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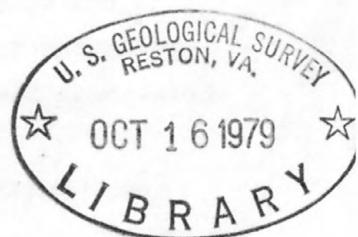
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Chemical analyses of lignite from the Wilcox Group, Texas region,  
central and eastern Texas

o/s by v/s  
LC LC  
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U.S. Geological Survey  
and v/s  
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Texas Bureau of Economic Geology



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This report is preliminary and has not been edited  
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## Introduction

As part of a continuing program by the U.S. Geological Survey to collect and chemically analyze representative samples of U.S. coal, 45 samples of lignite and lignite-associated rocks were collected from strip mines and drill holes in Freestone and Milam Counties in central Texas, and in Harrison, Rains, Titus, Van Zandt, and Wood Counties in eastern Texas. The sampled areas are in the Texas region of the Gulf province (Trumbull, 1960). Figure 1 shows the counties from which the samples were collected. Brief descriptions of the 45 samples are given in table 1. Thirty-one samples (twenty-six lignite and five lignite-associated rock) were collected from four active strip mines in Freestone, Harrison, Milam, and Titus Counties by the Texas Bureau of Economic Geology; 14 samples (13 lignite and 1 carbonaceous shale) were collected from nine drill holes in connection with the U.S. Bureau of Mines evaluation of coal resources in the proposed Carl L. Estes Lake site, Rains, Van Zandt, and Wood Counties (Ward, 1977).

All samples included in this report are from the Wilcox Group of Eocene age. The Wilcox Group is undifferentiated in Harrison, Rains, Titus, Van Zandt, and Wood Counties. Lignite in this area is in the upper two-thirds of the Wilcox. In Freestone and Milam Counties, the Wilcox Group is subdivided into the Hooper, Simsboro, and Calvert Bluff Formations. Lignite in this area is predominantly in the Calvert Bluff Formation, with minor amounts in the Hooper Formation. A generalized stratigraphic column of the Wilcox Group and associated Tertiary strata is given in figure 2.

The Calvert Bluff Formation and undifferentiated Wilcox Group consist of clastic debris deposited in a fluvial environment, in which major channel complexes characterized by sand deposition divide interchannel areas composed of mud. Lignite was deposited as a blanket peat in freshwater swamps and marshes within interchannel areas. Individual lignite beds are lenticular bodies extending 3 to 20 km laterally; thicknesses are generally 1 to 3 m, rarely as much as 6 m. Descriptions of geology and lignite occurrences are in Fisher (1963), Kaiser (1974, 1978), and Kaiser and others (1978).

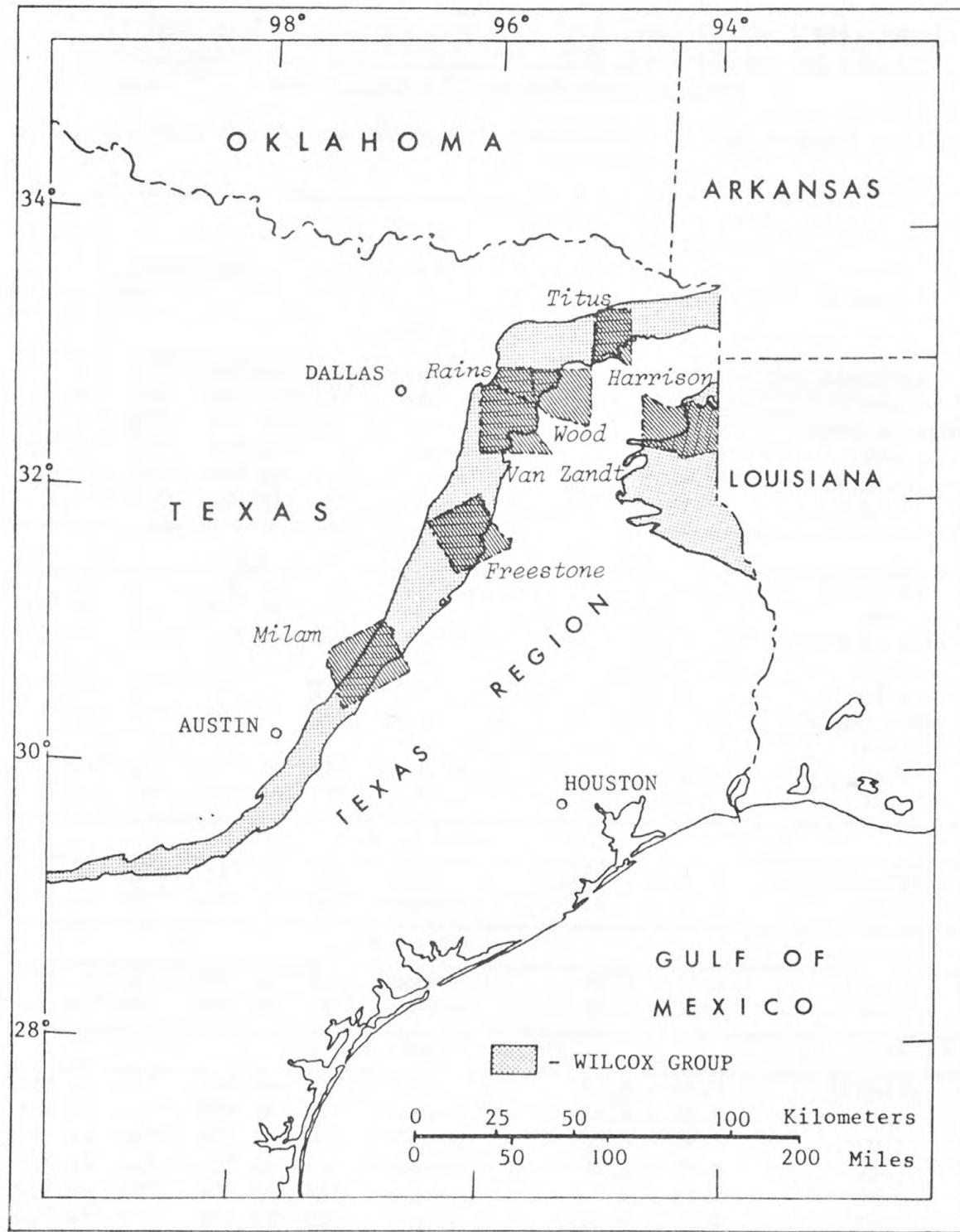


Figure 1.--Map showing counties in central and eastern Texas from which samples were collected and the outcrop area of the Wilcox Group (modified from Kaiser, 1974, and Trumbull, 1960).

Table 1.--U.S. Geological Survey sample numbers, locations, sample types, sample thickness or depth intervals represented, and brief descriptions for 45 lignite-lignite-associated rock samples from central and eastern Texas

[All samples are from the Wilcox Group of Eocene age. One foot = 0.305 meters]

USGS sample number	Location		Sample type	Sample thickness or depth interval represented, in meters	Brief description
	N. latitude	W. longitude			
Titus County					
D177688	33° 11' 05"	95° 05' 17"	Channel	1.83	Lignite.
D177690	33° 11' 05"	95° 05' 13"	--do--	1.83	Do.
D177700	33° 11' 05"	95° 05' 17"	--do--	.30	Lignite, bony.
D177701	33° 11' 05"	95° 05' 13"	--do--	.30	Do.
D177689	33° 11' 05"	95° 05' 17"	--do--	1.52	Lignite.
D177691	33° 11' 05"	95° 05' 13"	--do--	1.37	Do.
Harrison County					
D177692	32° 24' 25"	94° 26' 27"	Channel	.46	Lignite.
D177696	32° 24' 27"	94° 26' 26"	--do--	.46	Do.
D177702	32° 24' 27"	94° 26' 27"	--do--	.25	Carbonaceous clay.
D177693	32° 24' 27"	94° 26' 26"	--do--	1.83	Lignite.
D177703	32° 24' 27"	94° 26' 28"	--do--	.15	Carbonaceous clay.
D177694	32° 24' 24"	94° 26' 28"	--do--	1.52	Lignite.
D177695	32° 24' 25"	94° 26' 27"	--do--	1.52	Do.
Wood County					
D189370	32° 44' 28"	95° 37' 43"	Core	20.4 - 22.1	Lignite.
D189371	32° 43' 18"	95° 37' 52"	--do--	16.5 - 17.5	Do.
Rains County					
D189372	32° 47' 05"	95° 47' 01"	Core	30.8 - 31.3	Lignite.
D189373	32° 47' 05"	95° 47' 01"	--do--	31.3 - 31.6	Do.
Van Zandt County					
D189359	32° 41' 51"	95° 39' 34"	Core	47.3 - 48.3	Lignite.
D189360	32° 41' 51"	95° 39' 34"	--do--	59.8 - 60.4	Do.
D189361	32° 44' 02"	95° 44' 45"	--do--	25.9 - 26.5	Do.
D189362	32° 44' 02"	95° 44' 45"	--do--	34.5 - 35.1	Do.
D189363	32° 44' 02"	95° 44' 45"	--do--	35.1 - 35.7	Do.
D189364	32° 44' 53"	95° 48' 03"	--do--	22.0 - 22.9	Do.
D189365	32° 44' 06"	95° 49' 32"	--do--	15.9 - 16.3	Shale, carbonaceous.
D189366	32° 44' 06"	95° 49' 32"	--do--	16.3 - 17.1	Lignite.
D189367	32° 44' 06"	95° 49' 32"	--do--	18.9 - 19.7	Do.
D189368	32° 04' 58"	95° 51' 25"	--do--	19.5 - 20.4	Do.
D189369	32° 43' 02"	94° 56' 15"	--do--	12.5 - 13.7	Do.

