UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

Analysis of Ten Coal Samples from the Michigan Basin

by

Charles L. Oman

Robert B. Finkelman

Ronald T. Talley

U. S. Geological Survey Open-File Report 92-180

1992

INTRODUCTION

This report presents geologic, chemical, physical, and mineralogical data for ten coal samples from the Michigan Coal Basin. The data are from the U. S. Geological Survey's National Coal Resources Data System (NCRDS) which contains information on the stratigraphic occurrence and physical and chemical characteristics of coal samples from all major U. S. coal basins.

Sample locations are indicated in figure 1. Seven (all the samples with a "W" prefix) of the ten samples are grab samples and may not be representative of the deposit from which they were collected. Two specimens from the Uncle Henry No. 2 mine had distinctly different appearances and were analyzed as separate samples. They are identified in this report as W248058 and W248059. Samples W248054, W248056, W248057, W248058 and W248059 were collected in the 1920's; sample W248055 was collected in 1963 and sample W248053 in 1987.

Information on sample locations and some sample descriptions are in table 1. Table 2 contains the ultimate and proximate analyses, heat content, forms of sulfur, free-swelling index, and ash-fusion temperatures. Data on major- and minor- oxide concentrations are in table 3, and data on trace-element contents are in table 4. Semiquantitative, bulk X-ray mineralogical data are in table 5.

Information on analytical techniques cited in figure 2 can be found in Golightly and Simon (1989). In addition to this standard analytical scheme, X-ray mineralogy was determined on the low-temperature ash of seven of the samples. Furthermore, polished

