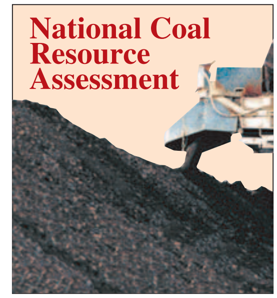
Chapter E

Characterization of the Quality of Coals from the Illinois Basin

By R.H. Affolter *and* J.R. Hatch



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Chapter E *of*

Resource Assessment of the Springfield, Herrin, Danville, and Baker Coals in the Illinois Basin

Edited by J.R. Hatch *and* R.H. Affolter

U.S. Geological Survey Professional Paper 1625–D

U.S. Department of the Interior
U.S. Geological Survey

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Characterization of the Quality of Coals from the Illinois Basin

By R.H. Affolter[1] *and* J.R. Hatch[1]

Introduction

The goal of the Illinois Basin Coal Assessment Project is to provide an overview of the geologic setting, distribution, resources, and quality of Pennsylvanian coal in the Illinois Basin. This assessment is part of the U.S. Geological Survey's National Coal Resource Assessment Program (NCRA), which includes, along with the Illinois Basin, the Colorado Plateau, the Northern Rocky Mountains and Northern Great Plains region, the Appalachian Basin, and the Gulf Coast region of the United States (fig. 1). Such studies are of considerable significance because environmental mandates and concerns relating to coal development have become increasingly important to the National interest.

This assessment is different from previous U.S. Geological Survey coal assessments in that the major emphasis is placed on coals that are most likely to be major sources of energy over the next few decades (Gluskoter and others, 1996). Another major difference is that data are being collected and stored in a digital format that can be updated as new information becomes available. In the future, environmental considerations may eventually control which coals will be mined and will determine what preventative procedures will be implemented in order to reduce sulfur and possibly trace element emissions from coal-burning power plants. It is also expected that in the future, emphasis will be placed on coal combustion products and the challenges of disposal and utilization of these products. Therefore, this coal-quality assessment includes not only information on ash, sulfur, and calorific content, but also information on the major-, minor-, and trace-element content of these coals. Characterization of coal quality is an important aspect of the assessment program in that it provides a synthesis and analysis of data that will influence future utilization of this valuable resource.

Acknowledgments and Products

The Illinois Basin coal assessment was completed in cooperation with multidisciplinary groups of scientists, technicians, and computer specialists from the U.S. Geological Survey (USGS), the Indiana Geological Survey (IGS), the Kentucky Geological Survey (KGS), and the Illinois State Geological Survey (ISGS). Together, these three state surveys make up the Illinois Basin Consortium (IBC). The main products of this assessment are digital databases that contain all publicly available point-source data on thickness, depth, and coal quality for the Springfield, Herrin, Danville, and Baker Coals, which are the major mined coals in the basin. From this database, statewide maps have been prepared that depict thickness, elevation (structure), mined-out areas, and extents of the principal areas where the coals may potentially be mined at the surface or recovered from underground. This information is available as digital products accessible in a variety of interpretive and interactive forms (see the ArcView section of this publication).

Geologic Framework

The Illinois Basin coal assessment area includes parts of Illinois, southwestern Indiana, and western Kentucky, containing the largest reserve base of bituminous coal of any basin in the United States. Coal production in 2000 was about 88.4 million short tons (Freme, 2001). However, this production level is declining (down from 104 million short tons in 1999) and is expected to decline further as electric utilities switch from high-sulfur Illinois Basin coal to low-sulfur western coal. Assessments of the original and remaining coal resources, coal compositions, and recoverable coal reserves in the Illinois Basin have at least a 100-year history. The last major coal assessment by the U.S. Geological Survey was done in 1974 (Averitt, 1975).

Coal-bearing rocks in the Illinois Basin are part of the Eastern Region of the Interior Coal Province (Trumball, 1960). These rocks are of Pennsylvanian age and were formed between about 325 and 290 million years ago. In the Illinois Basin, the Pennsylvanian rocks are divided into the Raccoon Creek Group, the Carbondale Group or Formation, and the McLeansboro Group. Correlations of these strata across Illinois, southwestern Indiana, and western Kentucky are shown in figure 2.

Stratigraphic Nomenclature

The Raccoon Creek Group, Carbondale Formation, and McLeansboro Group are defined the same in Illinois and western Kentucky (Jacobson and others, 1985), but are defined differently in Indiana (see fig. 2). The main differences are

(1) The Raccoon Creek Group in Illinois and western Kentucky is divided into the Caseyville and Tradewater Formations. The Raccoon Creek Group in Indiana consists of the Mansfield, Brazil, and Staunton Formations.

(2) The Carbondale Formation is recognized in Illinois and Kentucky. The Carbondale Group is recognized in Indiana, where it is divided into the Linton, Petersburg, and Dugger Formations.

(3) In Indiana, the Seelyville Coal Member is at the top of the Staunton Formation of the Raccoon Group, whereas in Illinois and western Kentucky the Seelyville Coal and equivalents are in the Carbondale Formation.

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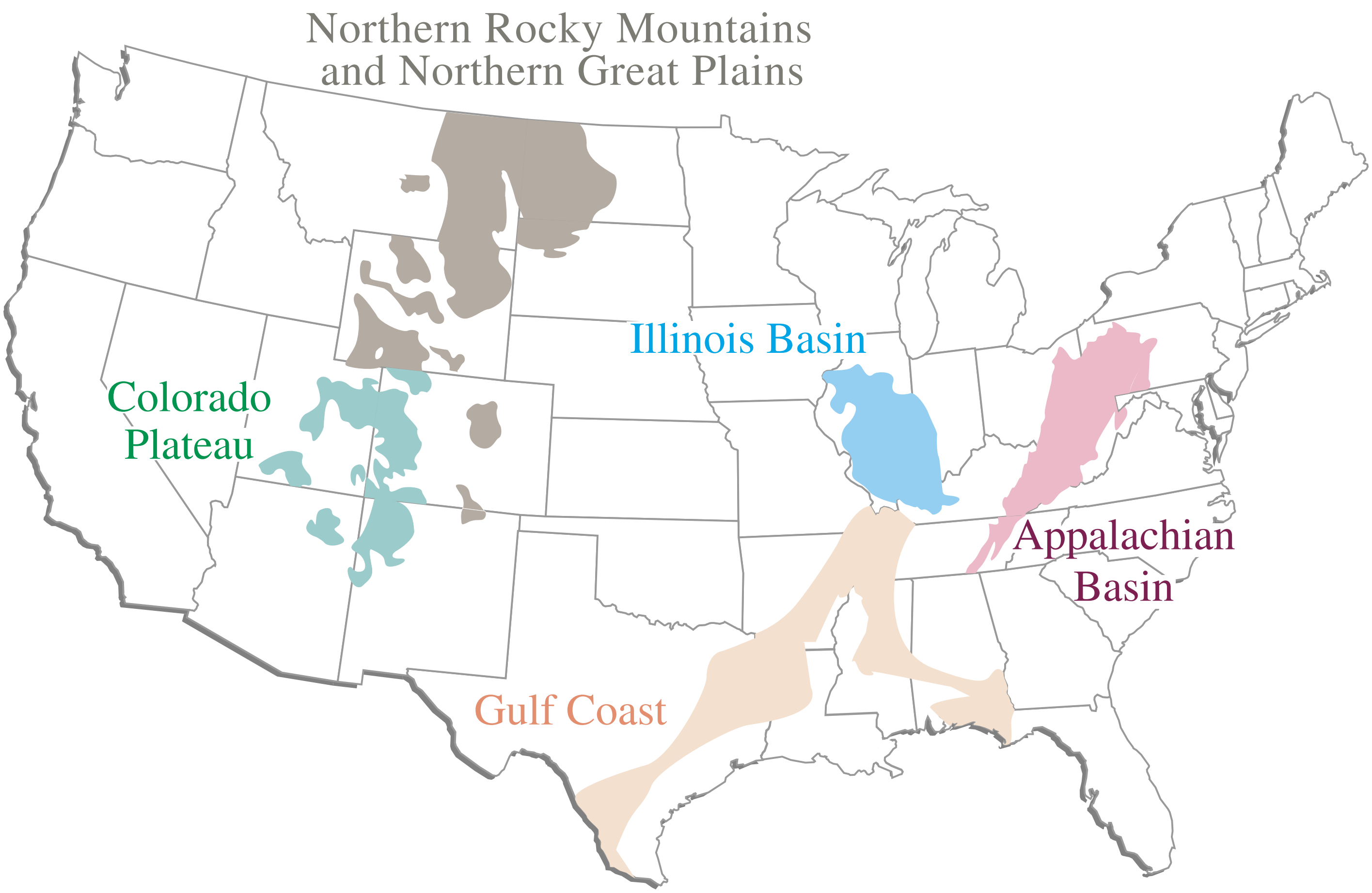

Figure 1. Map showing location of the Illinois Basin study area in the United States in relation to other areas assessed during the National Coal Resource Assessment Project.

(4) The base of the McLeansboro Group and the base of the Shelburn Formation in Illinois and Kentucky are at the top of the Herrin Coal. The base of the Shelburn Formation is at the top of the Danville Coal Member in Indiana.

(5) The Springfield Coal is in the Carbondale Formation in Illinois and western Kentucky and in the Petersburg Formation in Indiana. The Herrin Coal is in the Carbondale Formation in Illinois and western Kentucky and in the Dugger Formation in Indiana; however, the Herrin Coal Member is neither well developed nor mined in Indiana. The Danville Coal Member is in the Shelburn Formation of the McLeansboro Group in Illinois and in the Dugger Formation of the Carbondale Group in Indiana. The Baker coal is in the Shelburn Formation of the McLeansboro Group in western Kentucky.

(6) In Illinois (Hopkins and Simon, 1975) and Indiana (Mastalerz and Harper, 1998), the Springfield, Herrin, and Danville Coal Members, as well as most other coals, are formally recognized stratigraphic members. In western Kentucky, coals are not given that same status (for example, the Baker coal) (Greb and others, 1992). For this assessment report, when discussing coals in a given State we will follow the stratigraphic nomenclature previously established for that State. When referring to a coal, or coals, in an area that includes parts of States having different stratigraphic nomenclatures, we will list the coal name as the Springfield Coal, Herrin Coal, Danville Coal, or Baker Coal. When summarizing and comparing the chemistry of the coals, we have chosen to combine the Danville and Baker Coals (Danville-Baker) as stratigraphically equivalent units and also to list them as separate coals for each State.

The primary focus of this chapter is the chemical composition of coals from the Springfield Coal (Illinois No. 5, western Kentucky No. 9, Indiana V), the Herrin Coal (Illinois No. 6, western Kentucky No. 11), the Danville Coal (Illinois No. 7, Indiana VII), and the Baker coal (western Kentucky No. 13). The Springfield and Herrin Coals are in the Carbondale Formation or Group in all three States. The Danville-Baker Coals are within the McLeansboro Group in Illinois and western Kentucky but within the Carbondale Group in southwestern Indiana. The chemical

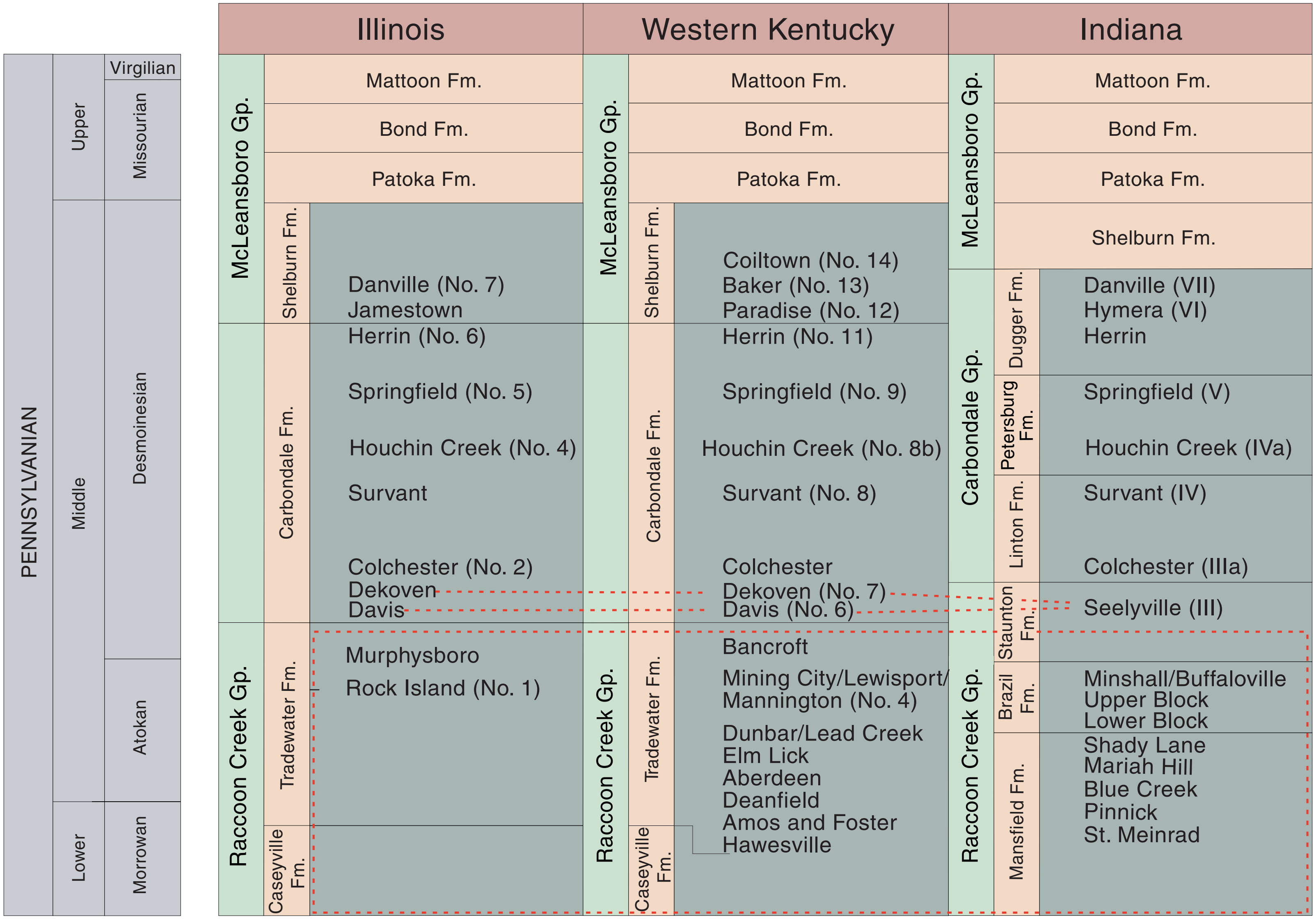

Figure 2. Stratigraphic chart of the Pennsylvanian system in the Illinois Basin, showing major coal members. Modified from Mastalerz and Harper (1998, fig. 2) and Greb and others (1992, fig. 22). Fm., Formation; Gp, Group; - - -, problematic coal correlations.

compositions of nonassessed coals from the McLeansboro Group, Carbondale Group or Formation, and Raccoon Creek Group from southwestern Indiana and western Kentucky have also been summarized. These additional analyses are included in summary charts or tables in the appendixes to provide an overall view of the quality and characterization of all coal (assessed and nonassessed) from the Illinois Basin.

