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Chemical Analysis and Evaluation of 22 Coal Samples from the Otter Creek Wilderness and Adjacent Areas, Randolph and Tucker Counties, West Virginia

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This report is preliminary and has not been reviewed for conformity with U.S. Geological Survey editorial standards.

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CONTENTS

ILLUSTRATIONS

TABLES

Abstract

This report contains tables of analytical data on 22 coal samples from the Otter Creek Wilderness and adjacent area, Randolph and Tucker Counties, W. Va.

The U.S. Geological Survey analytical laboratories have quantitatively determined the contents of 38 major, minor and trace elements in each sample. A search was also conducted for 24 other trace elements by semi-quantitative spectrographic methods. The coal was also analyzed for 11 major- and minor-element oxides. The U.S. Department of Energy laboratories in Pittsburgh performed ultimate and proximate analyses and analyses for forms of sulfur, heats of combustion, ash-fusion temperatures, and free-swelling indexes on 20 of the samples.

The arithmetic and geometric means of the analytical data obtained on these coal samples differ considerably from published geometric means for West Virginia coals. These differences probably reflect that the Otter Creek samples are weathered, whereas the mean samples from the State of West Virginia are unweathered.

Introduction

This report presents the chemical analyses and evaluation of coal samples collected during a mineral-resource survey of the Otter Creek Wilderness, Randolph and Tucker Counties, W. Va.; other topics investigated for this area are reported elsewhere by Warlow (1981), Behum and Mory (in press), and Warlow, Behum, and Mory (in press). The location of the Otter Creek Wilderness is shown in figure 1, and the distribution of the coal samples is shown in figure 2. Data in this report describe the quality of near-surface coal samples collected in this area. The coal beds are Pennsylvanian in age (fig. 3) and of medium volatile bituminous rank (Warlow, Behum, and Mory, in press). Twenty-two channel samples of the full thickness of coal from six coal beds were collected from adits, prospect pits, and outcrops. Many of the sampled coals appeared to be weathered. Locations and descriptions of samples are given in tables 1 and 2. Where necessary, a thickness of at least 1 foot of coal was removed from a coal face before a sample was taken. This outer layer was removed in an attempt to obtain the freshest coal possible.

The analyses performed on these coal samples and some of the analytical methods used are listed in figure 4. The analyses were made in two laboratories: (1) The U.S. Department of Energy laboratories in Pittsburgh, Pa., performed the proximate and ultimate analyses and determined forms of sulfur, heat of combustion, ash-fusion temperatures, and free-swelling indexes; (2) the U.S. Geological Survey (USGS) laboratories in Reston, Va., determined the concentrations of the major- and minor-element oxides and of the trace elements in the high-temperature ash; the USGS laboratories also determined concentrations of trace elements in the coal (fig. 4). The methods of collecting the samples and the details of some analytical procedures were described by Swanson and Huffman (1976), and the procedures and methods of interpretation of data were described by Zubovic and others (1979).

Acknowledgments

This report is a result of close cooperation between the U.S. Geological Survey and the U.S. Bureau of Mines. Kenneth J. Englund and Paul C. Lyons of the U.S. Geological Survey and Paul T. Behum and Peter C. Mory of the U.S. Bureau of Mines contributed many concepts and much work to this report. The Coal Analysis Section of the U.S. Department of Energy has provided proximate and ultimate analyses, heats of combustion, forms of sulfur, free-swelling indexes, and ash-fusion temperatures for 20 of the samples. The U.S. Geological Survey provided all other analyses.

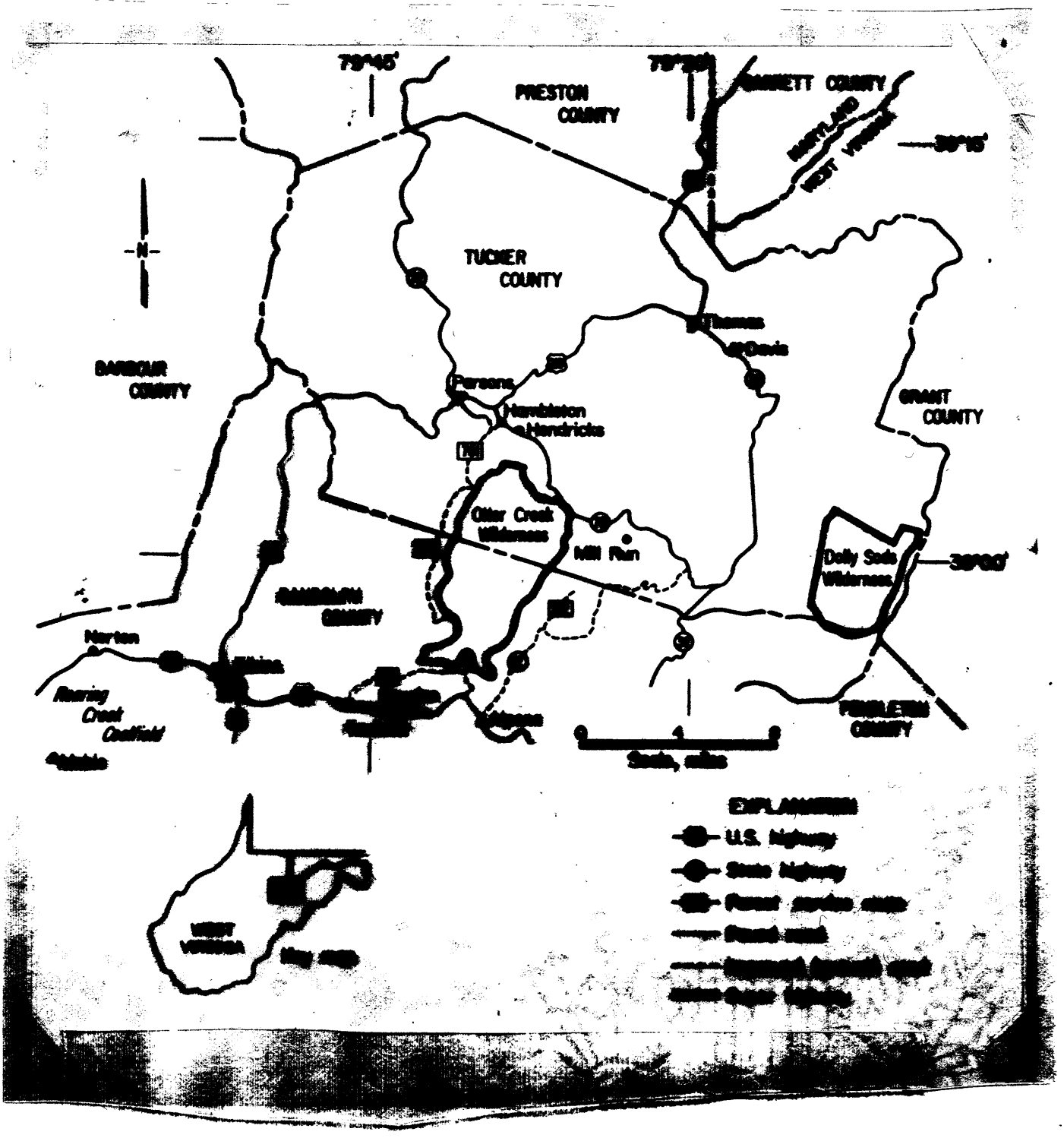

Figure 1.--Location of Otter Creek Wilderness, Randolph and Tucker Counties, W. Va.

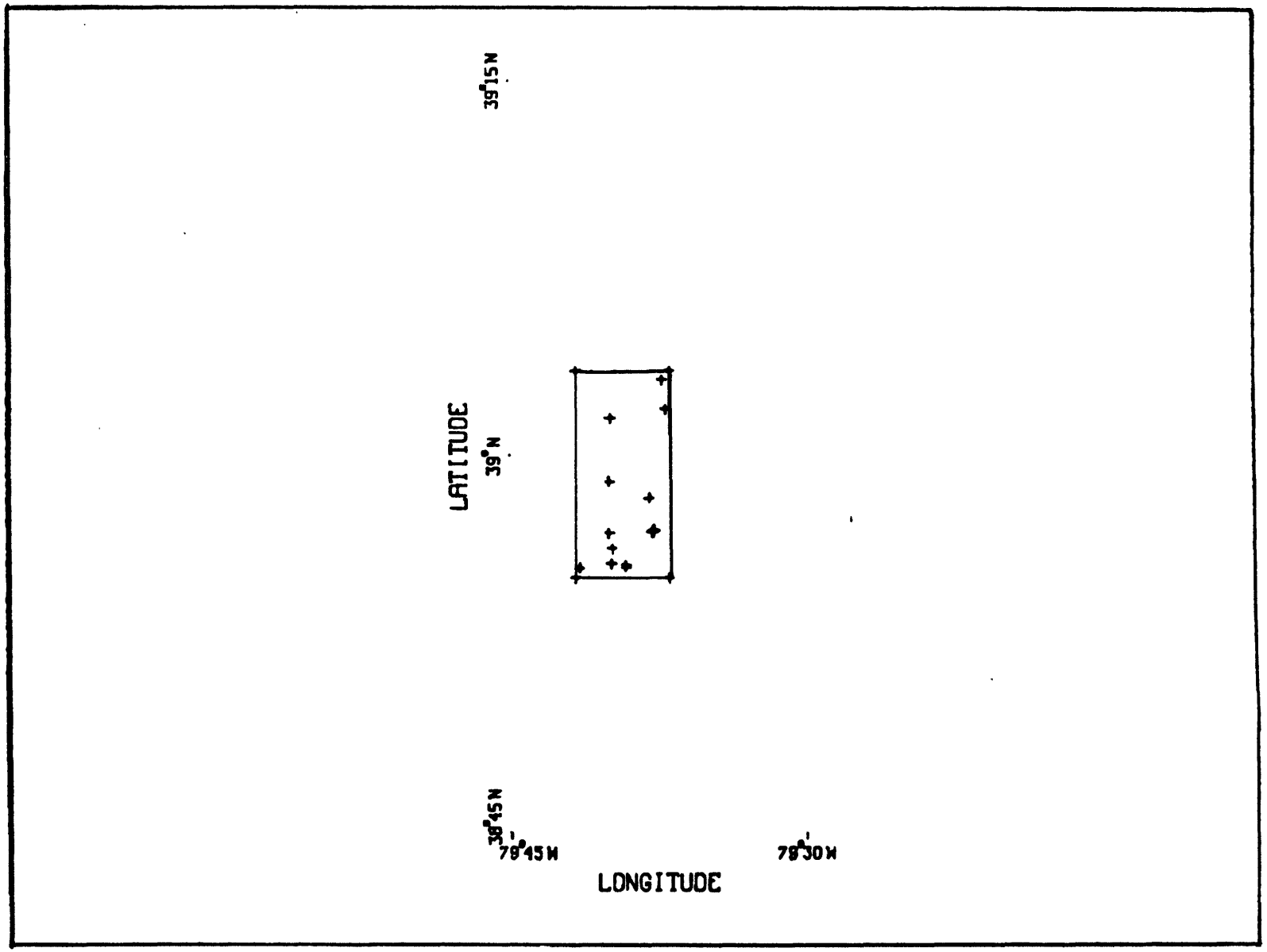

Figure 2.--Distribution of coal samples from the Otter Creek Wilderness, Randolph and Tucker Counties, W. Va.

