UNITED STATES DEPARTMENT OF THE INTERIOR

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Chemical analyses of coal from the Dakota and Straight Cliffs Formations, Southwestern Utah Region, Kane and Garfield Counties, Utah

By

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

INTRODUCTION

As part of a continuing program by the U.S. Geological Survey to collect and chemically analyze representative samples of U.S. coals, 26 coal samples were collected from the Cretaceous Dakota and Straight Cliffs Formations, Southwestern Utah Region, Kane and Garfield Counties, Utah. Seven samples are from four core holes in the Dakota Formation of the Kolob coal field; nine samples are from six core holes and one face channel in the Dakota Formation of the Alton coal field; and ten samples are from three core holes in the Straight Cliffs Formation of the Kaiparowits Plateau coal field. The location of the Southwestern Utah Region and the Kolob, Alton and Kaiparowits Plateau coal fields are shown in figure 1 and sample localities are shown in figure 2. Brief descriptions for all 26 samples are given in table 1.

Estimated coal reserves for the Southwestern Utah Region are 1.8 metric tonnes (2 billion short tons) for the Kolob coal field; 1.9 metric tonnes (2.1 billion short tons) for the Alton coal field; and 13.8 metric tonnes (15.2 billion short tons) for the Kaiparowits Plateau coal field (Doelling and Graham, 1972).

Samples D169763-D169765, D169559-D169560, and D169763 were collected in connection with the U.S. Bureau of Land Management's Alton EMRIA (Energy Mineral Rehabilitation Inventory and Analyses) study (U.S. Department of the Interior, 1975). These samples are included here in order to provide a more complete data listing.

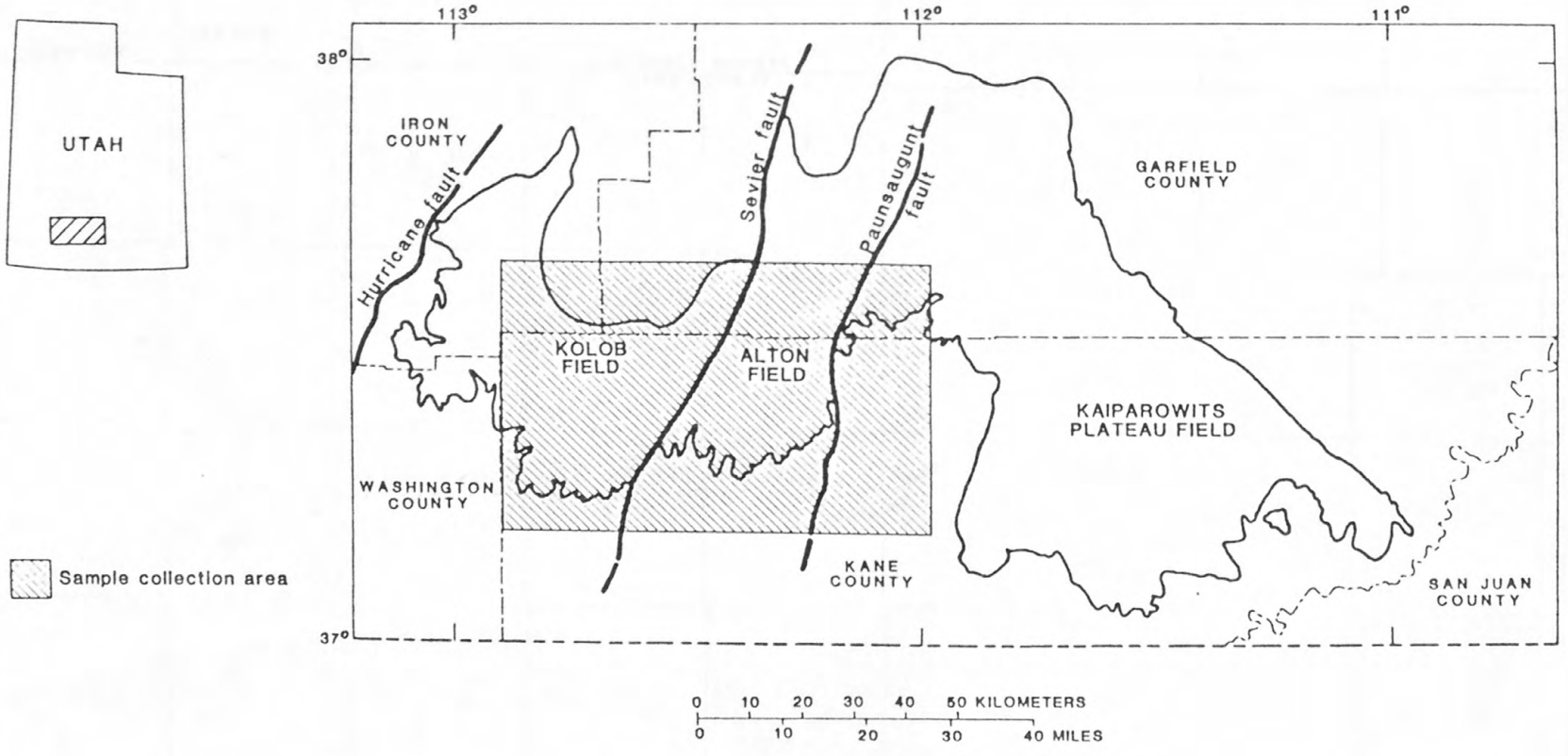

Figure 1.--Map of southwestern Utah showing the locations of the Kolob, Alton, and Kaiparowits Plateau coal fields, Iron, Washington, Kane, and Garfield Counties, Utah.