Methods

Proximate and ultimate analyses, calorific value, forms-of-sulfur analyses, and ash-fusion temperatures for this study were provided by the USGS, ISGS, IGS, and KGS. Major-, minor-, and trace-element analyses were supplied by the USGS, ISGS, and only selected elements by the KGS. For assessed coals, table 1 summarizes the data by State, coal-bearing stratigraphic unit, coal name of assessed coals, number of samples, data source, and name of ASCII file used to create the ArcView State views for the Springfield, Herrin, Danville, and Baker Coals. Table 2 summarizes the same information for nonassessed beds from the Raccoon Creek Group, Carbondale Group or Formation, and McLeansboro Group. Table 3 shows the data source, number of samples analyzed, name of ASCII file containing chemical data, State, coal-bearing stratigraphic unit, and coal names used to create the ArcView regional views for the Springfield, Herrin, Danville, and Baker Coals.

Because the data for this study were received from multiple sources, it is important to document the individual techniques and methods as well as what the data represent. Following is a brief summary of the methods used by the various sources.

U.S. Geological Survey

Since 1971 the USGS has maintained a program to evaluate the chemical composition of coal in the United States. This has been accomplished through a cooperative effort in the collection of coal samples by many different workers from State and Federal agencies, the coal mining industry, and various colleges and universities. The goals were to (1) provide baseline chemical and geologic data through the evaluation of site-specific, proposed or future surface and underground mining and future reclamation areas, and (2) store this information in digital form (Affolter and Hatch, 1995).

The USGS USCHEM coal-quality database is a geologic database in that it represents the quality of the coal as it is found in the ground, and it represents only single coals. Information on coal-mine products or washed coals that are directly utilized by utilities was not available. A complete description of the USCHEM database, along with a discussion of its weaknesses and strengths, was given by Finkelman and others (1994, table 7). Despite its limitations, the USCHEM database is one of the few comprehensive and publicly available sources of proximate and ultimate analyses, forms of sulfur, calorific values, and major-, minor-, and trace-element content of United States coals. Documentation and chemical analyses for coal samples processed during the USGS's collection program are available to the public in more than 40 published reports (Finkelman and others, 1991).

Ash yields were determined and major-, minor-, and trace-element contents were analyzed by USGS laboratories in Denver, Colo., and Reston, Va. Detailed descriptions of analytical methods are given by Swanson and Huffman (1976), Baedecker (1987), and Golightly and Simon (1989); figure 3 is a flow diagram of procedures used for the analysis of Illinois Basin coal samples (modified from Finkelman and others, 1994). Proximate and ultimate analyses, calorific value, and forms of sulfur were determined by commercial and government laboratories according to ASTM standards (American Society for Testing and Materials, 1999a). The raw analytical data are stored digitally in the USGS USCHEM Coal Quality Database. All chemical data are either on an as-received or whole-coal basis. The samples, primarily face-channel or bench mine samples, are representative of the coals in general and were carefully selected to provide an accurate view of the overall coal quality throughout the basin.

Some analytical data for the Illinois Basin were previously published by Swanson and others (1976), Zubovic and others (1979, 1980), and Oman and others (1992). Some of the data are also available digitally on the USGS COALQUAL database (Bragg and others, 1998) and the National Geochemical database: PLUTO Geochemical database for the United States (Baedecker and others, 1998).

Samples selected from the USCHEM database for the purpose of the present study were of Pennsylvanian age, with less than 50 percent ash yield, and were all within the Illinois Basin study area in Illinois, southwestern Indiana, and western Kentucky. All samples were edited for geographical and chemical information and were updated to reflect any changes. The resulting data therefore represent a modified subset of the USCHEM database. These data sets are listed in tables 1–3 and are stored on disc 2 of this CD-ROM as ASCII text files ilhechmu.txt, indachmu.txt, inspchmu.txt, incgchmu.txt, inrgchmu.txt, kyspchmu.txt, kydachmu.txt, kyhechmu.txt, kymgchmu.txt, kyrgchmu.txt, kycgchmu.txt, and uschmu.txt. In ArcView these text files were added as tables, the tables were added as event themes, and the themes were converted into shapefiles. A data dictionary explaining all the fields within this database is included in appendix 8 of this chapter and as uschmtm.pdf on disc 2 in the ArcView regional views. In the ArcView project, the data dictionary is linked to the individual ArcView geochemical shapefiles.

Illinois State Geological Survey

Chemical data from Illinois coals are primarily from face-channel samples collected in active or abandoned mines. Files for the Springfield, Herrin, and Danville Coals (il_loc.dif, il_prox.dif, il_ult.dif, il_misc.dif, il_rem.dif, and il_trace.dif) were supplied by Colin Treworgy of the ISGS, merged into one file and edited for content. Each analysis in the Illinois coal database has a unique 12-character identifier called LABNO (laboratory number). The first character in the item LABNO is a letter assigned by the ISGS indicating the laboratory that analyzed the sample. All chemical data are either on a dry basis or dry, whole-coal basis. Publications by Cady (1935, 1948), Rees (1966),

Table 1. State, coal-bearing stratigraphic unit, coal name of assessed coals, number of samples, data source, and name of ASCII file containing chemical data from coal samples for the Illinois Basin coal assessment.

State	Stratigraphic unit	Coal name	No. of samples	Data source	File name
Illinois	Shelburn Formation	Danville (No. 7)	170	ISGS[1]	Ildachms.txt
	Carbondale Formation	Herrin (No. 6)	77	USGS[2]	Ilhechmu.txt
			2,330	ISGS	Ilhechms.txt
		Springfield (No. 5)	1,171	ISGS	Ilspchms.txt
Indiana	Dugger Formation	Danville (VII)	115	IGS[3]	Indachms.txt
			19	USGS	Indachmu.txt
	Petersburg Formation	Springfield (V)	336	IGS	Inspchms.txt
			49	USGS	Inspchmu.txt
Kentucky	Shelburn Formation	Baker	19	KGS[4]	Kydachms.txt
		Baker (No. 13)	15	USGS	Kydachmu.txt
	Carbondale Formation	Herrin	121	KGS	Kyhechms.txt
		Herrin (No. 11)	20	USGS	Kyhechmu.txt
		Springfield	259	KGS	Kyspchms.txt
		Springfield (No. 9)	31	USGS	Kyspchmu.txt

[1]Illinois State Geological Survey
[2]U.S. Geological Survey
[3]Indiana Geological Survey
[4]Kentucky Geological Survey

Gluskoter and others (1977), and Harvey and others (1983, 1985) document and list in detail the analytical procedures used by the Illinois State Geological Survey for most coal samples.

Samples from this ISGS file were retrieved if they contained less than 50 percent ash yield and were within the Illinois part of the Illinois Basin study area. All samples were edited for geographical and chemical information and were updated to reflect any changes. The resulting data set is therefore a modified subset of the ISGS chemical database. These data sets are listed in tables 1 and 3 and stored on disc 2 of on this CD-ROM as ASCII text files ildachms.txt, ilhechms.txt, ilspchems.txt, and ilchms.txt. In ArcView the text files were added as tables, the tables were added as event themes, and the themes were converted into shapefiles. A data dictionary explaining all the fields within this database is included in appendix 8 and as ilchmtm.pdf on disc 2 in the ArcView regional views. This data dictionary is linked to the individual ArcView geochemical shapefiles.

Indiana Geological Survey

Samples from Indiana were collected by the IGS, primarily from face-channels in mines, with some mine tipple and grab samples where no other samples were available. These data were selected from "The Indiana Coal Analysis Database; Computer database 1" by Hasenmueller and Miller (1992). Some of these data were also published by Hasenmueller (1994) and Mastalerz and Harper (1998). All analyses were done according to ASTM standards (American Society for Testing and Materials, 1999a). Some of these analyses were performed on sample splits received from the USGS that were analyzed by several different laboratories, therefore resulting in slightly different analytical results. Also, some location descriptions have been updated.

Text files from Hasenmueller and Miller's 1992 report (igschm1l, igschm1c, igschm1r, igschm2l, igschm2c, igschm2r, igschm3l, igschm3c, igschm3r) were merged and modified. Samples from this merged file were retrieved if they contained less than 50 percent ash yield and were collected within the southwestern Indiana part of the Illinois Basin study area. All samples were edited for geological and chemical information and were updated to reflect any changes. This resulting data set is therefore a modified subset of the coal analysis database published by Hasenmueller and Miller (1992). The data are listed in tables 1–3 and stored as ASCII text files indachms.txt, inspchms.txt, incgchms.txt, inrgchms.txt, and inchms.txt on disc 2 of this CD-ROM. In ArcView, the text files were added as tables, the tables were added as event themes, and the themes were converted into shapefiles. All chemical data are on an as-received basis and contain no major-, minor-, or trace-element data. A data dictionary explaining all the fields within this database is included in appendix 8 and as inchmtm.pdf on disc 2 in the ArcView regional views. In the ArcView project the data dictionary is linked to the individual ArcView geochemical shapefiles.

Kentucky Geological Survey

Samples from Kentucky are primarily from face channels in mines and were collected either by the KGS or by the USGS. Files (wky1.xls, wky2.xls, wky3.xls, and wky4.xls) were supplied by Cortland Eble of the KGS, merged into one file, and then edited for content. Samples from this merged file were retrieved

Table 2. State, coal-bearing stratigraphic unit, coal names of nonassessed coals, number of samples, data source, and name of ASCII file containing chemical data from coal samples for the Illinois Basin coal assessment.

State	Stratigraphic unit	Coal names	No. of samples	Data source	File name
Indiana	Carbondale Group	Bucktown, Colchester, Houchin Creek, Hymera, Survant, unnamed Dugger, and unnamed Linton.	313	IGS[1]	Incgchms.txt
		Bucktown V-B, Colchester, Houchin Creek IV-A, Hymera VI, Survant IV.	44	USGS[2]	Incgchmu.txt
	Raccoon Creek Group	Blue Creek, Buffaloville, French Lick, Lower Block, Mariah Hill, Minshall, Pinnick, Seelyville, St. Meinrad, unnamed Brazil, unnamed Mansfield, unnamed Staunton, Upper Block	586	IGS	Inrgchms.txt
		Blue Creek, Buffaloville, Lower Block, Mariah Hill, Seelyville III, St. Meinrad, unnamed Brazil, unnamed Mansfield, unnamed Staunton, Upper Block	106	USGS	Inrgchmu.txt
Kentucky	Carbondale Formation	Briar Hill, Dekoven, No. 6, No. 7, No. 8, No. 8B, Schultztown	42	KGS[3]	Kycgchms.txt
		No. 6, No. 7, No. 8, No. 8B	42	USGS	Kycgchmu.txt
	Raccoon Creek Group	Aberdeen, Amos, Amos Rider, Bancroft, Bell, Deanfield, Dunbar, Elm Lick B, Elm Lick C, Foster, Main Nolin, No. 4A, No. 5	87	KGS	Kyrgchms.txt
		Amos, Deanfield, Dunbar, Elm Lick, Elm Lick Zone, Empire, Foster, Hawesville, Lead Creek, No. 1B, No. 4, No. 4A, No. 5, Nolin	43	USGS	Kyrgchmu.txt
	McLeansboro Group	Coiltown, No. 12, No. 13B split	57	KGS	Kymgchms.txt
		No. 12, No. 14	25	USGS	Kymgchmu.txt

[1]Indiana Geological Survey
[2]U.S. Geological Survey
[3]Kentucky Geological Survey

if they contained less than 50 percent ash yield and were collected within the western Kentucky part of the Illinois Basin study area. All samples were edited for geographical and chemical information and were updated to reflect any changes. The resulting data set is therefore a modified subset of the KGS's chemical database. All chemical data are on a dry basis or a dry, whole-coal basis and contain proximate and ultimate analyses, calorific values, and only selected major-, minor-, and trace element data; forms of sulfur or ash-fusion temperature data are not included. All proximate and ultimate analyses were done according to ASTM standards (American Society for Testing and Materials, 1999a). Some of the data may consist of duplicate analyses from the USGS that were analyzed by different methods. There is limited published information on the specific analytical methods that were used to determine KGS coal quality data. Some data were published by Currens (1986), and additional information about the samples may be obtained from the KGS.

Data acquired on Kentucky coals are listed in tables 1–3 and stored as ASCII text files kyspchms.txt, kyhechms.txt, kydachms.txt, kycgchms.txt, kyrgchms.txt, kymgchms.txt, and kychms.txt on disc 2 of this CD-ROM. In ArcView, the text files were added as tables, the tables were added as event themes, and the themes were converted into shapefiles. A data dictionary explaining all the fields within this database is included in appendix 8 and as kychmtm.pdf on disc 2 in the ArcView regional views. In the ArcView project, the data dictionary is linked to the individual ArcView geochemical shapefiles.

Explanation of Data Selected for the Illinois Basin Assessment

The chemical information on the Illinois Basin coals presented in this report is a compilation of data that were collected during the last 30–50 years by the USGS, ISGS, IGS, and KGS. The coal-quality data are primarily from samples of the Springfield, Herrin, Danville, and Baker Coals (assessed coals), with additional samples of coals (nonassessed) from the Raccoon Creek Group, the Carbondale Group or Formation, and the McLeansboro Group. Figure 4 shows the sample localities for

Table 3. Data source, number of samples analyzed, name of ASCII file containing chemical data, State, coal-bearing stratigraphic unit, and coal names of assessed coals for the regional summaries from the Illinois Basin coal assessment.

Data source	No. of samples	File name	State	Stratigraphic unit	Coal name
ISGS[1]	3,671	Ilchms.txt	Illinois	Shelburn Formation	Danville (No. 7)
				Carbondale Formation	Herrin (No. 6) Springfield (No. 5)
IGS[2]	451	Inchms.txt	Indiana	Dugger Formation Petersburg Formation	Danville (VII) Springfield (V)
KGS[3]	399	Kychms.txt	Kentucky	Shelburn Formation	Baker
				Carbondale Formation	Herrin Springfield
USGS[4]	211	Uschmu.txt	Indiana Kentucky Illinois Kentucky Indiana Kentucky	Dugger Formation Shelburn Formation Carbondale Formation Carbondale Formation Petersburg Formation Carbondale Formation	Danville (VII) Baker (No. 13) Herrin (No. 6) Herrin (No. 11) Springfield (V) Springfield (No. 9)

[1] Illinois State Geological Survey
[2] Indiana Geological Survey
[3] Kentucky Geological Survey
[4] U.S. Geological Survey

the assessed coals in the Illinois Basin, and figure 5 shows the sample localities for nonassessed coals in the Illinois Basin that have been chemically analyzed.