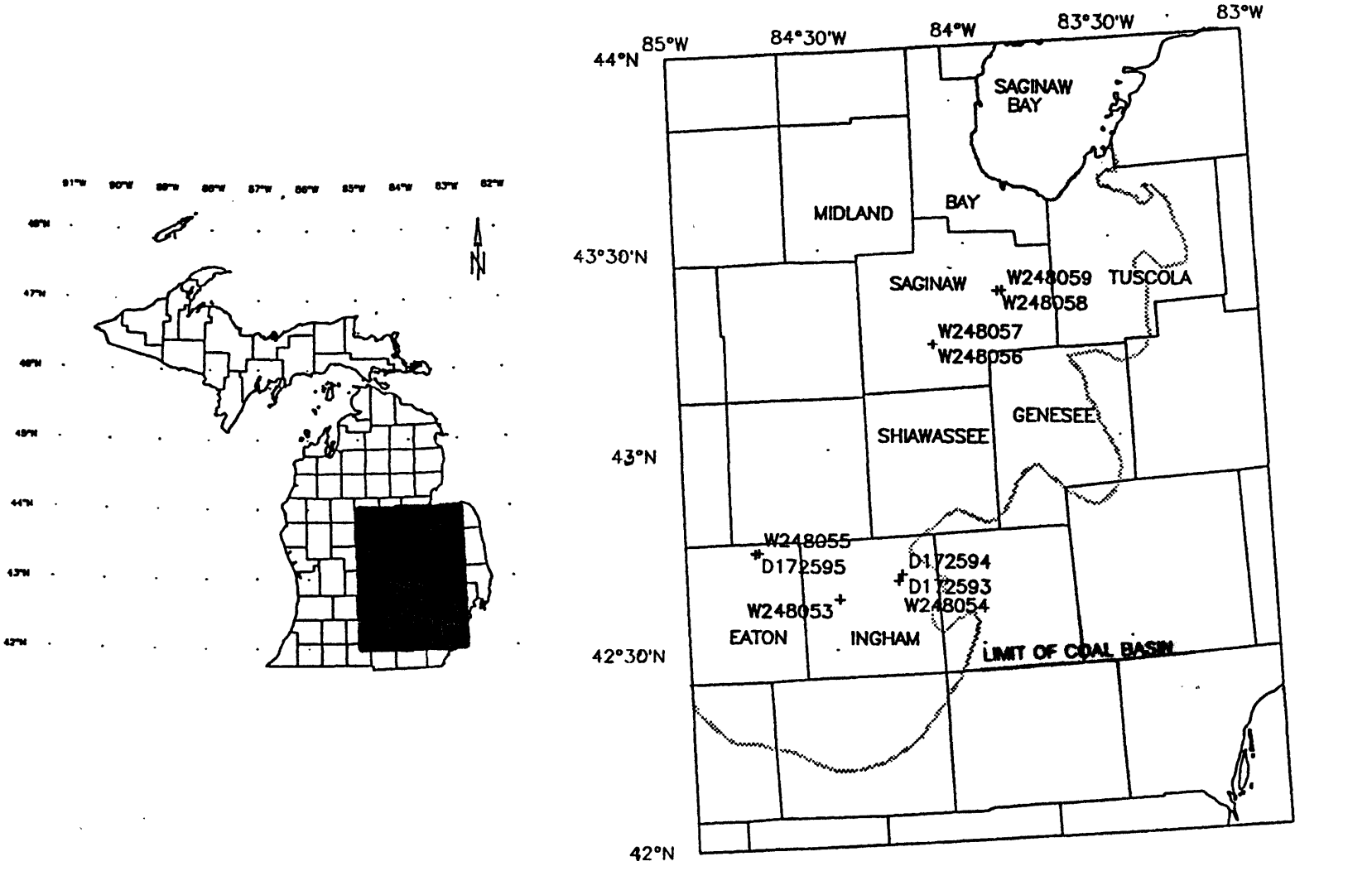

Figure 1.——Location of coal samples from the State of Michigan, described in this report.