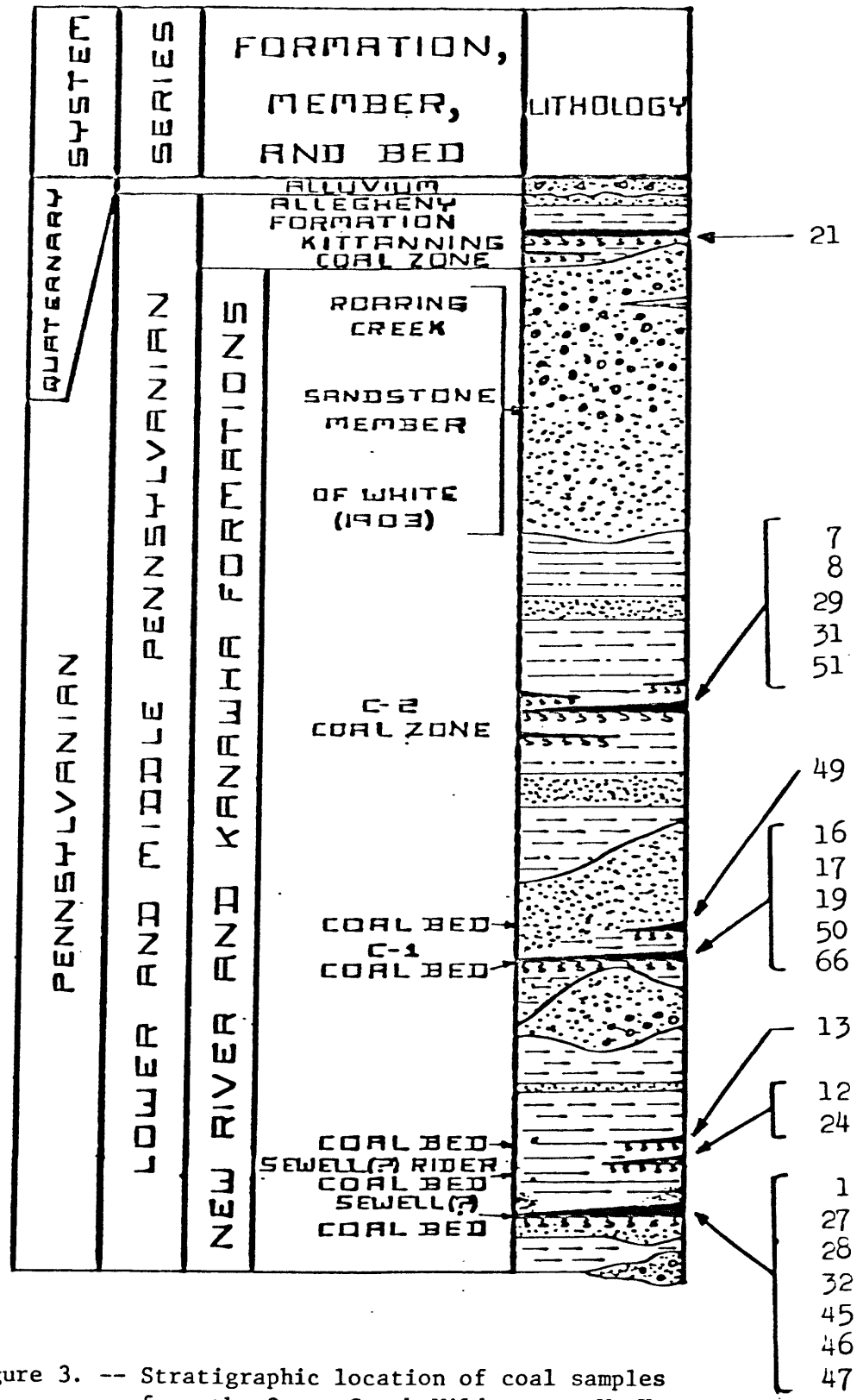

Figure 3. -- Stratigraphic location of coal samples from the Otter Creek Wilderness, W. Va. All sample numbers are preceded by WVOC.

Table 1. -- Field and analytical sample numbers and location by quadrangle.

Analytical identification number	Field identification number	Quadrangle
W 203810	WVOC 13	Bowden
W 203811	WVOC 7	Bowden
W 203812	WVOC 47	Bowden
W 203813	WVOC 46	Bowden
W 203814	WVOC 29	Bowden
W 203815	WVOC 1	Bowden
W 203816	WVOC 21	Bowden
W 203817	WVOC 49	Parsons
W 203818	WVOC 50	Parsons
W 203819	WVOC 51	Parsons
W 203820	WVOC 16	Parsons
W 203821	WVOC 8	Bowden
W 203822	WVOC 45	Bowden
W 203823	WVOC 32	Bowden
W 203824	WVOC 24	Bowden
W 203825	WVOC 27	Bowden
W 203826	WVOC 28	Bowden
W 203827	WVOC 31	Bowden
W 203828	WVOC 17	Bowden
W 203829	WVOC 19	Bowden
W 203830	WVOC 12	Bowden
W 203831	WVOC 66	Parsons

Table 2. -- Descriptions of 22 coal samples from the Otter Creek Wilderness, Randolph and Tucker Counties, W. Va.
[all samples are single-channel type]

Analytical ident. no.	Field ident. No. WVOC-	County	Latitude	Longitude	Formation	Coal bed	Rank	Sampled thickness (inches)
W 203816	21	Randolph	385900N	794000W	Allegheny	Kittanning	Bituminous	36.0
W 203811	7	"	385539N	793909W	New River & Kanawha, undivided	C-2	"	32.0
W 203821	8	"	385539N	793909W	"	"	"	35.0
W 203814	29	"	385700N	793750W	"	"	"	33.0
W 203827	31	"	385702N	793740W	"	"	"	25.0
W 203819	51	Tucker	390150N	793710W	"	"	"	20.0
W 203817	49	"	390150N	793710W	"	Uncorrelated	"	15.0
W 203820	16	"	390130N	793958W	"	C-1	"	24.0
W 203828	17	Randolph	385820N	793800W	"	"	"	21.0
W 203829	19	"	385820N	793800W	"	"	"	11.0
W 203818	50	Tucker	390150N	793710W	"	"	"	18.0
W 203831	66	"	390300N	793720W	"	"	"	34.0
W 203810	13	Randolph	385540N	793910W	"	Uncorrelated	"	18.0
W 203830	12	"	385620N	793950W	"	Sewell rider	"	21.0
W 203824	24	"	385700N	793750W	"	"	"	25.0
W 203815	1	"	385545N	793955W	"	Sewell	"	33.0
W 203825	27	"	385702N	793748W	"	"	"	50.0
W 203826	28	"	385702N	793748W	"	"	"	7.0
W 203823	32	"	385700N	793750W	"	"	"	52.0
W 203822	45	"	385535N	794130W	"	"	"	15.0
W 203812	47	"	385535N	794130W	"	"	"	34.0
W 203813	46	"	385535N	794130W	"	"	"	15.0

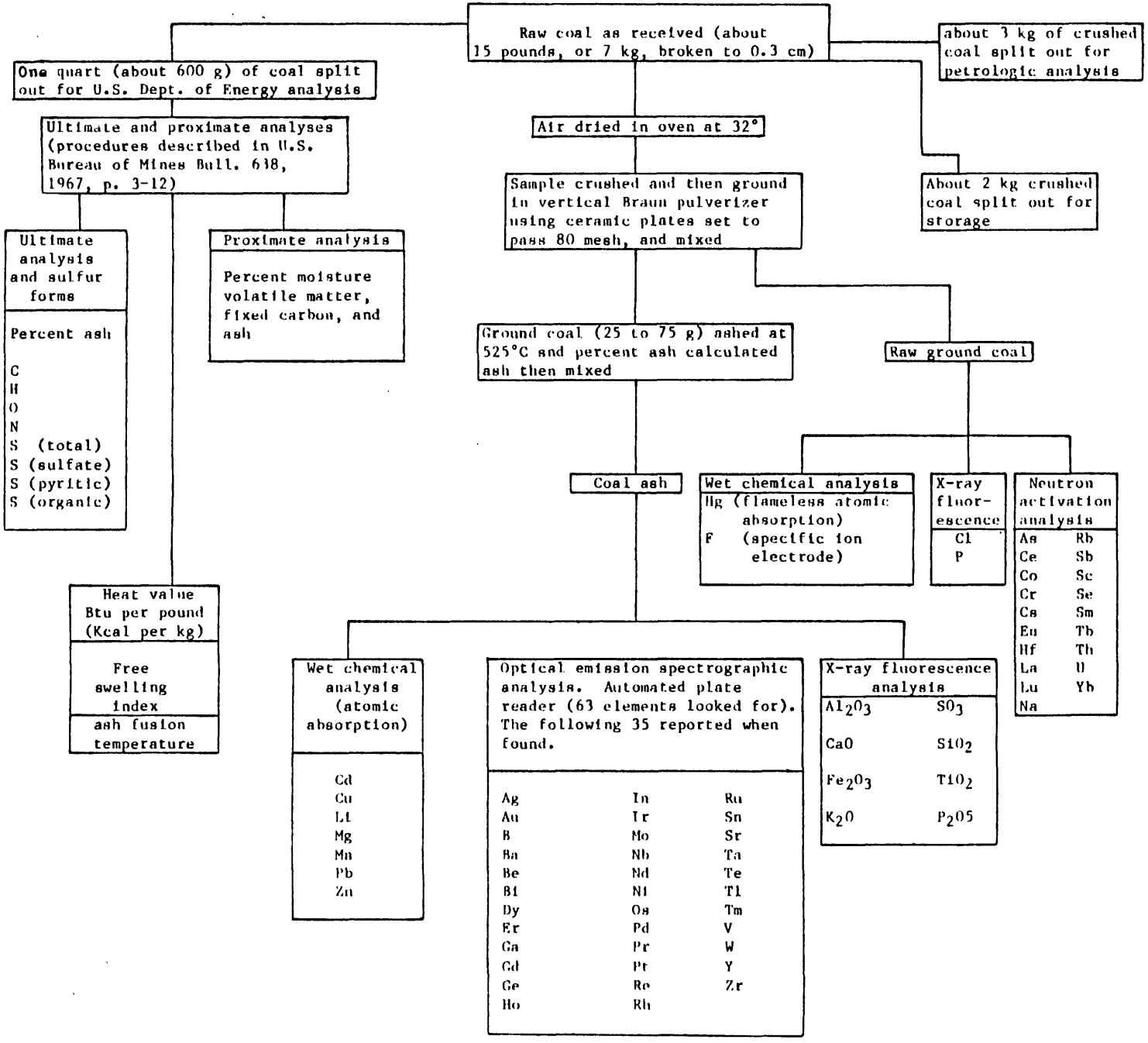

Figure 4 - Analyses performed on the coal samples.

