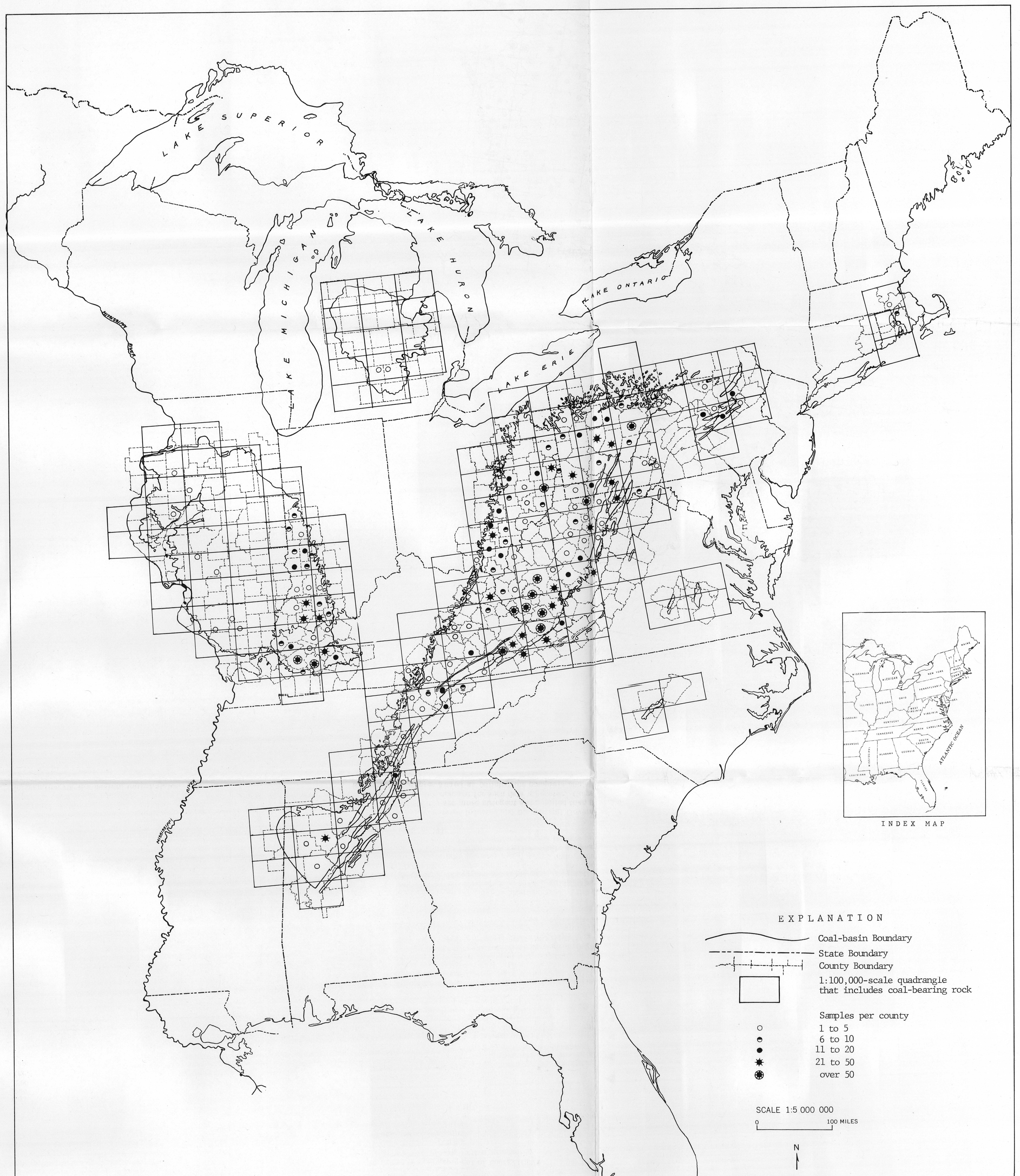
DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