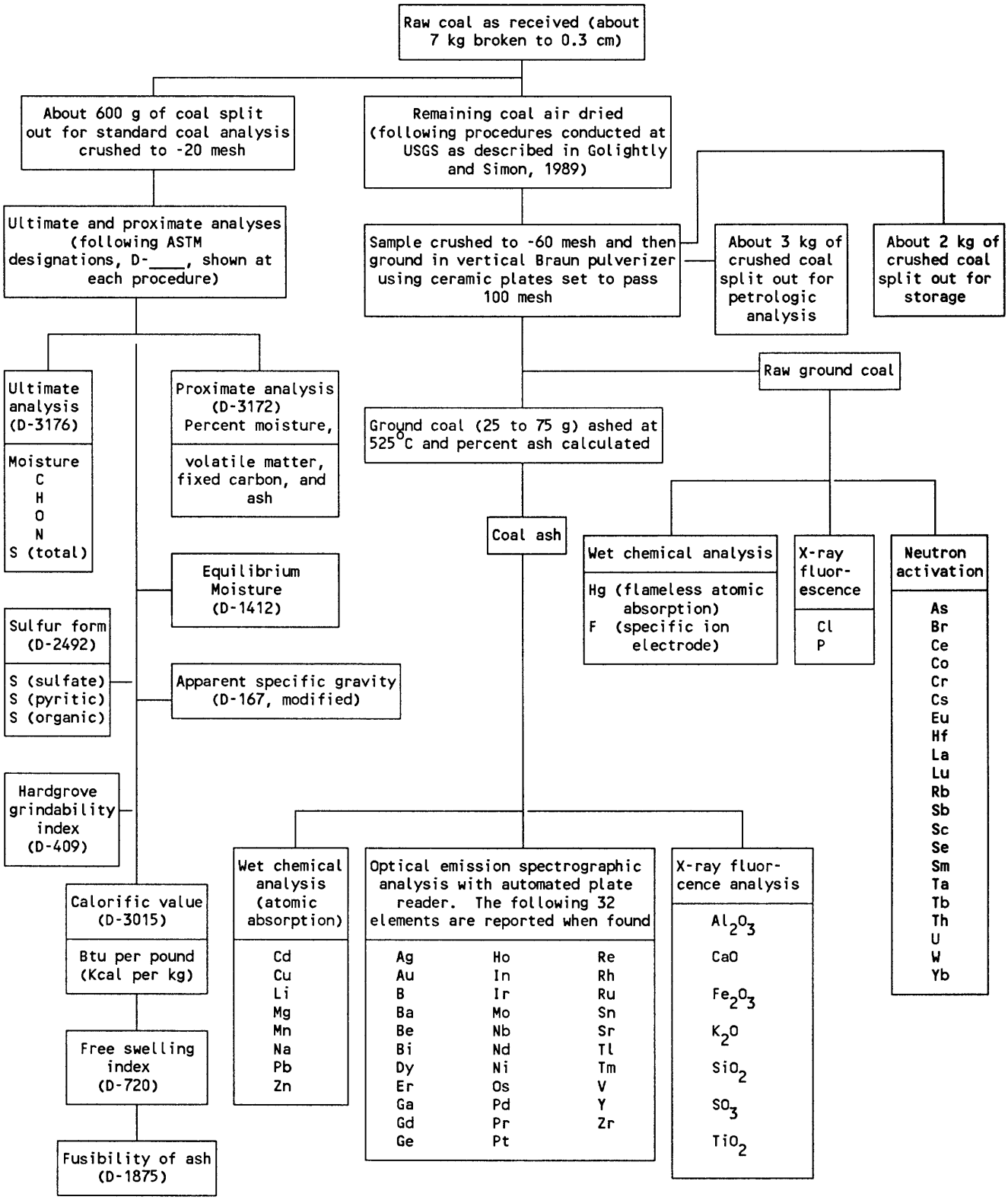

Figure 2. Flow diagram of procedures used by USGS for the analysis of coal samples. (ASTM-American Society for Testing and Materials)

blocks of coal were examined in a scanning electron microscope (SEM) with an energy dispersive X-ray detector (EXD).

RESULTS

The low moisture contents (table 2) of the seven grab samples may reflect a long storage period prior to analysis. The moisture contents of the other three samples (D172593, D172594, and D172595) are closer to the inherent moisture content. Oxidation of the seven "W" grab samples is indicated by the high sulfate/pyrite ratios ranging from 0.3 to 30 vs 0.04 to 0.1 for the "D" samples, which are presumed to be less oxidized. The low FSI's (0-1.0) of the "W" samples are a good indication of oxidation (Gray and Lowenhaupt, 1989).

All of the grab samples have high bromine contents (95 ppm or higher) compared to an arithmetic average of 17 ppm for U. S. coal (NCRDS, unpublished data). The reason for these high Br values in the Michigan coal samples is not known. There is no correlation between Br and chlorine: four samples have Cl values of 1300 ppm or greater, three others have less than 100 ppm.

Chemical analyses of only ten coal samples are insufficient to draw any firm conclusions regarding regional coal quality. Moreover, most of the samples in this study may not be representative of the coal bed from which they came. However, certain elements appear to be present at levels in excess of the national average (NCRDS, unpublished data). These include silver (national average of <0.1 ppm), cobalt (6.1), germanium (5.7), nickel (14), lead (11), and antimony (1.2). All of these elements have chalcophile

tendencies and may reflect the high sulfur content of these coals (0.7 to 3.81 weight percent on a dry basis).

The analytical data for the two splits from the Uncle Henry No. 2 mine (samples W248058 and W248059) are quite different. Sample W248059 has considerably higher sulfur (sulfate and pyritic) contents, whereas sample W248058 has higher contents of some chalcophile elements (Fe, Ag, As, Se, Tl), and lower contents of many other elements (Si, Al, K, Ti, B, Ba, Cs, Cu, F, Hf, Hg, La, Li, Mn, Nb, P, Ta, Th, and V). These differences are also reflected in the mineralogy (table 5).

Bulk X-ray mineralogy of the low-temperature ash indicates the presence of quartz, illite, kaolinite, and pyrite in most samples (table 5). Small amounts of feldspar, carbonates, chlorite, marcasite, apatite, anatse, rutile and analcime were detected in several samples. Kaolinite was the only phase that could be identified from the X-ray pattern for sample W248055.

The SEM-EDX analyses of polished blocks were consistent with the samples' bulk X-ray mineralogy and chemistry. For example, manganese-bearing "siderite" (mineral names in quotes denote identifications based solely on major element chemistry) and "barite" were observed in sample W248054, which has high Mn and Ba contents. "Chalcopyrite" and "apatite" were observed in sample W248058, which has high copper and fluorine. Among the phases observed were "chalcocite" (sample W248053), "florencite" (W248055), and "galena" (W248057).

The coal rank is high-volitile B and C bituminous. As-received Btu/lb ranges from 10,500 to 12,300, moisture is reported to be 8 to 13 wt percent, ash yield 3 to 9 wt percent, and sulfur 1 to 3 wt percent (Cohee and others, 1950). Kalliokoski (1976) presents analyses for about 40 Michigan coal samples.