Chemical data for this study were derived from many different sources; hence, they may reflect variations in the quality of analytical results. Analytical procedures have changed through time, with improved detection limits being made possible by new and more precise analytical methods. Because of differences in the precision of various analytical techniques and for consistency, the analytical values in the trace-element summary tables are reported to only two significant figures for most elements. Mercury and cadmium are reported to no more than two decimal places, and antimony and selenium to only one decimal place. Proximate and ultimate analyses and total sulfur are reported to one decimal place. Calorific values are reported to the nearest 10 Btu, ash-fusion temperatures to the nearest 5° F., and forms of sulfur to two decimal places. Also for consistency and meaningful comparison of the chemical composition of these coals, all proximate and ultimate analyses, calorific value, forms of sulfur, and ash-fusion temperatures were calculated to an as-received basis by formula ASTM D3180 (American Society for Testing and Materials, 1999b) (see appendixes 1 and 2). All elements were calculated to an as-received, whole-coal basis and are presented in percent or as parts per million (see appendixes 3 and 4). Because some of these coals show a wide range in values, the mean is not always the best estimate of the average value. Therefore, we have also included the median, which is a better measure of the central tendency when values have large ranges and (or) nonnormal data distributions.

A common problem in statistical summaries of trace-element data arises when element values are below the limits of analytical detection. This results in a censored distribution. To compute unbiased estimates of censored data for the summary statistics in this report (tables in appendixes 1–4), we adopted the protocol of reducing all “ less than” values by 50 percent before summary statistics were generated. For example, a reported value of 4.0L was changed to 2.0L, which was then used to calculate basic statistics.

The uneven geographic distribution of sample localities precludes a thorough and detailed analysis of all coals within the Illinois Basin assessment area. For comparison across the basin, representative coal samples were carefully selected and restricted to samples containing less than 50 percent ash yield (Wood and others, 1983). Samples were also carefully selected in order to provide a regional and State view of the quality for each coal. In order to adequately characterize these coals, some chemical comparisons were made among individual Illinois Basin coals and also among these coals and other major coals of Pennsylvanian, Cretaceous, and Tertiary ages that make up most of the marketable coal in the United States. Comparison with these other coals allowed us to evaluate and contrast the quality of Illinois Basin coal with other coal mined in the United States.

Appendix 1 consists of 11 tables that show the number of samples and summary statistics for the proximate and ultimate analyses, calorific value, forms-of-sulfur analyses, and ash-fusion temperatures for all coals in the Illinois Basin, presented on a regional basis; appendix 2 consists of 24 tables that show similar data for all coals in the Illinois Basin on a statewide basis. Appendix 3 consists of 11 tables that show the number of samples and summary statistics for ash yield and 38 elements in all coals in the Illinois Basin, on a regional basis; appendix 4 consists of 20 tables that show similar data for all coals in the Illinois Basin,

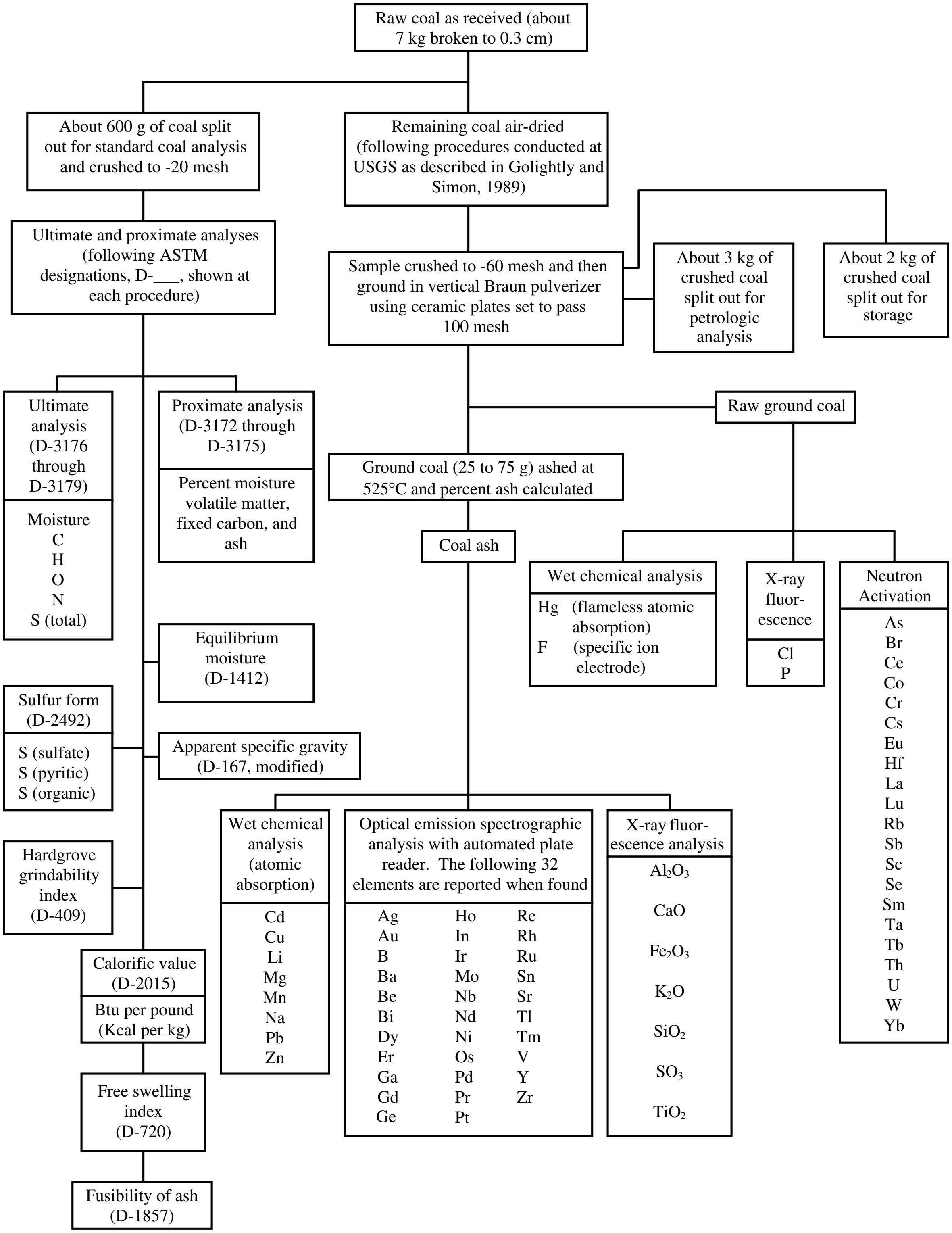

Figure 3. Flow diagram of analytical procedures used through September 1990 for the analysis of coal samples from the Illinois Basin assessment. Modified from Finkelman and others (1994). ASTM, American Society for Testing and Materials, 1999; USGS, United States Geological Survey.

presented on a statewide basis. Tables 1–3 list all ASCII text database file names for all coal samples that were used in this study. These files contain all the original (as received from the individual States) compositional data reported on the basis in which they were received and contains correct significant figures. Qualified data in these files are indicated by L (less than), B (not determined), N (not detected), or G (greater than).

Importance of Coal Quality

Hatch and Swanson (1977) suggested four general reasons why coal-quality data are necessary for the proper assessment and utilization of coal:

(1) Evaluation of environmental impacts of mining of coal

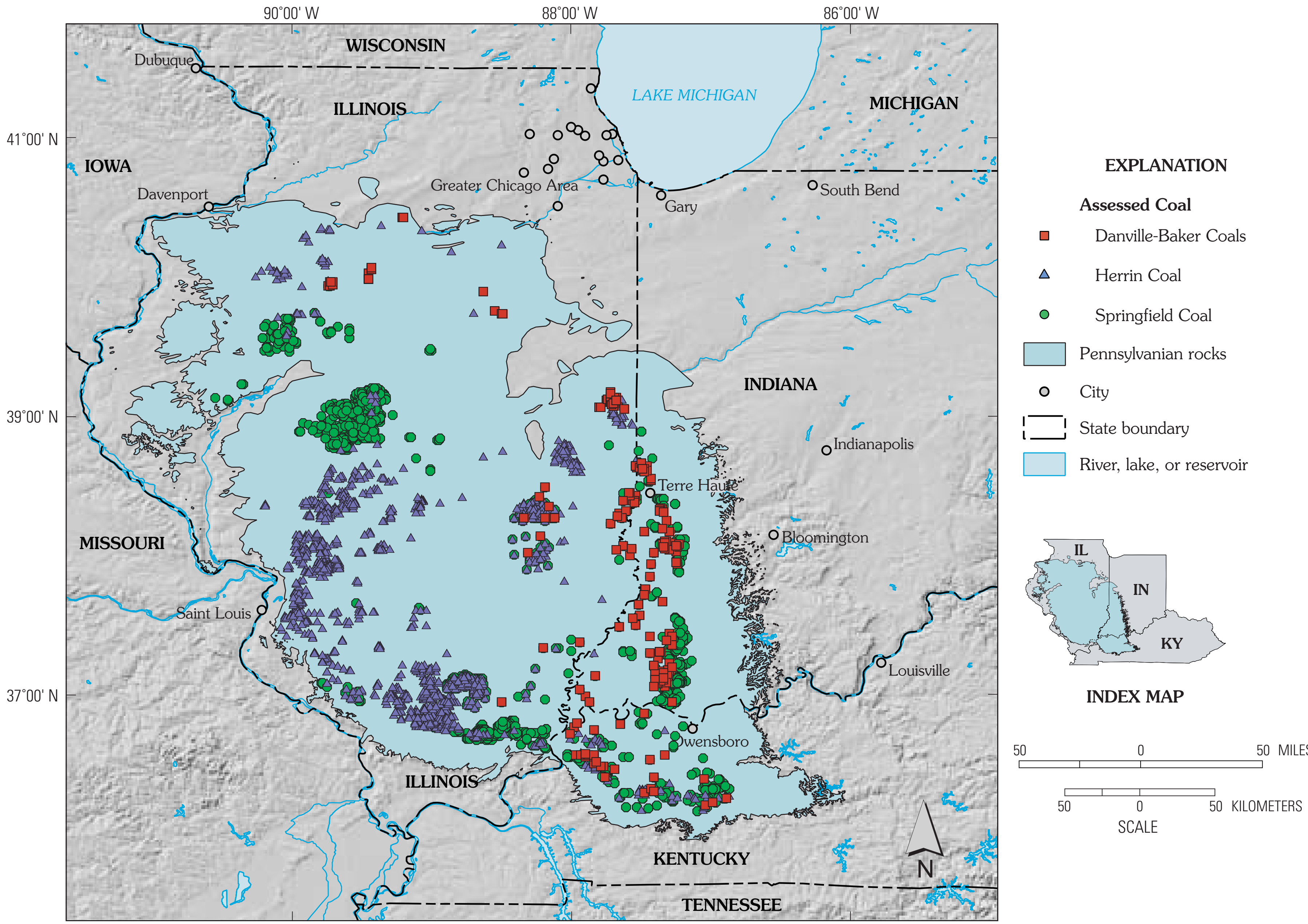

Figure 4. Localities of Pennsylvanian samples from assessed coals in the Illinois Basin for which chemical data are available.

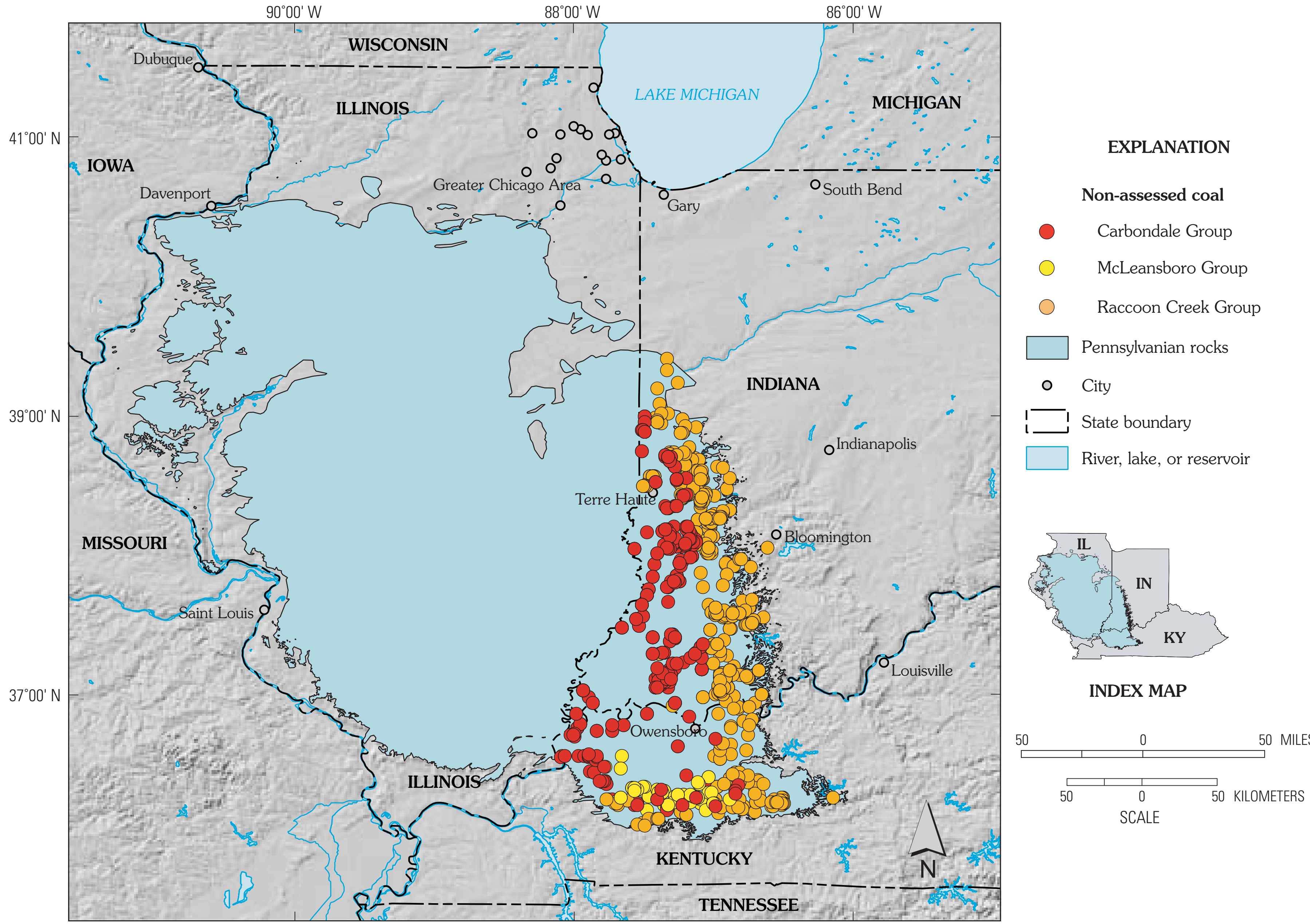

Figure 5. Localities of Pennsylvanian samples from nonassessed coals in the Illinois Basin for which chemical data are available.

