	19	36	26	1.3
CaO	8.0	2.1	16	5.8	2.3
MgO	.75	.37	1.55	.66	1.7
Na2O	.89	.50	1.21	.83	1.4
K2O	.47	.30	.70	.45	1.4
Fe2O3	2.4	.60	5.2	1.9	2.0
TiO2	1.1	.80	1.2	1.1	1.2
SO3	3.4	.080L	6.5	2.8	1.9

Table 8d.--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 nine coal samples from the Williams Fork Formation, Carbondale coal field, northwestern Colorado

[All samples were ashed at 525°C; all values except geometric deviation are in percent. L, less than the value shown]

Oxide	Arithmetic mean	Observed range		Geometric mean	Geometric deviation
		Minimum	Maximum		
(Ash)	7.9	4.1	11.7	7.6	1.4
SiO2	45	35	61	44	1.2
Al2O3	22	15	34	21	1.3
CaO	7.1	2.2	10	6.3	1.6
MgO	1.88	.81	2.49	1.72	1.5
Na2O	5.32	.03	4.40	1.72	4.9
K2O	.41	.20	.60	.39	1.4
Fe2O3	6.6	3.5	12	6.0	1.6
TiO2	.99	.87	1.1	.98	1.1
P2O5	1.1	.01L	2.7	.95	1.8
SO3	6.1	.080L	10	4.2	2.4

Table 9a.--Arithmetic mean, observed range, geometric mean, and geometric deviation of 37 elements in 63 coal samples from the Williams Fork Formation, Yampa coal field, northwestern Colorado

[All analyses are in percent or parts per million and are reported on a whole-coal basis. L, less than the value shown]

Element	Arithmetic mean	Observed range		Geometric mean	Geometric deviation
		Minimum	Maximum		
		Percent			
Si	3.1	0.34	13	2.2	2.3
Al	1.4	.30	9.3	1.2	1.8
Ca	0.41	.088	.89	.37	1.5
Mg	.079	.011	.31	.066	1.8
Na	.055	.005	.20	.035	2.6
K	.11	.003	.72	.061	2.9
Fe	.33	.067	1.9	.25	2.1
Ti	.059	.018	.23	.052	1.6
		Parts per million			
As	1.0	0.2	6.0	0.5	3.3
B	100	20	300	70	1.7
Ba	200	30	1,000	150	1.9
Be	.7	.15	5	.5	2.9
Cd	.12	.04L	.60	.06	3.3
Co	1.5	.1L	7	1	2.1
Cr	5	.1L	30	3	2.4
Cu	6.4	2.3	18	5.6	1.7
F	125	20L	740	95	2.1
Ga	5	1	20	3	1.8
Hg	.06	.01	.29	.04	2.3
Li	10	1.5	52	8.4	1.9
Mn	29	2.0	210	17	2.8
Mo	.7	.2	3	.3	2.9
Nb	3	.7L	15	2	2.2
Ni	2	.7	10	1.5	2.0
P	520	45L	2,000	120	5.6
Pb	6.0	1.5	33	4.4	2.2
Sb	.3	.1L	2.3	.2	1.9
Sc	1.5	.7	10	1.5	1.8
Se	1.0	.1L	6.4	.9	1.6
Sr	100	15	500	100	2.0
Th	3.2	.7	15	1.5	3.6
U	1.2	.2L	4.9	1.0	1.8
V	10	3	50	7	1.9
Y	7	1	20	5	2.0
Yb	.7	.1	2	.5	2.0
Zn	11	1.4	100	7.3	2.5
Zr	30	7	200	20	1.9

Table 9b.--Arithmetic mean, observed range, geometric mean, and geometric deviation of 35 elements in 22 coal samples from the Williams Fork Formation, Danforth Hills coal field, northwestern Colorado

[All analyses are in percent or parts per million and are reported on a whole-coal basis. L, less than the value shown]