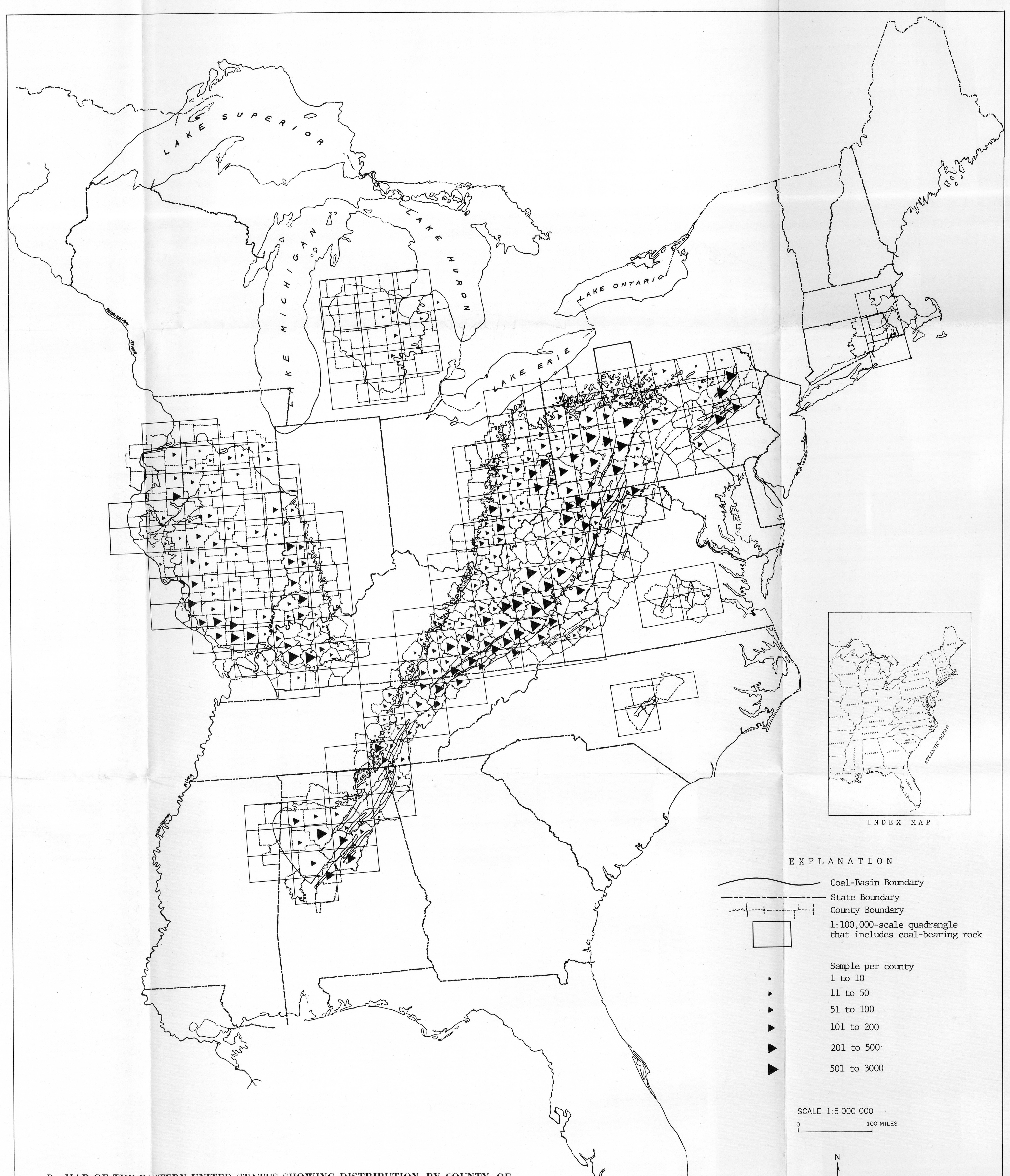
MISCELLANEOUS FIELD STUDIES
MAP MF-1190
TRENT—COAL-QUALITY INFORMATION FROM
EASTERN UNITED STATES



A, MAP OF THE EASTERN UNITED STATES SHOWING DISTRIBUTION, BY COUNTY, OF CHEMICALLY ANALYZED COAL BED SAMPLES BY THE U. S. GEOLOGICAL SURVEY

Base from U.S. Geological Survey, 1942, Coal Fields of the United States: scale 1:2,500,000.

Map compiled by V. A. Trent and L. J. Bragg, 1978



B, MAP OF THE EASTERN UNITED STATES SHOWING DISTRIBUTION, BY COUNTY, OF STANDARD COAL ANALYSES BY THE U. S. BUREAU OF MINES

Base from U. S. Geological Survey, 1942, Coal Fields of the United States: scale 1:2,500,000.

Bureau of Mines data stored in National Coal Resources Data System (NCRDS), U.S. Geological Survey. Compiled in 1978

Table 1.--Coal Production in the Eastern United States in 1975

Data from U.S. Bureau of Mines Minerals Yearbook, 1975

Rank	State	Total tonnage		Percent of total production	
		Short tons[1]	Metric tons	United States[2]	Eastern United States
1	Kentucky	143,613,000	130,320,327	21.9	26.4
2	West Virginia	109,283,000	99,167,877	16.7	20.1
3	Pennsylvania	90,000,000	81,669,692	13.7	16.6
4	Illinois	59,537,000	54,026,316	9.1	11.0
5	Ohio	46,778,000	42,448,276	7.1	8.6
6	Virginia	35,510,000	32,223,231	5.4	6.5
7	Indiana	25,124,000	22,798,548	3.8	4.6
8	Alabama	22,644,000	20,548,094	3.5	4.2
9	Tennessee	8,206,000	7,446,461	1.3	1.5
10	Maryland	2,606,000	2,364,791	0.4	0.5
11	Georgia	74,000	67,151	0.01	0.01
12	Michigan	0	0	0.	0.
	Total	543,375,000	493,080,763	82.9%	100 %

[1] 1 short ton = 2,000 pounds; 1 metric ton = 2,204 pounds; 1 metric ton = 1.102 short tons.