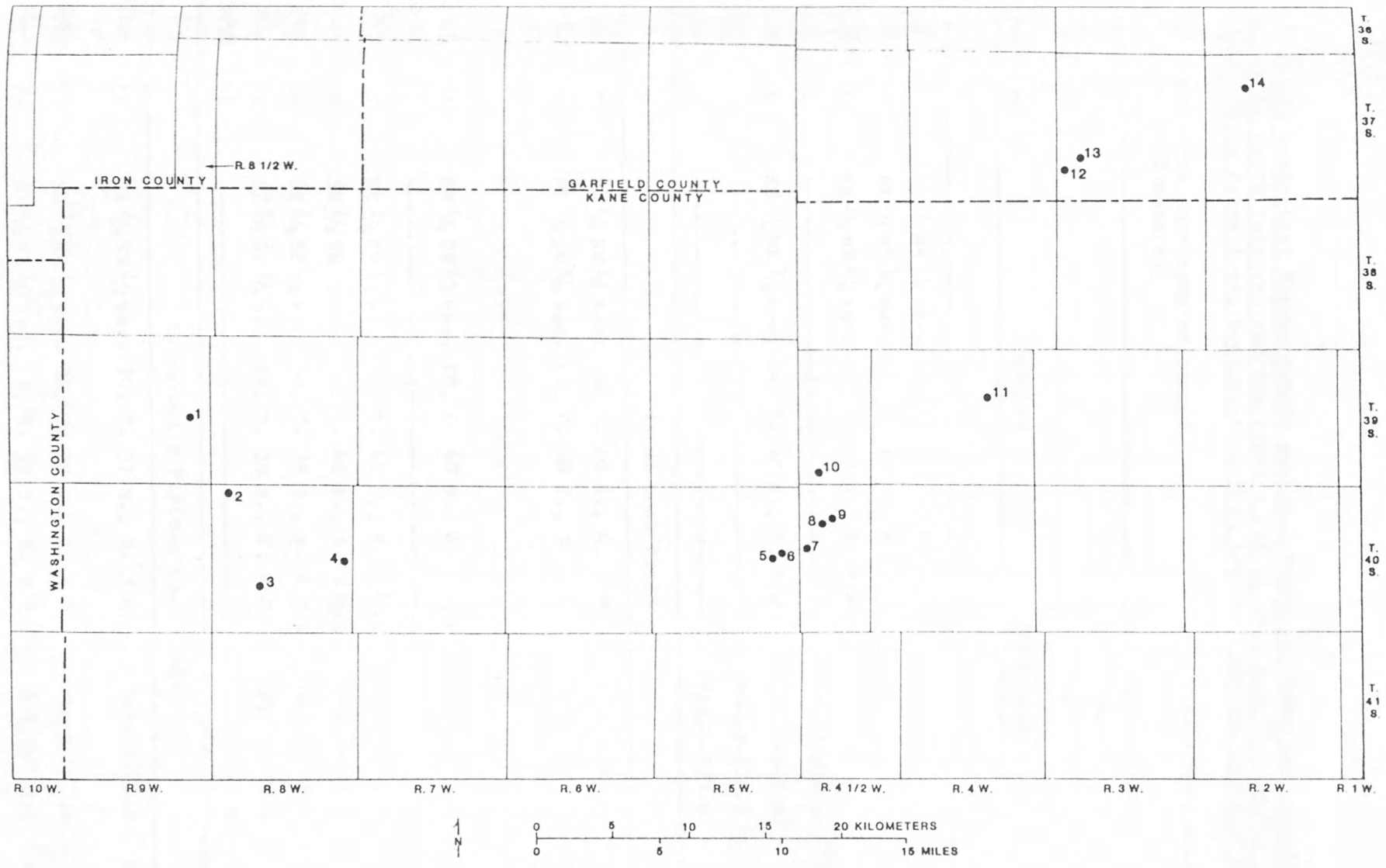

Figure 2.--Index map showing the location of sample sites in southwestern Utah, Kane, and Garfield Counties, Utah.

Table 1.--U.S. Geological Survey sample numbers, index map location, location, sample thickness or depth interval and description for 26 coal samples from the Dakota and Straight Cliffs Formations, Southwestern Utah Region, Kane and Garfield Counties, Utah.

[All samples are core samples except sample D169563 which is a face channel sample. 1 foot = 0.305 meters.]

USGS sample number	Index map location	Location	Thickness or depth interval (in feet)	Description
		Kolob coal field		
D196422	1	SE 1/4 NW 1/4 sec. 24, T. 39 S., R. 9 W.	172.2-178.1	unnamed coal bed.
D196421	2	NE 1/4 NE 1/4 sec. 6, T. 40 S., R. 8 W.	687.3-690.0	Do.
D196419	3	SE 1/4 NW 1/4 sec. 28, T. 40 S., R. 8 W.	280.0-288.2	Do.
D196420	3	----------do----------	627.7-635.8	Do.
D196416	4	SE 1/4 NE 1/4 sec. 24, T. 40 S., R. 8 W.	377.2-383.8	Do.
D196417	4	----------do----------	704.9-716.3	Do.
D196418	4	----------do----------	721.0-723.0	Do.
		Alton coal field		
D169765	5	NW 1/4 SW 1/4 sec. 13, T. 40 S., R. 5 W.	169.2-186.6	Smirl coal zone.
D169563	6	NE 1/4 SW 1/4 sec. 13, T. 40 S., R. 5 W.	10	Smirl coal zone, 0 .6 ft carbonaceous mudstone included.
D169763	7	NW 1/4 SW 1/4 sec. 18, T. 40 S., R. 4 1/2 W.	80.6- 97.9	Smirl coal zone.
D169764	7	----------do----------	264.6-268.7	Do.
D169560	8	NE 1/4 SW 1/4 sec. 8, T. 40 S., R. 4 1/2 W.	191.0-204.4	Do.
D169559	9	SW 1/4 SE 1/4 sec. 8, T. 40 S., R. 4 1/2 W.	200.0-214.3	Do.
D183136	10	SE 1/4 SE 1/4 sec. 34, T. 39 S., R. 4 1/2 W.	741.5-748.0	Do.
D183134	11	SE 1/4 SE 1/4 sec. 14, T. 39 S., R. 4 W.	386.7-388.8	Do.
D183135	11	----------do----------	411.0-412.5	Do.
		Kaiparowits Plateau coal field		
D183137	12	SE 1/4 SW 1/4 sec. 30, T. 37 S., R. 3 W.	271.3-277.4	Bald Knoll coal zone.
D183138	13	SE 1/4 NE 1/4 sec. 30, T. 37 S., R. 3 W.	458.8-462.6	Do.
D204048	14	SW 1/4 SE 1/4 sec. 8, T. 37 S., R. 2 E.	313.0-319.1	Alvey coal zone.
D204049	14	----------do----------	336.3-350.9	Do.

Table 1.--U.S. Geological Survey sample numbers, index map location, location, sample thickness or depth interval and description for 26 coal samples from the Dakota and Straight Cliffs Formations, Southwestern Utah Region, Kane and Garfield Counties, Utah.--continued

USGS sample number	Index map location	Location	Thickness or depth interval (in feet)	Description
D204050	14	----------do----------	547.2-555.4	Rees coal zone.
D204051	14	----------do----------	603.1-607.6	Do.
D204052	14	----------do----------	617.5-625.2	Do.
D204053	14	----------do----------	702.0-713.0	Christensen coal zone.
D204054	14	----------do----------	713.0-727.0	Do.
D204055	14	----------do----------	775.0-780.5	Do.

EXPLANATION OF TABLES

Proximate and ultimate analyses, heat-of-combustion, air-dried-loss, forms-of-sulfur, free-swelling-index, and ash-fusion-temperature determinations on 26 coal samples from the Southwestern Utah Region are listed in table 2. These analyses were provided by the U.S. Department of Energy, Pittsburgh, Pa. Analyses for ash content and 38 major and minor oxides and trace elements in the laboratory ash (table 3) and analyses of nine trace elements in whole coal (table 4) for all 26 samples were provided by the U.S. Geological Survey, Denver, Colo. Analytical procedures used by the U.S. Geological Survey are described in Swanson and Huffman (1976).

Table 5 contains the data listed in table 3 converted to a whole coal basis and for completeness the whole-coal analyses listed in table 4. Twenty-three additional elements not listed in tables 3, 4, and 5 were looked for but not found in amounts greater than their lower limits of detection (table 6). Unweighted statistical summaries of the analytical data for 26 coal samples from the Southwestern Utah Region in tables 2, 3, and 4 are listed in tables 7, 8, and 9. For comparison, data summaries for coal samples from the Blackhawk Formation, Wasatch Plateau coal field, Utah are included. Data summaries for Ag, Cd, and Nd contents in coal were not included in table 9 because these elements were detected in an insufficient number of samples to calculate meaningful statistics.

Arsenic contents of the samples summarized in this report have been determined by two different analytical methods: samples D169559-D169560, D169563, and samples D169763-D169765 were analyzed spectrophotometrically (lower detection limit 1.0 ppm); the remaining 20 samples were analyzed by instrumental neutron activation analysis (lower detection limit 0.1 ppm).

Thorium contents of the samples were also determined by two methods: samples D169559-D169560, D169563, and samples D169763-D169765 were analyzed by delayed neutron activation analysis (lower detection limit 3.0 ppm); the remaining 20 samples were analyzed by instrumental neutron activation analysis (lower detection limit 0.1 ppm).

P_2O_5 contents for all samples were determined by X-ray fluorescence spectroscopy. However, due to changes in technique, the lower detection limit for samples D169559-D169560, D169563, and samples D169763-D169765 was 0.1 percent in the ash; for samples D183134 through D183138 it was 1.0 percent in the ash; and for the remaining 15 samples it was 0.01 percent in whole coal.

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

Explanation of statistical terms used in summary tables

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

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

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

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

DISCUSSION

The apparent ranks of all coal samples from the Southwestern Utah Region, Kane and Garfield Counties, Utah were calculated using the data in table 2 and the formulas in ASTM designation D-388-77 (American Society for Testing and Materials, 1978). The apparent ranks range from lignite A (one sample) to subbituminous C coal (one sample) to subbituminous B coal (12 samples) to subbituminous A coal (12 samples).