Table 1.--U.S. Geological Survey sample numbers, locations, sample types, sample thickness or depth intervals represented, and brief descriptions for 45 lignite and lignite-associated rock samples from central and eastern Texas--continued

USGS sample number	Location		Sample type	Sample thickness or depth interval represented in meters	Brief description
Freestone County					
D177698	31° 45' 45"	96° 09' 17"	Channel	0.30	Carbonaceous clay.
D177684	----do----	96° 09' 17"	--do--	1.22	Lignite.
D177687	31° 46' 55"	96° 10' 06"	--do--	1.83	Do.
D177685	31° 45' 49"	96° 09' 21"	--do--	1.83	Do.
D177686	31° 46' 45"	96° 09' 36"	--do--	1.83	Do.
D177699	31° 46' 55"	96° 10' 06"	--do--	No data	Clay.
Milam County					
D177676	30° 34' 45"	97° 01' 55"	Channel	1.83	Lignite.
D177677	30° 35' 14"	97° 02' 01"	--do--	1.52	Do.
D177673	30° 34' 17"	97° 02' 16"	--do--	1.22	Do.
D177674	----do----	97° 02' 16"	--do--	1.22	Do.
D177675	----do----	97° 02' 16"	--do--	1.22	Do.
D177678	30° 35' 40"	97° 01' 56"	--do--	1.83	Do.
D177679	----do----	97° 01' 56"	--do--	1.22	Do.
D177680	30° 34' 40"	97° 02' 06"	--do--	1.22	Do.
D177697	----do----	97° 02' 06"	--do--	.15	Clay.
D177681	----do----	97° 02' 06"	--do--	1.22	Lignite.
D177682	----do----	97° 02' 06"	--do--	.92	Do.

C		E	N	O	Z	O	I	C	E R A		SYSTEM	SERIES	FORMATION		J A C K S O N	GROUP
T	E	E	R	T	I	A	R	Y								
													W H I T S E T T			
													M A N N I N G *			
													W E L L B O R N			
													C A D D E L L			
													Y E G U A *			
													C O O K M O U N T A I N			
													S T O N E C I T Y			
													S P A R T A			
													W E C H E S			
													Q U E E N C I T Y			
													R E K L A W			
													C A R R I Z O			
													C A L V E R T B L U F F *			
													S I M S B O R O			
													H O O P E R			
													W I L C O X *	C L A I B O R N E		
													M I D W A Y			

\* coal-bearing

Figure 2.--Generalized stratigraphic column of lower Tertiary strata in central and eastern Texas (after Kaiser, 1974).

Resource estimations by Kaiser (1974) for the Wilcox Group for beds more than 1.2 m thick having less than 60 m overburden by county are as follows: Freestone, 877 million metric tons; Harrison, 503 million metric tons; Milam, 737 million metric tons; Rains, 222 million metric tons; Titus, 403 million metric tons; Van Zandt, 709 million metric tons; and Wood, 180 million metric tons.

#### Explanation of data and statistical tables

Proximate and ultimate analyses, heat-of-combustion, air-dried-loss, forms-of-sulfur, and ash-fusion-temperature determinations for 27 lignite samples are given in table 2. These analyses were provided by the Coal Analysis Section, Department of Energy, Pittsburgh, Pa. Analyses for ash content, and contents of 35 major and minor oxides and trace elements in the laboratory ash (table 3), and analyses of seven trace elements in whole lignite (table 4) for the 45 samples were provided by the U.S. Geological Survey in Denver, Colo. Most of the 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-lignite basis and includes the whole-lignite 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 limit of detection (table 6).

Unweighted statistical summaries of analytical data on the 27 lignite samples in table 2, 3, and 5 are listed in table 7, 8, and 9 respectively. For comparison, data summaries for Mississippi region lignite samples, listed in Swanson and others (1976), are included in tables 7, 8, and 9. Data summaries for Ag, Cd, Ce, Ge, La, and Nd are not included in table 9 because these elements were detected in an insufficient number of samples to calculate meaningful statistics.

Arsenic contents of samples summarized in this report have been determined by three different analytical methods: samples D177697 - D177703 were analyzed spectrophotometrically (lower detection limit 1.0 ppm); samples D177673 - D177696 were analyzed by the graphite furnace-atomic absorption method (lower detection limit 0.5 ppm); the remaining 14 samples were analyzed by instrumental neutron activation analysis (lower detection limit 0.1 ppm).

Thorium contents of the samples were determined by two methods: samples D177673 - D177703 were analyzed by delayed neutron activation analysis (lower detection limit 3.0 ppm); the remaining 14 samples were analyzed by instrumental neutron activation analysis (lower detection limit 0.1 ppm).

To be consistent with the precision of the semiquantitative emission spectrographic technique, arithmetic and geometric means of elements determined by this method are reported as the midpoint of the enclosing six-step brackets. (See 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 GM is calculated by taking the logarithm of each analytical value, summing the logarithms, dividing the sum by the total number of values, and obtaining the antilogarithm of the result. The measure of scatter about the mode used here is the geometric deviation (GD), which is the antilog of the standard deviation of the logarithms of the analytical values. These statistics are used because the quantities of trace elements in natural materials commonly exhibit positively skewed frequency distributions; such distributions are normalized by statistically analyzing and summarizing trace-element data on a logarithmic basis.

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

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

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

#### Discussion

The apparent ranks for 27 samples from the Texas region were calculated using the data in table 2 and the formulae in ASTM designation D-388-77 (American Society for Testing and Materials, 1978). The heat of combustion (moist, mineral-matter-free basis) for the samples from the Texas region ranges from 4,260 Kcal/kg (7,650 Btu/lb) to 5,670 Kcal/kg (10,190 Btu/lb) and has an arithmetic mean of 4,590 Kcal/kg (8,260 Btu/lb). The apparent rank for the samples ranges from lignite A to subbituminous B coal.

An explanation for the apparent higher ranks of some of the samples is that they were exposed to the air and were partially dried before analysis. The samples with apparent ranks of subbituminous C and B coal are all from Milam County and have noticeably low as-received moisture and air-dried loss amounts. Conclusions based on the apparent ranks of these samples should be regarded with caution.

A statistical comparison, using student's t-test or approximate t-test, 95 percent confidence (Sokol and Rohlf, 1969) of geometric means for the U.S. Department of Energy data for 27 Texas region lignite samples with 19 Mississippi region lignite samples (Swanson and others, 1976) shows that the Texas region lignite has significantly higher contents of volatile matter, fixed carbon, and nitrogen; a significantly higher heat of combustion; and significantly lower contents of moisture, hydrogen, oxygen, and total, pyritic, and organic sulfur. Contents of ash and sulfate sulfur are not significantly different. When compared at the 99 percent confidence level, the content of organic sulfur is not significantly different.

A statistical comparison of geometric mean contents of lignite ash and contents of nine major and minor oxides in ash for 39 Texas region lignite samples with data for 34 samples of Mississippi region lignite (Swanson and others, 1976) shows that Texas region lignite has significantly lower ash content, significantly lower K<sub>2</sub>O and Fe<sub>2</sub>O contents in ash, and significantly higher contents of CaO, MgO, Na<sub>2</sub>O, TiO<sub>2</sub>, and SO<sub>3</sub> in ash. Contents of SiO<sub>3</sub> and Al<sub>2</sub>O<sub>3</sub> in ash are not significantly different. When compared at the 99 percent confidence level, the SO<sub>3</sub> content in ash is not significantly different.

A statistical comparison of geometric mean contents for 35 different elements in 39 Texas region lignite samples (whole-lignite basis) with data for 34 samples of Mississippi region lignite shows that the Texas region lignite has significantly higher contents of Ca, Na, Ti, B, Hg, Mn, Mo, and Nb, and significantly lower contents of Si, Al, K, Fe, As, Co, F, Li, Ni, Sr, Y, Yb, Zn, and Zr. The contents of Mg, Ba, Be, Cr, Cu, Ga, Pb, Sb, Sc, Se, Th, U, and V are not significantly different. When compared at the 99 percent confidence level, the contents of Si, Li, Nb, Sr, Y, and Zr are not significantly different.

Differences in the oxide composition of lignite ash and the element contents in lignite 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 lignite bed. A partial listing of the geologic factors that influence element distributions includes chemical composition of original plants; amounts and compositions of various detrital, diagenetic, and epigenetic minerals; temperatures and pressures during burial; and extent of weathering. No evaluation of these factors has been made for any of the lignite beds in the Texas region.

Compared to lignite from the Fort Union region, North Dakota and eastern Montana (Swanson and others, 1974), lignite of the Texas region is characterized by relatively high ash, high volatile matter, low fixed carbon, and low moisture content. The contents of such elements as Be, Hg, Mo, Sb, and Se are high in lignite from the Texas region when compared to lignite from the Fort Union region (Hatch and Swanson, 1977).

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Table 2.--Proximate and ultimate analyses, and heat-of-combustion, forms-of-sulfur, and ash-fusion-temperature determinations  
for 27 lignite samples from the Wilcox Group, Texas region, central and eastern Texas

[All analyses except Kcal/kg, Btu/lb, and ash-fusion temperatures in percent. For each sample number, the analyses are reported three ways: first, as received; second, moisture free; third, moisture and ash free. °F = (°C·1.8)+32; Kcal/kg = 0.556(Btu/lb). D177688\* is a composite of samples D177688 and D177690; D177689\* is a composite of D177689 and D177691; D177692\* is a composite of D177692 and D177696; D177694\* is a composite of D177694 and D177695; D177684\* is a composite of D177684 and D177687; D177685\* is a composite of D177685 and D177686; D177673\* is a composite of D177673, D177674, and D177675; D177678\* is a composite of D177678 and D177679; D177681\* is a composite of D177681 and D177682. L, less than the value shown]