(2) Evaluation of the best and most effective technological use of coal (for example, combustion, liquefaction, gasification)
(3) Determination of the potential economic benefits of the extraction of elements such as germanium, selenium, uranium, vanadium, and zinc from the coal
(4) Development of geologic and geochemical models for the interpretation and prediction of coal quality and for relating these factors to the stratigraphic and sedimentological framework

Health issues related to increased utilization of coal, either as a result of mining or combustion, are also important factors. Current coal-quality issues related to coal combustion are now focusing on the release of particulate matter, sulfur, and trace elements, as well as acid-rain and greenhouse-gas effects. The quality of the coal mined and burned impacts air and water quality. It also affects disposal of the solid waste (fly ash desulfurization sludge, washing plant sludge, and bottom ash), recovery of economic coal combustion products (CCP's), and power plant efficiency.

With emphasis on elements of environmental concern as indicated in the 1990 Clean Air Act Amendment (U.S. Statutes at Large, 1990, Public Law 101–549), there has been concern about the possible health effects of increased coal utilization. This Clean Air Act Amendment has identified several potentially hazardous air pollutants, including antimony, arsenic, beryllium, cadmium, cobalt, lead, manganese, mercury, nickel, selenium, and uranium. Because coal-quality data are an essential component of the USGS resource classification system (Wood and others, 1983), and because utilization of coal may be regulated by its possible effect on the environment, any evaluation of future coal resource potential must and should consider quality as well as quantity.

Coal Quality in the Illinois Basin

The main purpose of this coal-quality study is to list and summarize coal chemical information from the Illinois Basin, illustrating regional trends, and to graphically display the information. Summary tables of regional data (Illinois Basin) and individual State data were compiled. These tables are supplemented with range plots and histograms that compare ash, sulfur, calorific values, and contents of potentially hazardous air pollutants (antimony, arsenic, beryllium, cadmium, chromium, cobalt, lead, manganese, mercury, nickel, selenium, thorium, and uranium). Most of the chemical data listed and summarized for this coal assessment have been previously published and discussed by various authors over the last 30 years.

Appendix 5 consists of diagrams showing minimum, maximum, and median values for ash yield, sulfur content, and calorific value for the Danville-Baker, Herrin, and Springfield Coals. Also included for comparison are the McLeansboro Group, Carbondale Group or Formation, and Raccoon Creek Group Coals. In summarizing and comparing coals on a regional basis, we have chosen to treat the combined Danville and Baker Coals as stratigraphically equivalent coals; they are therefore summarized together as the Danville-Baker Coals. Appendix 6 consists of frequency histograms for ash yield, sulfur content, calorific value, and elements of environmental concern for the Danville-Baker, Herrin, and Springfield Coals from the Illinois Basin. Appendix 7 consists of graduated-symbol maps for ash yield, sulfur, calorific value, and elements of environmental concern for samples of assessed coal from the Illinois Basin.

Ash Yield

On a regional basis, the assessed coals can be characterized by mean ash yield of 11.9 percent for the Danville-Baker Coals (range 4.2–44.2 percent, fig. 6), 10.9 percent for the Herrin Coal (range 2.4–43.6 percent, fig. 7), and 11.2 percent for the Springfield Coal (range 2.8–49.7 percent, fig. 8). The mean for these assessed coals is 11.1 percent. Nonassessed coals can be characterized regionally by mean ash yields of 10 percent for coal in the Raccoon Creek Group (range 1.5–48.7 percent), 12.8 percent for coal from the nonassessed Carbondale Group or Formation (range 3.6–48.5 percent), and 14.1 percent for coal from the McLeansboro Group (range 6.0–28.7 percent). The mean for these nonassessed coals is 11.2 percent, which is essentially the same as the ash yield for the assessed coals.

Ash yield is variable within individual coals, both vertically and laterally, and the variability is probably the result of changes in the amounts and composition of the mineral matter in the coals. The mineralogical composition of Illinois Basin coal has been extensively studied by Gluskoter (1965,1967b, 1975), Rao and Gluskoter (1973), and Ward (1977). Based on low-temperature ash techniques on selected coals, the mineralogical composition (Damberger, 1999) of these coals is characterized by clay minerals (Herrin 9.4 percent, Springfield 7.0 percent), quartz (Herrin 2.4 percent, Springfield 2.4 percent), pyrite (Herrin 3.4 percent, Springfield 3.9 percent), and calcite (Herrin 1.3 percent, Springfield 1.6 percent).

Studies of other minerals and elements present in Illinois Basin coals have been reported by Gluskoter and Rees (1964) (chlorine), Gluskoter (1967a) (chlorine), Gluskoter and Ruch (1971) (chlorine and sodium), Bohor and Gluskoter (1973) (boron in illite), and Harvey and others (1983) (detailed studies on the spatial distribution of selected trace-element and mineral-matter associations within the Herrin and Springfield Coals in the Illinois Basin). Most zinc and cadmium in Illinois Basin coals are found in sphalerite (ZnS) and have been reported by Gluskoter and Lindahl (1973) (cadmium), Gluskoter and others (1973) (zinc), Hatch and others (1976) (zinc in sphalerite), Cobb and others (1979) (zinc in sphalerite), and Cobb and others (1980) (zinc and cadmium in sphalerite).

These studies show that the distributions and compositions of minerals within Illinois coals are dependent on many geologic and geochemical factors, including the chemical composition of original plants in the peat swamp, amounts and compositions of the various detrital, diagenetic, and epigenetic minerals, and the temperature and pressures during burial. For example, most zinc and cadmium in Illinois Basin coals are found in sphalerite (ZnS). This sphalerite was introduced into the coals millions of years after peat deposition by hydrothermal fluid-flow systems that were in operation at the end of the Permian (Hatch and others, 1976; Whelan and others, 1988).

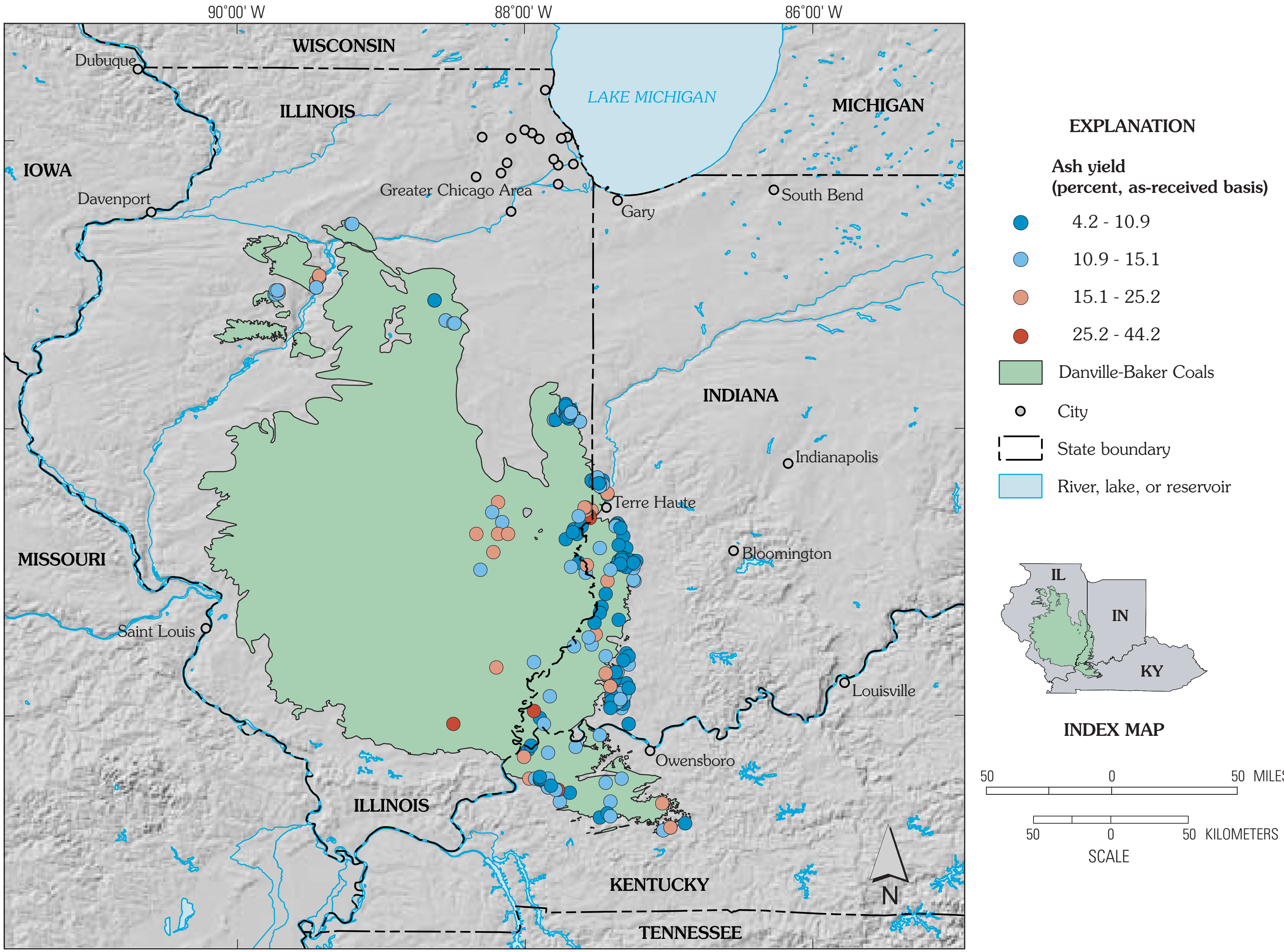

Figure 6. Graduated-symbol map for ash yield (percent, as-received basis) of the Danville-Baker Coals in the Illinois Basin.

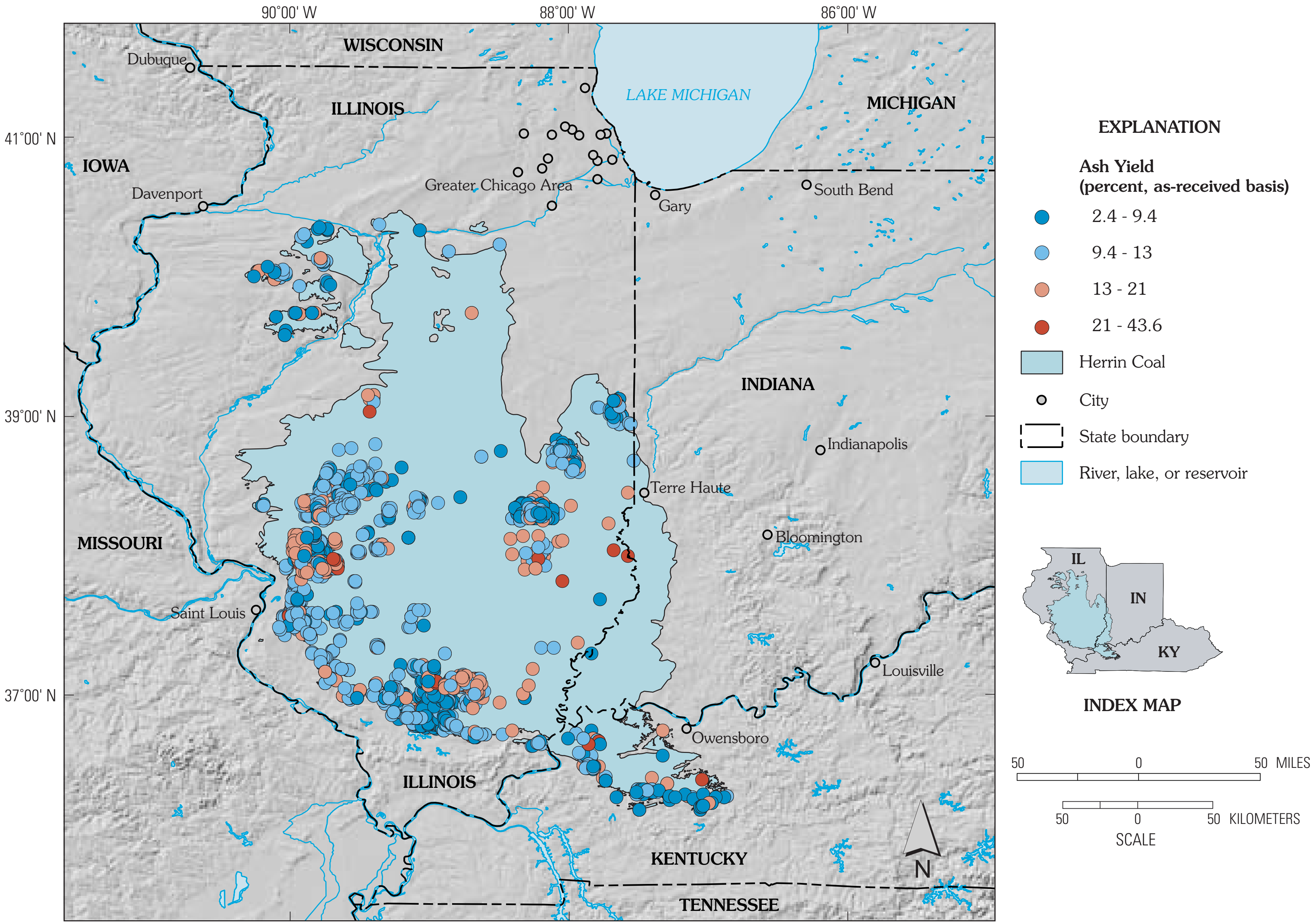

Figure 7. Graduated-symbol map for ash yield (percent, as-received basis) of the Herrin Coal in the Illinois Basin.