A statistical comparison (student's t-test, 95-percent confidence level) of the geometric mean contents of the U.S. Department of Energy's data for 26 coal samples from the Southwestern Utah Region with 40 coal samples from the Wasatch Plateau coal field shows that coal from the Southwestern Utah Region has significantly higher contents of moisture, hydrogen, oxygen, and total, pyritic and organic sulfur, and a significantly lower heat of combustion and significantly lower contents of volatile matter, fixed carbon, and carbon. The contents of ash, nitrogen, and sulfate sulfur, and ash-fusion temperatures are not significantly different. When compared at the 99-percent confidence level, the contents of hydrogen and pyritic sulfur are not significantly different.

A statistical comparison of the geometric mean contents of coal ash and the geometric mean contents of ten major and minor oxides in the ash for 26 coal samples from the Southwestern Utah Region with analyses of 52 coal samples from the Wasatch Plateau coal field shows that coal ash from the Southwestern Utah Region has significantly higher contents of CaO, MgO, Fe_2O_3 and SO_3 and significantly lower contents of SiO_2 and P_2O_5. The contents of ash and Al_2O_3, Na_2O, K_2O, and TiO_2 content in ash are not significantly different.

A statistical comparison of the geometric mean contents of 37 elements in 26 coal samples from the Southwestern Utah Region with analyses of 52 coal samples from the Wasatch Plateau coal field shows that coal from the Southwestern Utah Region has significantly higher contents of Ca, Mg, Fe, As, Ba, Hg, La, Li, Mn, Mo, Sb, and Th and significantly lower contents of P, Co, Cr, Ni, and Se. The contents of Si, Al, Na, K, Ti, B, Be, Cu, F, Ga, Nb, Pb, Sc, Sr, U, V, Y, Yb, Zn, and Zr are not significantly different. When compared at the 99-percent confidence level the contents of La, Li, Ni, and Th are not significantly different.

Differences in the oxide composition of coal ashes and the elemental contents of coal result from differences in the total and relative amounts of the various inorganic minerals, the elemental composition of these minerals, and the total and relative amounts of any organically bound elements. The chemical form and distribution of a given element are dependent on the geologic history of the coal bed. A partial listing of the factors that influence element distributions would include chemical composition of original plants; amounts and composition of the various detrital, diagenetic, and epigenetic minerals; chemical characteristics of the ground waters that come in contact with the bed; temperatures and pressures during burial; and extent of weathering. No evaluation of these factors has been made for coal from the Southwestern Utah Region.

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References cited

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.

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.

Connor, 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.

Doelling, H. H., and Graham, R. L., 1972, Southwestern Utah Coal fields: Alton, Kaiparowits Plateau and Kolob-Harmony: Utah Geological and Mineral Survey, Monograph Series No. 1, 333 p.

Hatch, J. R., Affolter, R. H., and Davis, F.D., 1979, Chemical analyses of coal from the Blackhawk Formation, Wasatch Plateau coal field, Carbon, Emery, and Sevier Counties, Utah, in Coal Studies: Utah Geological and Mineral Survey, Special study 49, p. 69-102.

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 Resources Series 1, p. 143-165.

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

U.S. Department of the Interior, 1975, Alton study site, Alton coal field, Resource and potential reclamation evaluation: U.S. Bureau of Land Management EMRIA Report 4, 130 p + Appendix.

Table 2.--Proximate and ultimate analyses, and heat-of-combustion, forms-of-sulfur, free-swelling-index and ash-fusion-temperature determinations for 26 coal samples from the Dakota and Straight Cliffs Formations, Southwestern Utah Region, Kane and Garfield Counties, Utah

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

Sample number	Proximate analysis				Ultimate analysis					Heat of combustion	
	Moisture	Volatile matter	Fixed carbon	Ash	Hydrogen	Carbon	Nitrogen	Oxygen	Sulfur	Kcal/kg	Btu/lb
D196422	18.5	34.2	41.4	5.9	6.1	57.6	1.1	28.2	1.0	5,540	9,980
	---	42.0	50.8	7.2	5.0	70.7	1.3	14.4	1.2	6,800	12,250
	---	45.2	54.8	---	5.3	76.2	1.5	15.5	1.3	7,330	13,200
D196421	20.0	32.9	39.4	7.7	6.1	54.9	1.0	29.1	1.1	5,290	9,530
	---	41.1	49.2	9.6	4.8	68.6	1.2	14.2	1.4	6,620	11,910
	---	45.5	54.5	---	5.4	75.9	1.4	15.7	1.5	7,320	13,180
D196419	19.4	33.2	39.6	7.8	5.9	55.4	.9	28.5	1.5	5,290	9,520
	---	41.2	49.1	9.7	4.6	68.7	1.1	14.0	1.9	6,560	11,810
	---	45.6	54.4	---	5.1	76.1	1.2	15.5	2.1	7,260	13,070
D196420	17.2	30.0	39.5	13.3	5.4	53.1	1.4	26.4	.3	4,980	8,970
	---	36.2	47.7	16.1	4.2	64.1	1.7	13.4	.4	6,020	10,830
	---	43.2	56.8	---	5.0	76.4	2.0	16.0	.4	7,170	12,910
D196416	18.4	33.8	41.0	6.8	6.0	56.6	1.2	27.7	1.7	5,470	9,840
	---	41.4	50.2	8.3	4.8	69.4	1.5	13.9	2.1	6,700	12,060
	---	45.2	54.8	---	5.3	75.7	1.6	15.2	2.3	7,310	13,150
D196417	16.6	32.0	39.6	11.8	5.7	52.8	.9	26.9	1.8	5,160	9,280
	---	38.4	47.5	14.1	4.6	63.3	1.1	14.6	2.2	6,180	11,130
	---	44.7	55.3	---	5.4	73.7	1.3	17.0	2.5	7,200	12,970
D196418	15.3	27.6	32.8	24.3	5.1	45.4	.8	23.2	1.2	4,330	7,790
	---	32.6	38.7	28.7	4.0	53.6	.9	11.3	1.4	5,110	9,200
	---	45.7	54.3	---	5.6	75.2	1.3	15.9	2.0	7,160	12,900
D169765	20.6	31.8	40.2	7.4	6.1	54.5	1.1	30.0	.9	5,290	9,530
	---	40.1	50.6	9.3	4.8	68.6	1.4	14.7	1.1	6,670	12,000
	---	44.2	55.8	---	5.3	75.7	1.5	16.2	1.2	7,350	13,240
D169563	29.9	30.3	29.2	10.6	5.8	39.3	.9	42.1	1.3	3,480	6,260
	---	43.2	41.7	15.1	3.5	56.1	1.3	22.1	1.9	4,960	8,930
	---	50.9	49.1	---	4.2	66.1	1.5	26.1	2.2	5,850	10,520
D169763	21.9	32.6	40.7	4.8	6.3	56.2	1.1	31.0	.6	5,430	9,780
	---	41.7	52.1	6.1	5.0	72.0	1.4	14.8	.8	6,960	12,520
	---	44.5	55.5	---	5.3	76.7	1.5	15.7	.8	7,410	13,340
D169764	16.2	28.2	34.7	20.9	5.3	46.6	.9	25.3	1.0	4,510	8,120
	---	33.7	41.4	24.9	4.2	55.6	1.1	13.0	1.2	5,380	9,690
	---	44.8	55.2	---	5.6	74.1	1.4	17.3	1.6	7,170	12,910
D169560	21.3	31.4	38.9	8.4	6.0	54.1	1.0	29.3	1.2	5,210	9,370
	---	39.9	49.4	10.7	4.6	68.7	1.3	13.2	1.5	6,610	11,910
	---	44.7	55.3	---	5.2	77.0	1.4	14.7	1.7	7,400	13,330

Table 2.--Proximate and ultimate analyses, and heat-of-combustion, forms-of-sulfur, free-swelling-index and ash-fusion-temperature determinations for 26 coal samples from the Dakota and Straight Cliffs Formations, Southwestern Utah Region, Kane and Garfield Counties, Utah--continued