Sample number	Proximate analysis				Ultimate analysis					Heat of combustion	
	Moisture	Volatile matter	Fixed carbon	Ash	Hydrogen	Carbon	Nitrogen	Oxygen	Sulfur	Kcal/kg	Btu/lb
D177688*	29.6	29.0	25.2	16.2	6.2	39.0	0.7	37.4	0.5	3,690	6,650
	--	41.2	35.8	23.0	4.1	55.4	1.0	15.8	.7	5,250	9,450
	--	53.5	46.5	--	5.4	72.0	1.3	20.5	.9	6,820	12,270
D177689*	29.8	27.6	22.0	20.6	6.1	34.9	.7	37.2	.5	3,330	6,000
	--	39.3	31.3	29.3	4.0	49.7	1.0	15.3	.7	4,750	8,550
	--	55.6	44.4	--	5.6	70.4	1.4	21.6	1.0	6,720	12,100
D177692*	31.9	29.2	28.1	10.8	6.5	40.7	.8	40.2	1.0	3,870	6,970
	--	42.9	41.3	15.9	4.3	59.8	1.2	17.4	1.5	5,690	10,230
	--	51.0	49.0	--	5.2	71.0	1.4	20.7	1.7	6,760	12,160
D177693	33.1	28.9	30.2	7.8	6.6	42.6	.8	41.3	.9	3,950	7,110
	--	43.2	45.1	11.7	4.4	63.7	1.2	17.8	1.3	5,900	10,630
	--	48.9	51.1	--	4.9	72.1	1.4	20.1	1.5	6,680	12,030
D177694*	33.1	30.0	30.3	6.6	6.7	43.1	.6	42.0	1.0	4,110	7,400
	--	44.8	45.3	9.9	4.5	64.4	.9	18.8	1.5	6,150	11,060
	--	49.8	50.2	--	5.0	71.5	1.0	20.9	1.7	6,820	12,270
D189370	35.3	28.2	27.0	9.5	6.7	40.4	.8	42.1	.4	3,830	6,900
	--	43.6	41.7	14.7	4.3	62.4	1.2	16.6	.6	5,920	10,660
	--	51.1	48.9	--	5.0	73.2	1.4	19.4	.7	6,940	12,500
D189371	35.1	27.2	27.5	10.2	6.8	39.7	.7	42.2	.5	3,770	6,790
	--	41.9	42.4	15.7	4.5	61.2	1.1	16.9	.8	5,810	10,460
	--	49.7	50.3	--	5.3	72.6	1.3	20.1	.9	6,900	12,410
D189372	34.0	28.8	27.5	9.7	6.7	40.7	.8	41.2	.9	3,930	7,070
	--	43.6	41.7	14.7	4.4	61.7	1.2	16.6	1.4	5,950	10,720
	--	51.2	48.8	--	5.2	72.3	1.4	19.5	1.6	6,980	12,560
D189373	34.1	29.4	27.3	9.2	6.9	41.5	.7	39.5	2.0	4,080	7,340
	--	44.6	41.4	14.0	4.7	63.0	1.1	13.9	3.0	6,190	11,140
	--	51.9	48.1	--	5.5	73.2	1.2	16.2	3.5	7,190	12,950
D189359	29.8	25.2	21.6	23.4	5.7	33.9	.6	35.9	.6	3,250	5,850
	--	35.9	30.8	33.3	3.4	48.3	.9	13.4	.9	4,630	8,330
	--	53.8	46.2	--	5.1	72.4	1.3	20.1	1.3	6,940	12,490
D189360	30.7	28.9	25.1	15.3	6.2	39.4	.7	37.9	.5	3,800	6,830
	--	41.7	36.2	22.1	4.0	56.9	1.0	15.3	.7	5,480	9,860
	--	53.5	46.5	--	5.2	73.0	1.3	19.7	.9	7,030	12,650
D189361	32.3	26.3	25.8	15.6	6.0	38.0	.7	39.1	.5	3,600	6,490
	--	38.8	38.1	23.0	3.6	56.1	1.0	15.3	.7	5,320	9,580
	--	50.5	49.5	--	4.6	72.9	1.3	19.9	1.0	6,920	12,450

Table 2.--Proximate and ultimate analyses, and heat-of-combustion, forms-of-sulfur, and ash-fusion-temperature determinations  
for 27 lignite samples from the Wilcox Group, Texas region, central and eastern Texas--continued

Sample number	Air-dried loss	Forms of sulfur			Ash-fusion temperature, °C		
		Sulfate	Pyritic	Organic	Initial deformation	Softening*	Fluid
D177688*	14.9	0.01L	0.01	0.49	1,190	1,210	1,230
	--	.01L	.01	.70			
	--	.02L	.02	.90			
D177689*	14.8	.02	.01	.47	1,290	1,310	1,330
	--	.03	.01	.67			
	--	.04	.02	.95			
D177692*	18.0	.12	.21	.64	1,165	1,195	1,350
	--	.18	.31	.94			
	--	.21	.37	1.12			
D177693	17.1	.08	.18	.60	1,140	1,165	1,195
	--	.12	.27	.90			
	--	.14	.30	1.02			
D177694*	18.7	.11	.24	.70	1,055	1,080	1,110
	--	.16	.36	1.05			
	--	.18	.40	1.16			
D189370	17.6	.01	.09	.34	1,195	1,250	1,315
	--	.02	.14	.53			
	--	.02	.16	.62			
D189371	17.8	.01	.12	.30	1,140	1,195	1,250
	--	.02	.18	.46			
	--	.02	.22	.55			
D189372	15.4	.01	.26	.63	1,120	1,180	1,235
	--	.02	.39	.95			
	--	.02	.46	1.12			
D189373	22.3	.01	1.50	.53	1,180	1,230	1,290
	--	.02	2.28	.80			
	--	.02	2.65	.93			
D189359	15.5	.01	.13	.43	1,290	1,340	1,395
	--	.01	.19	.61			
	--	.02	.28	.92			
D189360	13.7	.01	.09	.36	1,180	1,230	1,290
	--	.01	.13	.52			
	--	.02	.17	.67			
D189361	14.8	.01	.10	.39	1,485	1,540	1,540+
	--	.01	.15	.58			
	--	.02	.19	.75			

Table 2.--Proximate and ultimate analyses, and heat-of-combustion, forms-of-sulfur, and ash-fusion-temperature determinations  
for 27 lignite samples from the Wilcox Group, Texas region, central and eastern Texas--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
D189362	29.1	23.8	20.9	26.2	5.6	32.5	0.6	33.7	1.5	3,100	5,570
	--	33.6	29.5	37.0	3.3	45.8	.8	11.0	2.1	4,370	7,860
	--	53.2	46.8	--	5.3	72.7	1.3	17.5	3.4	6,930	12,470
D189363	35.1	30.7	27.3	6.9	6.8	42.5	.8	42.3	.6	4,120	7,410
	--	47.3	42.1	10.6	4.5	65.5	1.2	17.1	.9	6,340	11,410
	--	52.9	47.1	--	5.0	73.3	1.4	19.1	1.0	7,100	12,770
D189364	36.0	28.1	27.9	8.0	6.8	41.2	.8	42.6	.6	3,940	7,090
	--	43.9	43.6	12.5	4.4	64.4	1.2	16.6	.9	6,150	11,070
	--	50.2	49.8	--	5.0	73.6	1.4	18.9	1.1	7,030	12,650
D189366	33.8	28.8	27.5	9.9	6.5	41.3	.8	40.6	.9	3,970	7,140
	--	43.5	41.5	15.0	4.1	62.4	1.2	15.9	1.4	5,990	10,790
	--	51.2	48.8	--	4.9	73.4	1.4	18.7	1.6	7,050	12,690
D189367	32.0	27.5	25.1	15.4	6.2	38.4	.7	37.6	1.8	3,740	6,730
	--	40.4	36.9	22.6	3.9	56.5	1.0	13.5	2.6	5,500	9,900
	--	52.3	47.7	--	5.0	73.0	1.3	17.4	3.4	7,110	12,800
D189368	35.4	28.6	28.0	8.0	6.8	41.6	.8	42.0	.7	4,000	7,210
	--	44.3	43.3	12.4	4.4	64.4	1.2	16.3	1.1	6,200	11,160
	--	50.5	49.5	--	5.1	73.5	1.4	18.6	1.2	7,070	12,730
D189369	33.2	26.0	25.1	15.8	6.2	37.2	.6	39.7	.4	3,550	6,390
	--	38.9	37.6	23.7	3.8	55.7	.9	15.3	.6	5,310	9,560
	--	51.0	49.2	--	4.9	72.9	1.2	20.0	.8	6,960	12,530
D177684*	28.5	32.0	30.7	8.8	6.5	46.0	.8	37.3	.6	4,260	7,660
	--	44.8	42.9	12.3	4.7	64.3	1.1	16.7	.8	5,950	10,710
	--	51.0	49.0	--	5.3	73.4	1.3	19.1	1.0	6,790	12,220
D177685*	27.9	32.8	31.7	7.6	6.6	46.9	.8	37.4	.7	4,490	8,080
	--	45.5	44.0	10.5	4.9	65.0	1.1	17.5	1.0	6,230	11,210
	--	50.9	49.1	--	5.4	72.7	1.2	19.5	1.1	6,960	12,530
D177676	25.9	36.0	30.0	8.1	6.6	47.7	.9	35.7	1.0	4,650	8,370
	--	48.6	40.5	10.9	5.0	64.4	1.2	17.1	1.3	6,280	11,300
	--	54.5	45.5	--	5.6	72.3	1.4	19.2	1.5	7,050	12,680
D177677	18.6	40.3	32.1	9.0	6.1	52.2	1.0	30.7	1.0	5,090	9,170
	--	49.5	39.4	11.1	5.0	64.1	1.2	17.4	1.2	6,260	11,270
	--	55.7	44.3	--	5.6	72.1	1.4	19.6	1.4	7,040	12,670
D177673*	29.2	31.6	27.2	12.0	6.5	41.8	.9	37.8	1.0	4,020	7,230
	--	44.6	38.4	16.9	4.6	59.0	1.3	16.7	1.4	5,670	10,210
	--	53.7	46.3	--	5.5	71.1	1.5	20.1	1.7	6,830	12,300

Table 2.--Proximate and ultimate analyses, and heat-of-combustion, forms-of-sulfur, and ash-fusion-temperature determinations  
for 27 lignite samples from the Wilcox Group, Texas region, central and eastern Texas--continued