[2] Total United States coal production in 1975 was 654,600,000 short tons (U.S. Bureau of Mines, 1977, p. 387-484).

Table 2.—Distribution of other coal-quality data from the Eastern United States

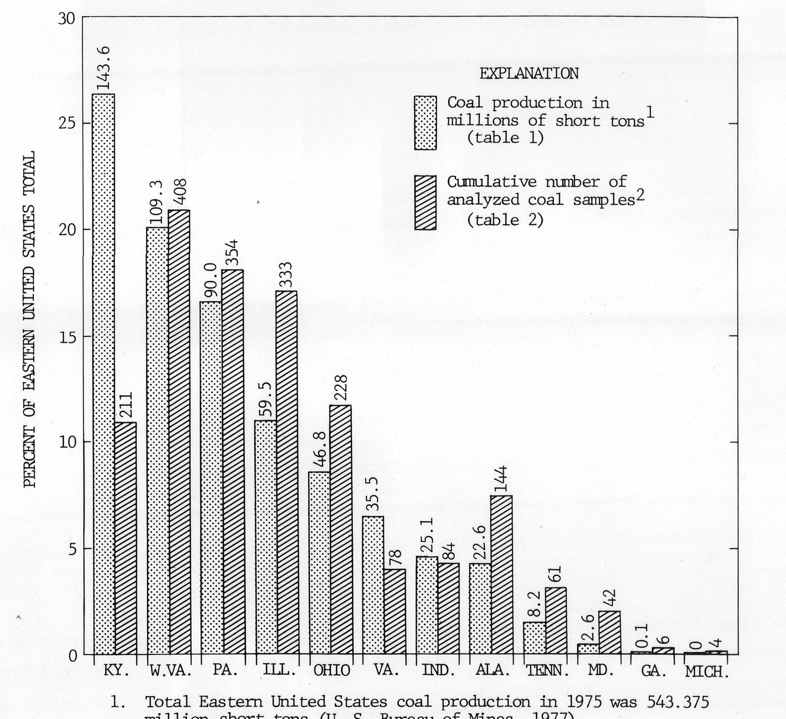
(excluding lignite and work by the U.S. Geological Survey since 1972)

State	Source No.[1]	Analyses performed[2] a	b	c	Number of analyzed coal samples	Percent of total number of analyzed coal samples
Kentucky	1	x			74	
	2			x	34	
	4	x	x	x	15	
	9	x			6	
	11	x			1	
	14		x	x	6	
	15	x	x		17	
	16	x			2	
	17	x			36	
	19	x			20	
subtotal		171	38	55	211	10.8
West Virginia	1	x			247	
	2			x	28	
	3	x		x	19	
	4	x	x	x	6	
	5	x	x	x	33	
	8	x	x	x	3	
	9	x			6	
	11	x			1	
	13	x			3	
	15	x	x		42	
	16	x			11	
	17	x			9	
subtotal		380	84	89	408	20.9
Pennsylvania	1	x			117	
	2			x	90	
	3	x		x	22	
	4	x	x	x	4	
	7	x		x	8	
	8	x	x	x	14	
	9	x			19	
	11	x			1	
	12	x	x	x	4	
	13	x			2	
	15	x	x		57	
	16	x			12	
	17	x			3	
	19	x			1	
subtotal		381	79	142	354	18.1
Illinois	1	x			29	
	2			x	31	
	3	x		x	2	
	4	x	x	x	104	
	8	x	x	x	3	
	9	x			3	
	10	x			55	
	13	x			4	
	15	x	x		32	
	17	x			35	
	18	x			35	
subtotal		302	139	36	333	17.1
Ohio	1	x			85	
	2			x	48	
	4	x	x	x	5	
	8	x	x	x	2	
	11	x			3	
	13	x			1	
	15	x	x		24	
	16	x			23	
	17	x			21	
	19	x			16	
subtotal		180	31	55	228	11.7
Virginia	1	x			51	
	2			x	4	
	3	x		x	14	
	15	x	x		5	
	16	x			2	
	17	x			2	
subtotal		74	5	18	78	4.0
Indiana	1	x			31	
	2			x	17	
	3	x		x	1	
	4	x	x	x	10	
	9	x			2	
	11	x			1	
	13	x			1	
	15	x	x		1	
	17	x			10	
	19	x			10	
subtotal		67	11	28	84	4.3
Alabama	1	x			39	
	2			x	6	
	3	x		x	4	
	4	x	x	x	6	
	6		x	x	23	
	9	x			3	
	14		x	x	1	
	15	x	x		16	
	17	x			23	
	19	x			23	
subtotal		114	46	40	144	7.4
Tennessee	1	x			25	
	2			x	6	
	3	x		x	7	
	4	x	x	x	4	
	15	x	x		5	
	17	x			7	
	19	x			7	
subtotal		55	9	17	61	3.1
Maryland	1	x			2	
	2			x	32	
	3	x		x	1	
	8	x	x	x	1	
	15	x	x		3	
	16	x			1	
	17	x			1	
	19	x			1	
subtotal		10	4	34	42	2.1
Georgia	17	x			3	
	19	x			3	
subtotal		6	0	0	6	0.3
Michigan	3	x		x	2	
	15	x	x		2	
subtotal		4	2	2	4	0.2
Total		1,744	448	516	1,953	100.0%