Element	Arithmetic mean	Observed range		Geometric mean	Geometric deviation
		Minimum	Maximum		
		Percent			
Si	5.3	0.69	15	3.1	2.9
Al	1.6	.30	4.2	1.2	2.2
Ca	.62	.24	2.2	.51	1.8
Mg	.13	.009	.36	.095	2.2
Na	.070	.003	.23	.026	4.2
K	.22	.009	.65	.089	3.9
Fe	.46	.086	1.0	.36	2.0
Ti	.081	.018	.20	.062	2.1
		Parts per million			
As	2.1	0.4	11	1.3	2.7
B	50	30	70	50	1.3
Ba	200	70	700	200	1.6
Be	1.0	.15L	5	.3	5.4
Cd	.12	.03L	.45	.05	4.0
Co	2.5	.5	6.2	1.9	2.0
Cr	12	.1L	47	4.7	4.1
Cu	10	2.8	33	7.8	2.0
F	135	20L	330	89	2.5
Ga	5	.7	15	3	2.4
Hg	.07	.01	.39	.05	2.4
Li	11	.7	63	6.0	3.0
Mn	38	1.6L	150	14	4.3
Mo	1	.3	3	.7	2.7
Ni	10	1	30	7	2.6
Pb	8.0	1.1	57	4.1	3.2
Sb	.6	.1L	3.3	.4	2.6
Sc	3	.3	10	1.5	3.0
Se	.8	.1L	1.9	.8	1.6
Sr	100	10	300	70	2.5
Th	3.0	.3	10	2.1	2.3
U	1.9	.2L	6.3	1.4	2.2
V	20	2	100	15	2.5
Y	10	1	20	7	2.2
Yb	.7	.1	2	.5	2.3
Zn	29	2.7	100	17	2.8
Zr	50	2	100	20	2.9

Table 9c.--Arithmetic mean, observed range, geometric mean, and geometric deviation of 36 elements in six coal samples from the Williams Fork Formation, Grand Hogback coal field, northwestern Colorado

[All analyses are in percent or parts per million and are reported on a whole-coal basis. L, less than the value shown]

Element	Arithmetic mean	Observed range		Geometric mean	Geometric deviation
		Minimum	Maximum		
		Percent			
Si	2.0	1.3	3.2	1.9	1.4
Al	1.4	.97	2.2	1.3	1.5
Ca	.50	.17	1.1	.38	2.2
Mg	.040	.026	.088	.036	1.6
Na	.058	.043	.072	.056	1.2
K	.038	.022	.071	.034	1.6
Fe	.15	.051	.34	.12	1.8
Ti	.062	.044	.088	.059	1.4
		Parts per million			
As	1.4	0.4	2.1	1.2	1.8
B	150	70	150	150	1.4
Ba	200	150	300	200	1.2
Be	.7	.3	1.5	.5	1.8
Co	1.5	1	2.3	1.4	1.3
Cr	2.5	1.5	3.5	2.4	1.3
Cu	6.8	3.9	10	6.4	1.4
F	45	25	85	40	1.6
Ga	7	3	15	7	1.7
Hg	.04	.01L	.10	.03	2.0
La	10	7	20	7	1.8
Li	11	7.8	15	11	1.3
Mn	31	7.2	110	19	2.8
Mo	2	1.5	2	2	1.2
Nb	3	1.5	7	2	2.0
Ni	2	1.5	3	2	1.3
Pb	5.6	3.0	9.2	5.1	1.6
Sb	.4	.1	1.1	.3	2.2
Sc	1.5	1	3	1.5	1.5
Se	1.2	.8	1.9	1.2	1.4
Sr	150	70	200	150	1.4
Th	2.4	1.0	4.6	1.8	2.1
U	1.0	.4	2.3	.8	2.0
V	10	5	15	10	1.6
Y	5	3	10	5	1.7
Yb	.5	.3	1	.5	1.7
Zn	5.3	3.2	11	4.8	1.6
Zr	30	15	70	20	1.8