Sample number	Air-dried loss	Forms of sulfur			Ash-fusion temperature, °C		
		Sulfate	Pyritic	Organic	Initial deformation	Softening	Fluid
D189362	15.9	0.01	0.97	0.50	1,150	1,215	1,270
	--	.01	1.37	.71			
	--	.02	2.17	1.12			
D189363	14.9	.01	.15	.45	1,165	1,225	1,285
	--	.02	.23	.69			
	--	.02	.26	.78			
D189364	17.8	.01	.16	.44	1,115	1,175	1,230
	--	.02	.25	.69			
	--	.02	.29	.79			
D189366	12.8	.02	.44	.47	1,130	1,180	1,235
	--	.03	.66	.71			
	--	.04	.78	.83			
D189367	16.0	.01	.93	.84	1,125	1,180	1,235
	--	.01	1.37	1.24			
	--	.02	1.77	1.60			
D189368	18.2	.02	.21	.47	1,125	1,175	1,240
	--	.03	.33	.73			
	--	.04	.37	.83			
D189369	15.7	.01	.08	.32	1,215	1,275	1,330
	--	.01	.12	.48			
	--	.02	.16	.63			
D177684*	13.3	.01	.03	.58	1,155	1,170	1,190
	--	.01	.04	.81			
	--	.02	.05	.93			
D177685*	12.8	.05	.02	.59	1,155	1,170	1,190
	--	.07	.03	.82			
	--	.08	.03	.91			
D177676	11.2	.03	.09	.86	1,140	1,165	1,225
	--	.04	.12	1.16			
	--	.05	.14	1.30			
D177677	2.3	.02	.09	.88	1,160	1,180	1,240
	--	.02	.11	1.08			
	--	.03	.12	1.22			
D177673*	14.4	.03	.12	.89	1,310	1,340	1,390
	--	.04	.17	1.26			
	--	.05	.20	1.51			

Table 2.--Proximate and ultimate analyses, and heat-of-combustion, forms-of-sulfur, and ash-fusion-temperature determinations  
for 27 lignite samples from the Wilcox Group, Texas region, central and eastern Texas--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
D177678*	27.9	31.7	27.7	12.7	6.4	42.4	0.8	36.7	1.0	4,090	7,370
	---	44.0	38.4	17.6	4.6	58.8	1.1	16.5	1.4	5,680	10,220
	---	53.4	46.6	---	5.6	71.4	1.3	20.0	1.7	6,890	12,410
D177680	21.5	36.0	33.5	9.0	6.2	50.5	1.0	32.4	.9	4,830	8,690
	---	45.9	42.7	11.5	4.9	64.3	1.3	16.9	1.1	6,150	11,070
	---	51.8	48.2	---	5.5	72.7	1.4	19.1	1.3	6,950	12,500
D177681*	22.3	34.6	29.5	13.6	6.0	45.6	.9	32.8	1.1	4,400	7,920
	---	44.5	38.0	17.5	4.5	58.7	1.2	16.7	1.4	5,660	10,190
	---	54.0	46.0	---	5.5	71.1	1.4	20.2	1.7	6,860	12,360

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Sample number	Air-dried loss	Forms of sulfur			Ash-fusion temperature, °C		
		Sulfate	Pyritic	Organic	Initial deformation	Softening	Fluid
D177678*	12.6	0.03	0.14	0.87	1,280	1,335	1,375
	---	.04	.19	1.21			
	---	.05	.24	1.46			
D177680	5.5	.02	.03	.82	1,170	1,195	1,220
	---	.03	.04	1.04			
	---	.03	.04	1.18			
D177681*	8.8	.02	.13	.95	1,165	1,195	1,305
	---	.03	.17	1.22			
	---	.03	.20	1.48			

**Table 3--Major- and minor-oxide and trace-element composition of the laboratory ash of 45 lignite and lignite-associated rock samples from the Wilcox Group, Texas region, central and eastern Texas**

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

Sample number	Ash (percent)	SiO <sub>2</sub> (percent)	Al <sub>2</sub> O <sub>3</sub> (percent)	CaO (percent)	MgO (percent)	Na <sub>2</sub> O (percent)	K <sub>2</sub> O (percent)	Fe <sub>2</sub> O <sub>3</sub> (percent)	TiO <sub>2</sub> (percent)	SO <sub>3</sub> (percent)	Sample number
D177688	20.3	55	16	7.5	2.02	0.22	0.72	2.2	1.7	8.6	D177688
D177690	22.6	45	19	9.7	2.06	.23	.71	2.4	1.6	7.8	D177690
D177700	26.4	67	11	5.5	1.59	.31	1.2	2.1	.91	4.2	D177700
D177701	38.7	71	12	3.5	1.29	.32	1.5	2.3	.97	3.1	D177701
D177689	19.1	36	26	8.3	2.45	.20	.59	3.4	1.7	8.8	D177689
D177691	29.2	45	28	4.7	1.91	.19	.83	2.9	1.5	6.0	D177691
D177692	20.2	58	9.3	4.3	1.23	.20	.62	6.8	.97	12	D177692
D177696	6.8	.50L	22	5.1	1.24	.26	.79	13	1.1	11	D177696
D177702	63.3	69	14	.82	.83	.18	1.5	3.9	.78	1.1	D177702
D177693	9.9	21	16	11	2.55	.32	.30	13	.78	23	D177693
D177703	77.6	54	27	.80	1.34	.22	2.9	2.9	1.1	.68	D177703
D177694	9.7	16	14	11	2.54	.38	.25	17	.66	24	D177694
D177695	10.1	23	14	11	1.82	.22	.23	16	.92	23	D177695
D189370	13.6	38	11	20	3.61	.74	.62	4.1	1.2	10	D189370
D189371	14.5	41	8.8	22	2.50	.36	.30	2.8	1.4	8.3	D189371
D189372	13.1	31	5.6	19	2.80	1.11	.57	9.5	.77	20	D189372
D189373	12.9	15	3.7	17	2.52	.98	.29	24	.45	28	D189373
D189359	29.1	55	13	6.6	1.17	.17	.94	5.6	1.2	5.0	D189359
D189360	19.9	52	10	13	1.98	.32	1.1	4.0	1.0	6.2	D189360
D189361	20.7	64	5.5	8.6	1.36	.25	.14	4.7	2.2	6.4	D189361
D189362	33.7	53	12	6.4	1.20	.32	.97	7.5	.96	7.6	D189362
D189363	9.1	23	8.2	25	3.63	.77	.25	10	.84	18	D189363
D189364	10.1	36	6.0	16	2.06	.79	.61	12	.78	16	D189364
D189365	64.8	70	7.4	1.5	.80	.95	1.9	5.3	.40	1.8	D189365
D189366	13.1	39	6.0	11	2.26	.57	.83	15	.61	17	D189366
D189367	20.4	49	6.1	7.5	1.60	.59	.92	12	.59	12	D189367
D189368	11.1	27	7.4	23	3.23	.43	.53	11	.86	16	D189368
D189369	20.5	52	9.8	12	2.02	.40	.66	3.0	1.5	6.2	D189369
D177698	92.9	74	14	.48	1.33	.77	2.2	2.5	.81	.20L	D177698
D177684	9.9	27	17	15	3.93	1.19	.23	4.0	1.3	21	D177684
D177687	13.6	39	13	14	3.25	.40	.24	2.6	2.0	15	D177687
D177685	9.2	28	13	17	4.44	.67	.21	4.5	1.7	22	D177685
D177686	10.7	38	12	14	4.64	.70	.18	2.5	1.8	18	D177686
D177699	90.7	100	.50L	.25	.05	.11	.070	.080	.73	.20L	D177699
D177676	10.1	25	16	17	2.50	.58	.13	3.5	1.4	24	D177676
D177677	10.3	29	16	15	2.69	.86	.22	4.0	1.6	24	D177677
D177673	19.6	41	24	8.2	2.16	.26	.58	2.6	1.4	11	D177673
D177674	12.3	27	24	14	2.99	.34	.15	1.7	1.1	19	D177674
D177675	13.7	28	23	12	2.99	.32	.35	2.3	1.2	19	D177675
D177678	19.3	34	25	7.5	1.96	.26	.48	3.2	1.4	14	D177678

Table 3.--Major- and minor-oxide and trace-element composition of the laboratory ash of 45 lignite and lignite-associated rock samples from the Wilcox Group, Texas region, central and eastern Texas--continued

Sample number	Ag-S (ppm)	B-S (ppm)	Ba-S (ppm)	Be-S (ppm)	Cd (ppm)	Ce-S (ppm)	Co-S (ppm)	Cr-S (ppm)	Cu (ppm)	Ga-S (ppm)	Sample number
D177688	N	700	1,000	7	1.0L	N	15	100	118	30	D177688
D177690	1	500	700	7	1.0L	500L	15	100	137	30	D177690
D177700	N	700	1,000	15	1.0L	500L	30	70	46	50	D177700
D177701	N	300	700	15	1.0L	500L	30	70	40	30	D177701
D177689	1.5	700	700	7	2.0	500L	15	150	190	70	D177689
D177691	1	300	700	N	2.0	500L	10L	150	165	50	D177691
D177692	N	700	1,500	15	1.0L	500L	20	70	76	30	D177692
D177696	1.5	2,000	2,000	30	3.0	500L	200	150	350	70	D177696
D177702	N	200	700	N	1.0L	500L	15	70	50	30	D177702
D177693	N	2,000	1,500	7	1.0L	N	15	150	108	50	D177693
D177703	N	200	1,000	N	1.0	500L	15	200	331	70	D177703
D177694	N	1,500	2,000	N	2.0	N	15	70	100	50	D177694
D177695	N	2,000	1,500	5	1.0	N	20	70	124	50	D177695
D189370	N	300	700	5	1.0L	N	10	70	151	20	D189370
D189371	N	300	700	7	1.0L	N	10	70	98	20	D189371
D189372	N	1,000	500	7	1.0L	N	N	30	75	15	D189372
D189373	N	1,000	500	10	1.0L	N	10	30	60	70	D189373
D189359	N	100	1,500	N	1.0L	N	10	50	75	20	D189359
D189360	N	200	1,000	10	1.0L	N	15	70	92	20	D189360
D189361	N	200	700	15	1.0L	N	7	50	98	50	D189361
D189362	N	150	700	10	1.0L	N	10	30	62	20	D189362
D189363	N	1,000	1,500	15	1.0L	N	10	50	120	30	D189363
D189364	N	1,000	500	10	1.0L	N	7	30	82	50	D189364
D189365	N	100	500	N	1.0L	N	7	30	17	10	D189365
D189366	N	1,000	1,000	7	1.0L	N	10	30	78	15	D189366
D189367	N	500	700	7	1.0L	N	10	30	50	20	D189367
D189368	N	1,000	1,000	7	1.0L	N	7	50	105	20	D189368
D189369	N	200	700	5	1.0L	N	10	50	85	20	D189369
D177698	N	100	700	N	1.0L	500L	30	70	20L	30	D177698
D177684	1	1,500	700	15	1.5	500L	100	150	183	70	D177684
D177687	N	1,500	2,000	15	1.0L	N	15	150	167	50	D177687
D177685	N	1,500	700	15	1.0L	500L	50	150	179	50	D177685
D177686	N	1,500	300	15	1.0L	N	30	150	160	30	D177686
D177699	N	150	100	N	1.0L	N	10L	30	20L	N	D177699
D177676	N	3,000	700	15	1.0L	N	15	150	148	70	D177676
D177677	N	2,000	700	10	1.0L	500L	30	150	150	70	D177677
D177673	1	1,500	700	7	1.0L	500L	15	150	154	70	D177673
D177674	1	2,000	700	7	1.0	500L	30	150	209	100	D177674
D177675	1	1,500	500	7	2.0	500L	30	150	221	70	D177675
D177678	N	1,500	500	7	3.0	500L	30	150	160	70	D177678