[1] Source No. indicates published reference listed under Sources of Coal-Quality Data.

[2] Analyses performed are indicated by letters keyed to source numbers under Sources of Coal-Quality Data; analyses are as follows:
a - major-, minor-, and trace-element chemical analyses on whole-coal and coal-ash samples;
b - U.S. Bureau of Mines standard ultimate and proximate coal analyses, heat content, and forms-of-sulfur determination;
c - specific gravity, hardness, cleaning characteristics, and coking properties.

Note - This compilation is not all inclusive, and the coal samples are of several different types: block, column, and bed channel samples; and composites of these: drill core, run-of-mine, and tipple.



1. Total Eastern United States coal production in 1975 was 543.375 million short tons (U. S. Bureau of Mines, 1977).

2. Total number of analyzed coal samples (excluding lignite and work by USGS since 1972) from the Eastern United States is 1,953; see table 2.

Figure 1.--Graph showing 1975 coal production and cumulative number of analyzed coal samples from each State in the Eastern United States.

COAL-QUALITY INFORMATION FROM THE EASTERN UNITED STATES

By
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1980

INTRODUCTION

The United States is attempting to increase domestic coal production in order to reduce dependence upon costly imported petroleum and to stabilize domestic fuel supplies, until alternative sources of energy are developed. In 1975, coal production for the United States amounted to roughly 654 million short tons (593.5 million metric tons) (U.S. Bureau of Mines, 1977, p. 388 and p. 458). A principal goal of industry and government is to increase this amount to 1 to 1.2 billion tons by 1985. Table 1 shows 1975 coal production from the Eastern United States. It is estimated that one-half to three-quarters of the yearly coal production between 1980 and 1985 will be used in coal-fired electric-generating plants scattered across the country (Averitt, 1973, p. 133; and Southwest Energy Federal Task Force, 1972). The need for modern coal-quality data will increase as the demand for coal and coal products expands and becomes more diversified because of changes in technology. Adequate information about the major-, minor-, and trace-element contents of coal is a substantial part of modern coal-quality data.

During coal combustion various chemical elements and compounds are differentially mobilized so that plant operations are often seriously disrupted and the environment adversely affected. Boiler fouling is commonplace, hazardous elements are discharged into the surrounding environment, and catalytic poisoning during coal conversion processes may result because of trace amounts of certain elements in coal. During coal combustion in modern power plants, air-borne emissions of some environmentally hazardous substances are being reduced by the use of electrostatic precipitators and scrubbers. However, precipitation and scrubbing create solid wastes from the gaseous and particulate substances that would otherwise have been emitted to the atmosphere. Subsequently the waste is buried underground or is disposed on the land surface or in lakes or ponds. Coal that is less prone to cause fouling can be selected or blended by combustion engineers utilizing coal quality data. Similarly, coal that could reduce or eliminate catalytic poisoning during conversion can be identified and burned. Coal producers, manufacturers, power companies, and governmental agencies need complete physical, chemical, and combustion specifications on all types of coal so they can efficiently determine how to locate, mine, purchase, prepare, and utilize suitable coal.

Coal quality may be defined as the sum of physical and chemical properties of a coal that affect its use. The purpose of this report is to appraise the available coal quality information for coal beds east of the Mississippi River. The study is based on published reports, an unpublished map compilation, and U.S. Geological Survey (USGS) project work in progress. Although not all published coal quality data is included, this report is broad enough in scope to present the general status of coal quality information for the Eastern United States.