Discussion of the samples

Statistical analytical summaries for the Otter Creek Wilderness coal beds are in tables 3a, b, and c. Comparative geometric means for West Virginia are also cited (Zubovic and others, 1979).

The as-received proximate and ultimate analyses for the Otter Creek samples are compared in table 3a with similar data for 168 coal samples collected from other localities in West Virginia. The geometric means for moisture, ash, and oxygen are higher for the Otter Creek samples than the geometric means for the 168 samples; volatile matter, fixed carbon, hydrogen, carbon, nitrogen, and sulfur are lower in the Otter Creek samples than in the 168 samples (table 3a).

The geometric means for the heat of combustion are more than 3,000 Btu/lb higher in the 168 samples than in the Otter Creek samples (table 3a). Additionally, pyritic sulfur and sulfate sulfur are lower by half in the Otter Creek samples, and organic sulfur is about the same in both sets of samples. By contrast, the ash-fusion temperatures are higher for the Otter Creek samples but are within 100°F of the 168 samples. The free-swelling index is three times higher for the 168 samples than for the Otter Creek samples. The data for heat of combustion, oxygen content, and free-swelling index indicate that most of the Otter Creek samples were highly weathered (oxidized). Sample 203819 (WVOC 51) from the C-2 coal zone (fig. 3) has the highest free-swelling index of the 22 samples (table 4). This sample also has the lowest oxygen content and the highest heat of combustion on a moisture- and ash-free basis. The samples from the C-1 coal bed having the highest free-swelling index have the lowest oxygen content.

Figure 5 is a graph of the oxygen content in contrast with the heat of combustion of_____ samples from the C-1 coal bed and the C-2 coal zone, which illustrates an inverse relationship of these properties. Increasing oxygen content (oxidation) correlates with decreasing Btu content. These samples in an unweathered state would probably average between 4 percent and 7 percent oxygen content and would average 14,500 Btu/lb heat of combustion on an ash- and moisture-free basis. The free-swelling indexes would probably exceed 5. Because of this weathering, all the analytical data for the Otter Creek area are biased and are not representative of unweathered coal. Data representative of unweathered coal could have been obtained only by core drilling.

Table 3b contains data for the major- and minor-element oxides in the high-temperature ash. The geometric mean for the percent ash is one and one-half times higher for the Otter Creek samples than the geometric mean of 252 other West Virginia samples. The geometric mean of Na_2O content is two and one-half times higher for the 252 samples, whereas CaO, MnO, K_2O, Fe_2O_3, and SO_3 contents are lower for the 252 samples. The other oxides have approximately equal geometric mean contents in the two sets of data.

The geometric means for the trace-element concentrations of the Otter Creek coal samples show a distinctly different distribution when compared to the means for the 252 samples. The mean contents of Se and B are lower in the Otter Creek coal samples (table 3c); the mean contents of all the other trace elements are higher in the Otter Creek samples than in the 252 samples. For example, mean contents of Cd, Cs, Eu, La, Mn, Mo, Nd, Ni, Pb, Sb, Sc, Sm, Tb, V, Y, Yb, and Zn are more than twofold higher in the Otter Creek samples, and the mean contents of other elements are slightly higher than to almost twice as high as contents in the 252 samples.

Zubovic (1966) reported that a significant increase in the trace-element content of coal can be caused by weathering. He concluded that weathering (oxidation) of coal produces an increase in oxygen-bearing functional groups that can complex metallic ions in solutions passing through the coal. The fact that the mean contents of 36 of 38 analyzed elements are higher in the Otter Creek coal samples than in the 252 less oxidized coal samples (table 3c) suggests that Zubovic's conclusion is correct and that complexing does take place. The high concentrations of trace elements in the Otter Creek samples (tables 5a, b, and c) may also be a result of migration of fluids carrying these elements through the coal or of the high ash content of the samples, which may have been caused by influxes of detritus into the coal-forming swamp.

Even though the analytical data were derived from weathered samples, they are of some value in determining a minimum coal quality. If, however, unweathered samples could have been collected, the analytical data would have been more relevant in assessing the economic value and environmental and technologic effects of mining this coal. Because the analytical data indicate that the samples may be of minimal quality, environmental and technologic effects of mining and using the coal are not evaluated in this report.

Table 3a.--Arithmetic mean, observed range, geometric mean, and geometric deviation of proximate and ultimate analyses, heat of combustion, forms of sulfur, ash-fusion temperature, and free-swelling index of 20 coal samples from the Otter Creek Wilderness, W. Va., and geometric means of these characteristics for 168 other West Virginia samples.

[All values are reported on the as-received basis]

	Arithmetic mean	Observed range		Geometric mean	Geometric deviation	Geometric mean 168 West Virginia samples (Zubovic and others, 1979)
		Minimum	Maximum			
Proximate and ultimate analyses, in weight percent						
Moisture	12.6	3.3	24.8	11	1.7	2.4
Volatile matter	21.1	14.1	23.4	21	1.1	29.7
Fixed carbon	50.8	31.5	65.1	50	1.2	56.6
Ash	15.5	5.4	44.4	13	1.8	8.1
Hydrogen	4.8	3.6	5.4	4.8	1.1	5.1
Carbon	59.2	36.5	74	58.2	1.2	74.7
Nitrogen	.89	.6	1.1	.89	1.2	1.2
Oxygen	18.7	8.4	34.5	17.1	1.5	7.7
Sulfur	.86	.3	3.4	.67	1.9	.96
Heat of combustion, in Btu/lb (kcal/kg = 0.556 Btu/lb)						
	10,100	6,200	12,800	9,900	1.2	13,260
Forms of sulfur, in weight percent						
Sulfate	0.03	0.01	0.31	0.01	2.5	0.04
Pyritic	.38	.05	3.	.16	3.0	.46
Organic	.46	.23	.75	.43	1.4	.45
Ash-fusion temperature, in °F (°F = 9/5 °C + 32)						
Initial deformation	2,450	1,450	2,750	2,430	1.2	2,350
Softening temperature	2,550	2,550	2,760	2,540	1.1	2,440
Fluid temperature	2,600	2,360	2,800	2,600	1.1	2,550
Free-swelling Index						
	2.7	1	9	1.9	2.1	5.8

Table 3b.--Arithmetic mean, observed range, geometric mean, and geometric deviation of ash content and contents of 11 major and minor oxides in the laboratory ash of 22 coal samples from the Otter Creek Wilderness, W. Va., and geometric means of these ash and oxide contents for 252 other West Virginia samples.

[All samples were ashed at 525°C; all analyses are in percent.]

Oxide	Arithmetic mean	Observed range		Geometric mean	Geometric deviation	Geometric mean 252 West Virginia samples (Zubovic and others, 1979)
		Minimum	Maximum			
(Ash)	17.2	5.7	50.9	14	1.8	8.3
SiO_2	45	25	57	44	1.2	49
Al_2O_3	28	17	40	28	1.2	27
CaO	2.5	.45	9.9	1.8	2.2	1.1
MgO	.98	.41	1.8	.91	1.4	.84
Na_2O	.25	.14	.49	.23	1.4	.57
K_2O	2.6	.52	5.1	2.3	1.7	.12
Fe_2O_3	10.6	3	27	8.9	1.8	6.5
MnO	.08	.01	.37	.04	3.0	.02
TiO_2	1.1	.39	1.6	1.1	1.4	1.4
P_2O_5	.82	.03	11	.16	3.8	.13
SO_3	3.8	.5	15	2.9	2.2	1.8

Table 3c.--Arithmetic mean, observed range, geometric mean, and geometric deviation of contents of 38 elements in 22 coal samples from the Otter Creek Wilderness, W. Va., and geometric means of these contents for 252 other West Virginia samples.

[All analyses are in parts per million and are reported on a whole-coal basis]

Element	Arithmetic mean	Observed range		Geometric mean	Geometric deviation	Geometric Mean 252 West Virginia samples (Zubovic and others, 1979)
		Minimum	Maximum			
Ag	0.06	0.01	0.16	0.05	2.2	0.04
As	14	1	44	7.3	3.6	4.8
B	12	1.3	39	8.7	2.1	16
Ba	130	34	350	110	1.9	61
Be	4.2	1.7	13	3.6	1.7	2.5
Cd	.33	.03	1.2	.23	2.4	.05
Ce	33	11	74	27	1.8	16
Co	10	2.1	31	8.1	2.0	5.2
Cr	26	9.3	63	23	1.7	13
Cs	2.1	.3	7.6	1.5	2.2	.68
Cu	34	7.8	135	26	2.1	14
Eu	.78	.27	2.9	.65	1.8	.30
F	110	11	360	78	2.3	53
Ga	11	3.6	29	9.5	1.7	5.2
Ge	3.4	.25	11	2.5	2.4	1.7
Hf	1	.4	3	.86	1.8	.67
Hg	.19	.02	1	.11	2.8	.07
La	19	5	44	16	1.9	7.9
Li	27	4.1	82	17	2.6	12
Lu	.27	.1	.8	.23	1.8	.13
Mn	83	12	520	42	3.0	10
Mo	4.4	1.1	11	3.7	1.8	1.2
Nb	3.8	.7	10	2.9	2.1	1.7
Nd	22	4.4	47	19	1.8	9.1
Ni	45	5.7	280	30	2.4	10
Pb	15	3.1	40	12	2	5.1
Sb	1.8	.2	9.8	1.3	2.2	.63
Sc	7	2.6	15	6.2	1.6	2.9
Se	2.9	1	6	2.4	1.7	3.3
Sm	3.6	1.2	12	3	1.8	1.4
Sr	110	55	280	110	1.4	67
Tb	.76	.3	2.9	.64	1.7	.25
U	2.1	.4	6.2	1.6	2	1.1
V	48	11	160	37	2	17
Y	19	5.4	43	17	1.7	7.0
Yb	1.7	.7	4.8	1.5	1.7	.71
Zn	38	10	150	29	2	8
Zr	44	81	120	34	2.1	18

Table 4.--Proximate and ultimate analyses, heat content, forms of sulfur, free-swelling index, and ash-fusion temperature determinations for 20 bituminous coal samples from Otter Creek Wilderness and vicinity, Randolph and Tucker Counties, W. Va.