Sample number	Air-dried loss	Forms of sulfur			Free swelling	Ash fusion temperature, °C		
		Sulfate	Pyritic	Organic		Initial deformation	Softening	Fluid
D196422	1.6	0.04	0.20	0.80	0.0	1,200	1,215	1,225
	---	.05	.25	.98				
	---	.05	.26	1.06				
D196421	5.5	.01	.41	.63	.0	1,100	1,120	1,150
	---	.01	.51	.79				
	---	.01	.57	.87				
D196419	3.4	.04	.35	1.09	.0	1,080	1,105	1,125
	---	.05	.43	1.35				
	---	.05	.48	1.50				
D196420	2.0	.01	.03	.32	.0	1,255	1,280	1,350
	---	.01	.04	.39				
	---	.01	.04	.46				
D196416	2.4	.02	.49	1.20	.0	1,100	1,115	1,130
	---	.02	.60	1.47				
	---	.03	.66	1.60				
D196417	2.7	.06	.92	.87	.0	1,165	1,190	1,225
	---	.07	1.10	1.04				
	---	.08	1.28	1.22				
D196418	1.2	.01	.18	1.00	.0	1,270	1,340	1,505
	---	.01	.21	1.18				
	---	.02	.30	1.66				
D169765	11.5	.01	.18	.73	B	B	B	B
	---	.01	.23	.92				
	---	.01	.25	1.01				
D169563	22.4	.64	.07	.58	B	B	B	B
	---	.91	.10	.83				
	---	1.08	.12	.97				
D169763	12.5	.02	.14	.46	B	B	B	B
	---	.03	.18	.59				
	---	.03	.19	.63				
D169764	9.3	.01	.45	.51	B	B	B	B
	---	.01	.54	.61				
	---	.02	.72	.81				
D169560	15.0	.02	.57	.65	B	B	B	B
	---	.03	.72	.83				
	---	.03	.81	.92				

Table 2.--Proximate and ultimate analyses, and heat-of-combustion, forms-of-sulfur, free-swelling-index and ash-fusion-temperature determinations for 26 coal samples from the Dakota and Straight Cliffs Formations, Southwestern Utah Region, Kane and Garfield Counties, Utah--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
D169559	19.9	34.1	37.7	8.3	6.0	55.0	1.0	28.3	1.4	5,300	9,540
	---	42.6	47.1	10.4	4.7	68.7	1.2	13.2	1.7	6,620	11,910
	---	47.5	52.5	---	5.3	76.6	1.4	14.8	1.9	7,380	13,290
D183136	19.0	29.5	42.0	9.5	5.7	55.1	1.0	28.1	.5	5,280	9,500
	---	36.4	51.9	11.7	4.4	68.0	1.2	13.8	.6	6,520	11,730
	---	41.3	58.7	---	5.0	77.1	1.4	15.7	.7	7,380	13,290
D183134	23.4	28.1	34.6	13.9	5.9	45.1	.9	30.7	3.5	4,480	8,070
	---	36.7	45.2	18.1	4.3	58.9	1.2	12.9	4.6	5,850	10,530
	---	44.8	55.2	---	5.3	71.9	1.4	15.8	5.6	7,150	12,870
D183135	24.2	28.8	38.6	8.4	6.3	51.9	1.0	31.8	.6	5,000	8,990
	---	38.0	50.9	11.1	4.8	68.5	1.3	13.6	.8	6,590	11,860
	---	42.7	57.3	---	5.4	77.0	1.5	15.3	.9	7,410	13,340
D183137	24.4	27.7	29.7	18.2	5.8	42.9	.8	31.7	.6	4,130	7,430
	---	36.6	39.3	24.1	4.1	56.7	1.1	13.2	.8	5,460	9,830
	---	48.3	51.7	---	5.4	74.7	1.4	17.4	1.0	7,190	12,950
D183138	25.9	26.7	37.2	10.2	6.2	48.9	.9	32.3	1.6	4,710	8,480
	---	36.0	50.2	13.8	4.5	66.0	1.2	12.5	2.2	6,360	11,440
	---	41.8	58.2	---	5.2	76.5	1.4	14.5	2.5	7,370	13,270
D204048	20.4	34.7	37.7	7.2	6.1	54.7	.8	30.1	1.0	5,250	9,440
	---	43.6	47.4	9.0	4.8	68.7	1.0	15.0	1.3	6,590	11,870
	---	47.9	52.1	---	5.3	75.6	1.1	16.5	1.4	7,250	13,050
D204049	19.7	35.1	37.0	8.2	6.1	54.6	.8	29.3	1.0	5,280	9,510
	---	43.7	46.1	10.2	4.9	68.0	1.0	14.7	1.2	6,580	11,840
	---	48.7	51.3	---	5.4	75.7	1.1	16.4	1.4	7,330	13,190
D204050	18.4	35.0	36.3	10.3	6.1	53.5	.9	28.6	.6	5,160	9,280
	---	42.9	44.5	12.6	5.0	65.6	1.1	15.0	.7	6,320	11,370
	---	49.1	50.9	---	5.7	75.0	1.3	17.2	.8	7,230	13,020
D204051	15.6	29.6	29.9	24.9	5.0	44.2	.8	24.5	.7	4,250	7,640
	---	35.1	35.4	29.5	3.9	52.4	.9	12.6	.8	5,030	9,060
	---	49.7	50.3	---	5.5	74.3	1.3	17.9	1.2	7,140	12,850
D204052	17.2	33.4	34.8	14.6	5.7	51.5	.8	26.7	.8	5,000	8,990
	---	40.3	42.0	17.6	4.6	62.2	1.0	13.8	1.0	6,030	10,860
	---	49.0	51.0	---	5.6	75.5	1.2	16.7	1.2	7,320	13,180
D204053	21.1	34.7	39.8	4.4	6.2	56.8	.9	31.1	.5	5,460	9,830
	---	44.0	50.4	5.6	4.9	72.0	1.1	15.6	.6	6,920	12,460
	---	46.6	53.4	---	5.2	76.2	1.2	16.6	.7	7,330	13,190

Table 2.--Proximate and ultimate analyses, and heat-of-combustion, forms-of-sulfur, free-swelling-index and ash-fusion-temperature determinations for 26 coal samples from the Dakota and Straight Cliffs Formations, Southwestern Utah Region, Kane and Garfield Counties, Utah--continued

Sample number	Air-dried loss	Forms of sulfur			Free swelling	Ash fusion temperature, °C		
		Sulfate	Pyritic	Organic		Initial deformation	Softening	Fluid
D169559	14.5	0.01	0.54	0.83	B	B	B	B
	---	.01	.67	1.04				
	---	.01	.75	1.16				
D183136	13.0	.01	.05	.49	.0	1,265	1,310	1,365
	---	.01	.06	.60				
	---	.01	.07	.69				
D183134	19.0	.31	1.85	1.34	.0	1,180	1,220	1,265
	---	.40	2.42	1.75				
	---	.49	2.95	2.14				
D183135	19.0	.03	.05	.51	.0	1,295	1,335	1,370
	---	.04	.07	.67				
	---	.04	.07	.76				
D183137	19.9	.01	.15	.42	.0	1,540	1,540	1,540
	---	.01	.20	.56				
	---	.02	.26	.73				
D183138	21.2	.02	1.07	.47	.0	1,080	1,180	1,235
	---	.03	1.44	.63				
	---	.03	1.67	.74				
D204048	11.6	.02	.50	.45	.0	1,070	1,125	1,190
	---	.03	.63	.57				
	---	.03	.69	.62				
D204049	11.2	.02	.64	.38	.0	1,125	1,190	1,230
	---	.02	.80	.47				
	---	.03	.89	.53				
D204050	10.5	.01	.19	.43	.0	1,150	1,200	1,260
	---	.01	.23	.53				
	---	.01	.27	.60				
D204051	8.6	.01	.25	.44	.0	1,315	1,375	1,440
	---	.01	.30	.52				
	---	.02	.42	.74				
D204052	9.7	.01	.23	.54	.0	1,200	1,265	1,315
	---	.01	.28	.65				
	---	.01	.34	.79				
D204053	12.8	.01	.10	.37	.0	1,125	1,190	1,230
	---	.01	.13	.47				
	---	.01	.13	.50				