Historical background

Investigations of coal quality in the United States began in a meaningful way when the USGS established a coal-testing plant for the Louisiana Purchase Exposition at St. Louis, Mo. in 1904 (Parker and others, 1905). Carload quantities of coal from the more productive coal beds in various sections of the country were thoroughly analyzed by coal specialists at the plant. Steam tests were run and combustion characteristics determined for all the coal samples. Clinkering and coking properties of the coals were studied and producer gas tests conducted. The results from the tests were so well received by the coal industry that a similar plant was built at Norfolk, Va. to continue the work. There were few published coal analyses in 1904, yet at that time the Federal Government was a major coal consumer; most buildings, naval ships, and the maritime fleet were heated and powered by coal-fired boilers. Analytical standards were needed to judge the value of the coal so that the Federal Government would not have to assume the quality of coal purchased, based only on the reputation of a coal bed name or mining district. The USGS was directed to analyze and report on the coal produced in the United States; and the published results proved very useful to government and industry. In an early USGS report (Randall, 1908, p. 5) coal buyers were chided for not requiring some form of certification of quality. The purpose of Randall's report was to convince industry and the public that the purchase of coal according to specific standards would be more efficient and economical. If delivered coal did not meet the standards the purchaser would then have legal recourse for compensation. Until Randall's report was published, when a seller was questioned about the quality of coal, he would cite the name of the bed, mine, and district from which the coal was mined, as the only guarantee.

In 1910 Congress created the U.S. Bureau of Mines and established the Coal Analysis Section within it. At that time the prime responsibility for the acquisition of coal quality data was transferred from the USGS to the Bureau of Mines and remained there until 1977 when responsibility was passed to the U.S. Department of Energy (DOE). The earliest standard coal tests included the determination of heating values and the ultimate and proximate analyses. Subsequently, the Bureau of Mines developed a series of physical tests, including coking properties, which served to further classify the coals. Additional refinements consisted of analyzing coal for its inorganic and maceral constituents. Such work is being done by the DOE and the USGS on a continuing basis.

Coal-quality definition

Since 1904 many tests have been devised by coal researchers to discern the origin, history, chemistry, physical characteristics, usage, conversion possibilities, pollution potential, and marketing possibilities of coal. Principal among these tests are determinations used in ascertaining rank, heat value, coal chemistry, cokeability, grade, ash content, and fusibility. All of these properties contribute to the quality of a coal. Quality is a function of how a coal can ultimately be used. A high-quality coal for one usage may be low-quality coal for other uses.

Classification of coal by rank is accomplished by chemical analyses that determine the percentage of fixed carbon and heat content or Btu value calculated on a mineral-matter-free basis (Averitt, 1975, p. 16). By definition, the British thermal unit (Btu) is the quantity of heat required to raise the temperature of 1 lb. of water through 1 degree Fahrenheit (Hausmann and Slack, 1948, p. 259). Therefore rank is a very sensitive indicator of progressive metamorphic change throughout coalification. It is a function of geologic time, heat and pressure effects, and depth of burial of the coal-forming plant materials.

Grade of coal is an informal description based on the content of ash, sulfur, and other deleterious substances. The limiting parameters for the concentration of ash, sulfur, and other substances in coal have not been designated. Thus, use of terms like high-, moderate- and low-grade are not truly descriptive, especially because a coal can be high-grade for one usage and low-grade for another. High-rank and informally designated high-grade coals are higher in heat value than low-rank and low-grade coals (Averitt and others, 1972, p. 12).

The requirements of industry and the Federal Government for data related to coal quality are more stringent and detailed than they were 10 to 25 years ago, and the demand for such data is greater. Currently the USGS is conducting studies aimed at defining the complete chemical analyses of whole coal and coal ash for major-, minor-, and trace-element content. These analyses supplement the standard coal proximate, ultimate, and other analyses performed by the Coal Analysis Section of the DOE. In addition, the DOE Coal Analysis Section conducts tests on the standard physical properties of coal for coking and cleaning characteristics.

Years ago, relative coal quality was determined by comparing Btu values and percentages of ash, sulfur, and moisture. However, any physical or chemical property of coal that affects its use, including the waste products when coal is used for combustion or conversion, is important in determining quality.

Coal-quality data

Coal samples collected in the field and analyzed in the laboratory are the primary source of data on coal quality. Two maps, (A and B) at a scale of 1:5,000,000, and a graph (figure 1) show the number and distribution of samples and analyses from which different types of data on coal quality were obtained in the Eastern United States. About 95 percent of the data shown on map A and in table 2 are from channel samples that accurately represent the total coal at each collection site; other data are from core samples from exploratory drilling programs. The Bureau of Mines standard coal analyses distribution shown on map B is derived from coal channel samples, delivered samples, and run-of-mine or tipple samples. Except for the samples of delivered coal, which may include a washed and (or) screened coal product, the analyses are considered to be representative of the sampled coal in a particular location or mine area. The following interpretation of each map and table 2 identifies gaps in the data base and suggests what additional kinds of quality information are needed. The sample locations were determined mostly by the locations of active mines where samples of unweathered coal could be collected near working faces or from mine pillars. Fewer samples were collected in States, such as Illinois, having strong coal-research programs, to avoid a duplication of effort.