[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 U.S. Department of Energy, Coal Analysis Section, Pittsburgh, Pa.]

Anal. ident. no. (field ident. no.)	Proximate analysis				Ultimate analysis					Heat of combustion	
	Moisture	Volatile matter	Fixed carbon	Ash	Hydrogen	Carbon	Nitrogen	Oxygen	Sulfur	Kcal/kg	Btu/lb
w203816	8.2	21.7	49.3	20.8	4.8	59.1	1.1	13.4	0.8	5,770	10,390
(WVOC-21)	---	23.6	53.7	22.7	4.2	64.4	1.2	6.7	.9	6,290	11,320
	---	30.6	69.4	---	5.5	83.2	1.5	8.6	1.1	8,130	14,630
w203811	15.8	23.1	55.7	5.4	4.8	62.7	.9	25.4	.6	5,740	10,340
(WVOC-7)	---	27.4	66.2	6.4	3.6	74.5	1.1	13.5	.7	6,820	12,280
	---	29.3	70.7	---	3.9	79.6	1.1	14.4	.8	7,290	13,120
w203821	16.4	23.4	54.7	5.5	5.0	62.4	.9	25.7	.6	5,710	10,280
(WVOC-8)	---	28.0	65.4	6.6	3.8	74.6	1.1	13.3	.7	6,830	12,300
	---	30.0	70.0	---	4.1	79.9	1.2	14.2	.8	7,310	13,160
w203827	17.6	21.1	50.3	11.0	5.2	57.5	.9	24.6	.6	5,360	9,640
(WVOC-31)	---	25.6	61.0	13.3	3.9	69.8	1.1	10.9	.7	6,500	11,710
	---	29.6	70.4	---	4.5	80.5	1.3	12.5	.8	7,500	13,510
w203819	7.4	23.1	59.4	10.1	5.2	72.0	1.0	10.2	1.5	7,080	12,740
(WVOC-51)	---	24.9	64.1	10.9	4.7	77.8	1.1	3.9	1.6	7,650	13,760
	---	28.0	72.0	---	5.3	87.3	1.2	4.4	1.8	8,580	15,450
w203817	9.2	22.5	46.6	21.7	4.8	57.3	.8	12.8	2.6	5,590	10,060
(WVOC-49)	---	24.8	51.3	23.9	4.2	63.1	.9	5.1	2.9	6,160	11,080
	---	32.6	67.4	---	5.5	82.9	1.2	6.7	3.8	8,090	14,560
w203820	4.9	21.4	62.0	11.7	4.7	71.7	1.0	10.4	.5	6,890	12,400
(WVOC-16)	---	22.5	65.2	12.3	4.4	75.4	1.1	6.4	.5	7,250	13,040
	---	25.7	74.3	---	5.0	86.0	1.2	7.2	.6	8,260	14,870
w203828	16.9	19.4	39.6	24.1	4.7	45.4	.8	24.5	.5	4,220	7,600
(WVOC-17)	---	23.3	47.7	29.0	3.4	54.6	1.0	11.4	.6	5,080	9,150
	---	32.9	67.1	---	4.8	76.9	1.4	16.1	.8	7,160	12,880
w203829	3.3	18.6	46.7	31.4	4.0	54.2	1.0	8.4	.9	5,280	9,500
(WVOC-19)	---	19.2	48.3	32.5	3.8	56.0	1.0	5.7	.9	5,460	9,820
	---	28.5	71.5	---	5.6	83.0	1.5	8.4	1.4	8,080	14,550
w203818	11.4	21.8	56.7	10.1	5.2	66.0	.9	16.7	1.1	6,380	11,490
(WVOC-50)	---	24.6	64.0	11.4	4.4	74.5	1.0	7.4	1.2	7,210	12,970
	---	27.8	72.2	---	5.0	84.1	1.1	8.4	1.4	8,130	14,640
w203831	13.8	20.1	50.8	15.3	4.9	59.7	.8	18.9	.4	5,620	10,110
(WVOC-66)	---	23.3	58.9	17.7	3.9	69.3	.9	7.7	.5	6,520	11,730
	---	28.3	71.7	---	4.7	84.2	1.1	9.4	.6	7,930	14,270

Table 4.--Proximate and ultimate analyses, heat content, forms of sulfur, free-swelling index, and ash-fusion temperature determinations for 20 bituminous coal samples from Otter Creek Wilderness and vicinity, Randolph and Tucker Counties, W. Va--continued

Anal. ident. no. (field ident. no.)	Air-dried loss	Forms of sulfur			Free-swelling index	Ash-fusion temperature, in °C		
		Sulfate	Pyritic	Organic		Initial deformation	softening	fluid
w203816	7.1	0.01	0.16	0.62	2.5	1,505	1,540	1,540
(WVOC-21)	---	.01	.17	.68				
	---	.01	.23	.87				
w203811	12.4	.01	.09	.54	.0	1,455	1,510	1,540
(WVOC-7)	---	.01	.11	.64				
	---	.01	.11	.69				
w203821	13.3	.01	.10	.46	.0	1,350	1,405	1,455
(WVOC-8)	---	.01	.12	.55				
	---	.01	.13	.59				
w203827	14.9	.01	.13	.43	.0	1,375	1,440	1,490
(WVOC-31)	---	.01	.16	.52				
	---	.01	.18	.60				
w203819	6.6	.08	.87	.60	9.0	1,265	1,325	1,375
(WVOC-51)	---	.09	.94	.65				
	---	.10	1.05	.73				
w203817	8.1	.31	1.58	.75	5.0	1,240	1,290	1,350
(WVOC-49)	---	.34	1.74	.83				
	---	.45	2.29	1.09				
w203820	3.6	.00	.07	.43	1.0	1,540	1,540	1,540
(WVOC-16)	---	.00	.07	.45				
	---	.00	.08	.52				
w203828	14.2	.01	.15	.38	.0	1,495	1,540	1,540
(WVOC-17)	---	.01	.18	.46				
	---	.02	.25	.64				
w203829	2.3	.01	.30	.63	1.5	1,540	1,540	1,540
(WVOC-19)	---	.01	.31	.65				
	---	.02	.46	.96				
w203818	9.9	.02	.43	.68	1.0	1,325	1,375	1,440
(WVOC-50)	---	.02	.49	.77				
	---	.03	.55	.87				
w203831	11.8	.01	.11	.25	.0	790	1,405	1,455
(WVOC-66)	---	.01	.13	.29				
	---	.01	.16	.35				

Table 4.--Proximate and ultimate analyses, heat content, forms of sulfur, free-swelling index, and ash-fusion temperature determinations for 20 bituminous coal samples from Otter Creek Wilderness and vicinity, Randolph and Tucker Counties, W. Va--continued

Anal. ident. no. (field ident. no.)	Proximate analysis				Ultimate analysis					Heat of combustion	
	Moisture	Volatile matter	Fixed carbon	Ash	Hydrogen	Carbon	Nitrogen	Oxygen	Sulfur	Kcal/kg	Btu/lb
w203810	23.6	22.3	47.0	7.1	5.3	54.7	0.9	31.7	0.4	4,950	8,910
(WVOC-13)	---	29.2	61.5	9.3	3.5	71.6	1.2	14.0	.5	6,480	11,660
	---	32.2	67.8	---	3.9	78.9	1.3	15.5	.6	7,140	12,850
w203830	10.8	21.6	58.4	9.2	4.8	67.0	.9	17.6	.5	6,310	11,360
(WVOC-12)	---	24.2	65.5	10.3	4.0	75.1	1.0	9.0	.6	7,070	12,730
	---	27.0	73.0	---	4.5	83.7	1.1	10.0	.6	7,890	14,190
w203824	24.4	18.8	35.2	21.6	4.9	39.9	.7	32.6	.4	3,550	6,390
(WVOC-24)	---	24.9	46.6	28.6	2.9	52.8	.9	14.4	.5	4,700	8,450
	---	34.8	65.2	---	4.1	73.9	1.3	20.2	.7	6,570	11,830
w203815	8.2	22.0	61.8	8.0	5.0	71.9	1.0	13.5	.5	6,930	12,470
(WVOC-1)	---	24.0	67.3	8.7	4.5	78.3	1.1	6.8	.5	7,550	13,580
	---	26.3	73.7	---	4.9	85.8	1.2	7.4	.6	8,270	14,880
w203825	13.8	22.8	55.0	8.4	5.4	65.6	1.0	19.0	.7	6,290	11,320
(WVOC-27)	---	26.5	63.8	9.7	4.5	76.1	1.2	7.8	.8	7,290	13,130
	---	29.3	70.7	---	5.0	84.3	1.3	8.7	.9	8,080	14,550
w203826	5.9	21.8	43.6	28.7	4.3	53.7	.9	8.9	3.4	5,370	9,660
(WVOC-28)	---	23.2	46.3	30.5	3.9	57.1	1.0	3.9	3.6	5,710	10,270
	---	33.3	66.7	---	5.6	82.1	1.4	5.6	5.2	8,210	14,780
w203823	24.8	22.0	45.9	7.3	5.3	51.8	.8	34.5	.4	4,620	8,310
(WVOC-32)	---	29.3	61.0	9.7	3.4	68.9	1.1	16.6	.5	6,140	11,050
	---	32.4	67.6	---	3.7	76.3	1.2	18.3	.6	6,800	12,240
w203812	10.0	14.1	31.5	44.4	3.6	36.5	.6	14.7	.3	3,430	6,170
(WVOC-47)	---	15.7	35.0	49.3	2.8	40.6	.7	6.5	.3	3,810	6,850
	---	30.9	69.1	---	5.5	80.0	1.3	12.7	.7	7,510	13,520
w203813	6.4	20.0	65.1	8.5	4.9	74.0	1.0	11.0	.5	7,130	12,830
(WVOC-46)	---	21.4	69.6	9.1	4.5	79.1	1.1	5.7	.5	7,610	13,700
	---	23.5	76.5	---	4.9	87.0	1.2	6.2	.6	8,370	15,070

Table 4.--Proximate and ultimate analyses, heat content, forms of sulfur, free-swelling index, and ash-fusion temperature determinations for 20 bituminous coal samples from Otter Creek Wilderness and vicinity, Randolph and Tucker Counties, W. Va--continued