**Table 3.--Major- and minor-oxide and trace-element composition of the laboratory ash of 45 lignite and lignite-associated rock samples from the Wilcox Group, Texas region, central and eastern Texas--continued**

Sample number	Ge-S (ppm)	La-S (ppm)	Li (ppm)	Mn (ppm)	Mo-S (ppm)	Nb-S (ppm)	Nd-S (ppm)	Ni-S (ppm)	Pb (ppm)	Sc-S (ppm)	Sample number
D177688	N	100L	53	430	20	70	150L	50	35	30	D177688
D177690	N	100L	58	1,480	15	50	N	50	45	30	D177690
D177700	150	100L	35	265	7	50	N	30	25L	30	D177700
D177701	70	100L	36	230	15	30	N	30	25L	20	D177701
D177689	N	150	121	475	15	70	150L	50	50	50	D177689
D177691	N	100	117	335	15	50	N	20	50	30	D177691
D177692	70	N	32	1,430	7	30	N	50	25L	30	D177692
D177696	70	100L	24	270	50	50	150	300	45	70	D177696
D177702	N	100L	40	870	N	30	N	30	25L	15	D177702
D177693	N	100L	92	2,360	20	30	N	70	30	50	D177693
D177703	N	100	70	115	15	50	150L	70	50	30	D177703
D177694	N	N	80	1,860	20	30	N	100	25	30	D177694
D177695	N	N	64	1,230	15	30	N	100	25L	30	D177695
D189370	N	N	38	1,030	N	20	B	20	30	15	D189370
D189371	20	N	38	1,860	N	N	B	15	25L	15	D189371
D189372	20	N	24	1,310	N	N	B	10	25L	10	D189372
D189373	150	N	16	1,320	N	N	B	20	25L	15	D189373
D189359	N	N	56	335	N	N	B	20	30	15	D189359
D189360	15	N	26	650	N	20	B	20	25	20	D189360
D189361	N	N	22	570	15	20	B	10	30	10	D189361
D189362	N	N	100	510	N	20	B	20	35	10	D189362
D189363	20	N	32	2,280	N	N	B	20	35	20	D189363
D189364	70	N	26	1,950	N	N	B	20	25L	10	D189364
D189365	N	N	19	370	N	N	B	10	25L	5	D189365
D189366	N	N	29	2,480	N	N	B	20	25L	10	D189366
D189367	15	N	30	715	N	N	B	20	25	10	D189367
D189368	15	N	37	1,090	N	N	B	20	30	15	D189368
D189369	N	N	42	565	N	20	B	10	35	15	D189369
D177698	N	100L	33	120	N	30	N	50	25L	15	D177698
D177684	50	100	35	1,030	15	30	N	100	35	70	D177684
D177687	N	100L	32	785	15	50	N	30	35	50	D177687
D177685	30	100L	41	1,850	15	30	N	50	30	50	D177685
D177686	30	100L	51	1,670	15	50	N	30	30	30	D177686
D177699	N	N	12	25	N	50	B	10L	25L	N	D177699
D177676	30	100L	100	1,580	15	50	N	30	30	70	D177676
D177677	30	100L	100	1,350	15	50	N	70	30	30	D177677
D177673	N	N	108	295	15	50	N	30	45	30	D177673
D177674	N	100L	171	550	30	50	150L	50	35	70	D177674
D177675	N	150	55	435	50	50	150L	70	45	70	D177675
D177678	N	100L	137	320	30	50	N	70	40	50	D177678

Table 3.--Major- and minor-oxide and trace-element composition of the laboratory ash of 45 lignite and lignite-associated rock samples from the Wilcox Group, Texas region, central and eastern Texas--continued

Sample number	Sr-S (ppm)	V-S (ppm)	Y-S (ppm)	Yb-S (ppm)	Zn (ppm)	Zr-S (ppm)	Sample number
D177688	300	200	70	7	52	300	D177688
D177690	300	300	70	7	45	200	D177690
D177700	700	150	100	10	68	500	D177700
D177701	300	100	70	10	120	1,000	D177701
D177689	500	300	70	10	37	200	D177689
D177691	200	300	70	7	107	200	D177691
D177692	300	150	100	10	22	300	D177692
D177696	300	300	200	10	241	300	D177696
D177702	150	150	30	5	35	300	D177702
D177693	700	300	70	7	29	200	D177693
D177703	300	500	70	7	56	300	D177703
D177694	700	300	70	7	131	150	D177694
D177695	700	200	70	7	36	200	D177695
D189370	1,000	100	50	5	53	150	D189370
D189371	1,000	100	50	5	39	150	D189371
D189372	700	70	30	3	50	100	D189372
D189373	1,000	150	50	7	31	50	D189373
D189359	700	150	50	5	51	150	D189359
D189360	700	150	70	7	51	150	D189360
D189361	500	100	70	7	84	300	D189361
D189362	500	70	50	5	102	150	D189362
D189363	1,500	100	100	10	51	100	D189363
D189364	500	100	50	5	42	100	D189364
D189365	150	50	20	2	64	200	D189365
D189366	700	70	50	5	48	70	D189366
D189367	500	70	50	5	44	100	D189367
D189368	1,000	100	50	5	63	70	D189368
D189369	500	100	50	7	53	200	D189369
D177698	300	150	70	7	193	300	D177698
D177684	1,500	300	70	10	59	300	D177684
D177687	1,500	300	70	10	56	300	D177687
D177685	1,000	200	70	10	52	300	D177685
D177686	700	300	70	10	18	300	D177686
D177699	70	30	70	7	20L	1,000	D177699
D177676	700	300	70	7	25	200	D177676
D177677	500	300	70	7	230	200	D177677
D177673	700	300	70	7	34	300	D177673
D177674	1,000	700	70	7	20	200	D177674
D177675	1,000	700	100	7	27	200	D177675
D177678	300	500	70	7	147	200	D177678

**Table 3.--Major- and minor-oxide and trace-element composition of the laboratory ash of 45 lignite and lignite-associated rock samples from the Wilcox Group, Texas region, central and eastern Texas--continued**

Sample number	Ash (percent)	SiO <sub>2</sub> (percent)	Al <sub>2</sub> O <sub>3</sub> (percent)	CaO (percent)	MgO (percent)	Na <sub>2</sub> O (percent)	K <sub>2</sub> O (percent)	Fe <sub>2</sub> O <sub>3</sub> (percent)	TiO <sub>2</sub> (percent)	SO <sub>3</sub> (percent)	Sample number
D177679	12.8	31	18	14	2.95	0.34	0.26	1.3	1.5	17	D177679
D177680	11.1	29	16	16	3.15	.70	.21	2.1	1.2	19	D177680
D177697	63.4	53	29	1.8	1.43	.22	1.1	2.1	1.4	.40	D177697
D177681	17.3	35	23	9.6	2.12	.40	.40	1.7	1.8	14	D177681
D177682	14.1	30	22	12	2.79	.40	.41	3.4	1.1	19	D177682

Sample number	Ag-S (ppm)	B-S (ppm)	Ba-S (ppm)	Be-S (ppm)	Cd (ppm)	Ce-S (ppm)	Co-S (ppm)	Cr-S (ppm)	Cu (ppm)	Ga-S (ppm)	Sample number
D177679	N	2,000	1,500	15	1.0	500	20	150	238	70	D177679
D177680	N	3,000	300	15	1.0L	N	15	100	110	70	D177680
D177697	N	300	200	N	1.0	N	10L	150	150	70	D177697
D177681	I	1,500	500	7	1.0	500L	15	150	207	70	D177681
D177682	N	2,000	700	15	2.0	500L	50	150	236	70	D177682

Sample number	Ge-S (ppm)	La-S (ppm)	Li (ppm)	Mn (ppm)	Mo-S (ppm)	Nb-S (ppm)	Nd-S (ppm)	Ni-S (ppm)	Pb (ppm)	Sc-S (ppm)	Sample number
D177679	N	300	127	920	30	50	300	50	35	50	D177679
D177680	30	N	71	445	20	30	B	50	25L	70	D177680
D177697	N	100L	95	75	15	30	150L	30	60	20	D177697
D177681	N	100	103	260	30	50	150	50	50	70	D177681
D177682	N	150	54	180	30	30	150	100	50	70	D177682