U.S. Geological Survey coal-quality program

Map A shows the distribution of 2,092 coal samples, mostly channel samples, excluding lignite, collected for the coal quality project of the USGS. The samples are from 149 counties in 14 States east of the Mississippi River, and were plotted as of May 8, 1978 using symbols representing five levels of sample concentration. The reliability of the analytical data is very high because the coal samples are representative of the coal bed and the chemical analyses are performed using techniques with a high degree of accuracy. These data consist of (1) ultimate and proximate analyses, forms-of-sulfur and ash fusion temperature determinations, heat content or Btu values, and free-swelling index for coking properties as determined by the DOE Coal Analysis Section; and (2) major-, minor-, and trace-element concentrations of approximately 70 inorganic elements and oxides on whole coal and coal ash (USGS analyses). These Bureau of Mines, DOE, and USGS results comprise the most modern detailed body of coal analytical data that are available for planning purposes and technological study. All data are stored in the National Coal Resources Data System (NCRDS), U.S. Geological Survey, Reston, Virginia.

Discussion of sample distribution in map A: The sample distribution on map A reveals that the greatest concentrations of coal samples are from a few areas. These are southern West Virginia, southwestern Virginia along the West Virginia state line, and in the western Kentucky-southwestern Indiana portions of the Illinois Basin.

Areas least represented by analyzed coal samples are eastern Kentucky, which for the past few years has ranked number one in coal production in the United States, and several coal-producing counties in western Pennsylvania, including Beaver and Allegheny Counties; other counties including Greene County, Pennsylvania have only had from 1 to 5 samples analyzed. The Panhandle area of West Virginia has few samples and therefore little available modern data. Furthermore, only a few coal samples from Illinois were analyzed by the USGS because the Illinois State Geological Survey has assumed primary responsibility for local coal-quality studies (Gluskoter and others, 1977).

A paucity of coal samples is noteworthy in north-central West Virginia where the principal coal-bearing sequence is at depth and is overlain by rocks of the Dunkard Group which contain relatively minor amounts of coal. A need exists in that area to have an exploratory drilling program in order to obtain information on the deep coals.

U.S. Bureau of Mines standard coal analyses distribution

According to estimates, approximately 270,000 coal samples have been analyzed by the U.S. Bureau of Mines for inclusion in the Bureau's coal data bank (Robert E. Harris, oral commun., June 1979). Many of these analyses, however, are from composite samples of different coals so they are not representative bed analyses; that is, the analytical results are not characteristic of a particular coal bed at a single geographic location or mine area. Most of the coal samples, which were collected in the conterminous United States, have been assimilated into a data file containing 53,000 records of standard coal analyses. These analyses were derived from channel, delivered, and tipple coal samples. All of these types of samples, except the delivered coal samples which may be washed and or screened, are considered to be representative of a particular coal bed at a specific location or mine area. Map B shows the locations of that part of the 53,000 analytical records derived from coal east of the Mississippi River. The data are presented by county and number of samples in six frequency categories. For each coal sample, the ultimate and proximate analyses, heat content, forms-of-sulfur, free-swelling index, and ash fusion temperature were determined. These standard coal analyses were performed by the Coal Analysis Section, U.S. Bureau of Mines, and the results are considered to be very reliable.

Sample distribution in map B: Examination of map B shows that large numbers of coal samples are clustered in the heavily mined districts. There are counties situated on the fringes and outside of old mining areas that lack standard coal analysis data. Some of these counties are in eastern and western Kentucky and also in central and southern West Virginia. The distribution of the coal analyses on map B relates closely to the extent of coal mining. The total number of chemically analyzed coal samples represented by the plotted symbols on map B is greater than shown because some analytical records are composites of many sample analyses from the same coal and general mine location. The resulting mean analyses are therefore more representative of those coals. Thus, the reliability of the data is further increased, and the accuracy of the analytical determinations is considered very high.

Distribution of other coal-quality data

Some published Eastern United States coal-quality data as determined by individuals, companies, and some government agencies are summarized in table 2 showing the number of analyzed coal samples per State. Excluded from this compilation is all lignite data and work by the USGS since 1972. The quality information is grouped into three broad categories of analyses performed: a) major-, minor-, and trace-element chemical analyses on whole coal and coal ash samples; b) standard U.S. Bureau of Mines ultimate and proximate coal analyses, heat content and forms-of-sulfur determinations; and c) physical properties tests including specific gravity, hardness, cleaning characteristics, and coking properties. The references listed under Sources of Coal-Quality Data are numbered, and classified by letter(s) indicating type of analysis performed. Table 2 shows the States and source numbers to references where specific types of coal-quality information are available. Furthermore, it shows the number of analyzed coal samples and percent of total number of analyzed coal samples for each State, so the proportional distribution of the number of coal samples among the States is comparable and fairly accurate. The reliability of the data appears to be high, even though many of the analyses were done years ago. Most of the coal samples were channel samples that accurately depict the chemical and physical properties of the coal beds.