Anal. ident. no. (field ident. no.)	Air-dried loss	Forms of sulfur			Free-swelling index	Ash-fusion temperature, in °C		
		Sulfate	Pyritic	Organic		Initial deformation	softening	fluid
w203810	19.6	0.00	0.12	0.23	0.0	1,180	1,230	1,295
(WVOC-13)	---	.00	.16	.30				
	---	.00	.17	.33				
w203830	8.7	.00	.08	.38	.0	1,540	1,540	1,540
(WVOC-12)	---	.00	.09	.43				
	---	.00	.10	.47				
w203824	21.0	.01	.05	.30	.0	1,510	1,540	1,540
(WVOC-24)	---	.01	.07	.40				
	---	.02	.09	.56				
w203815	6.9	.01	.07	.45	1.0	1,455	1,515	1,540
(WVOC-1)	---	.01	.08	.49				
	---	.01	.08	.54				
w203825	11.9	.01	.12	.59	1.5	1,430	1,480	1,540
(WVOC-27)	---	.01	.14	.68				
	---	.01	.15	.76				
w203826	5.2	.01	2.99	.43	.0	1,475	1,540	1,540
(WVOC-28)	---	.01	3.18	.46				
	---	.02	4.57	.66				
w203823	19.9	.01	.08	.28	.0	1,350	1,405	1,455
(WVOC-32)	---	.01	.11	.37				
	---	.01	.12	.41				
w203812	8.7	.01	.06	.26	.0	1,540	1,540	1,540
(WVOC-47)	---	.01	.07	.29				
	---	.02	.13	.57				
w203813	5.3	.01	.08	.45	1.5	1,540	1,540	1,540
(WVOC-46)	---	.01	.09	.48				
	---	.01	.09	.53				

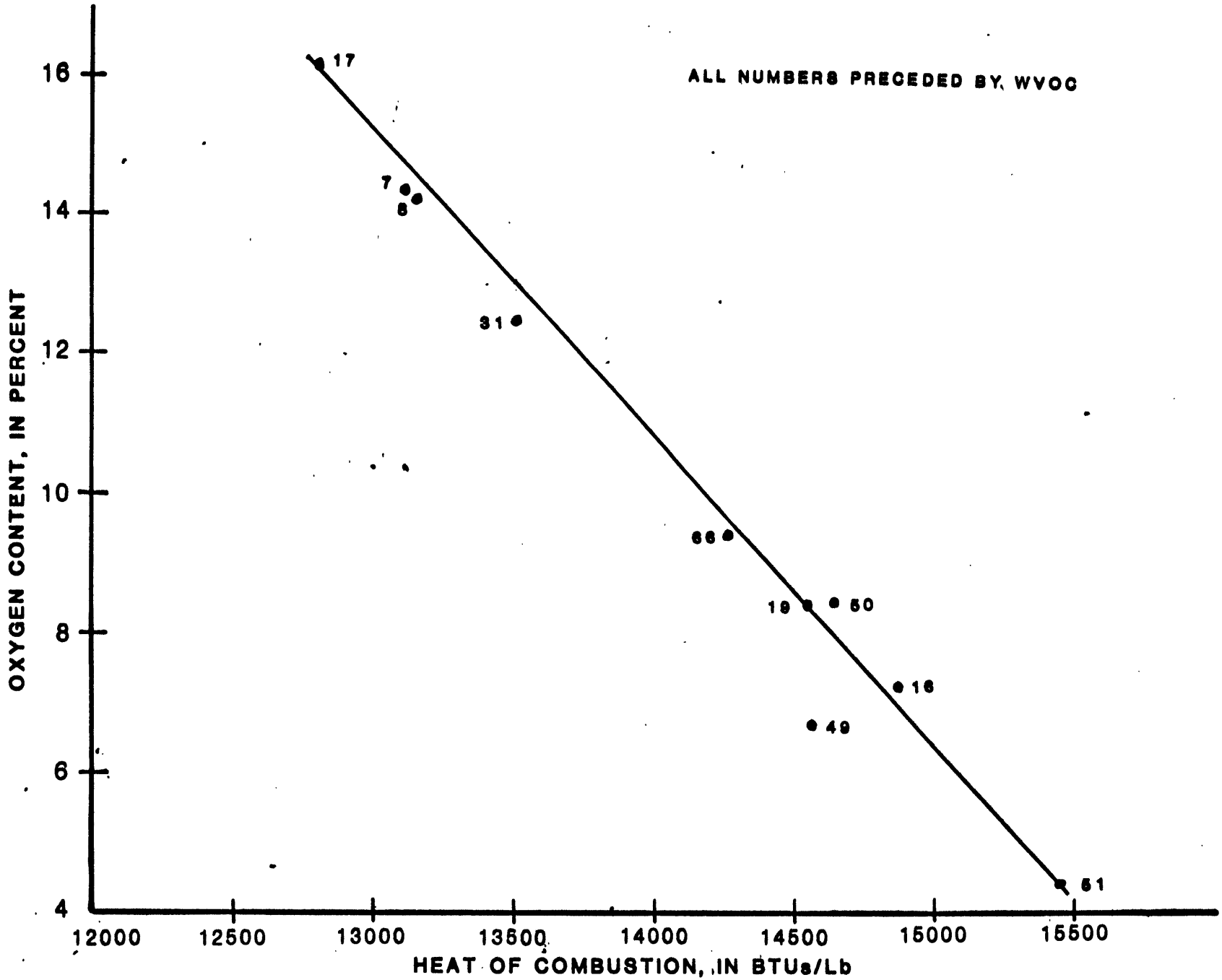

Figure 5.--Relation of the oxygen contents and heats of combustion of coal samples from the C-1 coal bed, the C-2 coal zone, and a coal bed in between them. Data are on moisture-and ash-free basis; see figure 3, tables 1,4.

Table 5a.--Major- and minor-oxides and trace-element concentration of the laboratory ash of 22 bituminous coal samples from Otter Creek Wilderness and vicinity, Randolph and Tucker Counties, W. Va.

[Coal ashed at 525° C. L means less than the value shown; S after element title indicates determinations by automatic plate-reading computer-assisted emission spectograph. The standard deviation of any single answer should be taken as plus 50% and minus 35%. Methods of analyses for other elements as shown in figure 4.]

Anal. ident. no.	Ash (percent)	SiO2 (percent)	Al2O3 (percent)	CaO (percent)	MgO (percent)	Na2O (percent)	K2O (percent)	Fe2O3 (percent)	TiO2 (percent)	P2O5 (percent)	Field ident. no.
w203816	24.3	47	33	0.62	0.65	0.17	2.3	9.9	1.6	0.03	WVOC-21
w203811	5.7	41	30	2.6	.65	.24	1.7	11	1.3	.01L	WVOC-7
w203821	6.5	44	29	2.5	.66	.21	1.9	12	1.4	.01L	WVOC-8
w203814	17.3	39	25	2.2	.80	.23	3.6	19	.78	.03	WVOC-29
w203827	11.8	46	24	2.4	1.0	.23	2.4	12	1.3	.01	WVOC-31
w203819	11.0	45	22	2.2	.78	.37	3.1	20	.75	.00L	WVOC-51
w203817	26.3	41	26	.88	.51	.21	1.5	22	.95	.04	WVOC-49
w203820	12.3	51	32	1.6	.86	.22	2.0	4.0	1.3	.02	WVOC-16
w203828	27.7	46	30	.67	.99	.29	4.6	9.5	1.1	.04	WVOC-17
w203829	33.7	53	29	.48	.95	.28	5.1	5.9	1.0	.02	WVOC-19
w203818	11.2	48	23	1.8	.76	.24	3.7	10	1.5	.00L	WVOC-50
w203831	18.1	42	29	2.3	1.1	.15	2.2	13	.97	.07	WVOC-66
w203810	8.1	25	17	9.9	1.8	.17	.88	27	.65	.01	WVOC-13
w203830	9.9	49	29	3.1	.75	.14	1.9	5.9	1.2	.01	WVOC-12
w203824	27.5	47	32	1.6	1.3	.15	3.3	5.6	1.2	.03	WVOC-24
w203815	8.4	49	27	3.0	1.1	.32	2.6	5.6	1.0	.01	WVOC-1
w203825	8.3	41	29	3.1	1.7	.49	2.3	7.0	1.1	.01	WVOC-27
w203826	30.5	46	30	.45	.68	.18	2.2	13	1.0	.02	WVOC-28
w203823	8.1	37	34	4.4	1.5	.33	2.9	4.8	1.6	.02	WVOC-32
w203822	11.2	44	28	5.3	1.7	.36	1.9	9.5	.92	.02	WVOC-45
w203812	50.9	57	28	.59	.91	.32	4.4	3.0	1.1	.02	WVOC-47
w203813	8.4	44	40	2.2	.41	.16	.52	3.6	.39	.14	WVOC-46

Table 5a.--Major- and minor-oxides and trace-element concentration of the laboratory ash of 22 bituminous coal samples from Otter Creek Wilderness and vicinity, Randolph and Tucker Counties, W. Va--continued

Anal. ident. no.	SO3 (percent)	Ag-S (ppm)	B-S (ppm)	Ba-S (ppm)	Be-S (ppm)	Cd (ppm)	Ce (ppm)	Co (ppm)	Cr (ppm)	Cs (ppm)	Field ident. no.
w203816	0.75	0.10L	76	340	13	0.88	140	39	150	6.6	WVOC-21
w203811	4.5	.30	84	590	35	2.2	190	51	160	5.3	WVOC-7
w203821	4.0	.90	78	630	33	1.9	170	51	170	9.2	WVOC-8
w203814	3.8	.40	80	960	23	4.2	190	70	140	12	WVOC-29
w203827	4.5	.30	54	900	34	3.6	210	35	160	10	WVOC-31
w203819	3.3	.30	67	540	31	1.4	120	33	120	9.1	WVOC-51
w203817	1.5	.30	19	370	23	.40	110	53	130	8.0	WVOC-49
w203820	2.3	.30	72	530	22	.88	210	140	160	8.1	WVOC-16
w203828	1.5	.30	89	770	19	.88	220	14	160	17	WVOC-17
w203829	1.0	.40	99	500	24	.24	190	23	140	14	WVOC-19
w203818	2.5	.40	70	980	46	.24	120	19	180	12	WVOC-50
w203831	3.5	.10	45	1,200	16	1.0	200	98	140	9.9	WVOC-66
w203810	15	.40	17	1,500	21	3.2	300	110	210	7.4	WVOC-13
w203830	4.3	.20	64	570	25	3.0	160	150	160	8.1	WVOC-12
w203824	2.3	.60	70	920	10	4.0	200	19	150	14	WVOC-24
w203815	4.0	.10	96	590	22	1.2	180	100	140	7.1	WVOC-1
w203825	6.3	.30	120	980	21	5.2	230	69	170	14	WVOC-27
w203826	1.3	.50	44	300	13	1.2	150	100	170	14	WVOC-28
w203823	7.8	1.1	72	2,000	34	6.0	360	94	250	19	WVOC-32
w203822	7.3	.60	37	3,100	120	11	300	110	230	8.9	WVOC-45
w203812	.50	.10L	77	580	12	.24	150	33	120	15	WVOC-47
w203813	2.1	.40	49	1,600	73	4.0	640	150	140	3.6L	WVOC-46