Michigan Coal Basin Geology

Most of the information in this section was obtained from Cohee and others (1950) and from Kalliokoski (1976). For detailed discussions of the geology of the Michigan coal basin the reader is referred to these papers and those of Dorr and Eschram (1970), and Wanless and Shideler (1975).

Coal was discovered in Michigan in 1835. Initial coal production was from small mines until shaft mining began in Bay and Saginaw Counties in 1897. Production peaked in 1907 with slightly more than 2 million short tons. Production then dropped steadily until the early 1950s. Since that time, the only commercial mining in Michigan occurred in 1974-1975 when one small surface mine produced 20,000 tons near Williamstown, in Ingham Co. (U. S. Bureau of Mines, 1976).

The coal-bearing rocks in Michigan cover approximately 11,500 square miles in the central part of the state (figure 2), with the Lower Pennsylvanian Saginaw Formation containing all of the coal beds. Based on examination of available drill logs, Kalliokoski (1976) concluded that coal occurrences in Michigan are primarily restricted to the following counties: Midland, Bay, Saginaw,

Tuscola, Shiawassee, and Genesse, although coal does occur in several other counties.

Cohee and others (1950), report as many as 14 coal beds in Bay and adjoining counties. However, the discontinuous nature of these coal beds makes it difficult to estimates the number of coal beds in the state. Cohee and others (1950, p. 2), describe the coals in Michigan as occurring "... sporadically in isolated beds that vary greatly in thickness, and generally pinch out within relatively short distances." Cross (1987), cited these characteristics as the primary factors limiting economic development of Michigan Basin coals. He notes that the coal beds are generally discontinuous, less than one meter thick, with small areal extent and variable partings.

Cohee and others (1950) estimate that the basin contains 220 million tons of total resources. Kalliokoski (1976) calculated total resources to be about 211 million tons.

ACKNOWLEDGMENTS

Aureol T. Cross of Michigan State University provided all of the "W" samples. Frank Dulong of the U. S. Geological Survey provided the semiquantitative X-ray analyses.

REFERENCES

Cohee, G. V., Burnes, R. N., Brown, A., Brandt, R. A., and Wright, D., 1950, Coal resources of Michigan: U. S. Geological Survey Circular 77, 56 p.

Cross, A. T., 1987, Michigan Basin coals: factors limiting economic development and priorities for exploration program: GSA Abstracts with Program, v. 19, no. 7, p. 631.

Dorr J. A. Jr. and Eschman, D. F., 1970, Geology of Michigan: The University of Michigan, Ann Arbor Press, 127-135 p.

Golightly, D. W. and Simon, F. O., Eds., 1989, Methods for sampling and inorganic analysis of coal: U. S. Geological Survey Bulletin 1823, 72 p.

Gray, R.J. and Lowenhaupt, D.E., 1989, Aging and weathering, In Sample selection, aging and reactivity of coal. R. Klein and R. Wellek, eds. J. Wiley and Sons, New York, ch. 6., p. 255-334.

Kalliokoski, J., 1976, Magnitude and quality of Michigan's coal reserves: U. S. Bureau of Mines Open-File Report 102-76, 33 p.

Wanless, H. R. and Shideler, G. L., 1975, Michigan basin region. **In** Paleotechtonic investigations of the Pennsylvanian System in the United States, E. D. McKee and E. J. Crosby, coordinators: U. S. Geological Survey Professional. Paper 853, Pt. I, Introduction and regional analysis of the Pennsylvanian system, p. 63-70.

U. S. Bureau of Mines, 1976, Minerals Yearbook, Volume II, Area Reports: Domestic, p. 377-378.

Table 1.--Descriptions and locations for 10 bituminous coal samples from the state of Michigan.

USGS Lab No.	Latitude	Longitude	Quadrangle Map Name	County	Sample Thickness (inches)	Sample Thickness (centimeters)	Type of Sample	Part of Bed Represented
D172593	424053N	841614W	Williamson (7.5′)	Ingham	42.0	106.7	Surface mine	Full Thickness
D172594	424056N	841614W	Williamson (7.5′)	Ingham	42.0	106.7	Surface mine	Full Thickness
D172595	424456N	844546W	Charlotte (15′)	Eaton	24.0	60.9	Surface mine	Full Thickness
W248053	423736N	842900W	East Lansing (7.5′)	Ingham			Breslin Sports Area	Grab
W248054	424000N	841700W	Williamson (7.5′)	Ingham			Surface mine	Grab
W248055	424500N	844500W	Wacousta (7.5′)	Eaton			Grand Ledge Clay Products	Grab
W248056	431500N	840730W	Alicia (7.5′)	Saginaw			Big Chief Mine	Grab
W248057	431500N	840730W	Alicia (7.5′)	Saginaw			Henry Gage Coal Co.	Grab
W248058	432230N	835330W	Saginaw (7.5′)	Saginaw			Uncle Henry No. 2 Mine	Grab
W248059	432230N	835230W	Saginaw (7.5′)	Saginaw			Uncle Henry No. 2 Mine	Grab