Table 2.--Proximate and ultimate analyses, and heat-of-combustion, forms-of-sulfur, free-swelling-index and ash-fusion-temperature determinations for 26 coal samples from the Dakota and Straight Cliffs Formations, Southwestern Utah Region, Kane and Garfield Counties, Utah--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
D204054	20.1	33.3	40.9	5.7	6.3	56.6	0.9	30.0	0.5	5,460	9,840
	---	41.7	51.2	7.1	5.1	70.8	1.1	15.2	.6	6,840	12,310
	---	44.9	55.1	---	5.5	76.3	1.2	16.4	.7	7,370	13,260
D204055	19.7	34.6	39.9	5.8	6.1	56.6	1.0	30.1	.6	5,480	9,860
	---	43.1	49.7	7.2	4.9	70.5	1.2	15.7	.7	6,820	12,280
	---	46.4	53.6	---	5.2	76.0	1.3	16.9	.8	7,350	13,240

Sample number	Air-dried loss	Forms of sulfur			Free swelling	Ash fusion temperature, °C		
		Sulfate	Pyritic	Organic		Initial deformation	Softening	Fluid
D204054	12.0	0.01	0.17	0.36	0.0	1,170	1,230	1,280
	---	.01	.21	.45				
	---	.01	.23	.49				
D204055	11.6	.01	.07	.48	.0	1,180	1,235	1,295
	---	.01	.09	.60				
	---	.01	.09	.64				

Table 3.--Major- and minor-oxide and trace element composition of the laboratory ash of 26 coal samples from the Dakota and Straight Cliffs Formations, Southwestern Utah Region, Kane and Garfield Counties, Utah.

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

Sample number	Ash (percent)	SiO2 (percent)	Al2O3 (percent)	CaO (percent)	MgO (percent)	Na2O (percent)	K2O (percent)	Fe2O3 (percent)	TiO2 (percent)	P2O5 (percent)	Sample number
D196422	6.9	25	13	11	1.86	5.40	0.30	9.1	0.60	0.14	D196422
D196421	9.7	31	12	12	1.88	4.40	.60	11	.80	.41	D196421
D196419	9.4	32	16	10	1.95	3.30	.40	8.8	.90	.11L	D196419
D196420	16.4	53	19	6.6	1.18	2.21	.30	2.0	.80	.060L	D196420
D196416	8.0	30	16	11	2.36	3.90	.40	11	1.2	.13L	D196416
D196417	12.5	42	19	5.8	1.28	2.32	.40	12	.70	.080L	D196417
D196418	28.0	70	17	2.1	1.19	1.35	.40	2.0	.80	.040L	D196418
D169765	11.7	39	28	6.5	1.54	2.41	.33	4.1	.75	.10L	D169765
D169563	13.8	46	19	5.9	1.34	2.40	.74	9.3	.79	.10L	D169563
D169763	6.2	34	21	14	4.05	1.00	.11	4.0	1.1	.10L	D169763
D169764	25.3	54	35	2.3	.68	1.13	.29	4.6	1.3	.10L	D169764
D169560	10.7	38	17	8.2	1.38	2.82	.060	12	1.1	.10L	D169560
D169559	9.6	35	24	9.3	2.59	1.59	.12	8.2	1.1	.10L	D169559
D183136	10.1	44	17	8.1	2.06	3.48	.42	3.7	1.0	1.0L	D183136
D183134	16.7	36	20	3.7	1.23	2.00	1.2	21	.55	1.0L	D183134
D183135	10.2	39	21	8.2	1.74	3.38	.19	3.2	1.4	1.0L	D183135
D183137	21.3	44	30	3.3	.86	1.63	.16	1.9	1.8	1.0L	D183137
D183138	11.5	45	17	7.7	1.66	3.88	.51	3.6	1.2	1.0L	D183138
D204048	8.4	32	9.3	22	3.20	.05	.12	9.0	.53	.24	D204048
D204049	8.5	32	12	18	3.30	.05	.12	10	.68	.24	D204049
D204050	12.4	56	13	10	2.30	.11	.66	3.7	.72	.24	D204050
D204051	31.6	66	18	3.5	1.10	.09	1.4	2.1	.87	.030L	D204051
D204052	16.2	60	15	7.4	1.70	.11	.90	4.0	.85	.060	D204052
D204053	6.3	39	10	20	3.80	.30	.24	3.7	.58	.16L	D204053
D204054	6.4	41	11	18	3.80	.23	.24	4.7	.73	.16L	D204054
D204055	7.8	56	13	12	2.20	.61	.24	1.7	.89	.26	D204055

Table 3.--Major- and minor-oxide and trace element composition of the laboratory ash of 26 coal samples from the Dakota and Straight Cliffs Formations, Southwestern Utah Region, Kane and Garfield Counties, Utah.--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
D196422	90	330	10	N	B	15	25L	10	2,000	70	D196422
D196421	124	320	15	N	B	10	25L	10	5,000	70	D196421
D196419	226	215	7	N	B	10	35	10	2,000	70	D196419
D196420	109	1,060	20	20	N	15	50	15	700	150	D196420
D196416	227	240	10	20L	B	20	25L	15	3,000	100	D196416
D196417	69	380	20	20	150	15	50	15	1,000	100	D196417
D196418	40	78	10	20	N	10	50	10	500	50	D196418
D169765	210	200	7	20	N	20	50	10	1,000	100	D169765
D169563	170	50	10	20L	N	15	25	15	1,000	150	D169563
D169763	158	200	15	20	N	30	40	15	2,000	100	D169763
D169764	122	200	30	20	200	15	65	15	500	150	D169764
D169560	326	100	15	20	N	20	40	15	2,000	100	D169560
D169559	314	150	10	20	B	15	25	15	2,000	150	D169559
D183136	373	170	15	30	N	30	25	15	700	100	D183136
D183134	117	230	15	30	N	30	35	20	700	150	D183134
D183135	328	342	15	30	150L	15	30	15	1,000	150	D183135
D183137	329	208	20	50	N	20	50	20	300	150	D183137
D183138	153	178	15	30	N	20	25	20	1,000	150	D183138
D204048	42	610	7L	N	N	30	118	15	1,000	70	D204048
D204049	73	270	7L	N	B	30	49	15	1,000	70	D204049
D204050	115	205	7L	N	N	50	32	15	700	100	D204050
D204051	90	105	7L	N	N	30	29	15	200	100	D204051
D204052	118	255	7	20	B	30	36	15	700	100	D204052
D204053	46	470	7	N	B	20	64	10	700	50	D204053
D204054	51	235	10	N	B	30	37	15	700	70	D204054
D204055	79	265	7	20L	B	70	33	15	700	70	D204055

Table 3.--Major- and minor-oxide and trace element composition of the laboratory ash of 26 coal samples from the Dakota and Straight Cliffs Formations, Southwestern Utah Region, Kane and Garfield Counties, Utah.--continued