Table 5a.--Major- and minor-oxides and trace-element concentration of the laboratory ash of 22 bituminous coal samples from Otter Creek Wilderness and vicinity, Randolph and Tucker Counties, W. Va--continued

Anal. ident. no.	Cu (ppm)	Dy-S (ppm)	Er-S (ppm)	Eu (ppm)	Ga-S (ppm)	Gd-S (ppm)	Ge-S (ppm)	Hf (ppm)	Ho-S (ppm)	La (ppm)	Field ident. no.
w203816	80	22L	13	2.8	67	15	23	7.8	7.0L	74	WVOC-21
w203811	140	26	10L	4.9	76	15L	30	7.0	7.0L	88	WVOC-7
w203821	120	22L	10L	4.2	77	20	38	7.7	15L	92	WVOC-8
w203814	140	31	16	5.5	61	27	10	6.4	9.0	120	WVOC-29
w203827	190	22L	19	6.6	92	33	39	7.6	15L	140	WVOC-31
w203819	140	22L	11	3.2	61	17	10	4.5	7.0L	55	WVOC-51
w203817	140	22L	10L	1.9	47	15L	12	4.9	7.0L	57	WVOC-49
w203820	140	22L	12	4.0	89	18	39	5.7	7.0L	110	WVOC-16
w203828	220	22L	10L	4.4	47	15L	2.0L	5.4	7.0L	160	WVOC-17
w203829	400	22L	13	3.4	52	17	33	5.3	7.0L	100	WVOC-19
w203818	160	22L	10L	3.0	97	16	51	6.3	7.0L	63	WVOC-50
w203831	130	24	10L	4.1	58	22	39	4.4	7.0L	120	WVOC-66
w203810	700	31	10L	7.8	110	39	25	6.2	15L	120	WVOC-13
w203830	170	32	10L	4.1	84	24	52	5.1	7.0L	81	WVOC-12
w203824	240	22L	12	4.0	61	18	6.0	5.5	7.0L	110	WVOC-24
w203815	120	22L	10L	3.7	53	15	25	6.0	7.0L	110	WVOC-1
w203825	180	34	17	5.5	44	28	3.0	7.2	8.0	130	WVOC-27
w203826	180	30	10	2.5	72	15	12	5.9	7.0	85	WVOC-28
w203823	340	22L	17	6.8	77	31	8.0	11	15L	220	WVOC-32
w203822	440	74	10L	27	74	98	41	5.4	68L	210	WVOC-45
w203812	92	22L	10L	2.6	57	15L	3.0	5.9	7.0L	81	WVOC-47
w203813	200	43	27	11	71	50	9.0	4.8	11	430	WVOC-46

Table 5a.--Major- and minor-oxides and trace-element concentration of the laboratory ash of 22 bituminous coal samples from Otter Creek Wilderness and vicinity, Randolph and Tucker Counties, W. Va--continued

Anal. ident. no.	Li (ppm)	Lu (ppm)	Mn (ppm)	Mo-S (ppm)	Nb-S (ppm)	Nd-S (ppm)	Ni-S (ppm)	Pb (ppm)	Pr-S (ppm)	Rb (ppm)	Field ident. no.
w203816	220	0.8	250	44	33	100	100	58	68L	86	WVOC-21
w203811	74	2	240	23	13	46L	100	54	68L	350L	WVOC-7
w203821	120	2	220	21	23	68	120	65	150L	150	WVOC-8
w203814	44	2	120	31	30	140	140	61	150L	230L	WVOC-29
w203827	110	2	210	22	39	210	330	64	150L	140	WVOC-31
w203819	82	2	110	27	14	100	87	67	68L	270L	WVOC-51
w203817	310	.8	400	21	17	68	120	66	68L	150L	WVOC-49
w203820	120	2	400	24	26	130	270	68	68L	240L	WVOC-16
w203828	100	2	150	9.0	7	61	55	90	68L	230	WVOC-17
w203829	120	2	62	15	24	130	110	120	68L	250	WVOC-19
w203818	120	2	140	55	25	96	66	120	68L	270L	WVOC-50
w203831	220	1	2,900	29	21	150	290	65	150L	120	WVOC-66
w203810	50	2	1,000	23	11	160	260	290	100	250L	WVOC-13
w203830	180	2	1,900	32	50	150	330	73	68L	200L	WVOC-12
w203824	280	1	98	36	27	150	390	110	68L	170	WVOC-24
w203815	110	1	1,200	48	16	88	260	58	68L	300L	WVOC-1
w203825	96	1	200	64	28	130	560	70	68L	360L	WVOC-27
w203826	260	1	100	17	18	87	220	63	68L	120	WVOC-28
w203823	94	2	170	54	31	180	580	270	150L	370L	WVOC-32
w203822	110	7	2,900	34	17	390	2,500	87	150L	120	WVOC-45
w203812	120	1	240	2.0	20	92	110	60	68L	170	WVOC-47
w203813	120	2	180	65	14	260	350	85	110	360L	WVOC-46

Table 5a.--Major- and minor-oxides and trace-element concentration of the laboratory ash of 22 bituminous coal samples from Otter Creek Wilderness and vicinity, Randolph and Tucker Counties, W. Va--continued

Anal. ident. no.	Sc (ppm)	Sm (ppm)	Sn-S (ppm)	Sr-S (ppm)	Tb (ppm)	Th (ppm)	Tl-S (ppm)	Tm (ppm)	U (ppm)	V-S (ppm)	Field ident. no.
w203816	32	13	2.0L	310	3.7	25	3.0L	5.0L	7.8	230	WVOC-21
w203811	61	21	2.0L	970	5.3	25	3.0L	5.0L	14	260	WVOC-7
w203821	57	18	2.0L	980	4.6	31	3.0L	5.0L	17	380	WVOC-8
w203814	39	25	2.0L	710	5.2	24	3.0L	5.0L	10	190	WVOC-29
w203827	36	31	2.0L	730	5.9	22	3.0L	5.0L	7.6	200	WVOC-31
w203819	39	14	2.0L	910	3.6	16	3.0L	5.0L	7.3	240	WVOC-51
w203817	31	8.4	2.0L	410	2.3	25	3.0L	5.0L	8.4	210	WVOC-49
w203820	41	18	5.0	720	3.3	24	3.0L	5.0L	8.1	310	WVOC-16
w203828	39	20	2.0L	440	3.6	34	3.0L	5.0L	15	200	WVOC-17
w203829	45	16	3.0	320	3.6	32	6.0	5.0L	18	470	WVOC-19
w203818	38	13	2.0L	880	3.6	21	45	5.0L	12	390	WVOC-50
w203831	37	20	2.0L	950	3.9	25	3.0L	5.0L	9.4	250	WVOC-66
w203810	84	40	2.0L	850	7.4	35	3.0L	5.0L	64	140	WVOC-13
w203830	41	18	3.0	980	4.0	20	3.0L	5.0L	9.1	210	WVOC-12
w203824	39	19	3.0	510	3.6	27	5.0	5.0L	13	400	WVOC-24
w203815	31	17	2.0	1,200	3.6	19	3.0L	5.0L	4.8	230	WVOC-1
w203825	40	27	2.0L	1,900	6.0	28	3.0L	5.0L	9.6	330	WVOC-27
w203826	43	12	2.0L	320	2.3	24	3.0L	5.0L	8.5	340	WVOC-28
w203823	60	32	6.0	1,500	4.9	57	3.0L	5.0L	16	440	WVOC-32
w203822	71	100	2.0L	810	26	20	3.0L	8.0	14	150	WVOC-45
w203812	28	13	7.0	240	1.8	24	3.0L	5.0L	7.9	210	WVOC-47
w203813	63	49	8.0	3,300	14	24	3.0L	5.0	8.3	330	WVOC-46

Table 5a.--Major- and minor-oxides and trace-element concentration of the laboratory ash of 22 bituminous coal samples from Otter Creek Wilderness and vicinity, Randolph and Tucker Counties, W. Va--continued

Anal. ident. no.	Y-S (ppm)	Yb (ppm)	Zn (ppm)	Zr-S (ppm)	Field ident. no.
w203816	85	6.6	140	300	WVOC-21
w203811	94	14	180	140	WVOC-7
w203821	130	12	200	180	WVOC-8
w203814	130	12	300	360	WVOC-29
w203827	150	11	240	500	WVOC-31
w203819	130	12	380	160	WVOC-51
w203817	56	4.2	80	240	WVOC-49
w203820	120	8.9	100	270	WVOC-16
w203828	58	11	160	82	WVOC-17
w203829	130	11	60	350	WVOC-19
w203818	110	8.9	140	230	WVOC-50
w203831	96	7.7	190	190	WVOC-66
w203810	120	12	160	170	WVOC-13
w203830	170	10	260	510	WVOC-12
w203824	120	8.0	340	360	WVOC-24
w203815	100	8.3	180	170	WVOC-1
w203825	130	9.6	300	360	WVOC-27
w203826	83	7.5	190	210	WVOC-28
w203823	150	15	560	260	WVOC-32
w203822	360	43	1,300	190	WVOC-45
w203812	68	6.1	120	190	WVOC-47
w203813	340	19	220	260	WVOC-46

Table 5b.--Concentration of 23 trace elements in 22 bituminous coal samples from Otter Creek Wilderness and vicinity, Randolph and Tucker Counties, W.Va.

[Analysis performed on whole coal. L, less than the value shown.]