Table 2.--Proximate and ultimate analyses, heat content, forms of sulfur, free-swelling index, and ash-fusion temperature determinations for 10 bituminous coal samples from the state of Michigan.

[All analyses except heat contents, free-swelling indexes 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 Analysis Section, Department of Energy, Pittsburgh, Pa. and a commercial testing laboratory following ASTM standards. G for ash-fusion temperatures means greater than; B not determined. Lab number is the USGS laboratory number. The U.S.G.S. makes no claims as to the accuracy of rank calculated from these parameters.]

	PROXIMATE ANALYSIS				ULTIMATE ANALYSIS					HEAT CONTENT		
Sample Number	Moisture	Volatile Matter	Fixed Carbon	Ash	Hydrogen	Carbon	Nitrogen	Oxygen	Sulfur	KCal/KG	Btu/lb	Lab Number
D172593	13.3	36.3	48.7	1.7	6.1	69.5	1.5	20.2	1.0	6,890	12,410	D172593
	---	41.9	56.1	2.0	5.3	80.2	1.7	9.6	1.2	7,960	14,320	
	---	42.8	57.2	---	5.4	81.8	1.7	9.9	1.2	8,120	14,610	
D172594	10.3	36.1	51.0	2.6	5.8	70.0	1.4	19.0	1.2	7,120	12,630	D172594
	---	40.2	56.9	2.9	5.2	78.1	1.6	10.8	1.4	7,820	14,070	
	---	41.4	58.6	---	5.4	80.3	1.6	11.3	1.4	8,050	14,490	
D172595	18.6	33.3	42.3	5.8	6.1	59.8	1.1	25.8	1.4	5,930	10,660	D172595
	---	40.9	52.0	7.1	4.9	73.5	1.3	11.5	1.7	7,280	13,100	
	---	44.0	56.0	---	5.3	79.2	1.4	12.2	1.9	7,830	14,100	
W248053	2.61	37.75	50.53	9.11	4.97	69.82	1.18	11.19	3.7	6,990	12,589	W248053
	---	38.76	51.89	9.35	4.80	71.69	1.21	9.12	3.81	7,180	12,926	
	---	42.76	57.24	---	5.30	79.08	1.34	10.07	4.21	7,920	14,260	
W248054	2.77	23.28	27.84	46.11	3.05	36.94	.71	11.48	1.69	3,450	6,207	W248054
	---	23.94	28.64	47.42	2.82	37.99	.73	9.28	1.74	3,550	6,384	
	---	45.54	54.46	---	5.37	72.27	1.39	17.66	3.31	6,750	12,142	
W248055	4.85	38.63	53.99	2.53	5.40	71.27	1.49	17.99	1.30	6,900	12,420	W248055
	---	40.60	56.74	2.66	5.10	74.90	1.57	14.38	1.37	7,250	13,053	
	---	41.71	58.29	---	5.24	76.95	1.62	14.78	1.41	7,450	13,410	
W248056	1.98	51.96	38.57	7.49	7.02	73.76	1.25	9.01	1.29	7,740	13,926	W248056
	---	53.01	39.35	7.64	6.94	75.25	1.28	7.39	1.32	7,890	14,207	
	---	57.40	42.60	---	7.53	81.63	1.39	8.02	1.43	8,550	15,383	
W248057	4.06	32.90	58.34	4.7	4.81	72.67	1.50	15.12	.67	6,900	12,423	W248057
	---	34.29	60.81	4.9	4.54	75.75	1.56	12.00	.70	7,190	12,949	
	---	36.06	63.94	---	4.80	80.12	1.65	12.69	.74	7,560	13,616	
W248058	4.40	31.17	55.91	8.52	4.49	67.98	1.42	16.13	.95	6,370	11,461	W248058
	---	32.60	58.49	8.91	4.18	71.11	1.49	12.79	.99	6,660	11,988	
	---	35.79	64.21	---	4.62	78.52	1.65	14.12	1.09	7,310	13,161	
W248059	3.28	40.52	52.04	4.16	5.65	72.65	1.26	14.27	1.62	7,200	12,964	W248059
	---	41.89	53.81	4.30	5.46	75.11	1.30	11.76	1.67	7,450	13,404	
	---	43.78	56.22	---	5.73	78.81	1.36	12.34	1.75	7,780	14,006	