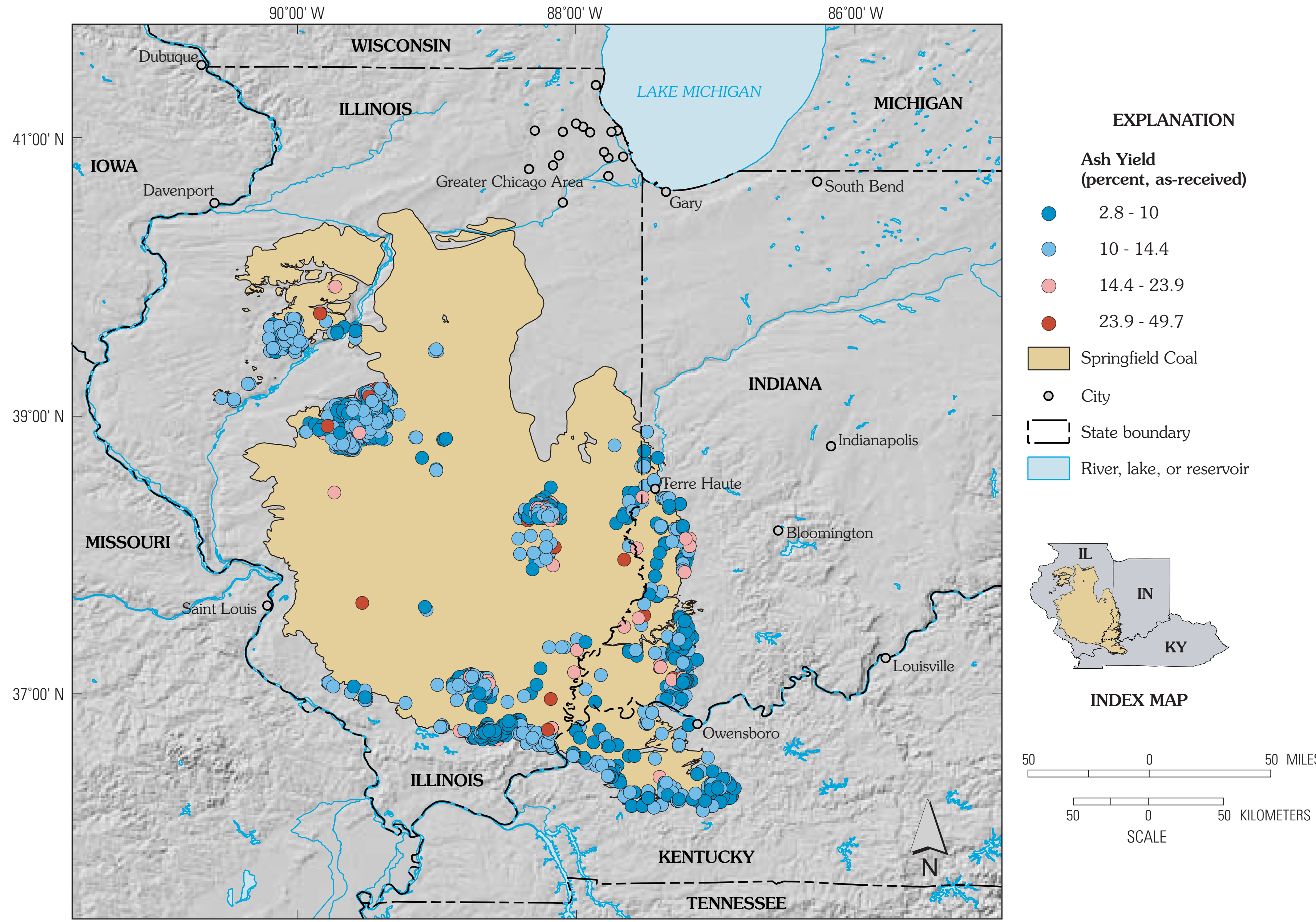

Figure 8. Graduated-symbol map for ash yield (percent, as-received basis) of the Springfield Coal in the Illinois Basin.

One of the characteristics of the Springfield in western Illinois and in the Springfield area (Sangamon, Logan, and Menard Counties of west-central Illinois) is the occurrence of a relatively high number of claystone dikes ("horsebacks"). These dikes cut through the coal seam from top to bottom as well as its roof strata and therefore may seriously influence the ash and sulfur content of the coal and strength of the roof strata.

Sulfur

On a regional basis, the assessed coals can be characterized by mean sulfur content of 2.9 percent for the Danville-Baker Coals (range 0.3–9.7 percent, fig. 9), 3.0 percent for the Herrin Coal (range 0.3–14.5 percent, fig. 10), and 3.5 percent for the Springfield Coal (range 0.5–19.5 percent, fig. 11). The mean is 3.2 percent. Nonassessed coals are characterized regionally by mean sulfur content of 2.9 percent for coal from the Raccoon Creek Group (range 0.1–30.1 percent), 3.2 percent for coal from the nonassessed Carbondale Group or Formation (range 0.3–28.1 percent), and 3.7 for coal from the McLeansboro Group (range 1.7–8.0 percent). The mean is 3.0 percent, which is similar to the sulfur content of the assessed coals.

Sulfur content has been related to the type of roof rocks that directly overlie the coal. Most of the coals that are overlain by marine rocks, such as black shales or limestone, tend to have higher sulfur content, greater than 2.5 percent. Coals that are overlain by nonmarine gray shales more than 20 ft thick usually contain less than 2.5 percent sulfur (Gluskoter and Simon, 1968). Lower sulfur content in the Herrin and Springfield Coals has been reported for samples located near various sandstone channels (for example, the Walshville channel in the Herrin and the Galatia channel in the Springfield) that may be related to fluvial splay deposits (Harvey and others, 1983).

In the Illinois Basin, the Springfield Coal is normally overlain by a 6- to 24-in.-thick, black, fissile shale. However, in a 4- to 10-mi-wide area extending from Gibson County, Ind., to Saline County, Ill., a delta distributary system was active during deposition of peats that formed the Springfield Coal. Within this belt, the coal is absent or irregularly developed and is overlain by the gray, silty Dykersburg Shale Member of the Carbondale Formation (Illinois and Kentucky) or by the Dugger Formation (Indiana) (Hopkins, 1968). In this area, the Springfield Coal is from 5 to 10 ft thick and commonly split by shale partings. Where the Dykersburg Shale Member is thicker than about 20 ft, the coal typically is relatively low in sulfur (1.5–3 percent) (Cady, 1935; Damberger, 1999).

The Herrin Coal of the Dugger Formation (Indiana) or the Carbondale Formation (Illinois and western Kentucky) is normally overlain by as much as 4 ft of black, fissile shale (Anna Shale Member, Dugger Formation in Indiana, Carbondale Formation in Illinois and western Kentucky) or limestone (Brereton Limestone Member of the Dugger Formation in Indiana, Carbondale Formation in Illinois and western Kentucky). However, in parts of southern and central Illinois a delta distributary system (Walshville channel system) was active during deposition of peats that formed the Herrin Coal. Within this belt, the coal is eroded by a channel sandstone as much as 1 mi wide and 60–80 ft thick, or was irregularly developed and overlain by the silty, gray Energy Shale Member of the Carbondale Formation, which is as much as 100 ft thick (Allgaier and Hopkins, 1975; Nelson, 1983). Where the Energy Shale Member is thick, the coal commonly is relatively low in sulfur. The thick Energy Shale Member overlies the Herrin Coal in four areas: (1) the Franklin-Williamson-Jefferson County area of southeastern Illinois (known as the "Quality Circle" area); (2) northern St. Clair County and adjacent Madison and Clinton Counties, in southwestern Illinois; (3) eastern Macoupin County and adjacent Montgomery and Christian Counties, in west-central Illinois; and (4) southern Vermillion County, in east-central Illinois.

The sulfur content of the assessed Illinois Basin coals, which is mostly in the form of pyrite or organic sulfur (fig. 12 and appendixes 1 and 2), is relatively high as compared to other United States coals. The sulfur content of most United States coals was primarily dependent on pH-controlled levels of bacterial activity in the ancestral peat swamps (Cecil and others, 1982). This bacterial activity, along with the general presence of marine shales and carbonates overlying the coal, probably accounts for the high sulfur content of many of the Illinois Basin coals. Sulfur content might also be controlled by the location of the peat swamp. Affolter and Stricker (1989) suggested that the activity of sulfate-reducing bacteria in peat is related to temperature, as indicated by the paleolatitude of the peat swamp, and could affect the sulfur content. A comparison of paleolatitudes as calculated from paleomagnetic poles and sulfur contents of United States coals, indicates that the higher the latitude in which a peat swamp developed, the lower the mean sulfur content of the resulting coal deposit. For example, low-sulfur coals such as those in Cretaceous rocks of the Colorado Plateau formed at higher paleolatitudes (lat >35°), whereas higher sulfur coals such as those in the Pennsylvanian of the Illinois Basin formed at low paleolatitudes (lat 0°–15°).

Calorific Value

On a regional basis, the assessed coals of the Illinois Basin can be characterized by mean calorific values of 10,920 Btu/lb for the Danville-Baker Coals (range 5,800–12,990 Btu/lb, fig. 13), 11,170 Btu/lb for the Herrin Coal (range 5,770–13,420 Btu/lb, fig. 14), and 11,280 Btu/lb for the Springfield Coal (range 4,810–3,910 Btu/lb, fig. 15). The mean is 11,200 Btu/lb for these assessed coals. The nonassessed coals are characterized regionally by mean calorific values of 10,920 Btu/lb for coals from the nonassessed Carbondale Group or Formation (range 5,440–13,200 Btu/lb), 11,190 Btu/lb for coals from the Raccoon Creek Group (range 4,540–13,620 Btu/lb), and 11,260 Btu/lb for coals from the McLeansboro Group (range 9,080–12,660 Btu/lb). The mean is 11,110 Btu/lb for these nonassessed coals.

Calorific values generally increase from the northwestern part of the coal basin to the southeastern part (Cady, 1935, 1948; Damberger, 1971). In western Kentucky, calorific value increases from east to west (Greb and others, 1992). The coal rank in much of the northern part of the basin in Illinois and Indiana is high-volatile-C bituminous coal (Cady, 1935, 1948; Damberger, 1971). In a small area in southeastern Illinois and western Kentucky, coal rank reaches high-volatile-A bituminous coal. These differences in rank were most likely caused by

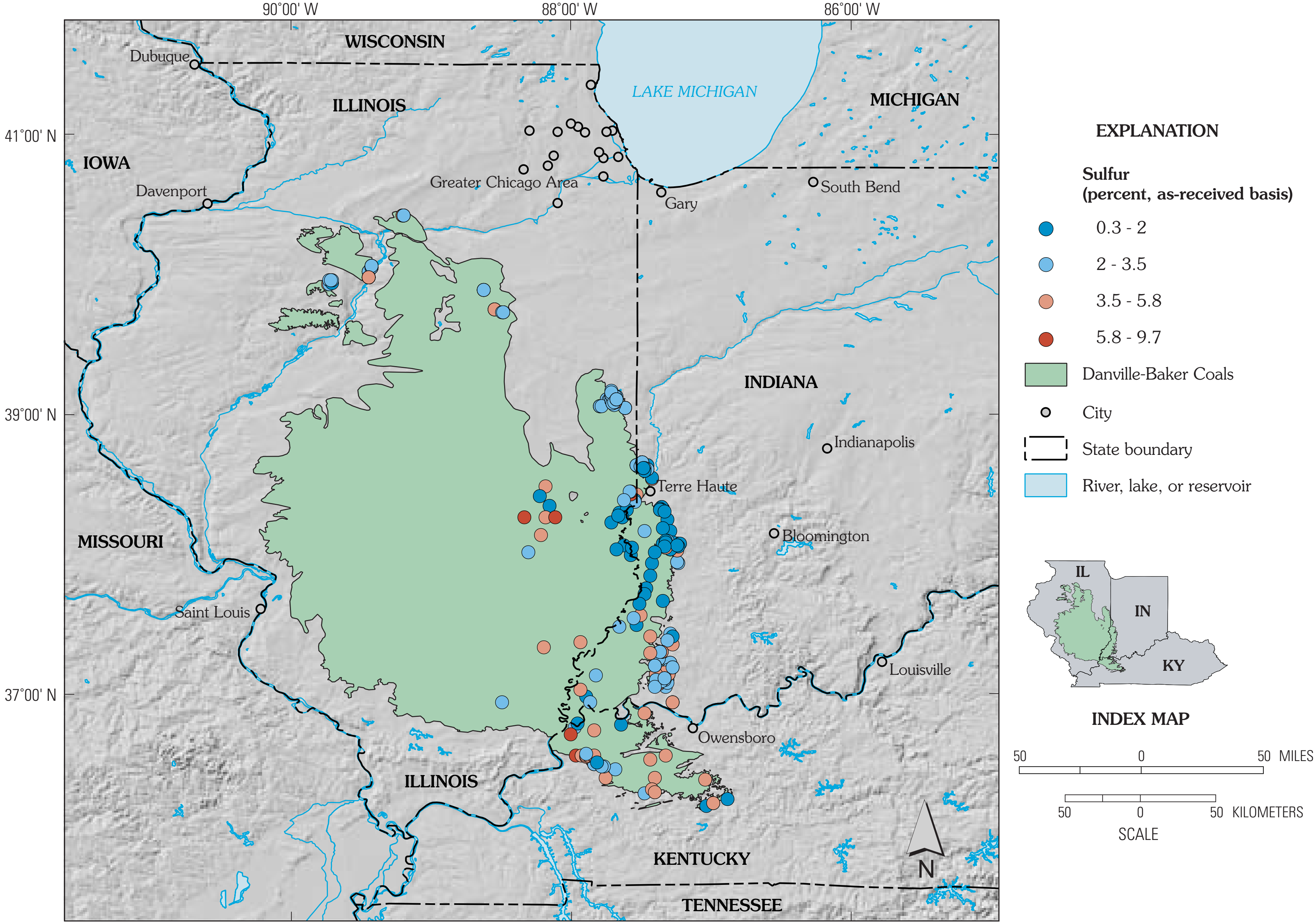

Figure 9. Graduated-symbol map for sulfur content (percent, as-received basis) of the Danville-Baker Coals in the Illinois Basin.

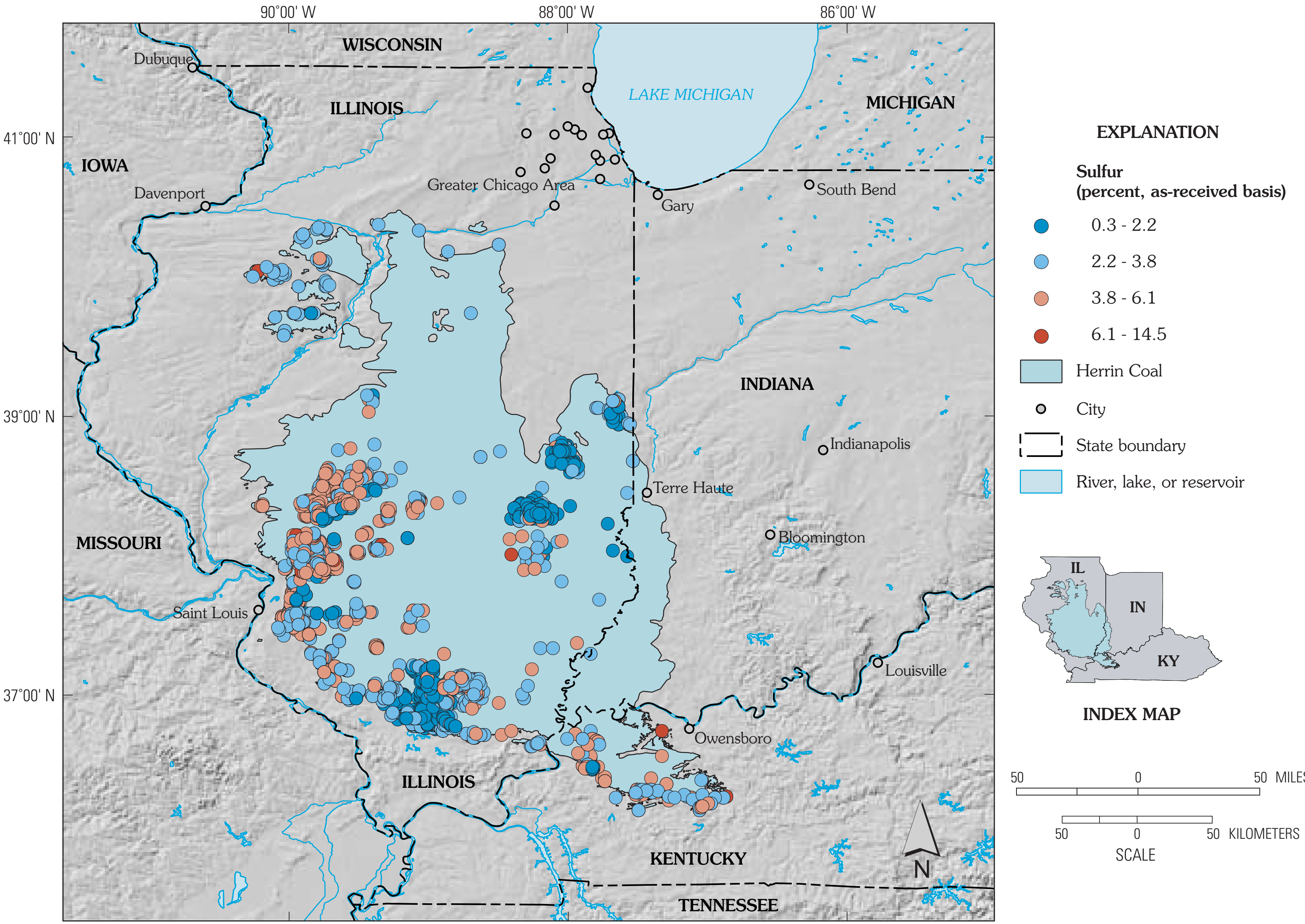

Figure 10. Graduated-symbol map for sulfur content (percent, as-received basis) of the Herrin Coal in the Illinois Basin.