Anal. ident. no.	As (ppm)	Ce (ppm)	Cl (ppm)	Co (ppm)	Cr (ppm)	Cs (ppm)	Eu (ppm)	F (ppm)	Hf (ppm)	Hg (ppm)	Field ident. no.
w203816	19	34	480	9.4	37	1.6	0.68	99	1.9	0.36	WVOC-21
w203811	13	11	240	2.9	9.3	.3	.28	59	.4	.24	WVOC-7
w203821	10	11	280	3.3	11	.6	.27	60	.5	.12	WVOC-8
w203814	44	33	150	12	23	2.0	.95	11	1.1	.29	WVOC-29
w203827	36	25	350	4.1	19	1.2	.78	63	.9	.22	WVOC-31
w203819	10	13	840	3.6	13	1.0	.35	91	.5	.10	WVOC-51
w203817	42	28	650	14	33	2.1	.49	54	1.3	1.0	WVOC-49
w203820	2.0	26	800	17	20	1.0	.49	99	.7	.020	WVOC-16
w203828	33	61	150	3.8	44	4.7	1.2	230	1.5	.22	WVOC-17
w203829	33	63	310	7.6	46	4.8	1.1	290	1.8	.18	WVOC-19
w203818	25	13	840	2.1	20	1.3	.34	75	.7	.64	WVOC-50
w203831	4.0	36	290	18	25	1.8	.75	99	.8	.030	WVOC-66
w203810	2.0	24	230	8.8	17	.6	.63	67	.5	.080	WVOC-13
w203830	1.0	16	400	14	16	.8	.41	39	.5	.050	WVOC-12
w203824	17	54	90	5.3	41	3.9	1.1	150	1.5	.20	WVOC-24
w203815	1.0	15	700	8.6	12	.6	.31	11	.5	.060	WVOC-1
w203825	2.0	19	750	5.7	14	1.2	.46	91	.6	.010L	WVOC-27
w203826	8.0	45	260	31	52	4.2	.76	130	1.8	.090	WVOC-28
w203823	4.0	29	200	7.6	20	1.5	.55	51	.9	.030	WVOC-32
w203822	7.0	34	300	13	26	1.0	3.0	99	.6	.060	WVOC-45
w203812	2.0	74	120	17	63	7.6	1.3	360	3.0	.030	WVOC-47
w203813	1.0	54	610	13	12	.3L	.93	95	.4	.060	WVOC-46

Table 5b.--Concentration of 23 trace elements in 22 bituminous coal samples from Otter Creek Wilderness and vicinity, Randolph and Tucker Counties, W.Va--continued

Anal. ident. no.	La (ppm)	Lu (ppm)	Na (ppm)	P (ppm)	Rb (ppm)	Sb (ppm)	Sc (ppm)	Se (ppm)	Sm (ppm)	Tb (ppm)	Field ident. no.
w203816	18	0.2	310	29	21	0.90	7.8	6.3	3.1	0.9	WVOC-21
w203811	5	.1	100	1L	20L	.40	3.5	3.7	1.2	.3	WVOC-7
w203821	6	.1	100	1L	10	.20	3.7	1.9	1.2	.3	WVOC-8
w203814	21	.3	290	22	40L	1.6	6.8	2.4	4.3	.9	WVOC-29
w203827	16	.2	200	4	17	.90	4.3	1.3	3.6	.7	WVOC-31
w203819	6	.2	300	2L	30L	.80	4.3	3.6	1.5	.4	WVOC-51
w203817	15	.2	410	43	40L	1.8	8.2	5.9	2.2	.6	WVOC-49
w203820	14	.2	200	9	30L	1.3	5.1	1.0L	2.2	.4	WVOC-16
w203828	44	.5	600	44	64	3.6	11	2.1	5.6	1	WVOC-17
w203829	35	.6	700	29	84	9.8	15	2.1	5.5	1	WVOC-19
w203818	7	.2	200	2L	30L	2.3	4.2	5.0	1.4	.4	WVOC-50
w203831	22	.2	200	56	22	2.1	6.7	1.0L	3.7	.7	WVOC-66
w203810	10	.2	100	3	20L	.80	6.8	1.0L	3.2	.6	WVOC-13
w203830	8	.2	100	3	20L	2.6	4.1	1.0	1.8	.4	WVOC-12
w203824	31	.3	310	32	47	2.4	11	1.1	5.1	1	WVOC-24
w203815	9	.1	200	2	25L	.80	2.6	1.5	1.4	.3	WVOC-1
w203825	11	.1	300	4	30L	.70	3.3	9.0L	2.2	.5	WVOC-27
w203826	26	.3	410	20	36	2.2	13	20L	3.8	.7	WVOC-28
w203823	18	.2	200	6	30L	1.1	4.9	9.0L	2.6	.4	WVOC-32
w203822	23	.8	300	10	14	1.4	7.9	2.0L	12	3	WVOC-45
w203812	41	.5	1,200	33	88	2.1	15	20L	6.6	.9	WVOC-47
w203813	36	.2	100	52	30L	.70	5.3	2.5	4.1	1	WVOC-46

Table 5b.--Concentration of 23 trace elements in 22 bituminous coal samples from Otter Creek Wilderness and vicinity, Randolph and Tucker Counties, W.Va--continued

Anal. ident. no.	Th (ppm)	U (ppm)	Yb (ppm)	Field ident. no.
w203816	6.0	1.9	1.6	WVOC-21
w203811	1.4	.80	.8	WVOC-7
w203821	2.0	1.1	.8	WVOC-8
w203814	4.2	1.8	2.1	WVOC-29
w203827	2.6	.90	1.3	WVOC-31
w203819	1.8	.80	1.3	WVOC-51
w203817	6.7	2.2	1.1	WVOC-49
w203820	3.0	1.0	1.1	WVOC-16
w203828	9.3	4.1	3.0	WVOC-17
w203829	11	6.2	3.8	WVOC-19
w203818	2.3	1.3	1.0	WVOC-50
w203831	4.5	1.7	1.4	WVOC-66
w203810	2.8	5.2	1.0	WVOC-13
w203830	2.0	.90	1.0	WVOC-12
w203824	7.4	3.7	2.2	WVOC-24
w203815	1.6	.40	.7	WVOC-1
w203825	2.3	.80	.8	WVOC-27
w203826	7.2	2.6	2.3	WVOC-28
w203823	4.6	1.3	1.2	WVOC-32
w203822	2.2	1.6	4.8	WVOC-45
w203812	12	4.0	3.1	WVOC-47
w203813	2.0	.70	1.6	WVOC-46

Table 5c.--Major-, minor-, and trace-element concentration of 22 bituminous coal samples from Otter Creek Wilderness and vicinity, Randolph and Tucker Counties, W. Va., reported on whole-coal basis.

[22 values are from direct determinations on whole coal; all other values calculated from analyses of ash. S means analysis by emission spectography; L, less than the value shown.]

Anal. ident. no.	Si (percent)	Al (percent)	Ca (percent)	Mg (percent)	Na (percent)	K (percent)	Fe (percent)	Ti (percent)	Ag-S (ppm)	As (ppm)	Field ident. no.
w203816	5.3	4.2	0.11	0.095	0.031	0.47	1.7	0.23	0.02L	19	WVOC-21
w203811	1.1	.90	.11	.022	.010	.081	.44	.044	.02	13	WVOC-7
w203821	1.3	1.0	.12	.026	.010	.10	.55	.055	.06	10	WVOC-8
w203814	3.2	2.3	.27	.083	.029	.52	2.3	.081	.07	44	WVOC-29
w203827	2.5	1.5	.20	.073	.020	.24	.99	.092	.04	36	WVOC-31
w203819	2.3	1.3	.17	.052	.030	.28	1.5	.049	.03	10	WVOC-51
w203817	5.0	3.6	.17	.081	.041	.33	4.0	.15	.08	42	WVOC-49
w203820	2.9	2.1	.14	.064	.020	.20	.34	.096	.04	2.0	WVOC-16
w203828	6.0	4.4	.13	.17	.060	1.1	1.8	.18	.08	33	WVOC-17
w203829	8.3	5.2	.12	.19	.070	1.4	1.4	.20	.13	33	WVOC-19
w203818	2.5	1.4	.14	.051	.020	.35	.78	.10	.04	25	WVOC-50
w203831	3.6	2.8	.30	.12	.020	.33	1.6	.11	.02	4.0	WVOC-66
w203810	.95	.73	.57	.089	.010	.059	1.5	.032	.03	2.0	WVOC-13
w203830	2.3	1.5	.22	.045	.010	.16	.41	.071	.02	1.0	WVOC-12
w203824	6.0	4.7	.31	.22	.031	.76	1.1	.20	.17	17	WVOC-24
w203815	1.9	1.2	.18	.056	.020	.18	.33	.050	.01	1.0	WVOC-1
w203825	1.6	1.3	.18	.083	.030	.16	.41	.055	.02	2.0	WVOC-27
w203826	6.6	4.8	.098	.12	.041	.56	2.8	.18	.15	8.0	WVOC-28
w203823	1.4	1.5	.25	.074	.020	.20	.27	.078	.09	4.0	WVOC-32
w203822	2.3	1.7	.42	.11	.030	.18	.74	.062	.07	7.0	WVOC-45
w203812	14	7.5	.21	.28	.12	1.9	1.1	.34	.05L	2.0	WVOC-47
w203813	1.7	1.8	.13	.021	.010	.036	.21	.020	.03	1.0	WVOC-46

Table 5c.--Major-, minor-, and trace-element concentration of 22 bituminous coal samples from Otter Creek Wilderness and vicinity, Randolph and Tucker Counties, W. Va., reported on whole-coal basis--continued

Anal. ident. no.	B-S (ppm)	Ba-S (ppm)	Be-S (ppm)	Cd (ppm)	Ce (ppm)	Cl (ppm)	Co (ppm)	Cr (ppm)	Cs (ppm)	Cu (ppm)	Field ident. no.
w203816	18	83	3.2	0.21	34	480	9.4	37	1.6	19	WVOC-21
w203811	4.8	34	2.0	.13	11	240	2.9	9.3	.3	8.0	WVOC-7
w203821	5.1	41	2.1	.12	11	280	3.3	11	.6	7.8	WVOC-8
w203814	14	170	4.0	.73	33	150	12	23	2.0	24	WVOC-29
w203827	6.4	110	4.0	.42	25	350	4.1	19	1.2	22	WVOC-31
w203819	7.4	59	3.4	.15	13	840	3.6	13	1.0	15	WVOC-51
w203817	5.0	97	6.0	.11	28	650	14	33	2.1	37	WVOC-49
w203820	8.9	65	2.7	.11	26	800	17	20	1.0	17	WVOC-16
w203828	25	210	5.3	.24	61	150	3.8	44	4.7	61	WVOC-17
w203829	33	170	8.1	.08	63	310	7.6	46	4.8	130	WVOC-19
w203818	7.8	110	5.2	.03	13	840	2.1	20	1.3	18	WVOC-50
w203831	8.1	220	2.9	.18	36	290	18	25	1.8	24	WVOC-66
w203810	1.4	120	1.7	.26	24	230	8.8	17	.6	57	WVOC-13
w203830	6.3	56	2.5	.30	16	400	14	16	.8	17	WVOC-12
w203824	19	250	2.8	1.1	54	90	5.3	41	3.9	66	WVOC-24
w203815	8.1	50	1.8	.10	15	700	8.6	12	.6	10	WVOC-1
w203825	10	81	1.7	.43	19	750	5.7	14	1.2	15	WVOC-27
w203826	13	91	4.0	.37	45	260	31	52	4.2	55	WVOC-28
w203823	5.8	160	2.8	.49	29	200	7.6	20	1.5	28	WVOC-32
w203822	4.1	350	13	1.2	34	300	13	26	1.0	49	WVOC-45
w203812	39	300	6.1	.12	74	120	17	63	7.6	47	WVOC-47
w203813	4.1	130	6.1	.34	54	610	13	12	.3L	17	WVOC-46

Table 5c.--Major-, minor-, and trace-element concentration of 22 bituminous coal samples from Otter Creek Wilderness and vicinity, Randolph and Tucker Counties, W. Va., reported on whole-coal basis--continued