Table 9d.--Arithmetic mean, observed range, geometric mean, and geometric deviation of 37 elements in nine coal samples from the Williams Fork Formation, Carbondale coal field, northwestern Colorado

[All analyses are in percent or parts per million and are reported on a whole-coal basis. L, less than the value shown]

Element	Arithmetic mean	Observed range		Geometric mean	Geometric deviation
		Minimum	Maximum		
		Percent			
Si	1.7	0.67	2.9	1.6	1.6
Al	.94	.41	2.1	.85	1.6
Ca	.37	.16	.62	.34	1.5
Mg	.081	.055	.10	.078	1.3
Na	.32	.001	.25	.096	5.2
K	.027	.010	.048	.024	1.6
Fe	.35	.19	.70	.31	1.6
Ti	.047	.027	.070	.044	1.4
		Parts per million			
As	0.7	0.1L	2.5	0.4	3.4
B	50	20	70	50	1.6
Ba	200	200	300	200	1.2
Be	.3	.2	1	.3	1.8
Co	1.0	.8	1.4	1.0	1.2
Cr	2.1	.1L	3.8	1.9	1.4
Cu	4.6	3.5	6.0	4.5	1.2
F	89	40	200	78	1.7
Ga	3	2	7	3	1.7
Hg	.06	.01	.31	.03	3.5
La	7	5	10	5	1.6
Li	8.7	5.2	20	8.0	1.5
Mn	13	4.8	40	10	2.0
Mo	.7	.5L	1.5	.7	1.6
Nb	2	1.5	3	1.5	1.3
Ni	2	.7	5	1.5	1.7
P	370	38L	880	280	2.1
Pb	2.9	1.6L	4.7	2.8	1.4
Sb	.2	.1L	.3	.2	1.5
Sc	1	.7	1.5	1	1.3
Se	1.0	.1L	1.5	.9	1.4
Sr	150	70	300	150	1.6
Th	2.0	.7	3.8	1.8	1.7
U	.6	.2L	1.2	.2	4.0
V	7	5	7	5	1.2
Y	5	2	7	3	1.7
Yb	.5	.2	.7	.3	1.7
Zn	4.3	1.2L	9.8	3.7	1.8
Zr	20	7	30	15	1.7

Table 10.--Arithmetic mean, observed range, geometric mean, and geometric deviation of proximate and ultimate analyses, and heat of combustion, forms of sulfur, and ash-fusion temperatures of 76 coal samples from the Williams Fork Formation, northwestern Colorado

[All values are in percent except kcal/kg, Btu/lb, and ash-fusion temperatures, and are reported on the as-received basis. °F = (°C x 1.8) + 32; kcal/kg = 0.556 x (Btu/lb). L, less than the value shown; leaders (--) indicate no data. For comparison, geometric means for 86 Rocky Mountain province coal samples (Swanson and others, 1976, table 33a) are included]

	Arithmetic mean	Observed range		Geometric mean	Geometric deviation	Rocky Mountain province geometric mean
		Minimum	Maximum			
Proximate and ultimate analyses						
Moisture	11.7	0.8	23.8	8.3	2.3	10.5
Volatile matter	32.8	11.3	40.3	32.2	1.2	35.7
Fixed carbon	46.0	22.5	69.6	45.2	1.2	41.5
Ash	10.7	3.0	45.8	9.0	1.8	7.7
Hydrogen	5.4	2.5	7.1	5.4	1.1	5.6
Carbon	61.5	33.5	85.7	60.6	1.2	58.9
Nitrogen	1.3	.5	2.1	1.3	1.4	1.1
Oxygen	21.3	2.6	30.6	18.0	1.8	22.4
Sulfur	.6	.3	3.1	.6	1.5	.5
Heat of combustion						
Kcal/kg	5,990	3,210	8,390	5,890	1.2	6,180
Btu/lb	10,780	5,780	15,090	10,600	1.2	11,110
Forms of sulfur						
Sulfate	0.01	0.01L	0.10	0.01	1.6	0.02
Pyritic	.16	.01	2.18	.10	2.8	.11
Organic	.45	.12	2.27	.40	1.6	.22
Ash-fusion temperatures, °C						
Initial deformation	1,305	1,070	1,600+	1,300	1.1	--
Softening temperature	1,345	1,095	1,600+	1,340	1.1	--
Fluid temperature	1,375	1,115	1,600+	1,370	1.1	--