Sample distribution of other coal-quality data: A total of 1,953 coal samples of various types and amounts are listed in table 2. West Virginia is first in the number of coal samples per State, while Pennsylvania ranks second, Illinois third, Ohio fourth, and Kentucky fifth. Interpretations of table 1, showing 1975 coal production, and table 2, showing distribution of coal-quantity data, reveals a disparity between the tonnage of coal mined in Kentucky and available supporting coal quality data. This disparity is apparent by direct comparison of percent of total Eastern United States coal production to percent of total number of other analyzed coal samples, as shown by the graph in figure 1. Coal production per annum in Kentucky exceeds that of any other State by a large amount and current mining trends and potential suggest that this rate will continue.

A compilation of coal-quality data is being prepared for the Narragansett Basin of Massachusetts and Rhode Island. Analytical data are available for about 150 coal samples according to Paul C. Lyons (oral commun., August 1978), the compiler. Ultimate and proximate coal analyses are available for about one-third of these samples; partial or complete proximate analyses plus or minus sulfur are available for the remainder. However, these data were not available until after table 2 was completed. Many of the Narragansett Basin analyses were collated from old literature sources, so the value or reliability of these analyses is questionable (Peter Zubovic, oral commun., June 1978).

Conclusions

The availability of coal-quality information in the Eastern United States can be assessed by inspecting the two coal-quality data maps (A and B) and the distribution of other coal quality data by State (table 2). When this information is evaluated along with the 1975 coal production (see table 1), interesting relationships become apparent. In 1975, over 50 percent of the coal produced in the United States was from three States. Kentucky produced 143 million tons of coal, West Virginia 110 million tons, and Pennsylvania 90 million tons (U.S. Bureau of Mines, 1977, p. 414, 458). These production figures and the current coal mining trends imply that the near-future emphasis in coal mining will be centered in 8 contiguous industrial States. These States are, in order of descending production in 1975, Kentucky, West Virginia, Pennsylvania, Illinois, Ohio, Virginia, Indiana, and Maryland. The distribution of coal-quality information compared to the production figures presented in this report, indicate that quality data is deficient in several States. Coal-quality information is needed from scattered counties in the old mining districts in western Pennsylvania, eastern Ohio, West Virginia, and particularly eastern Kentucky.

On a broader scale, one may conclude that industry and science are just beginning to scratch the surface in securing adequate coal-quality information for this country. There are approximately three samples per billion tons of coal resources in the Eastern United States (Peter Zubovic, oral commun., December 1978). This is very sparse coal-quality data in view of the large numbers of detailed analyses which are needed. Furthermore, because most of the coal produced in the Eastern United States has been from relatively few coal beds, about 15 in number, the samples for testing have necessarily been limited to those coals. Therefore, the great number of coal beds for which little or no quality data are available, should be sampled and analyzed. The results should be made available to research scientists and combuston engineers so the coal can be utilized more efficiently.

If adequate coal-quality data are available for effective technical planning, it will be possible for industry to wisely use the coal resources of this country. Then, manufacturers or electric utilities can design power plants and the associated equipment to fit the character of the coals to be burned, and thus meet the requirements that insure environmental integrity.

REFERENCES CITED

Averitt, Paul, 1942, Coal fields in the Untied States: U.S. Geological Survey Map, 2 sheets, scale 1:2,500,000.

Averitt, Paul, 1973, Coal, *in* Brobst, D. A., and Pratt, W. P., eds., United States mineral resources: U.S. Geological Survey Professional Paper 820, p. 133-142.

_______ 1975, Coal resources of the United States, January 1, 1974: U.S. Geological Survey Bulletin 1412, 131 p.

Averitt, Paul, and others, 1972, Coal resources and reserves of the southwestern United States, pt. 1 *of* Southwest energy study (appendix J): (U.S. Department of the Interior) Coal Resources Work Group, 72 p. Appendix 1 and 2, (12) p. (See Southwest Energy Federal Task Force, 1972).

Gluskoter, H. J., Ruch, R. R., Miller, W. G., Cahill, R. A., Dreher, G. B., and Kuhn, J. K., 1977, Trace elements in coal: occurrence and distribution: Illinois State Geological Survey Circular 499, 154 p., 79 figs.

Hausmann, Erich, and Slack, E. P., 1948, Physics (3d ed.): New York, D. Van Nostrand Company, 793 p.

Parker, E. W., Holmes, J. A., and Campbell, M. R., 1905, Preliminary report on the operation of the coal-testing plant of the United States Geological Survey at the Louisiana Purchase Exposition, St. Louis, Mo., 1904: U.S. Geological Survey Bulletin 261, 172 p.

Randall, D. T., 1908, The purchase of coal under Government and commercial specifications on the basis of its heating value, with analyses of coal delivered under Government contracts: U.S. Geological Survey Bulletin 339, 27 p.

Southwest Energy Federal Task Force, 1972, Southwest energy study: U.S. Department of Commerce, National Technical Information Service PB232096-PB232109, 42 sheets microfiche (14 v.).