Anal. ident. no.	Dy-S (ppm)	Er-S (ppm)	Eu (ppm)	F (ppm)	Ga-S (ppm)	Gd-S (ppm)	Ge-S (ppm)	Hf (ppm)	Hg (ppm)	Ho-S (ppm)	Field ident. no.
w203816	5.3L	3.2	0.68	99	16	3.6	5.6	1.9	0.36	1.7L	WVOC-21
w203811	1.5	.6L	.28	59	4.3	.86L	1.7	.4	.24	.40L	WVOC-7
w203821	1.4L	.7L	.27	60	5.0	1.3	2.5	.5	.12	.98L	WVOC-8
w203814	5.4	2.8	.95	11	11	4.7	1.7	1.1	.29	1.6	WVOC-29
w203827	2.6L	2.2	.78	63	11	3.9	4.6	.9	.22	1.8L	WVOC-31
w203819	2.4L	1.2	.35	91	6.7	1.9	1.1	.5	.10	.77L	WVOC-51
w203817	5.8L	2.6L	.49	54	12	3.9L	3.2	1.3	1.0	1.8L	WVOC-49
w203820	2.7L	1.5	.49	99	11	2.2	4.8	.7	.020	.86L	WVOC-16
w203828	6.1L	2.8L	1.2	230	13	4.2L	.55L	1.5	.22	1.9L	WVOC-17
w203829	7.4L	4.4	1.1	290	18	5.7	11	1.8	.18	2.4L	WVOC-19
w203818	2.5L	1.1L	.34	75	11	1.8	5.7	.7	.64	.78L	WVOC-50
w203831	4.3	1.8L	.75	99	10	4.0	7.1	.8	.030	1.3L	WVOC-66
w203810	2.5	.8L	.63	67	8.9	3.2	2.0	.5	.080	1.2L	WVOC-13
w203830	3.2	1.0L	.41	39	8.3	2.4	5.1	.5	.050	.69L	WVOC-12
w203824	6.1L	3.3	1.1	150	17	5.0	1.7	1.5	.20	1.9L	WVOC-24
w203815	1.8L	.8L	.31	11	4.5	1.3	2.1	.5	.060	.59L	WVOC-1
w203825	2.8	1.4	.46	91	3.7	2.3	.25	.6	.010L	.66	WVOC-27
w203826	9.2	3.1	.76	130	22	4.6	3.7	1.8	.090	2.1	WVOC-28
w203823	1.8L	1.4	.55	51	6.2	2.5	.65	.9	.030	1.2L	WVOC-32
w203822	8.3	1.1L	3.0	99	8.3	11	4.6	.6	.060	7.6L	WVOC-45
w203812	11L	5.1L	1.3	360	29	7.6L	1.5	3.0	.030	3.6L	WVOC-47
w203813	3.6	2.3	.93	95	6.0	4.2	.76	.4	.060	.92	WVOC-46

Table 5c.--Major-, minor-, and trace-element concentration of 22 bituminous coal samples from Otter Creek Wilderness and vicinity, Randolph and Tucker Counties, W. Va., reported on whole-coal basis--continued

Anal. ident. no.	La (ppm)	Li (ppm)	Lu (ppm)	Mn (ppm)	Mo-S (ppm)	Nb-S (ppm)	Nd-S (ppm)	Ni-S (ppm)	P (ppm)	Pb (ppm)	Field ident. no.
w203816	18	53	0.2	61	11	8.0	24	24	29	14	WVOC-21
w203811	5	4.2	.1	14	1.3	.74	2.6L	5.7	1L	3.1	WVOC-7
w203821	6	7.8	.1	14	1.4	1.5	4.4	7.8	1L	4.2	WVOC-8
w203814	21	7.6	.3	21	5.4	5.2	24	24	22	11	WVOC-29
w203827	16	13	.2	25	2.6	4.6	25	39	4	7.6	WVOC-31
w203819	6	9.0	.2	12	3.0	1.5	11	9.6	2L	7.4	WVOC-51
w203817	15	82	.2	110	5.5	4.5	18	32	43	17	WVOC-49
w203820	14	15	.2	49	3.0	3.2	16	33	9	8.4	WVOC-16
w203828	44	28	.5	42	2.5	1.9	17	15	44	25	WVOC-17
w203829	35	40	.6	21	5.1	8.1	44	37	29	40	WVOC-19
w203818	7	13	.2	16	6.2	2.8	11	7.4	2L	13	WVOC-50
w203831	22	40	.2	520	5.2	3.8	27	52	56	12	WVOC-66
w203810	10	4.1	.2	81	1.9	.89	13	21	3	23	WVOC-13
w203830	8	18	.2	190	3.2	5.0	15	33	3	7.2	WVOC-12
w203824	31	77	.3	27	9.9	7.4	41	110	32	30	WVOC-24
w203815	9	9.2	.1	100	4.0	1.3	7.4	22	2	4.9	WVOC-1
w203825	11	8.0	.1	17	5.3	2.3	11	46	4	5.8	WVOC-27
w203826	26	79	.3	31	5.2	5.5	27	67	20	19	WVOC-28
w203823	18	7.6	.2	14	4.4	2.5	15	47	6	22	WVOC-32
w203822	23	12	.8	320	3.8	1.9	44	280	10	9.7	WVOC-45
w203812	41	61	.5	120	1.0	10	47	56	33	31	WVOC-47
w203813	36	10	.2	15	5.5	1.2	22	29	52	7.1	WVOC-46

Table 5c.--Major-, minor-, and trace-element concentration of 22 bituminous coal samples from Otter Creek Wilderness and vicinity, Randolph and Tucker Counties, W. Va., reported on whole-coal basis--continued

Anal. ident. no.	Pr-S (ppm)	Rb (ppm)	Sb (ppm)	Sc (ppm)	Se (ppm)	Sm (ppm)	Sn-S (ppm)	Sr-S (ppm)	Tb (ppm)	Th (ppm)	Field ident. no.
w203816	17L	21	0.90	7.8	6.3	3.1	0.49L	75	0.9	6.0	WVOC-21
w203811	3.9L	20L	.40	3.5	3.7	1.2	.11L	55	.3	1.4	WVOC-7
w203821	9.8L	10	.20	3.7	1.9	1.2	.13L	64	.3	2.0	WVOC-8
w203814	26L	40L	1.6	6.8	2.4	4.3	.35L	120	.9	4.2	WVOC-29
w203827	18L	17	.90	4.3	1.3	3.6	.24L	86	.7	2.6	WVOC-31
w203819	7.5L	30L	.80	4.3	3.6	1.5	.22L	100	.4	1.8	WVOC-51
w203817	18L	40L	1.8	8.2	5.9	2.2	.53L	110	.6	6.7	WVOC-49
w203820	8.4L	30L	1.3	5.1	1.0L	2.2	.62	89	.4	3.0	WVOC-16
w203828	19L	64	3.6	11	2.1	5.6	.55L	120	1	9.3	WVOC-17
w203829	23L	84	9.8	15	2.1	5.5	1.0	110	1	11	WVOC-19
w203818	7.6L	30L	2.3	4.2	5.0	1.4	.22L	99	.4	2.3	WVOC-50
w203831	27L	22	2.1	6.7	1.0L	3.7	.36L	170	.7	4.5	WVOC-66
w203810	8.1	20L	.80	6.8	1.0L	3.2	.16L	69	.6	2.8	WVOC-13
w203830	6.7L	20L	2.6	4.1	1.0	1.8	.30	97	.4	2.0	WVOC-12
w203824	19L	47	2.4	11	1.1	5.1	.83	140	1	7.4	WVOC-24
w203815	5.7L	25L	.80	2.6	1.5	1.4	.17	100	.3	1.6	WVOC-1
w203825	5.6L	30L	.70	3.3	9.0L	2.2	.17L	160	.5	2.3	WVOC-27
w203826	21L	36	2.2	13	20L	3.8	.61L	98	.7	7.2	WVOC-28
w203823	12L	30L	1.1	4.9	9.0L	2.6	.49	120	.4	4.6	WVOC-32
w203822	17L	14	1.4	7.9	2.0L	12	.22L	91	3	2.2	WVOC-45
w203812	35L	88	2.1	15	20L	6.6	3.6	120	.9	12	WVOC-47
w203813	9.2	30L	.70	5.3	2.5	4.1	.67	280	1	2.0	WVOC-46

Table 5c.--Major-, minor-, and trace-element concentration of 22 bituminous coal samples from Otter Creek Wilderness and vicinity, Randolph and Tucker Counties, W. Va., reported on whole-coal basis--continued

Anal. ident. no.	Tl-S (ppm)	Tm-S (ppm)	U (ppm)	V-S (ppm)	Y-S (ppm)	Yb (ppm)	Zn (ppm)	Zr-S (ppm)	Field ident. no.
w203816	0.73L	1.2L	1.9	56	21	1.6	34	73	WVOC-21
w203811	.17L	.29L	.80	15	5.4	.8	10	8.0	WVOC-7
w203821	.20L	.33L	1.1	25	8.5	.8	13	12	WVOC-8
w203814	.52L	.87L	1.8	33	22	2.1	52	62	WVOC-29
w203827	.35L	.59L	.90	24	18	1.3	28	59	WVOC-31
w203819	.33L	.55L	.80	26	14	1.3	42	18	WVOC-51
w203817	.79L	1.3L	2.2	55	15	1.1	21	63	WVOC-49
w203820	.37L	.62L	1.0	38	15	1.1	12	33	WVOC-16
w203828	.83L	1.4L	4.1	55	16	3.0	44	23	WVOC-17
w203829	2.0	1.7L	6.2	160	44	3.8	20	120	WVOC-19
w203818	5.0	.56L	1.3	44	12	1.0	16	26	WVOC-50
w203831	.54L	.91L	1.7	45	17	1.4	34	34	WVOC-66
w203810	.24L	.41L	5.2	11	9.7	1.0	13	14	WVOC-13
w203830	.30L	.50L	.90	21	17	1.0	26	50	WVOC-12
w203824	1.4	1.4L	3.7	110	33	2.2	93	99	WVOC-24
w203815	.25L	.42L	.40	19	8.4	.7	15	14	WVOC-1
w203825	.25L	.42L	.80	27	11	.8	25	30	WVOC-27
w203826	.92L	1.5L	2.6	100	25	2.3	58	64	WVOC-28
w203823	.24L	.41L	1.3	36	12	1.2	45	21	WVOC-32
w203822	.34L	.90	1.6	17	40	4.8	150	21	WVOC-45
w203812	1.5L	2.5L	4.0	110	35	3.1	61	97	WVOC-47
w203813	.25L	.42	.70	28	29	1.6	18	22	WVOC-46

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