Table 2.--(Continued)

Sample Number	Air-dried Loss	FORMS OF SULFUR			Free-swelling index	ASH-FUSION TEMPERATURE, °C			Lab Number
		Sulfate	Pyritic	Organic		Initial deformation	Softening	Fluid	
D172593	4.7	0.03	0.66	0.36	B	B	B	B	D172593
	---	.03	.76	.42					
	---	.03	.77	.43					
D172594	3.12	.05	.77	.42	B	B	B	B	D172594
	---	.05	.85	.46					
	---	.06	.88	.48					
D172595	15.95	.08	.99	.34	B	B	B	B	D172595
	---	.12	1.22	.41					
	---	.11	1.31	.44					
W248053	B	.45	1.63	1.63	0.5	1,060	1,080	1,100	W248053
	---	.46	1.67	1.68					
	---	.51	1.85	1.84					
W248054	B	.54	.81	.34	0.0	1,310	1,340	1,370	W248054
	---	.56	.83	.35					
	---	1.06	1.58	.67					
W248055	B	.86	.03	.41	0.0	1,060	1,070	1,090	W248055
	---	.90	.03	.44					
	---	.93	.03	.44					
W248056	B	.34	.25	.70	1.0	1,260	1,300	1,360	W240856
	---	.35	.26	.71					
	---	.38	.28	.76					
W248057	B	.05	.02	.60	0.0	1,480G	1,480G	1,480G	W248057
	---	.05	.02	.63					
	---	.05	.02	.66					
W248058	B	.07	.10	.78	0.0	1,480G	1,480G	1,480G	W248058
	---	.07	.10	.82					
	---	.08	.11	.90					
W248059	B	.36	.49	.77	0.5	1,080	1,110	1,130	W248059
	---	.37	.51	.79					
	---	.39	.53	.83					

Table 3.--Major- and minor-oxide concentrations in the laboratory ash of 10 bituminous coal samples from the State of Michigan.

[Concentrations in percent. Coal ashed at 525°C. L means less than the concentration shown. Sample number is the USGS laboratory number.]

Sample Number	Ash	SiO_2	Al_2O_3	CaO	MgO	Na_2O	K_2O	Fe_2O_3	TiO_2	P_2O_5	SO_3	Sample Number
D172593	2.1	25	19	1.7	0.73	0.12	0.78	37	0.76	0.10L	2.0	D172593
D172594	2.6	33	20	1.5	.73	.11	1.2	33	.73	.10	1.7	D172594
D172595	6.0	29	15	4.7	1.26	.24	1.3	31	.72	.13	7.2	D172595
W248053	9.1	42	19	.87	.28	.11	.64	34	1.0	.06	1.5	W248053
W248054	47.1	57	24	.36	1.2	.16	3.5	12	1.3	.13	1.5	W248054
W248055	2.4	25	14	3.4	1.1	.76	.60	44	1.3	.18	6.9	W248055
W248056	7.4	50	25	1.4	.75	.68	3.4	11	1.3	1.0	3.1	W248056
W248057	4.5	46	36	2.9	1.3	1.8	3.1	2.4	1.2	.11	5.0	W248057
W248058	8.5	51	33	2.9	1.1	1.2	3.3	4.0	1.3	.26	2.9	W248058
W248059	4.2	38	23	3.1	.18	.32	1.4	25	.71	.21	5.3	W248059

Table 4.--Major-, minor-, and trace-element composition of 10 bituminous coal samples from the state of Michigan, reported on a whole-coal basis.