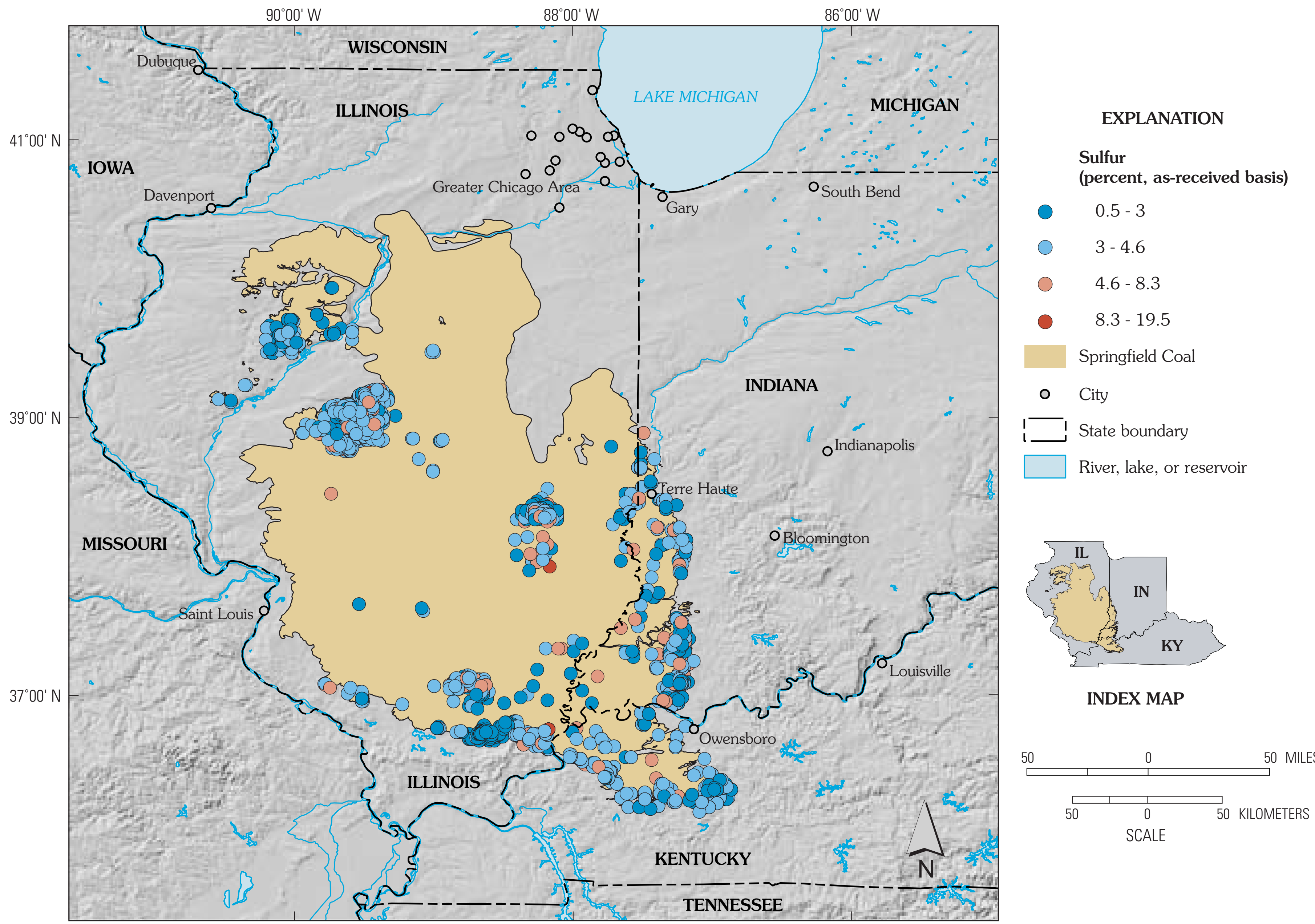

Figure 11. Graduated-symbol map for sulfur content (percent, as-received basis) of the Springfield Coal in the Illinois Basin.

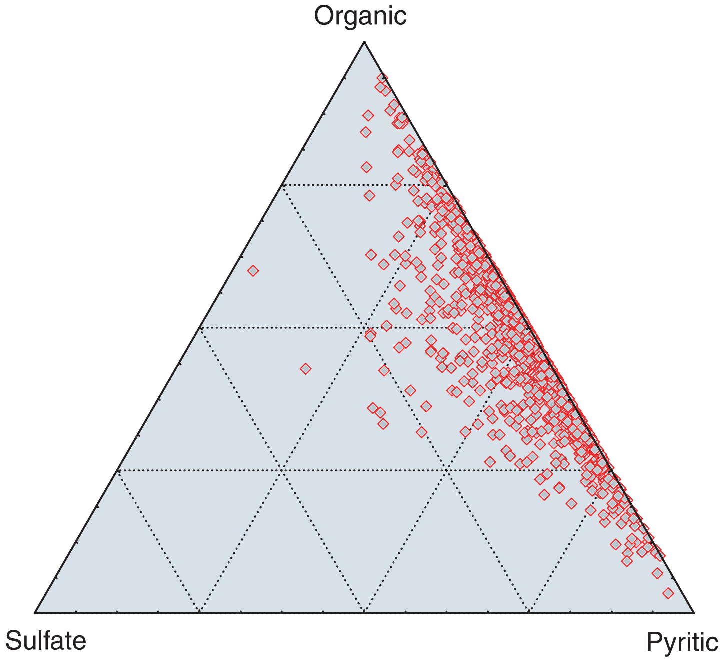

Figure 12. Diagram showing distribution of sulfate, organic, and pyritic sulfur from the assessed Pennsylvanian Springfield, Herrin, and Danville-Baker Coals in the Illinois Basin.

increased depths of burial. The southward increase was caused by increasing depth of burial during the coalification process. However, in the southeastern part of the Illinois Basin, many of the coals are relatively shallow and it has been suggested by Damberger (1971) that the increase in calorific value in that area may be attributed to increased heat flow related to possible plutonic intrusions.

Element Composition

Table 4 lists the mean content of elements of environmental concern (1990 Clean Air Act Amendment) for assessed and nonassessed coals from the Illinois Basin. Table 5 compares the mean content of these elements of environmental concern from the Illinois Basin with selected summaries of coal from the Appalachian Basin, Colorado Plateau, Gulf Coast, and Tertiary regions of the Western United States. Appendix 7 consists of graduated-symbol maps for each element of environmental concern in the assessed coals of the Illinois Basin. Appendix 5 consists of range plots of minimum, maximum, and mean contents of elements of environmental concern for all of the assessed and nonassessed coals. Comparison of elements of environmental concern in the Illinois Basin coals with other coal regions within the United States shows that (1) contents of antimony, arsenic, cadmium, chromium, lead, nickel, selenium, and uranium are generally higher in Illinois Basin coals when compared to either Colorado Plateau Cretaceous coals or western Tertiary coals; (2) contents of antimony, cadmium, chromium, nickel, and uranium in Illinois Basin coals are similar to Appalachian Basin Pennsylvanian age coals; and (3) contents of beryllium, chromium, cobalt, lead, manganese, mercury, selenium, and uranium are generally lower in Illinois Basin coals as compared to Gulf Coast coals.

Conclusion

Differences in the quality of coal result from variations in the total and relative amounts of detrital and authigenic 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 geological history of the coal. A partial listing of the factors that might influence element distributions includes (1) chemical composition of the original plant community in the peat swamp; (2) amounts and compositions of the various detrital, diagenetic, and epigenetic minerals; (3) chemical characteristics of the ground waters that come in contact with the coal bed; (4) temperature and pressures during burial; and (5) extent of chemical weathering. As yet, many of these factors have not been fully evaluated in detail for many of the Illinois Basin assessed coals. Thus, the currently available databases are considered inadequate to provide a complete characterization of coal quality throughout the basin.

Currently, the databases represent only a generalized view of Illinois Basin coal quality, based on a limited number of samples. Many of the samples are more than 30 years old and represent coal that has already been mined.

In order to better predict potential environmental impacts resulting from the increased utilization of coal from the region, it will be necessary to identify the modes of occurrence of the various elements within the coal and the nature of the coal combustion products. Accomplishing this would involve collecting additional samples from mines, power plants, and many other localities to obtain essential mineralogical and related data.

More than 92 percent of the United States' yearly production of coal is consumed in the production of electricity by utilities (U.S. Energy Information Administration, 2001).

Coal quality, composition of stack emissions, and coal combustion byproducts have become major environmental concerns as the rate of coal utilization increases, especially with regard to meeting the requirements of the 1990 Clean Air Act Amendment. With increasing emphasis on environmental issues, information on the quality of coal (which includes ash yield, sulfur content, calorific value, and major-, minor-, and trace-element content) has become almost as important as information on the quantity of the resource.

The future of coal utilization in the Illinois Basin therefore depends on a careful evaluation of coal distribution, resources, coal quality, mining methods, beneficiation costs, transportation, coal combustion byproducts, and waste disposal. Almost 84 percent of low-sulfur coal and 61 percent of medium-sulfur coal is found in coal fields in the Western United States. Seventy-one percent of the high-sulfur coal in the United States is from the Interior region (U.S. Energy Information Administration, 1999). Since 1990, production in the Illinois Basin has dropped. This decrease in the demand has primarily been a result of the enactment and implementation of the 1990 Clean Air Act Amendment and increasing price competition from Western United States coal. Because Illinois Basin assessment coals are high in sulfur, and high in many of the elements of environmental concern, these coals may play a much smaller role in supplying future United States energy needs unless technological advances can

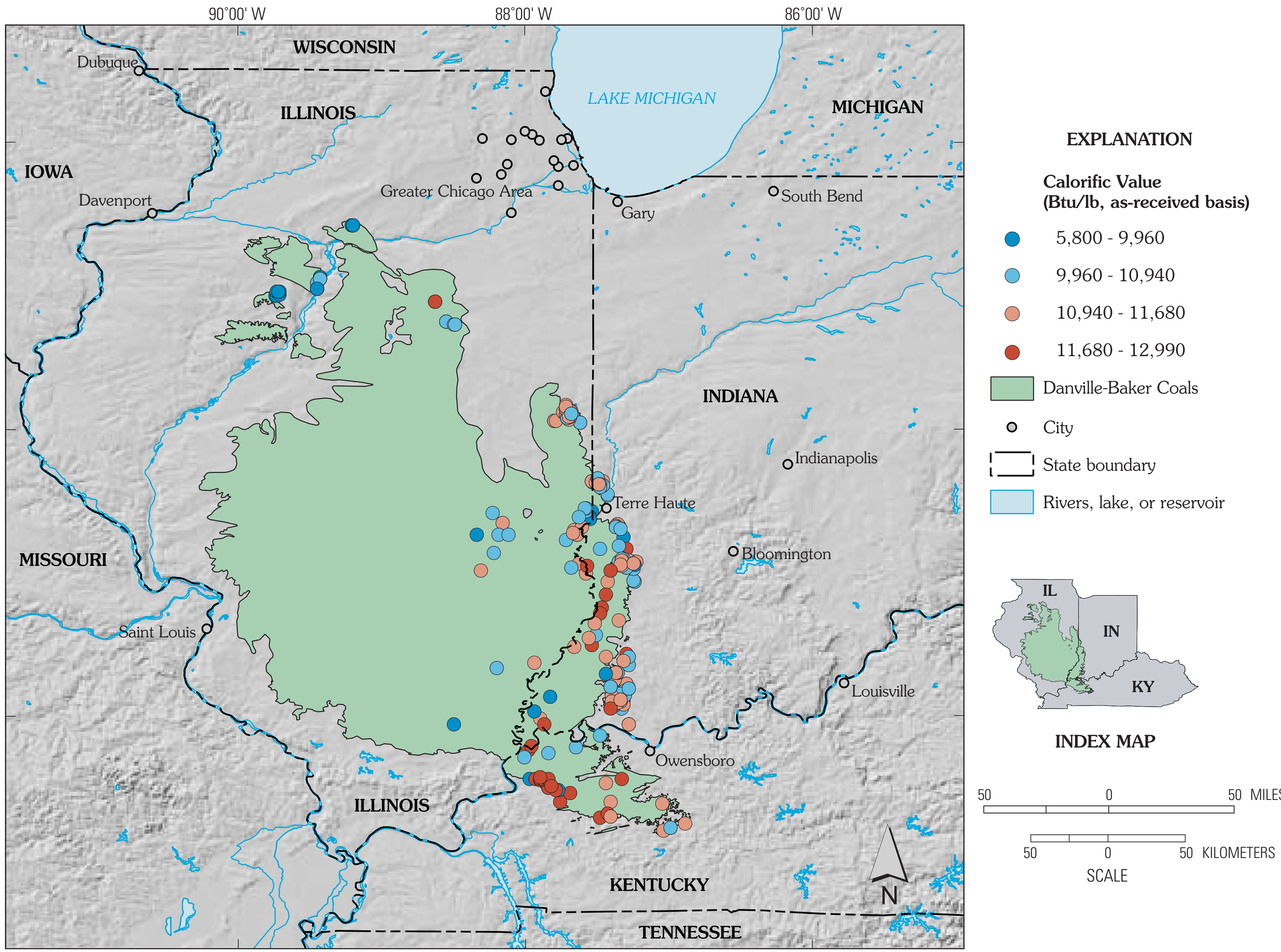

Figure 13. Graduated-symbol map for calorific values (Btu/lb, as-received basis) of the Danville-Baker Coals in the Illinois Basin.