Sample number	SO3 (percent)	Ag-S (ppm)	B-S (ppm)	Ba-S (ppm)	Be-S (ppm)	Cd (ppm)	Cu (ppm)	Ga-S (ppm)	Ge-S (ppm)	La-S (ppm)	Sample number
D196422	12	N	1,000	1,500	N	1.0L	69	30	N	N	D196422
D196421	9.5	N	1,000	1,500	N	1.0L	57	30	N	N	D196421
D196419	8.6	N	1,000	1,000	7	1.0L	69	30	N	N	D196419
D196420	2.2	N	700	500	15	1.0L	65	50	N	100	D196420
D196416	10	N	1,500	2,000	7	1.0L	91	70	20L	N	D196416
D196417	5.2	N	1,000	700	15	1.0L	53	70	20	150	D196417
D196418	1.6	N	300	300	10	1.0L	30	30	N	100	D196418
D169765	1.2	N	1,000	700	5	1.0L	54	50	20	70	D169765
D169563	15	N	1,000	500	N	1.0L	60	30	N	70	D169563
D169763	18	N	2,000	1,500	3	1.0L	106	30	N	100	D169763
D169764	3.4	N	300	200	15	1.0L	62	50	50	200	D169764
D169560	18	N	1,000	1,500	N	1.0L	82	30	N	70	D169560
D169559	19	N	1,500	500	5	1.0L	74	50	30	N	D169559
D183136	11	N	1,500	700	5	1.0	92	20	N	100L	D183136
D183134	8.5	N	1,000	200	15	1.0	58	30	N	N	D183134
D183135	13	N	1,000	700	N	1.0L	98	30	N	150	D183135
D183137	5.3	N	500	500	7	1.0L	107	50	N	100L	D183137
D183138	12	N	1,500	7,000	7	1.0L	86	30	30	100L	D183138
D204048	22	N	2,000	500	7	1.0	68	20	N	100L	D204048
D204049	18	N	1,500	300	5	1.0	61	20	N	N	D204049
D204050	6.8	N	1,000	500	3	1.0L	65	20	N	100L	D204050
D204051	2.4	N	300	300	5	1.0L	51	20	N	100L	D204051
D204052	6.3	N	700	500	5	1.0L	60	30	N	N	D204052
D204053	17	N	2,000	2,000	7	1.0L	55	20	N	N	D204053
D204054	17	7	1,500	1,000	N	1.0L	67	20	N	N	D204054
D204055	12	N	1,000	700	15	1.0L	79	30	N	N	D204055

Table 3.--Major- and minor-oxide and trace element composition of the laboratory ash of 26 coal samples from the Dakota and Straight Cliffs Formations, Southwestern Utah Region, Kane and Garfield Counties, Utah.--continued

Sample number	Y-S (ppm)	Yb-S (ppm)	Zn (ppm)	Zr-S (ppm)
D196422	20	B	80	100
D196421	20	B	36	150
D196419	20	2	129	100
D196420	70	7	112	300
D196416	30	B	95	150
D196417	50	B	117	200
D196418	50	3	56	300
D169765	30	3	45	150
D169563	30	3	48	200
D169763	50	3	32	200
D169764	100	15	98	200
D169560	20	5	20	200
D169559	20	3	27	200
D183136	50	3	146	150
D183134	70	7	281	150
D183135	70	5	100	150
D183137	70	5	91	300
D183138	70	5	221	200
D204048	70	5	77	150
D204049	50	3	57	150
D204050	50	3	101	150
D204051	30	3	152	150
D204052	50	5	89	150
D204053	30	3	191	150
D204054	30	3	105	150
D204055	70	5	80	200

Table 4.--Contents of nine trace elements in 26 coal samples from the Dakota and Straight Cliffs Formations, Southwestern Utah Region, Kane and Garfield Counties, Utah

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

Sample number	As (ppm)	Co (ppm)	Cr (ppm)	F (ppm)	Hg (ppm)	Sb (ppm)	Se (ppm)	Th (ppm)	U (ppm)	Sample number
D196422	1.1	0.8	1.3	20	0.10	0.1	0.4	0.5	0.2L	D196422
D196421	3.3	.5	1.9	20	.10	.1	.7	1.0	.2L	D196421
D196419	2.1	1.0	2.0	25	.16	.2	.1L	1.5	.5	D196419
D196420	1.0	2.0	3.2	100	.06	1.0	.8	4.3	1.9	D196420
D196416	2.7	1.1	2.0	20	.16	.2	1.0	.8	.2	D196416
D196417	19	1.5	1.7	50	.47	.9	.8	2.8	.7	D196417
D196418	11	2.1	2.9	295	.13	1.3	.1L	8.8	3.0	D196418
D169765	2.0	1.5	3.0	35	.14	1.0	.7	8.8	2.0	D169765
D169563	5.0	1.5L	5.0	95	.17	.5	.6	4.7	2.7	D169563
D169763	1.0	1.0	3.0	20	.06	.4	.5	1.7	.5	D169763
D169764	5.0	3.0	5.0	135	.19	5.2	1.5	17	9.5	D169764
D169560	4.0	1.0L	3.0	30	.31	.5	1.3	3.1	1.1	D169560
D169559	1.0	1.0L	5.0	20	.09	.4	.6	4.4	1.2	D169559
D183136	1.3	.8	4.6	25	.06	.3	1.1	2.6	1.1	D183136
D183134	13	1.5	14	75	.23	.5	1.8	3.7	11	D183134
D183135	1.0	.8	4.0	30	.05	.3	1.1	2.8	.8	D183135
D183137	2.3	2.0	9.0	55	.08	1.0	1.6	7.7	3.3	D183137
D183138	2.5	1.1	9.1	90	.13	.7	.1L	2.2	1.6	D183138
D204048	27	1.1	3.9	55	.01	.2	.8	.6	.3	D204048
D204049	3.7	.7	4.8	40	.10	.2	1.3	.9	.5	D204049
D204050	.7	1.1	9.7	75	.04	.3	1.6	1.4	1.3	D204050
D204051	2.0	3.6	34	240	.06	.6	2.0	4.4	2.9	D204051
D204052	2.3	1.4	13	85	.07	.4	2.2	2.2	1.8	D204052
D204053	.6	.4	2.3	40	.04	.1	1.0	.5	.2	D204053
D204054	.6	.5	3.1	40	.08	.2	1.6	.6	.7	D204054
D204055	.5	1.5	4.1	40	.02	.2	1.1	.9	.7	D204055

Table 5.--Major-, minor-, and trace-element composition of 26 coal samples from the Dakota and Straight Cliffs Formations, Southwestern Utah Region, Kane and Garfield Counties, Utah.

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

Sample number	Si (percent)	Al (percent)	Ca (percent)	Mg (percent)	Na (percent)	K (percent)	Fe (percent)	Ti (percent)	Ag-S (ppm)	As (ppm)	Sample number
D196422	0.81	0.47	0.54	0.077	0.28	0.017	0.44	0.025	N	1.1	D196422
D196421	1.4	.62	.83	.11	.32	.048	.75	.046	N	3.3	D196421
D196419	1.4	.80	.67	.11	.23	.031	.58	.051	N	2.1	D196419
D196420	4.1	1.6	.77	.12	.27	.041	.23	.079	N	1.0	D196420
D196416	1.1	.68	.63	.11	.23	.027	.62	.058	N	2.7	D196416
D196417	2.5	1.3	.52	.096	.21	.042	1.0	.052	N	19	D196417
D196418	9.2	2.5	.42	.20	.28	.093	.39	.13	N	11	D196418
D169765	2.1	1.7	.54	.11	.21	.032	.33	.053	N	2.0	D169765
D169563	2.9	1.4	.58	.11	.25	.085	.90	.065	N	5.0	D169563
D169763	.98	.70	.62	.15	.046	.006	.17	.042	N	1.0	D169763
D169764	6.4	4.6	.42	.10	.21	.061	.81	.20	N	5.0	D169764
D169560	1.9	.97	.63	.089	.22	.005	.91	.069	N	4.0	D169560
D169559	1.5	1.2	.64	.15	.11	.010	.55	.065	N	1.0	D169559
D183136	2.1	.91	.58	.13	.26	.035	.26	.061	N	1.3	D183136
D183134	2.8	1.8	.44	.12	.25	.17	2.5	.055	N	13	D183134
D183135	1.9	1.1	.60	.11	.26	.016	.23	.086	N	1.0	D183135
D183137	4.4	3.4	.50	.11	.26	.028	.28	.23	N	2.3	D183137
D183138	2.4	1.0	.63	.11	.33	.049	.29	.083	N	2.5	D183138
D204048	1.3	.41	1.3	.16	.003	.008	.53	.027	N	27	D204048
D204049	1.3	.54	1.1	.17	.003	.009	.59	.035	N	3.7	D204049
D204050	3.2	.85	.89	.17	.010	.068	.32	.053	N	.7	D204050
D204051	9.7	3.0	.79	.21	.021	.37	.46	.16	N	2.0	D204051
D204052	4.5	1.3	.86	.17	.013	.12	.45	.082	N	2.3	D204052
D204053	1.1	.33	.88	.14	.014	.013	.16	.022	N	.6	D204053
D204054	1.2	.37	.82	.15	.011	.013	.21	.028	.5	.6	D204054
D204055	2.0	.54	.67	.10	.035	.016	.093	.042	N	.5	D204055