[Concentrations in percent or parts-per-million. L means less than the value shown; B, not determined; H, interference for an element which cannot be resolved by any routine method; S, after element title indicates determinations by automatic plate reading computer assisted, emission spectrographic analyses. For elements by emission spectrographic analysis, the standard deviation of any answer should be taken as plus 50% and minus 35%. Sample number is USGS laboratory number.]

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
D172593	0.25	0.21	0.025	0.048	0.035	0.014	0.54	0.0095	0.042	5.0	D172593
D172594	.40	.28	.028	.049	.043	.026	.60	.011	.039	8.0	D172594
D172595	.81	.48	.20	.060	.065	.065	1.3	.026	.18	40	D172595
W248053	1.8	.91	.057	.029	.046	.048	2.2	.054	.15	3.8	W248053
W248054	12	6.0	.12	.013	.058	1.4	4.0	.34	.047L	11	W248054
W248055	.28	.18	.053	.019	.048	.037	.74	.019	B	11	W248055
W248056	1.7	.98	.058	.26	.10	.21	.57	.058	.15	12	W248056
W248057	.99	.86	.093	.086	.064	.12	.076	.032	.02	.50L	W248057
W248058	2.0	1.5	.18	.026	.012	.23	.24	.066	.094	2.2	W248058
W248059	.75	.51	.093	.022	.013	.038	.73	.018	.23	21	W248059

Table 4.--(Continued)

Sample Number	B-S (ppm)	Ba-S (ppm)	Be-S (ppm)	Br (ppm)	Cd (ppm)	Ce (ppm)	Cl (ppm)	Co (ppm)	Cr (ppm)	Cs (ppm)	Sample Number
D172593	63	4.2	2.1	B	0.02L	6.3	B	11	3.2	B	D172593
D172594	78	7.8	1.8	B	.026L	N	B	3.9	3.9	B	D172594
D172595	90	18	4.2	B	.12	N	B	6.0	9.0	B	D172595
W248053	57	8.1	3.5	125	.029	7.5	100L	2.5	11	0.12	W248053
W248054	110	270	3.7	95	.099	68	100L	13	52	4.4	W248054
W248055	B	B	B	95	.005	2.6	100L	16	4.9	0.07L	W248055
W248056	36	290	6.2	102	.065	13	1300	11	15	.68	W248056
W248057	42	20	5.0	151	.006	5.7	4300	12	8.4	.54	W248057
W248058	60	34	5.7	128	.028	13	4000	5.3	17	1.2	W248058
W248059	29	10	3.1	123	.015	5.6	3100	7.8	5.8	.20	W248059

Table 4.--(Continued)

Sample Number	Cu (ppm)	Dy-S (ppm)	Er-S (ppm)	Eu (ppm)	F (ppm)	Ga-S (ppm)	Gd-S (ppm)	Ge-S (ppm)	Hf (ppm)	Hg (ppm)	Sample Number
D172593	8.9	3.5L	1.1L	N	20	B	2.1	15	N	0.11	D172593
D172594	6.2	4.0L	1.2L	N	20L	B	N	13	N	.10	D172594
D172595	17	3.9L	1.2L	N	20	B	N	42	N	.17	D172595
W248053	6.0	3.9L	1.2L	0.25	20L	2.4	2.0L	3.6	0.46	.03	W248053
W248054	21	.80L	.33	1.4	300	21	10L	5.2	3.0	.09	W248054
W248055	12L	B	B	.19	20L	B	B	B	.21	.01	W248055
W248056	20	8.3L	2.6L	.51	90	10	2.3L	5.0	.82	.005L	W248056
W248057	7.2	3.9L	1.2L	.15	20	6.3	.99L	28	.22	.19	W248057
W248058	59	1.4L	.64L	.38	300	9.4	1.9L	17	.82	.23	W248058
W248059	9.2	1.2L	.54L	.19	20	2.9	.92L	8.0	.22	.005L	W248059

Table 4.--(Continued)