U.S. Bureau of Mines, 1977, Minerals yearbook, 1975, v. 1: Washington, U.S. Government Printing Office, 1550 p.

SOURCES OF COAL-QUALITY DATA

Analyses Performed[1]	Source No.
a	1. Abernethy, R. F., Peterson, M. J., and Gibson, F. H., 1969, Spectrochemical analyses of coal ash for trace elements: U.S. Bureau of Mines, Report of Investigations 7281, 30 p.
c	2. Deurbrouck, A. W., 1972, Sulfur reduction potential of the coals of the United States: U.S. Bureau of Mines, Report of Investigations 7633, 289 p., 122 figs.
a b c	3. Fieldner, A. C., Hall, A. E., and Field, A. L., 1918, The fusibility of coal ash and the determination of the softening temperature: U.S. Bureau of Mines Bulletin 129, 146 p.
a b c	4. Gluskoter H. J., Ruch, R. R., Miller, W. G., Cahill, R. A., Dreher, G. B., and Kuhn, J. K., 1977, Trace elements in coal: occurrence and distribution: Illinois State Geological Survey Circular 499, 154 p., 79 figs.
a b c	5. Headlee, A. J. W., Hunter, R. G., Hoskins, H. A., and McClelland, R. E., 1955, Characteristics of minable coals of West Virginia: West Virginia Geological Survey Reports, v. 13A (part 3-7), 166 p.
b c	6. Hertzog, E. S., Cudworth, J. R., Selvig, W. A., and Ode, W. H., 1940, Friability, grindability, chemical analyses, and high- and low- temperature carbonization assays of Alabama coals: U.S. Bureau of Mines Technical Paper 611, 59 p., 11 figs.
a c	7. Jones, D. J., and Buller, E. L., 1936, Analyses and softening temperatures of coal ash from coals in the Northern Anthracite Field: Industrial Engineering Chemistry, analytical editons, v. 8, p. 25-27.
a b c	8. Nicholls, P., and Selvig, W. A., 1932, Clinker formation as related to the fusibility of coal ash: U.S. Bureau of Mines Bulletin 364, 71 p.
a	9. O'Gorman, J. V., and Walker, P. L., Jr., 1972, Mineral matter and trace elements in U.S. Coals: U.S. Office of Coal Research, Research and Development Report, no. 61 (Interim report), 183 p., 21 figs.
a	10. Ruch, R. R., Gluskoter, H. J., and Kennedy, E. J., 1971, Mercury content of Illinois coals: Illinois State Geological Survey, Environmental Geology Notes No. 43, 15 p.
a	11. Schlesinger, M. D., and Schultz, Hyman, 1972, An evaluation of methods for detecting mercury in some U.S. coals: U.S. Bureau of Mines, Report of Investigations 7609, 11 p.
a b c	12. Selvig, W. A., and Seaman, Henry, 1929, Sulfur forms and ash-forming minerals in Pittsburgh coal: Carnegie Institute of Technology, Mining and Metallurgy Advisory Boards, Mining and Metallurgical Investigations, Cooperative Bulletin 43, 21 p.
a	13. Selvig, W. A., and Gibson, F. H., 1933, Chlorine determination in coal: Industrial and Engineering Chemistry, analytical edition, v. 5, p. 189-191.
b c	14. Selvig, W. A., Ode, W. H., and Gibson, F. H., 1943, Coke from low-ash Appalachian coals for carbon electrodes in the aluminum industry: U.S. Bureau of Mines, Report of Investigations 3731, 22 p.
a b	15. Selvig, W. A., and Gibson, F. H., 1956, Analyses of ash from United States coals: U.S. Bureau of Mines Bulletin 567, 33 p.
a	16. Stadnichenko, Taisia, Murata, K. J., Zubovic, Peter, and Hufschmidt, E. L., 1953, Concentration of germanium in the ash of American coals - a progress report: U.S. Geological Survey Circular 272, 34 p.
a	17. Stadnichenko, Taisia, Zubovic, Peter, and Sheffey, N. B., 1961, Beryllium content of American coals: U.S. Geological Survey Bulletin 1084-K, p. 253-295.
a	18. Zubovic, Peter, Stadnichenko, Taisia, and Sheffey, N. B., 1964, Distribution of minor elements in coal beds of the Eastern Interior Region: U.S. Geological Survey Bulletin 1117-B, 41 p., 1 map, 1 fig.
a	19. Zubovic, Peter, Stadnichenko, Taisia, and Sheffey, N. B., 1966, Distribution of minor elements in coals of the Appalachian Region: U.S. Geological Survey Bulletin 1117-C, 37 p., 1 fig.

[1] Analyses are as follows:
a - major-, minor-, and trace-element chemical analyses on whole-coal and coal-ash samples;
b - U.S. Bureau of Mines standard ultimate and proximate coal analyses, heat content, and forms-of-sulfur determination;
c - specific gravity, hardness, cleaning characteristics, and coking properties.

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