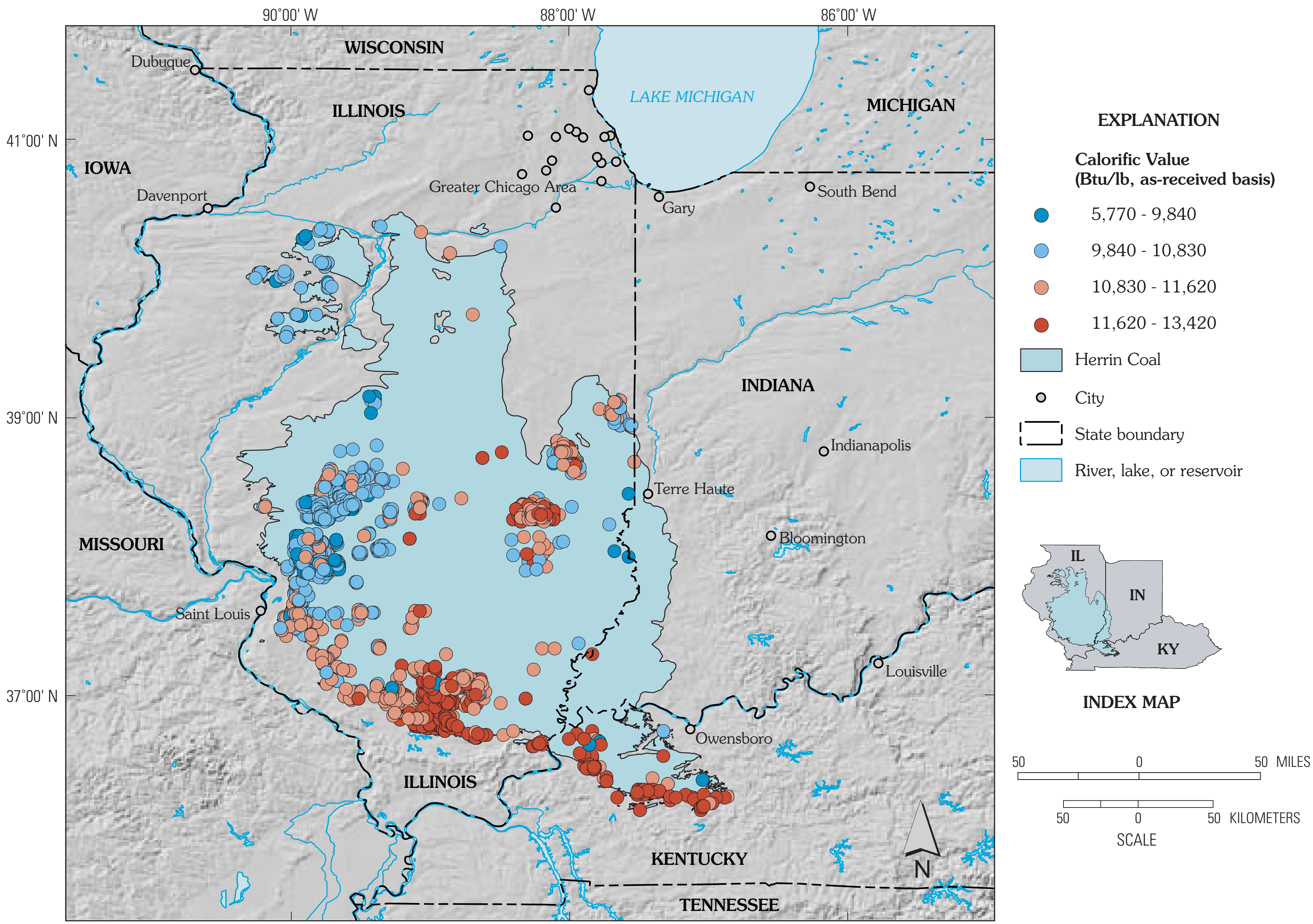

Figure 14. Graduated-symbol map for calorific values (Btu/lb, as-received basis) of the Herrin Coal in the Illinois Basin.

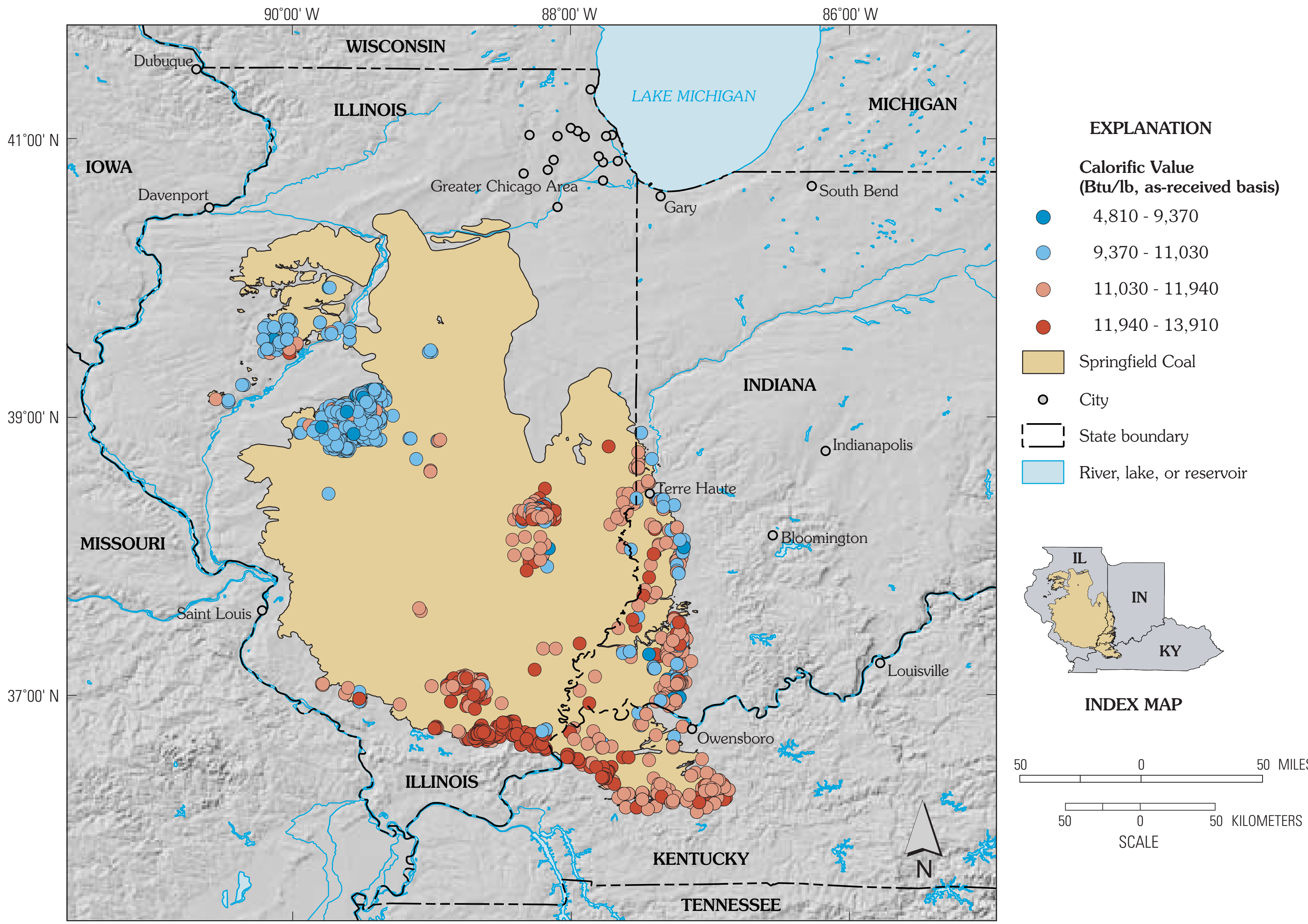

Figure 15. Graduated-symbol map for calorific values (Btu/lb, as-received basis) of the Springfield Coal in the Illinois Basin.

Table 4. Mean content of elements of environmental concern (1990 Clean Air Act Amendment) for coals from the Illinois Basin coal assessment.

[All elements are in parts per million (ppm), on a whole-coal basis. Element contents are reported to two significant figures for most elements. However, mercury and cadmium are reported to two decimal places and antimony and selenium are reported to one decimal place. A common problem in statistical summaries of trace-element data arises when element values are below the limits of analytical detection. This results in a censored distribution. To compute unbiased estimates of the means for censored data, we adopted the protocol of reducing all "less than" values by 50 percent before summary statistics were generated.]

Coal name or coal-bearing unit	As	Be	Cd	Co	Cr	Hg	Mn	Ni	Pb	Sb	Se	Th	U
Danville	12	3.2	0.40	6.3	19	0.10	55	24	17	2.3	1.3	2.5	1.3
Baker	27	2.2	0.19	5.2	19	0.13	62	36	20	1.5	1.8	2.0	2.5
Danville and Baker	19	2.7	0.30	5.6	19	0.11	59	31	18	1.9	1.5	2.2	1.9
Herrin	5.8	1.6	1.3	4.0	19	0.12	58	17	18	0.8	2.1	2.1	2.0
Springfield	12	1.9	0.60	3.6	16	0.12	43	12	13	1.1	2.5	1.7	2.6
Carbondale Group or Formation	34	3.5	0.45	7.1	20	0.14	51	28	27	1.5	3.3	2.1	3.3
Raccoon Creek Group	20	3.7	0.35	9.2	15	0.12	17	38	24	1.6	3.7	2.2	1.8
McLeansboro Group	9.5	2.2	0.14	5.3	20	0.08	56	20	7.7	0.7	2.1	2.1	1.6
Assessed coals	9.5	1.8	0.99	4.0	18	0.12	52	16	16	1.0	2.2	2.0	2.2
Non-assessed coals	23	3.4	0.35	7.9	17	0.12	35	31	23	1.4	3.4	2.2	2.2
All coals in Illinois Basin	15	2.5	0.70	5.6	17	0.12	45	22	19	1.2	2.7	2.1	2.2

Table 5. Comparison of the mean content of elements of environmental concern (1990 Clean Air Act Amendment) for the Illinois Basin assessed coals (Danville, Baker, Herrin, and Springfield Coals only) with coals from the Appalachian Basin, Colorado Plateau coal assessment area, Gulf Coast, and Western United States Tertiary coal.

[All elements are in parts per million (ppm), on a whole-coal basis.]

Element	Illinois Basin Assessment (Danville, Baker, Herrin, and Springfield Coals) Mean (n=580)	Appalachian Basin Pennsylvanian Mean[1] (n=4,700)	Colorado Plateau Coal Assessment Area Cretaceous Mean[2] (n=1,265)	Gulf Coast Tertiary Mean[1] (n=200)	Western United States Tertiary Mean[3] (n=520)
Antimony	1.0	1.4	0.5	1.0	0.6
Arsenic	9.4	35	1.6	10	7.4
Beryllium	1.8	2.5	1.2	2.4	1.1
Cadmium	0.99	0.10	0.10	0.55	0.10
Chromium	18	17	4.5	24	10
Cobalt	4.0	7.2	1.5	7.2	3.5
Lead	16	8.4	6.5	21	4.2
Manganese	52	29	22	150	60
Mercury	0.12	0.21	0.06	0.22	0.12
Nickel	16	17	3.7	13	4.6
Selenium	2.2	3.5	1.2	5.7	0.7
Uranium	2.2	1.7	1.3	23	1.7

[1]Finkelman and others, 1994
[2]Affolter, 2000
[3]Summarized from Affolter and Hatch, 1993

make them more economically and environmentally competitive with low-sulfur western coal.

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Appendix 1. Summary descriptive statistics of proximate and ultimate analyses, calorific values, forms-of-sulfur analyses, and ash-fusion temperatures for all assessed and nonassessed coals in the Illinois Basin.

Table 1. Number of samples, mean, median, range, and standard deviation of proximate and ultimate analyses, calorific value, forms-of-sulfur analyses, and ash-fusion temperatures for all assessed coals (Danville, Baker, Herrin, and Springfield) in the Illinois Basin.

[All values are reported on an as-received basis and are in percent, except calorific value (Btu/lb) and ash-fusion temperatures (°F). G, greater than value shown.]

	Number of samples	Mean	Median	Range		Standard deviation
				Minimum	Maximum	
Proximate and ultimate analyses						
Moisture	4,711	10.5	10.4	0.5	34.7	3.7
Volatile matter	4,392	35.1	35.1	17.7	56.7	2.9
Fixed carbon	4,392	43.4	42.9	14.0	62.7	4.8
Ash	4,708	11.1	10.4	2.4	49.7	4.0
Hydrogen	2,062	4.6	4.4	2.7	7.1	0.7
Carbon	2,070	61.8	62.1	28.0	77.8	5.3
Nitrogen	2,055	1.2	1.2	0.3	2.7	0.2
Oxygen	2,054	9.6	7.7	0.2	42.2	4.7
Sulfur	4,682	3.2	3.3	0.3	19.5	1.5
Calorific value						
Btu/lb	4,455	11,200	11,250	4,810	13,910	910
Forms of sulfur						
Sulfate	1,548	0.09	0.04	0.01	2.02	0.17
Pyritic	1,888	1.74	1.67	0.02	18.28	1.16
Organic	1,891	1.49	1.56	0.16	5.11	0.60
Ash-fusion temperatures (˚F)						
Initial deformation	1,214	2,055	2,015	1,680	2,800G	165
Softening temperature	1,290	2,135	2,095	1,820	2,995G	173
Fluid temperature	1,213	2,245	2,230	1,845	2,910G	181

Table 2. Number of samples, mean, median, range, and standard deviation of proximate and ultimate analyses, calorific value, forms-of-sulfur analyses, and ash-fusion temperatures for the Danville Coal in the Illinois Basin.

[All values are reported on an as-received basis and are in percent, except calorific value (Btu/lb) and ash-fusion temperatures (°F). G, greater than value shown.]

	Number of samples	Mean	Median	Range		Standard deviation
				Minimum	Maximum	
Proximate and ultimate analyses						
Moisture	300	12.2	12.7	1.9	28.2	3.5
Volatile matter	291	35.6	35.8	25.2	56.7	3.5
Fixed carbon	291	40.4	39.7	20.4	52.3	3.9
Ash	300	11.8	10.7	4.2	44.2	4.5
Hydrogen	136	5.3	5.5	3.3	6.3	0.7
Carbon	139	60.5	61.2	36.9	69.5	4.7
Nitrogen	134	1.3	1.3	0.7	1.9	0.2
Oxygen	134	15.4	17.3	4.0	24.4	5.6
Sulfur	301	2.9	3.0	0.3	9.7	1.3
Calorific value						
Btu/lb	261	10,820	11,020	5,800	12,630	840
Forms of sulfur						
Sulfate	65	0.16	0.08	0.01	1.68	0.25
Pyritic	74	1.51	1.36	0.03	6.01	1.06
Organic	74	1.13	1.17	0.22	2.17	0.43
Ash-fusion temperatures (˚F)						
Initial deformation	118	2,100	2,045	1,822	2,745	183
Softening temperature	135	2,230	2,200	1,905	2,800G	200
Fluid temperature	118	2,350	2,335	1,935	2,800G	206

Table 3. Number of samples, mean, median, range, and standard deviation of proximate and ultimate analyses, calorific value, forms-of-sulfur analyses, and ash-fusion temperatures for the Baker coal in the Illinois Basin.