Sample number	Sr-S (ppm)	V-S (ppm)	Y-S (ppm)	Yb-S (ppm)	Zn (ppm)	Zr-S (ppm)	Sample number
D177679	1,500	500	100	10	50	300	D177679
D177680	1,000	300	70	10	27	200	D177680
D177697	700	300	50	7	59	300	D177697
D177681	700	500	70	7	39	300	D177681
D177682	1,000	700	70	10	34	200	D177682

Table 4--Content of seven trace elements in 45 lignite and lignite-associated rock samples from the Wilcox Group, Texas region, central and eastern Texas

[Analyses on air-dried (32°C) lignite. Values in parts per million. L, less than the value shown]

Sample number	As	F	Hg	Sb	Se	Th	U	Sample number
D177688	2.5	20	0.30	0.8	5.2	8.2	2.4	D177688
D177690	2.0	60	.43	.7	6.6	3.0L	3.7	D177690
D177700	3.0	100	.14	2.1	4.8	6.9	1.9	D177700
D177701	5.0	130	.11	1.7	4.4	9.1	2.9	D177701
D177689	2.5	70	.52	1.1	7.6	9.1	2.9	D177689
D177691	3.0	140	.45	1.3	8.8	14	3.5	D177691
D177692	4.0	30	.09	.8	6.3	4.9	1.3	D177692
D177696	7.0	30	.12	1.5	6.3	3.0L	1.4	D177696
D177702	8.0	295	.13	1.2	8.3	13	3.3	D177702
D177693	4.0	20L	.08	.9	9.5	3.0L	1.9	D177693
D177703	12	495	.27	2.9	21	26	7.7	D177703
D177694	7.0	20L	.28	1.2	14	3.0L	2.2	D177694
D177695	6.0	20L	.23	1.0	16	4.8	1.2	D177695
D189370	2.6	20	.27	.5	8.4	2.4	1.5	D189370
D189371	2.1	20L	.31	1.2	8.3	3.0	1.6	D189371
D189372	2.6	20L	.23	.2	4.2	1.1	.9	D189372
D189373	3.5	20L	.61	.6	3.4	.8	.7	D189373
D189359	3.4	80	.27	.7	11	5.4	2.9	D189359
D189360	2.4	60	.37	1.3	7.2	3.3	2.1	D189360
D189361	1.4	20L	.14	.9	4.8	4.0	2.0	D189361
D189362	18	70	.61	.7	8.2	5.1	2.4	D189362
D189363	5.1	20L	.28	.5	4.0	1.3	1.0	D189363
D189364	1.9	20	.16	.3	2.8	.9	.9	D189364
D189365	18	110	.22	.3	3.2	3.9	1.9	D189365
D189366	2.2	20	.17	.3	2.7	1.0	.9	D189366
D189367	5.1	20	.20	.6	4.2	1.6	1.3	D189367
D189368	2.6	20	.16	.3	3.0	1.1	1.1	D189368
D189369	2.0	35	.33	.7	10	4.2	2.1	D189369
D177698	10	480	.11	.4	5.0	13	4.9	D177698
D177684	3.5	25	.18	.6	5.0	3.0L	1.3	D177684
D177687	1.5	20L	.27	.5	6.3	8.6	2.0	D177687
D177685	2.0	40	.15	.5	4.3	3.0L	1.1	D177685
D177686	1.5	30	.16	.5	5.6	5.3	1.4	D177686
D177699	2.0	50	.06	.4	.8	3.0L	3.3	D177699
D177676	1.0	30	.11	.5	7.5	3.0L	1.5	D177676
D177677	1.5	45	.12	.3	7.0	3.0L	1.2	D177677
D177673	2.0	80	.19	.5	10	8.2	1.7	D177673
D177674	3.0	20L	.20	1.2	10	6.5	4.4	D177674
D177675	3.5	40	.25	1.0	10	7.4	4.7	D177675
D177678	3.0	60	.46	1.5	13	11	3.7	D177678

Table 4.--Content of seven trace elements in 45 lignite and lignite-associated rock samples from the Wilcox Group, Texas region, central and eastern Texas--continued

Sample number	As	F	Hg	Sb	Se	Th	U	Sample number
D177679	2.0	35	0.10	0.6	9.8	6.7	2.0	D177679
D177680	2.0	20L	.07	.5	7.5	5.6	1.3	D177680
D177697	3.0	465	.40	1.2	15	24	4.2	D177697
D177681	2.5	40	.18	1.1	13	12	3.9	D177681
D177682	4.0	40	.23	.9	12	11	4.2	D177682

**Table 5.--Major-, minor-, and trace-element composition of 45 lignite and lignite-associated rock samples from the Wilcox Group,  
Texas region, central and eastern Texas**

[Values in percent or parts per million and reported on a whole-lignite basis. As, F, Hg, Sb, Se, Th, and U values are from direct determinations on air-dried (32°C) lignite; all other values calculated from analyses of ash. S means analysis by semi-quantitative 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
D177688	5.2	1.7	1.1	0.25	0.033	0.12	0.32	0.21	N	2.5	D177688
D177690	4.8	2.3	1.6	.28	.039	.13	.38	.22	.2	2.0	D177690
D177700	8.3	1.6	1.0	.25	.061	.27	.39	.14	N	3.0	D177700
D177701	13	2.4	.98	.30	.092	.49	.63	.22	N	5.0	D177701
D177689	3.2	2.6	1.1	.28	.028	.094	.45	.20	.3	2.5	D177689
D177691	6.2	4.4	.98	.34	.041	.20	.59	.27	.3	3.0	D177691
D177692	5.5	.99	.62	.15	.030	.10	.96	.12	N	4.0	D177692
D177696	.016L	.78	.25	.051	.013	.045	.61	.044	.1	7.0	D177696
D177702	20	4.8	.37	.32	.084	.76	1.7	.30	N	8.0	D177702
D177693	.99	.84	.77	.15	.023	.025	.90	.046	N	4.0	D177693
D177703	20	.14	.44	.63	.13	1.8	1.5	.51	N	12	D177703
D177694	.74	.72	.77	.15	.027	.020	1.1	.038	N	7.0	D177694
D177695	1.1	.76	.79	.11	.016	.019	1.1	.056	N	6.0	D177695
D189370	2.4	.79	1.9	.30	.075	.070	.39	.098	N	2.6	D189370
D189371	2.8	.68	2.3	.22	.039	.036	.28	.12	N	2.1	D189371
D189372	1.9	.39	1.8	.22	.062	.87	.060	N	2.6	D189372	
D189373	.90	.25	1.6	.20	.094	.031	2.2	.035	N	3.5	D189373
D189359	7.5	2.0	1.4	.20	.037	.23	1.1	.21	N	3.4	D189359
D189360	4.8	1.1	1.8	.24	.047	.18	.56	.12	N	2.4	D189360
D189361	6.2	.60	1.3	.17	.038	.024	.68	.27	N	1.4	D189361
D189362	8.3	2.1	1.5	.24	.080	.27	1.8	.19	N	18	D189362
D189363	.98	.39	1.6	.20	.052	.019	.64	.046	N	5.1	D189363
D189364	1.7	.32	1.2	.13	.059	.051	.85	.047	N	1.9	D189364
D189365	21	2.5	.69	.31	.46	1.0	2.4	.16	N	18	D189365
D189366	2.4	.42	1.0	.18	.055	.091	1.4	.048	N	2.2	D189366
D189367	4.7	.66	1.1	.20	.089	.16	1.7	.072	N	5.1	D189367
D189368	1.4	.43	1.8	.22	.035	.049	.85	.057	N	2.6	D189368
D189369	5.0	1.1	1.8	.25	.061	.11	.43	.18	N	2.0	D189369
D177698	32	6.7	.32	.74	.53	1.7	1.6	.45	N	10	D177698
D177684	1.2	.89	1.1	.23	.087	.019	.28	.075	.1	3.5	D177684
D177687	2.5	.94	1.4	.27	.040	.027	.25	.16	N	1.5	D177687
D177685	1.2	.61	1.1	.25	.046	.016	.29	.093	N	2.0	D177685
D177686	1.9	.65	1.1	.30	.056	.016	.18	.11	N	1.5	D177686
D177699	42	.24L	.16	.027	.074	.053	.051	.40	N	2.0	D177699
D177676	1.2	.84	1.3	.15	.043	.011	.25	.084	N	1.0	D177676
D177677	1.4	.87	1.1	.17	.066	.019	.29	.098	N	1.5	D177677
D177673	3.7	2.5	1.1	.25	.038	.095	.35	.17	.2	2.0	D177673
D177674	1.5	1.5	1.2	.22	.031	.015	.15	.084	.15	3.0	D177674
D177675	1.8	1.7	1.2	.25	.032	.040	.22	.098	.15	3.5	D177675
D177678	3.0	2.5	1.0	.23	.037	.077	.42	.16	N	3.0	D177678

Table 5.--Major-, minor-, and trace-element composition of 45 lignite and lignite-associated rock samples from the Wilcox Group,  
Texas region, central and eastern Texas--continued