Table 5.--Major-, minor-, and trace-element composition of 26 coal samples from the Dakota and Straight Cliffs Formations, Southwestern Utah Region, Kane and Garfield Counties, Utah.--continued

Sample number	B-S (ppm)	Ba-S (ppm)	Be-S (ppm)	Cd (ppm)	Co (ppm)	Cr (ppm)	Cu (ppm)	F (ppm)	Ga-S (ppm)	Ge-S (ppm)	Sample number
D196422	70	100	N	0.07L	0.8	1.3	4.8	20	2	N	D196422
D196421	100	150	N	.10L	.5	1.9	5.5	20	3	N	D196421
D196419	100	100	.7	.09L	1.0	2.0	6.5	25	3	N	D196419
D196420	100	70	2	.16L	2.0	3.2	11	100	7	N	D196420
D196416	100	150	.5	.08L	1.1	2.0	7.3	20	5	1.5L	D196416
D196417	150	100	2	.13L	1.5	1.7	6.6	50	10	2	D196417
D196418	100	100	3	.28L	2.1	2.9	8.4	295	10	N	D196418
D169765	100	70	.7	.12L	1.5	3.0	6.3	35	7	2	D169765
D169563	150	70	N	.14L	1.5L	5.0	8.3	95	5	N	D169563
D169763	150	100	.2	.06L	1.0	3.0	6.6	20	2	N	D169763
D169764	70	50	3	.25L	3.0	5.0	16	135	15	15	D169764
D169560	100	150	N	.11L	1.0L	3.0	8.8	30	3	N	D169560
D169559	150	50	.5	.10L	1.0L	5.0	7.1	20	5	3	D169559
D183136	150	70	.5	.10	.8	4.6	9.3	25	2	N	D183136
D183134	150	30	2	.17	1.5	14	9.7	75	5	N	D183134
D183135	100	70	N	.10L	.8	4.0	10	30	3	N	D183135
D183137	100	100	1.5	.21L	2.0	9.0	23	55	10	N	D183137
D183138	150	700	.7	.12L	1.1	9.1	9.9	90	3	3	D183138
D204048	150	50	.7	.08	1.1	3.9	5.7	55	1.5	N	D204048
D204049	150	20	.5	.09	.7	4.8	5.2	40	1.5	N	D204049
D204050	150	70	.3	.12L	1.1	9.7	8.1	75	2	N	D204050
D204051	100	100	1.5	.32L	3.6	34	16	240	7	N	D204051
D204052	100	70	.7	.16L	1.4	13	9.7	85	5	N	D204052
D204053	150	150	.5	.06L	.4	2.3	3.5	40	1.5	N	D204053
D204054	100	70	N	.06L	.5	3.1	4.3	40	1.5	N	D204054
D204055	70	50	1	.08L	1.5	4.1	6.2	40	2	N	D204055

Table 5.--Major-, minor-, and trace-element composition of 26 coal samples from the Dakota and Straight Cliffs Formations, Southwestern Utah Region, Kane and Garfield Counties, Utah.--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
D196422	0.10	N	6.2	23	0.7	N	B	1	42	1.7L	D196422
D196421	.10	N	12	31	1.5	N	B	1	170	2.4L	D196421
D196419	.16	N	21	20	.7	N	B	1	45L	3.3	D196419
D196420	.06	15	18	170	3	3	N	2	43L	8.2	D196420
D196416	.16	N	18	19	.7	1.5L	B	1.5	45L	2.0L	D196416
D196417	.47	20	8.6	48	2	2	20	2	44L	6.3	D196417
D196418	.13	30	11	22	3	5	N	3	49L	14	D196418
D169765	.14	7	25	23	.7	2	N	2	51L	5.9	D169765
D169563	.17	10	23	6.9	1.5	3L	N	2	60L	3.5	D169563
D169763	.06	7	9.8	12	1	1.5	N	2	27L	2.5	D169763
D169764	.19	50	31	51	7	5	50	3	110L	16	D169764
D169560	.31	7	35	11	1.5	2	N	2	47L	4.3	D169560
D169559	.09	N	30	14	1	2	B	1.5	42L	2.4	D169559
D183136	.06	10L	38	17	1.5	3	N	3	440L	2.5	D183136
D183134	.23	N	20	38	2	5	N	5	730L	5.8	D183134
D183135	.05	15	33	35	1.5	3	15L	1.5	450L	3.1	D183135
D183137	.08	20L	70	44	5	10	N	5	930L	11	D183137
D183138	.13	10L	18	20	1.5	3	N	2	500L	2.9	D183138
D204048	.01	10L	3.5	51	.7L	N	N	2	88	9.9	D204048
D204049	.10	N	6.2	23	.7L	N	B	2	89	4.2	D204049
D204050	.04	15L	14	25	1L	N	N	7	130	4.0	D204050
D204051	.06	30L	28	33	2L	N	N	10	41L	9.2	D204051
D204052	.07	N	19	41	1	3	B	5	42	5.8	D204052
D204053	.04	N	2.9	30	.5	N	B	1.5	44L	4.0	D204053
D204054	.08	N	3.3	15	.7	N	B	2	45L	2.4	D204054
D204055	.02	N	6.2	21	.5	1.5L	B	5	89	2.6	D204055

Table 5.--Major-, minor-, and trace-element composition of 26 coal samples from the Dakota and Straight Cliffs Formations, Southwestern Utah Region, Kane and Garfield Counties, Utah.--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
D196422	0.1	0.7	0.4	150	0.5	0.2L	5	1.5	B	5.5	D196422
D196421	.1	1	.7	500	1.0	.2L	7	2	B	3.5	D196421
D196419	.2	1	.1L	200	1.5	.5	7	2	.2	12	D196419
D196420	1.0	2	.8	100	4.3	1.9	20	10	1	18	D196420
D196416	.2	1	1.0	200	.8	.2	7	2	B	7.6	D196416
D196417	.9	2	.8	150	2.8	.7	15	7	B	15	D196417
D196418	1.3	3	.1L	150	8.8	3.0	15	15	1	16	D196418
D169765	1.0	1	.7	100	8.8	2.0	10	3	.3	5.3	D169765
D169563	.5	2	.6	150	4.7	2.7	20	5	.5	6.6	D169563
D169763	.4	1	.5	150	1.7	.5	7	3	.2	2.0	D169763
D169764	5.2	3	1.5	150	16.8	9.5	30	20	3	25	D169764
D169560	.5	1.5	1.3	200	3.1	1.1	10	2	.5	2.1	D169560
D169559	.4	1.5	.6	200	4.4	1.2	15	2	.3	2.6	D169559
D183136	.3	1.5	1.1	70	2.6	1.1	10	5	.3	15	D183136
D183134	.5	3	1.8	100	3.7	11	20	10	1	47	D183134
D183135	.3	1.5	1.1	100	2.8	.8	15	7	.5	10	D183135
D183137	1.0	5	1.6	70	7.7	3.3	30	15	1	19	D183137
D183138	.7	2	.1L	100	2.2	1.6	15	7	.7	25	D183138
D204048	.2	1.5	.8	100	.6	.3	7	7	.5	6.5	D204048
D204049	.2	1.5	1.3	100	.9	.5	7	5	.2	4.8	D204049
D204050	.3	2	1.6	100	1.4	1.3	15	7	.3	13	D204050
D204051	.6	5	2.0	70	4.4	2.9	30	10	1	48	D204051
D204052	.4	2	2.2	100	2.2	1.8	15	7	.7	14	D204052
D204053	.1	.7	1.0	50	.5	.2	3	2	.2	12	D204053
D204054	.2	1	1.6	50	.6	.7	5	2	.2	6.7	D204054
D204055	.2	1	1.1	50	.9	.7	5	5	.5	6.2	D204055