Sample Number	La (ppm)	Li (ppm)	Lu (ppm)	Mn (ppm)	Mo-S (ppm)	Nb-S (ppm)	Nd-S (ppm)	Ni-S (ppm)	P (ppm)	Pb (ppm)	Sample Number
D172593	2.1L	1.2	N	3.2	1.5	0.42L	3.2	32	48L	19	D172593
D172594	3.9	1.7	N	3.9	.78	.52	5.2	26	11	15	D172594
D172595	N	3.6	N	18	.90	1.2	9L	42	34	28	D172595
W248053	4.8	9.1	0.10	8.6	3.0	2.0	2.9L	7.2	24	27	W248053
W248054	39	52	.33	400	3.9	9.9	47	66	270	20	W248054
W248055	1.3	12L	.10	100	B	B	B	B	19	12L	W248055
W248056	7.1	3.9	.062	8.9	1.4	.81	16	42	340	30	W248056
W248057	3.3	3.8	.04L	3.9	.68	.45	3.1	81	22	3.4	W248057
W248058	8.3	14	.14	16	2.4	1.9	6.1	41	97	11	W248058
W248059	3.3	.59	.062	1.6	2.7	.50	H	25	39	7.6	W248059

Table 4.--(Continued)

Sample Number	Pr-S (ppm)	Rb (ppm)	Sb (ppm)	Sc (ppm)	Se (ppm)	Sm (ppm)	Sn-S (ppm)	Sr-S (ppm)	Ta (ppm)	Tb (ppm)	Sample Number
D172593	N	B	3.4	1.5	2.6	N	0.63	3.2	N	B	D172593
D172594	N	B	1.7	2.6	2.3	N	N	5.2	N	B	D172594
D172595	N	B	8.4	3.0	2.1	N	N	9.0	N	B	D172595
W248053	.88	18L	.085	1.4	4.2	1.1	3.1	25	0.17	0.22	W248053
W248054	3.4	54	1.3	12	4.1	7.5	6.6	160	.91	.93	W248054
W248055	B	16L	2.7	2.3	1.3	.66	B	B	.08	.19L	W248055
W248056	1.1	21L	2.6	1.5	4.0	3.0	2.4L	420	.16	.27	W248056
W248057	.33	22L	4.9	2.1	.98	.69	.63	41	.10	.10	W248057
W248058	.68	22L	4.4	5.6	2.0	1.9	2.4	51	.21	.39L	W248058
W248059	.29L	23L	1.5	1.4	7.6	.86	1.9	32	.062	.14	W248059

Table 4.--(Continued)

Sample Number	Th (ppm)	Tl-S (ppm)	U (ppm)	V-S (ppm)	W (ppm)	Y-S (ppm)	Yb (ppm)	Zn (ppm)	Zr-S (ppm)	Sample Number
D172593	N	2.8	0.28	3.1	N	11	B	12	2.1	D172593
D172594	N	1.2L	.46	7.8	N	7.8	B	11	3.9	D172594
D172595	N	1.2L	.96	9.0	N	12	B	26	9.0	D172595
W248053	1.4	1.2L	.33	14	0.7L	10	0.73	3.4	17	W248053
W248054	9.5	.30	3.5	75	.8L	24	2.8	35	75	W248054
W248055	.70	.88	.21	B	.5L	B	.69	12L	B	W248055
W248056	3.2	2.6L	1.1	20	.6L	6.2	.66	20	37	W248056
W248057	1.2	1.2L	.32	9.5	.7L	2.7	.35	6.8	6.3	W248057
W248058	4.4	.20L	3.1	37	.8L	7.8	1.15	11	19	W248058
W248059	1.7	1.9	1.1	8.8	.7L	4.0	.53	5.5	5.5	W248059

Table 5.--Summary of the semiquantitative x-ray mineralogy of the low-temperature ash from seven bituminous coal samples from the state of Michigan.
(Concentrations in percent, R means observed, - means not observed.)

Sample Number	Quartz	Feldspar	Illite	Kaolinite	Chlorite	Pyrite	Calcite	Siderite	Bassanite	Marcasite	Apatite	Anatase	Rutile	Analcime
W248053	17	4	2	42	-	31	-	-	2	1	-	-	R	R
W248054	33	2	26	32	4	3	-	<1	-	-	R	-	R	-
W248055	-	-	-	56*	-	-	-	-	-	-	-	-	-	-
W248056	29	6	18	27	-	13	-	R	-	-	-	5	-	-
W248057	8	1	14	76	-	-	<1	-	-	-	-	-	-	-
W240858	12	<1	18	65	-	2	2	R	-	-	<1	-	-	-
W240859	7	4	6	56	-	21	2	-	3	-	-	-	-	R

* Kaolinite was the only mineral identified from the x-ray diffraction pattern.