Sample number	B-S (ppm)	Ba-S (ppm)	Be-S (ppm)	Cd (ppm)	Ce-S (ppm)	Co-S (ppm)	Cr-S (ppm)	Cu (ppm)	F (ppm)	Ga-S (ppm)	Sample number
D177688	150	200	1.5	0.20L	N	3	20	24	20	7	D177688
D177690	100	150	1.5	.23L	100L	3	20	31	60	7	D177690
D177700	200	300	5	.26L	150L	7	20	12	100	15	D177700
D177701	100	300	7	.39L	200L	10	30	15	130	10	D177701
D177689	150	150	1.5	.38	100L	3	30	36	70	15	D177689
D177691	100	200	N	.58	150L	3L	50	48	140	15	D177691
D177692	150	300	3	.20L	100L	5	15	15	30	7	D177692
D177696	150	150	2	.20	30L	15	10	24	30	5	D177696
D177702	150	500	N	.63L	300L	10	50	32	295	20	D177702
D177693	200	150	.7	.10L	N	1.5	15	11	20L	5	D177693
D177703	150	700	N	.78	500L	10	150	260	495	50	D177703
D177694	150	200	N	.19	N	1.5	7	9.7	20L	5	D177694
D177695	200	150	.5	.10	N	2	7	13	20L	5	D177695
D189370	50	100	.7	.14L	N	1.5	10	21	20	3	D189370
D189371	50	100	1	.15L	N	1.5	10	14	20L	3	D189371
D189372	150	70	1	.13L	N	N	5	9.8	20L	2	D189372
D189373	150	70	1.5	.13L	N	1.5	5	7.7	20L	10	D189373
D189359	30	500	N	.29L	N	3	15	22	80	7	D189359
D189360	50	200	2	.20L	N	3	15	18	60	5	D189360
D189361	50	150	3	.21L	N	1.5	10	20	20L	10	D189361
D189362	50	200	3	.34L	N	3	10	21	70	7	D189362
D189363	100	150	1.5	.09L	N	1	5	11	20L	3	D189363
D189364	100	50	1	.10L	N	.7	3	8.3	20	5	D189364
D189365	70	300	N	.65L	N	5	20	11	110	7	D189365
D189366	150	150	1	.13L	N	1.5	5	10	20	2	D189366
D189367	100	150	1.5	.20L	N	2	7	10	20	5	D189367
D189368	100	100	.7	.11L	N	.7	5	12	20	2	D189368
D189369	50	150	1	.21L	N	2	10	17	35	5	D189369
D177698	100	700	N	.93L	500L	30	70	19L	480	30	D177698
D177684	150	70	1.5	.15	50L	10	15	18	25	7	D177684
D177687	200	300	2	.14L	N	2	20	23	20L	7	D177687
D177685	150	70	1.5	.09L	50L	5	15	16	40	5	D177685
D177686	150	30	1.5	.11L	N	3	15	17	30	3	D177686
D177699	150	100	N	.91L	N	10L	30	18L	50	N	D177699
D177676	300	70	1.5	.10L	N	1.5	15	15	30	7	D177676
D177677	200	70	1	.10L	50L	3	15	15	45	7	D177677
D177673	300	150	1.5	.20L	100L	3	30	30	80	15	D177673
D177674	200	100	1	.12	70L	3	20	26	20L	15	D177674
D177675	200	70	1	.27	70L	5	20	30	40	10	D177675
D177678	300	100	1.5	.58	100L	7	30	31	60	15	D177678

Table 5.--Major-, minor-, and trace-element composition of 45 lignite and lignite-associated rock samples from the Wilcox Group,  
Texas region, central and eastern Texas--continued

Sample number	Ge-S (ppm)	Hg (ppm)	La-S (ppm)	Li (ppm)	Mn (ppm)	Mo-S (ppm)	Nb-S (ppm)	Nd-S (ppm)	Ni-S (ppm)	Pb (ppm)	Sample number
D177688	N	0.30	20L	11	87	5	15	30L	10	7.1	D177688
D177690	N	.43	20L	13	340	3	10	N	10	10	D177690
D177700	50	.14	30L	9.2	70	2	15	N	7	6.6L	D177700
D177701	30	.11	50L	14	89	7	10	N	10	9.7L	D177701
D177689	N	.52	30	23	91	3	15	30L	10	9.6	D177689
D177691	N	.45	30	34	98	5	15	N	7	15	D177691
D177692	15	.09	N	6.5	290	1.5	7	N	10	5.1L	D177692
D177696	5	.12	7L	1.6	18	3	3	10	20	3.1	D177696
D177702	N	.13	70L	25	550	N	20	N	20	16L	D177702
D177693	N	.08	10L	9.1	230	2	3	N	7	3.0	D177693
D177703	N	.27	70	54	89	10	50	100L	50	39	D177703
D177694	N	.28	N	7.8	180	2	3	N	10	2.4	D177694
D177695	N	.23	N	6.5	120	1.5	3	N	10	2.5L	D177695
D189370	N	.27	N	5.2	140	N	3	B	3	4.1	D189370
D189371	3	.31	N	5.5	270	N	N	B	2	3.6L	D189371
D189372	3	.23	N	3.1	170	N	N	B	1.5	3.3L	D189372
D189373	20	.61	N	2.1	170	N	N	B	2	3.2L	D189373
D189359	N	.27	N	16	97	N	N	B	7	8.7	D189359
D189360	3	.37	N	5.2	130	N	5	B	5	5.0	D189360
D189361	N	.14	N	4.6	120	3	5	B	2	6.2	D189361
D189362	N	.61	N	34	170	N	7	B	7	12	D189362
D189363	2	.28	N	2.9	210	N	N	B	2	3.2	D189363
D189364	7	.16	N	2.6	200	N	N	B	2	2.5L	D189364
D189365	N	.22	N	12	240	N	N	B	7	16L	D189365
D189366	N	.17	N	3.8	320	N	N	B	3	3.3L	D189366
D189367	3	.20	N	6.1	150	N	N	B	5	5.1	D189367
D189368	1.5	.16	N	4.1	120	N	N	B	2	3.3	D189368
D189369	N	.33	N	8.6	120	N	5	B	2	7.2	D189369
D177698	N	.11	100L	31	110	N	30	N	50	23L	D177698
D177684	5	.18	10	3.5	100	1.5	3	N	10	3.5	D177684
D177687	N	.27	15L	4.4	110	2	7	N	5	4.8	D177687
D177685	3	.15	10L	3.8	170	1.5	3	N	5	2.8	D177685
D177686	3	.16	10L	5.5	180	1.5	5	N	3	3.2	D177686
D177699	N	.06	N	11	23	N	50	B	10L	23L	D177699
D177676	3	.11	10L	10	160	1.5	5	N	3	3.0	D177676
D177677	3	.12	10L	10	140	1.5	5	N	7	3.1	D177677
D177673	N	.19	N	21	58	3	10	N	7	8.8	D177673
D177674	N	.20	15L	21	68	3	7	20L	7	4.3	D177674
D177675	N	.25	20	7.5	60	7	7	20L	10	6.2	D177675
D177678	N	.46	20L	26	62	7	10	N	15	7.7	D177678

Table 5.--Major-, minor-, and trace-element composition of 45 lignite and lignite-associated rock samples from the Wilcox Group,  
Texas region, central and eastern Texas--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
D177688	0.8	7	5.2	70	8.2	2.4	50	15	1.5	11	D177688
D177690	.7	7	6.6	70	3.0L	3.7	70	15	1.5	10	D177690
D177700	2.1	7	4.8	200	6.9	1.9	50	30	3	18	D177700
D177701	1.7	7	4.4	100	9.1	2.9	50	30	5	46	D177701
D177689	1.1	10	7.6	100	9.1	2.9	70	15	2	7.1	D177689
D177691	1.3	10	8.8	70	14.1	3.5	100	20	2	31	D177691
D177692	.8	7	6.3	70	4.9	1.3	30	20	2	4.4	D177692
D177696	1.5	5	6.3	20	3.0L	1.4	20	15	.7	16	D177696
D177702	1.2	10	8.3	100	13.0	3.3	100	20	3	22	D177702
D177693	.9	5	9.5	70	3.0L	1.9	30	7	.7	2.9	D177693
D177703	2.9	20	21	200	25.5	7.7	500	50	5	43	D177703
D177694	1.2	3	14	70	3.0L	2.2	30	7	.7	13	D177694
D177695	1.0	3	16	70	4.8	1.2	20	7	.7	3.6	D177695
D189370	.5	2	8.4	150	2.4	1.5	15	7	.7	7.2	D189370
D189371	1.2	2	8.3	150	3.0	1.6	15	7	.7	5.7	D189371
D189372	.2	1.5	4.2	100	1.1	.9	10	5	.5	6.6	D189372
D189373	.6	2	3.4	150	.8	.7	20	7	1	4.0	D189373
D189359	.7	5	11	200	5.4	2.9	50	15	1.5	15	D189359
D189360	1.3	5	7.2	150	3.3	2.1	30	15	1.5	10	D189360
D189361	.9	2	4.8	100	4.0	2.0	20	15	1.5	17	D189361
D189362	.7	3	8.2	150	5.1	2.4	20	15	1.5	34	D189362
D189363	.5	2	4.0	150	1.3	1.0	10	10	1	4.6	D189363
D189364	.3	1	2.8	50	.9	.9	10	5	.5	4.2	D189364
D189365	.3	3	3.2	100	3.9	1.9	30	15	1.5	41	D189365
D189366	.3	1.5	2.7	100	1.0	.9	10	7	.7	6.3	D189366
D189367	.6	2	4.2	100	1.6	1.3	15	10	1	9.0	D189367
D189368	.3	1.5	3.0	100	1.1	1.1	10	5	.5	7.0	D189368
D189369	.7	3	10	100	4.2	2.1	20	10	1.5	11	D189369
D177698	.4	15	5.0	300	13.4	4.9	150	70	7	180	D177698
D177684	.6	7	5.0	150	3.0L	1.3	30	7	1	5.8	D177684
D177687	.5	7	6.3	200	8.6	2.0	50	10	1.5	7.6	D177687
D177685	.5	5	4.3	100	3.0L	1.1	20	7	1	4.8	D177685
D177686	.5	3	5.6	70	5.3	1.4	30	7	1	1.9	D177686
D177699	.4	N	.8	70	3.0L	3.3	30	70	7	18L	D177699
D177676	.5	7	7.5	70	3.0L	1.5	30	7	.7	2.5	D177676
D177677	.3	3	7.0	50	3.0L	1.2	30	7	.7	24	D177677
D177673	.5	7	10	150	8.2	1.7	70	15	1.5	6.7	D177673
D177674	1.2	10	10	150	6.5	4.4	100	10	1	2.5	D177674
D177675	1.0	10	10	150	7.4	4.7	100	15	1	3.7	D177675
D177678	1.5	10	13	70	10.7	3.7	100	15	1.5	28	D177678

Table 5.--Major-, minor-, and trace-element composition of 45 lignite and lignite-associated rock samples from the Wilcox Group,  
Texas region, central and eastern Texas--continued