Table 11.--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 100 coal samples from the Williams Fork Formation, northwestern Colorado

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

Oxide	Arithmetic mean	Observed range		Geometric mean	Geometric deviation	Rocky Mountain province geometric mean
		Minimum	Maximum			
(Ash)	12.2	3.4	48.9	10.1	1.8	10.9
SiO2	49	18	82	47	1.3	44
Al2O3	22	7.8	40	21	1.4	19
CaO	7.3	.50	23	5.4	2.2	6.2
MgO	1.32	.25	3.42	1.16	1.7	1.4
Na2O	.92	.030	5.33	.49	3.1	.68
K2O	.84	.060	2.5	.69	1.8	.45
Fe2O3	5.0	.40	29	3.7	2.2	4.5
TiO2	.90	.55	1.8	.88	1.2	.81
P2O5	1.9	.01L	11	.24	7.9	--
SO3	5.0	.080L	19	3.7	2.1	5.1

Table 12.--Arithmetic mean, observed range, geometric mean, and geometric deviation of 37 elements in 100 coal samples from the Williams Fork Formation, northwestern Colorado

[All analyses are in percent or parts per million and are reported on a whole-coal basis. L, less than the value shown; leaders (--) indicate no data. For comparison, geometric means for 295 Rocky Mountain province coal samples (Hatch and Swanson, 1977, table 3b) are included]

Element	Arithmetic mean	Observed range		Geometric mean	Geometric deviation	Rocky Mountain province geometric mean
		Minimum	Maximum			
			Percent			
Si	3.2	0.34	15	2.3	2.3	2.3
Al	1.4	.30	9.3	1.1	1.9	1.1
Ca	.45	.088	2.2	.40	1.6	.48
Mg	.087	.008	.36	.070	1.9	.089
Na	.072	.001	.25	.037	3.2	.055
K	.11	.003	.72	.059	3.1	.041
Fe	.35	.051	1.9	.26	2.1	.34
Ti	.062	.018	.23	.054	1.7	.047
			Parts per million			
As	1.4	0.1L	11	0.6	4.0	2
B	70	20	300	70	1.7	70
Ba	200	30	1,000	200	1.8	150
Be	.7	.15	5	.5	3.0	.5
Cd	.1	.04L	.6	.05	3.6	.05
Co	1.5	.1L	7	1	2.2	1.5
Cr	5	.1L	50	3	2.7	5
Cu	7.0	2.3	33	6.0	1.7	8.4
F	120	20L	740	87	2.1	69
Ga	5	.7	20	3	1.9	3
Hg	.06	.01L	.39	.04	2.5	.05
Li	10	.68	63	7.9	2.1	8.0
Mn	29	2.0	210	15	3.2	20
Mo	.7	.2	3	.5	3.0	1.5
Nb	3	.7L	15	1.5	2.8	.5
Ni	3	.7	30	2	2.5	2
P	420	38L	2,000	120	5.0	--
Pb	6.1	1.0	57	4.1	2.4	4.7
Sb	.4	.1L	3.3	.3	2.2	.3
Sc	2	.3	10	1.5	2.2	1.5
Se	1.0	.1L	6.4	.9	1.7	1.2
Sr	150	10	500	100	2.1	100
Th	3.5	.1L	15	1.4	3.9	--
U	1.3	.2L	6.3	.9	2.3	1.1
V	10	2	100	10	2.1	10
Y	7	1	20	5	2.0	5
Yb	.7	.1	2	.5	2.0	.5
Zn	14	1.4	100	8.0	2.8	6.8
Zr	30	2	200	20	2.1	20