Table 5.--Major-, minor-, and trace-element composition of 26 coal samples from the Dakota and Straight Cliffs Formations, Southwestern Utah Region, Kane and Garfield Counties, Utah.--continued

Sample number	Zr-S (ppm)
D196422	7
D196421	15
D196419	10
D196420	50
D196416	10
D196417	20
D196418	100
D169765	15
D169563	30
D169763	15
D169764	50
D169560	20
D169559	20
D183136	15
D183134	20
D183135	15
D183137	70
D183138	20
D204048	15
D204049	15
D204050	20
D204051	50
D204052	20
D204053	10
D204054	10
D204055	15

Table 6.--Elements looked for, but not detected, in 26 coal samples from the Dakota and Straight Cliffs Formations, Southwestern Utah Region, Kane and Garfield Counties, Utah

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

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

Table 7.--Arithmetic mean, observed range, geometric mean, and geometric deviation of proximate and ultimate analyses, heat of combustion, forms of sulfur, and ash-fusion-temperatures of 26 coal samples from the Dakota and Straight Cliffs Formations, Southwestern Utah Region, Kane and Garfield Counties, Utah

[For comparison, geometric means for 40 coal samples from the Blackhawk Formation, Wasatch Plateau coal field, Utah are included (Hatch and others, 1979, Table 7). All values are in percent except Kcal/kg, Btu/lb, ash-fusion temperatures and geometric deviations, and are reported on the as-received basis. L, less than the value shown. $^{o}F = (^{o}C \times 1.8) + 32$. Kcal/kg = 0.556 (Btu/lb).]

	Arithmetic mean	Observed range		Geometric mean	Geometric deviation	Wasatch Plateau field geometric mean
		Minimum	Maximum			
Proximate and ultimate analyses						
Moisture	20.2	15.3	29.9	19.9	1.1	4.2
Volatile matter	31.7	26.7	35.1	31.6	1.1	40.2
Fixed carbon	37.4	29.2	42.0	37.7	1.1	43.4
Ash	10.7	4.4	24.9	9.6	1.6	9.3
Hydrogen	5.9	5.0	6.3	5.9	1.1	5.6
Carbon	52.1	39.3	57.6	51.8	1.1	66.2
Nitrogen	.9	.8	1.4	.9	1.1	1.0
Oxygen	29.3	23.2	42.1	29.1	1.1	14.7
Sulfur	1.1	.3	3.5	.9	1.7	.6
Heat of combustion						
Kcal/kg	5,015	3,480	5,550	4,980	1.1	6,580
Btu/lb	9,020	6,260	9,980	8,960	1.1	11,840
Forms of sulfur						
Sulfate	0.03	0.01L	.64	0.02	2.9	0.02
Pyritic	.40	.03	1.85	.23	2.8	.14
Organic	.63	.32	1.34	.58	1.5	.11
Ash-fusion temperatures, ^{o}C						
Initial deformation	1,190	1,070	1,540	1,190	1.1	1,225
Softening temperature	1,240	1,100	1,540	1,230	1.1	1,245
Fluid temperature	1,290	1,130	1,540	1,280	1.1	1,300

Table 8.--Arithmetic mean, observed range, geometric mean, and geometric deviation of ash content and contents of 10 major and minor oxides in the laboratory ash of 26 coal samples from the Dakota and Straight Cliffs Formations, Southwestern Utah Region, Kane and Garfield Counties, Utah

[For comparison, geometric means for 52 coal samples from the Blackhawk Formation, Wasatch Plateau coal field, Utah are included (Hatch and others, 1979, Table 8). All samples were ashed at 525°C; all analyses except geometric deviation are in percent. L, less than the value shown]

Oxide	Arithmetic mean	Observed range		Geometric mean	Geometric deviation	Wasatch Plateau field geometric mean
		Minimum	Maximum			
(Ash)	12.8	6.2	31.6	11.5	1.6	9.7
SiO_2	43	25	70	42	1.3	51
Al_2O_3	18	9.3	35	17	1.4	15
CaO	9.7	2.1	22	8.0	1.9	4.8
MgO	2.0	.68	4.1	1.8	1.6	.98
Na_2O	2.9	.05	5.4	1.0	4.4	1.8
K_2O	.43	.06	1.4	.32	2.2	.42
Fe_2O_3	6.6	1.7	21	5.2	2.0	3.4
TiO_2	.92	.53	1.8	.87	1.4	.91
SO_3	12	1.2	22	8.3	2.3	3.4
P_2O_5	.08	.06	.41	.02	5.7	.10

Table 9.--Arithmetic mean, observed range, geometric mean, and geometric deviation of 38 elements in 26 coal samples from the Dakota and Straight Cliffs Formations, Southwestern Utah Region, Kane and Garfield Counties, Utah

[For comparison, geometric means for 52 coal samples from the Blackhawk Formation, Wasatch Plateau coal field, Utah are included (Hatch and others, 1979, Table 9). All analyses except geometric deviation are in percent or parts per million and are reported on a whole-coal basis. As, Co, Cr, F, Hg, Sb, Se, Th, and U values used to calculate the statistics were determined directly on whole coal. All other values used were calculated from determinations made on coal ash. L, less than the value shown. Leaders (---) indicate no data]

Element	Arithmetic mean	Observed range		Geometric mean	Geometric deviation	Wasatch Plateau coal field geometric mean
		Minimum	Maximum			
Si	2.8	.81	9.7	2.2	1.9	2.3
Al	1.3	.33	4.6	1.0	2.0	.78
Ca	.69	.42	1.3	.66	1.3	.33
Mg	.13	.08	.21	.13	1.3	.057
Na	.27	.003	.33	.086	4.7	.13
K	.053	.005	.37	.031	2.9	.034
Fe	.54	.09	2.5	.42	2.0	.23
Ti	.073	.022	.23	.061	1.8	.053
P	.004	.004L	.017	.002	3.0	.005
			Parts per million			
As	4.2	.5	27	2.3	3.0	0.7
B	100	70	150	100	1.3	100
Ba	100	20	700	100	1.9	50
Be	1	.2	3	.5	3.1	.7
Co	.2	.02	1	.1	3.5	1.5
Cr	1	.1	10	.5	2.9	7
Cu	8.5	3.5	23	7.8	1.5	8.2
F	65	20	300	49	2.1	46
Ga	5	1.5	15	3	2.0	3
Ge	1.5	2L	15	.7	3.7	---
Hg	.12	.01L	.47	.09	2.3	.04
La	7	7L	50	5	3.2	3
Li	21	2.9	70	15	2.3	9.2
Mn	32	6.9	170	26	1.9	6.7
Mo	1.5	.5L	7.0	1	2.3	.5
Nb	2	1.5L	10	1.5	2.3	2
Ni	3	1	10	2	1.8	3
Pb	5.3	2.4L	16	4.3	1.9	4.1
Sb	.6	.08	5	.4	2.6	.2
Sc	2	.7	5	1.5	1.7	1.5
Se	1	.4L	2.2	.9	1.8	1.6
Sr	150	50	500	100	1.7	70
Th	3.5	.5	17	2.2	2.6	1.5
U	2.0	.2L	11	1.0	3.4	.8
V	15	3	30	10	1.9	10
Y	7	1.5	20	5	2.1	7
Yb	.7	.2	3	.5	2.1	.7
Zn	14	2	48	9.6	2.3	7
Zr	20	7	100	20	1.9	20