Sample number	Zr-S (ppm)
D177688	70
D177690	50
D177700	150
D177701	500
D177689	30
D177691	70
D177692	70
D177696	20
D177702	200
D177693	20
D177703	200
D177694	15
D177695	20
D189370	20
D189371	20
D189372	15
D189373	7
D189359	50
D189360	30
D189361	70
D189362	50
D189363	10
D189364	10
D189365	150
D189366	10
D189367	20
D189368	7
D189369	50
D177698	300
D177684	30
D177687	50
D177685	30
D177686	30
D177699	1,000
D177676	20
D177677	20
D177673	70
D177674	20
D177675	30
D177678	50

Table 5.--Major-, minor-, and trace-element composition of 45 lignite and lignite-associated rock samples from the Wilcox Group,  
Texas region, central and eastern Texas--continued

Sample number	Si (percent)	Al (percent)	Ca (percent)	Mg (percent)	Na (percent)	K (percent)	Fe (percent)	Tl (percent)	Ag-S (ppm)	As (ppm)	Sample number
D177679	1.9	1.2	1.3	0.23	0.032	0.028	0.12	0.12	N	2.0	D177679
D177680	1.5	.92	1.2	.21	.058	.019	.16	.078	N	2.0	D177680
D177697	16	9.6	.80	.55	.10	.58	.93	.53	N	3.0	D177697
D177681	2.8	2.1	1.2	.22	.051	.058	.21	.19	.15	2.5	D177681
D177682	2.0	1.7	1.2	.24	.042	.048	.33	.094	N	4.0	D177682

Sample number	B-S (ppm)	Ba-S (ppm)	Be-S (ppm)	Cd (ppm)	Ce-S (ppm)	Co-S (ppm)	Cr-S (ppm)	Cu (ppm)	F (ppm)	Ga-S (ppm)	Sample number
D177679	200	200	2	0.13	70	2	20	30	35	10	D177679
D177680	300	30	1.5	.11L	N	1.5	10	12	20L	7	D177680
D177697	200	150	N	.63	N	7L	100	95	465	50	D177697
D177681	200	100	1	.17	100L	2	20	36	40	10	D177681
D177682	300	100	2	.28	70L	7	20	33	40	10	D177682

Sample number	Ge-S (ppm)	Hg (ppm)	La-S (ppm)	Li (ppm)	Mn (ppm)	Mo-S (ppm)	Nb-S (ppm)	Nd-S (ppm)	Ni-S (ppm)	Pb (ppm)	Sample number
D177679	N	0.10	50	16	120	5	7	50	7	4.5	D177679
D177680	3	.07	N	7.9	49	2	3	B	5	2.8L	D177680
D177697	N	.40	70L	60	48	10	20	100L	20	38	D177697
D177681	N	.18	15	18	45	5	10	20	10	8.7	D177681
D177682	N	.23	20	7.6	25	5	5	20	15	7.1	D177682

Table 5.--Major-, minor-, and trace-element composition of 45 lignite and lignite-associated rock samples from the Wilcox Group,  
Texas region, central and eastern Texas--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
D177679	0.6	7	9.8	200	6.7	2.0	70	15	1.5	6.4	D177679
D177680	.5	7	7.5	100	5.6	1.3	30	7	1	3.0	D177680
D177697	1.2	15	15	500	23.7	4.2	200	30	5	37	D177697
D177681	1.1	10	13	100	12.2	3.9	100	10	1	6.7	D177681
D177682	.9	10	12	150	10.8	4.2	100	10	1.5	4.8	D177682

Sample number	Zr-S (ppm)
D177679	50
D177680	20
D177697	200
D177681	50
D177682	30

Table 6.--Elements looked for but not detected in lignite and lignite-associated rock samples from the Wilcox Group, Texas region, central and eastern Texas

[Approximate lower detection limits in ash, as determined by the six-step spectrographic method of the U.S. Geological Survey, are included for all elements except P. The reported lower detection of P is for the X-ray spectroscopic method]

Element name	Symbol	Lower limit of detection in ash (ppm)
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
Phosphorous	P	4,400
Palladium	Pd	5
Praseodymium	Pr	200
Platinum	Pt	100
Rhenium	Re	100
Samarium	Sm	200
Tin	Sn	20
Tantalum	Ta	1,000
Terbium	Tb	700
Tellerium	Te	5,000
Thallium	Tl	100
Thulium	Tm	50
Tungsten	W	200

Table 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 27 lignite samples from the Texas region, central and eastern Texas

[All values are in percent except Kcal/kg, Btu/lb and ash-fusion temperatures and are reported on the as-received basis.  $^{\circ}\text{F} = (^{\circ}\text{C} \cdot 1.8) + 32$ ; Kcal/kg = 0.556(Btu/lb). L, less than the value shown. Leaders (---) indicate no data. For comparison, geometric means for 19 Mississippi region lignite samples (Swanson and others, 1976, table 25a) are included]

	Arithmetic mean	Observed range		Geometric mean	Geometric deviation	Mississippi region geometric mean
		Minimum	Maximum			
Proximate and ultimate analyses						
Moisture	30.6	18.6	36.0	30.2	1.2	46.6
Volatile matter	29.9	23.8	40.3	29.7	1.1	20.1
Fixed carbon	27.5	20.9	33.5	27.3	1.1	16.0
Ash	12.0	6.6	26.2	11.2	1.5	12.8
Hydrogen	6.4	5.6	6.9	6.4	1.1	7.0
Carbon	41.6	32.5	52.2	41.3	1.1	24.2
Nitrogen	.8	.6	1.0	.8	1.2	.5
Oxygen	38.4	30.7	42.6	38.2	1.1	49.5
Sulfur	.9	.4	2.0	.8	1.5	1.7
Heat of combustion						
Kcal/kg	3,980	3,100	5,100	3,960	1.1	2,240
Btu/lb	7,170	5,570	9,170	7,120	1.1	4,030
Forms of sulfur						
Sulfate	0.03	0.01L	0.12	0.02	2.2	0.02
Pyritic	.25	.01	1.5	.12	3.4	.40
Organic	.59	.30	.95	.55	1.4	.80
Ash-fusion temperatures, $^{\circ}\text{C}$						
Initial deformation	1,185	1,055	1,485	1,180	1.1	---
Softening temperature	1,225	1,080	1,540	1,255	1.1	---
Fluid temperature	1,275	1,110	1,540	1,275	1.1	---

Table 8.--Arithmetic mean, observed range, geometric mean, and geometric deviation of ash content and contents of nine major and minor oxides in the laboratory ash of 39 lignite samples from the Wilcox Group, Texas region, central and eastern Texas

[All samples were ashed at 525°C; all values except geometric deviation are in percent. L, less than the value shown. For comparison, geometric means of 34 Mississippi region lignite samples (Swanson and others, 1976, table 25b) are included]

Oxide	Arithmetic mean	Observed range		Geometric mean	Geometric deviation	Mississippi region geometric mean
		Minimum	Maximum			
(Ash)	16.4	6.8	38.7	15.0	1.5	22.4
SiO <sub>2</sub>	38	.50L	71	35	1.5	41
Al <sub>2</sub> O <sub>3</sub>	15	3.7	28	13	1.7	13
CaO	12	3.5	25	11	1.6	3.7
MgO	2.5	1.2	4.6	2.3	1.4	1.3
Na <sub>2</sub> O	.46	.17	1.2	.40	1.7	.10
K <sub>2</sub> O	.54	.13	1.5	.43	1.9	.80
Fe <sub>2</sub> O <sub>3</sub>	6.2	1.3	24	4.6	2.2	10
TiO <sub>2</sub>	1.2	.45	2.2	1.2	1.4	.82
SO <sub>3</sub>	15	3.1	28	13	1.7	8.3

Table 9.--Arithmetic mean, observed range, geometric mean, and geometric deviation of 35 elements in 39 lignite samples from the Texas region, central and eastern Texas

[All analyses are in percent or parts per million and are reported on a whole-lignite basis. As, F, Hg, Sb, Se, Th, and U values used to calculate statistics were determined directly on whole lignite. All other values used were calculated from determinations made on lignite ash. L, less than the value shown. For comparison, geometric means for 34 Mississippi region lignite samples (Swanson and others, 1976, table 25c) are included]

Element	Arithmetic mean	Observed range		Geometric mean	Geometric deviation	Mississippi region geometric mean
		Minimum	Maximum			
Percent						
Si	3.3	0.02L	13	2.5	2.2	4.2
Al	1.3	.25	4.4	1.0	2.0	1.6
Ca	1.3	.25	2.3	1.2	1.5	.60
Mg	.22	.051	.34	.21	1.4	.17
Na	.050	.013	.11	.045	1.6	.009
K	.087	.011	.49	.054	2.7	.15
Fe	.64	.12	2.2	.49	2.1	1.6
Ti	.12	.035	.27	1.0	1.8	.11
Parts per million						
As	3.3	1.0	18	2.9	1.7	5
B	150	30	300	150	1.8	100
Ba	150	30	500	150	1.9	150
Be	1.5	.5L	7	1.5	1.9	2
Co	3	.7	15	2	2.2	5
Cr	15	3	50	15	1.9	15
Cu	20	7.7	48	18	1.6	20
F	40	20L	140	29	2.2	91
Ga	7	2	15	7	1.8	7
Hg	.25	.07	.61	.21	1.7	.13
Li	10	1.6	34	7.8	2.2	14
Mn	140	18	340	120	1.9	51
Mo	2	1.5L	7	2	2.1	.7
Nb	7	3L	15	5	2.0	2
Ni	7	1.5	20	5	2.0	15
Pb	4.9	2.4L	15	3.9	2.0	2.8
Sb	.83	.2	2.1	.7	1.7	.7
Sc	5	1	10	5	2.0	5
Se	7.6	2.7	16	6.8	1.6	5.8
Sr	100	20	200	100	1.6	150
Th	5.6	.8	14.1	2.6	3.4	3.0
U	2.1	.7	4.7	1.8	1.7	2.4
V	50	10	100	30	2.1	30
Y	10	5	30	10	1.6	15
Yb	1.5	.5	5	1	1.6	1.5
Zn	10	1.9	46	7.7	2.2	28
Zr	50	7	500	30	2.3	50

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