[All values are reported on an as-received basis and are in percent, except calorific value (Btu/lb) and ash-fusion temperatures (°F).]

	Number of samples	Mean	Median	Range		Standard deviation
				Minimum	Maximum	
Proximate and ultimate analyses						
Moisture	34	6.7	6.6	3.4	10.8	1.4
Volatile matter	34	34.8	35.4	25.7	40.8	3.2
Fixed carbon	34	45.9	46.2	34.5	54.7	4.2
Ash	34	12.7	11.7	6.5	27.6	4.4
Hydrogen	34	4.7	4.7	3.1	5.6	0.6
Carbon	34	64.8	65.9	52.7	72.7	4.8
Nitrogen	34	1.4	1.4	0.9	1.7	0.2
Oxygen	34	9.1	7.7	3.1	18.1	4.4
Sulfur	34	3.7	3.8	1.5	7.7	1.5
Calorific value						
Btu/lb	34	11,670	12,070	9,300	12,990	880
Forms of sulfur						
Sulfate	15	0.15	0.13	0.01	0.45	0.12
Pyritic	15	2.25	2.67	0.69	3.72	0.94
Organic	15	1.36	1.24	0.57	2.04	0.46
Ash-fusion temperatures (˚F)						
Initial deformation	15	2,080	2,030	1,930	2,610	169
Softening temperature	15	2,140	2,080	2,030	2,710	176
Fluid temperature	15	2,310	2,260	2,080	2,800	194

Table 4. Number of samples, mean, median, range, and standard deviation of proximate and ultimate analyses, calorific value, forms-of-sulfur analyses, and ash-fusion temperatures for the Danville-Baker Coals in the Illinois Basin.

[All values are reported on an as-received basis and are in percent, except calorific value (Btu/lb) and ash-fusion temperatures (°F). G, greater than value shown.]

	Number of samples	Mean	Median	Range		Standard deviation
				Minimum	Maximum	
Proximate and ultimate analyses						
Moisture	334	11.7	12.3	1.9	28.2	3.8
Volatile matter	325	35.6	35.8	25.2	56.7	3.5
Fixed carbon	325	40.9	40.0	20.4	54.7	4.3
Ash	334	11.9	10.8	4.2	44.2	4.5
Hydrogen	170	5.2	5.3	3.1	6.3	0.7
Carbon	173	61.4	61.9	36.9	72.7	5.0
Nitrogen	168	1.3	1.3	0.7	1.9	0.2
Oxygen	168	14.1	15.8	3.1	24.4	5.9
Sulfur	335	2.9	3.0	0.3	9.7	1.4
Calorific value						
Btu/lb	295	10,920	11,060	5,800	12,990	880
Forms of sulfur						
Sulfate	80	0.16	0.09	0.01	1.68	0.23
Pyritic	89	1.63	1.49	0.03	6.01	1.07
Organic	89	1.17	1.24	0.22	2.17	0.44
Ash-fusion temperatures (˚F)						
Initial deformation	133	2,095	2,040	1,820	2,745	181
Softening temperature	150	2,220	2,175	1,905	2,800G	199
Fluid temperature	133	2,340	2,330	1,935	2,800G	204

Table 5. Number of samples, mean, median, range, and standard deviation of proximate and ultimate analyses, calorific value, forms-of-sulfur analyses, and ash-fusion temperatures for the Herrin Coal in the Illinois Basin.

[All values are reported on an as-received basis and are in percent, except calorific value (Btu/lb) and ash-fusion temperatures (°F). G, greater than value shown.]

	Number of samples	Mean	Median	Range		Standard deviation
				Minimum	Maximum	
Proximate and ultimate analyses						
Moisture	2,545	10.7	10.6	1.2	22.2	3.4
Volatile matter	2,375	34.8	34.8	19.5	45.2	2.8
Fixed carbon	2,375	43.7	43.2	25.3	58.5	4.6
Ash	2,542	10.9	10.3	2.4	43.6	3.6
Hydrogen	939	4.3	4.3	2.9	5.9	0.4
Carbon	939	61.5	61.4	41.4	73.6	5.4
Nitrogen	935	1.2	1.2	0.3	2.7	0.2
Oxygen	935	8.2	7.6	2.3	20.5	2.6
Sulfur	2,517	3.0	3.2	0.3	14.5	1.5
Calorific value						
Btu/lb	2,390	11,170	11,170	5,770	13,420	830
Forms of sulfur						
Sulfate	860	0.09	0.04	0.01	2.02	0.17
Pyritic	1,108	1.62	1.61	0.02	8.48	1.08
Organic	1,110	1.46	1.52	0.16	5.08	0.64
Ash-fusion temperatures (˚F)						
Initial deformation	531	2,100	2,060	1,680	2,800G	170
Softening temperature	534	2,160	2,140	1,820	2,995G	163
Fluid temperature	530	2,280	2,270	1,860	2,910G	160

Table 6. Number of samples, mean, median, range, and standard deviation of proximate and ultimate analyses, calorific value, forms-of-sulfur analyses, and ash-fusion temperatures for the Springfield Coal in the Illinois Basin.

[All values are reported on an as-received basis and are in percent, except calorific value (Btu/lb) and ash-fusion temperatures (°F). G, greater than value shown.]

	Number of samples	Mean	Median	Range Minimum	Range Maximum	Standard deviation
Proximate and ultimate analyses						
Moisture	1,832	10.0	9.3	0.5	34.7	4.0
Volatile matter	1,692	35.5	35.5	17.7	55.0	2.9
Fixed carbon	1,692	43.3	43.2	14.0	62.7	5.0
Ash	1,832	11.2	10.4	2.8	49.7	4.4
Hydrogen	953	4.7	4.5	2.7	7.1	0.7
Carbon	958	62.2	62.9	28.0	77.8	5.3
Nitrogen	952	1.2	1.2	0.3	2.2	0.2
Oxygen	951	10.2	7.6	0.2	42.2	5.4
Sulfur	1,830	3.5	3.4	0.5	19.5	1.4
Calorific value						
Btu/lb	1,770	11,280	11,430	4,810	13,910	990
Forms of sulfur						
Sulfate	608	0.09	0.04	0.01	1.28	0.15
Pyritic	691	1.96	1.77	0.06	18.28	1.25
Organic	692	1.58	1.65	0.29	5.11	0.52
Ash-fusion temperatures (˚F)						
Initial deformation	550	2,000	1,970	1,795	2,800G	139
Softening temperature	606	2,090	2,050	1,835	2,910G	162
Fluid temperature	550	2,185	2,150	1,845	2,910G	176

Table 7. Number of samples, mean, median, range, and standard deviation of proximate and ultimate analyses, calorific value, forms-of-sulfur analyses, and ash-fusion temperatures for all nonassessed coals in the Illinois Basin.

[All values are reported on an as-received basis and are in percent, except calorific value (Btu/lb) and ash-fusion temperatures (°F). G, greater than value shown.]

	Number of samples	Mean	Median	Range		Standard deviation
				Minimum	Maximum	
Proximate and ultimate analyses						
Moisture	1,285	10.5	10.2	0.7	52.8	5.1
Volatile matter	1,278	35.5	35.7	16.5	54.0	3.6
Fixed carbon	1,278	42.8	43.1	7.9	59.8	5.7
Ash	1,285	11.2	9.8	1.5	48.7	6.4
Hydrogen	1,012	5.2	5.4	1.7	8.2	0.8
Carbon	1,042	62.1	62.8	24.0	82.9	6.6
Nitrogen	1,006	1.3	1.3	0.4	2.5	0.2
Oxygen	1,001	15.7	16.1	2.0	51.2	6.1
Sulfur	1,315	3.0	2.8	0.1	30.1	2.1
Calorific value						
Btu/lb	1,282	11,110	11,310	4,540	13,620	1,220
Forms of sulfur						
Sulfate	270	0.25	0.15	0.01	2.31	0.28
Pyritic	270	1.85	1.52	0.03	12.10	1.54
Organic	271	1.28	1.17	0.05	5.78	0.77
Ash-fusion temperatures (˚F)						
Initial deformation	846	2,120	2,025	1,760	2,860G	252
Softening temperature	951	2,240	2,160	1,810	2,910G	239
Fluid temperature	846	2,340	2,315	1,900	2,910G	223

Table 8. Number of samples, mean, median, range, and standard deviation of proximate and ultimate analyses, calorific value, forms-of-sulfur analyses, and ash-fusion temperatures for all nonassessed coals from the McLeansboro Group in the Illinois Basin.

[All values are reported on an as-received basis and are in percent, except calorific value (Btu/lb) and ash-fusion temperatures (°F).]

	Number of samples	Mean	Median	Range		Standard deviation
				Minimum	Maximum	
Proximate and ultimate analyses						
Moisture	82	7.3	7.5	3.8	12.6	1.1
Volatile matter	82	35.0	34.7	29.7	38.5	2.2
Fixed carbon	82	43.7	43.2	34.0	50.6	3.8
Ash	82	14.1	13.7	6.0	28.7	4.4
Hydrogen	82	4.4	4.3	3.0	5.5	0.6
Carbon	82	62.5	62.7	50.6	70.1	3.9
Nitrogen	82	1.3	1.3	0.7	1.6	0.2
Oxygen	82	8.9	7.8	2.1	20.5	3.8
Sulfur	82	3.7	3.5	1.7	8.0	1.2
Calorific value						
Btu/lb	82	11,260	11,320	9,080	12,660	710
Forms of sulfur						
Sulfate	24	0.13	0.08	0.01	0.70	0.17
Pyritic	24	1.83	1.69	0.84	4.04	0.89
Organic	24	1.42	1.51	0.50	1.92	0.43
Ash-fusion temperatures (˚F)						
Initial deformation	25	2,145	2,115	1,905	2,615	153
Softening temperature	25	2,240	2,190	2,015	2,710	153
Fluid temperature	25	2,380	2,340	2,130	2,800	172

Table 9. Number of samples, mean, median, range, and standard deviation of proximate and ultimate analyses, calorific value, forms-of-sulfur analyses, and ash-fusion temperatures for all nonassessed coals from the Carbondale Group or Formation in the Illinois Basin.

[All values are reported on an as-received basis and are in percent, except calorific value (Btu/lb) and ash-fusion temperatures (°F). G, greater than value shown.]

	Number of samples	Mean	Median	Range		Standard deviation
				Minimum	Maximum	
Proximate and ultimate analyses						
Moisture	425	9.9	10.1	0.8	37.1	4.7
Volatile matter	420	35.9	36.2	19.7	44.3	3.4
Fixed carbon	420	41.4	41.7	8.5	59.8	5.0
Ash	425	12.8	10.9	3.6	48.5	6.5
Hydrogen	348	5.2	5.3	1.7	6.8	0.7
Carbon	355	60.6	61.7	24.0	73.6	6.3
Nitrogen	342	1.3	1.3	0.4	2.1	0.2
Oxygen	340	15.6	16.6	2.0	32.0	5.3
Sulfur	432	3.2	2.9	0.3	28.1	2.2
Calorific value						
Btu/lb	425	10,920	11,170	5,440	13,200	1,150
Forms of sulfur						
Sulfate	91	0.28	0.18	0.01	1.08	0.28
Pyritic	91	2.17	1.79	0.30	12.10	1.65
Organic	91	1.45	1.33	0.26	5.78	0.82
Ash-fusion temperatures (˚F)						
Initial deformation	280	2,050	2,000	1,780	2,800G	183
Softening temperature	322	2,175	2,115	1,900	2,800G	185
Fluid temperature	280	2,285	2,250	1,930	2,805G	187

Table 10. Number of samples, mean, median, range, and standard deviation of proximate and ultimate analyses, calorific value, forms-of-sulfur analyses, and ash-fusion temperatures for all nonassessed coals from the Raccoon Creek Group in the Illinois Basin.

[All values are reported on an as-received basis and are in percent, except calorific value (Btu/lb) and ash-fusion temperatures (°F). G, greater than value shown.]

	Number of samples	Mean	Median	Range		Standard deviation
				Minimum	Maximum	
Proximate and ultimate analyses						
Moisture	778	11.3	11.0	0.7	52.8	5.4
Volatile matter	776	35.4	35.5	16.5	54.0	3.9
Fixed carbon	776	43.4	44.1	7.9	58.7	6.2
Ash	778	10.0	8.4	1.5	48.7	6.2
Hydrogen	582	5.4	5.5	2.4	8.2	0.7
Carbon	605	63.0	63.6	27.7	82.9	6.9
Nitrogen	582	1.3	1.3	0.6	2.5	0.2
Oxygen	579	16.6	16.6	4.3	51.2	6.2
Sulfur	801	2.9	2.5	0.1	30.1	2.2
Calorific value						
Btu/lb	775	11,190	11,400	4,540	13,620	1,290
Forms of sulfur						
Sulfate	155	0.26	0.15	0.01	2.31	0.29
Pyritic	155	1.66	1.26	0.03	7.46	1.53
Organic	156	1.16	0.90	0.05	5.43	0.76
Ash-fusion temperatures (˚F)						
Initial deformation	541	2,150	2,040	1,760	2,860G	278
Softening temperature	604	2,275	2,200	1,810	2,910G	260
Fluid temperature	541	2,370	2,360	1,900	2,910G	237

Table 11. Number of samples, mean, median, range, and standard deviation of proximate and ultimate analyses, calorific value, forms-of-sulfur analyses, and ash-fusion temperatures for all coals (assessed and nonassessed) in the Illinois Basin.

[All values are reported on an as-received basis and are in percent, except calorific value (Btu/lb) and ash-fusion temperatures (°F). G, greater than value shown.]

	Number of samples	Mean	Median	Range		Standard deviation
				Minimum	Maximum	
Proximate and ultimate analyses						
Moisture	5,996	10.5	10.4	0.5	52.8	4.0
Volatile matter	5,670	35.2	35.2	16.5	56.7	3.1
Fixed carbon	5,670	43.2	43.0	7.9	62.7	5.0
Ash	5,993	11.1	10.3	1.5	49.7	4.6
Hydrogen	3,074	4.8	4.6	1.7	8.2	0.8
Carbon	3,112	61.9	62.5	24.0	82.9	5.8
Nitrogen	3,061	1.2	1.3	0.3	2.7	0.2
Oxygen	3,055	11.6	8.6	0.2	51.2	5.9
Sulfur	5,997	3.1	3.2	0.1	30.1	1.6
Calorific value						
Btu/lb	5,737	11,180	11,270	4,540	13,910	990
Forms of sulfur						
Sulfate	1,818	0.12	0.04	0.01	2.31	0.19
Pyritic	2,158	1.76	1.66	0.02	18.28	1.21
Organic	2,162	1.46	1.53	0.05	5.78	0.63
Ash-fusion temperatures (˚F)						
Initial deformation	2,060	2,080	2,020	1,680	2,860G	207
Softening temperature	2,241	2,180	2,120	1,810	2,995G	210
Fluid temperature	2,059	2,285	2,260	1,845	2,910G	205

Appendix 2. Summary descriptive statistics of proximate and ultimate analyses, calorific values, forms-of-sulfur analyses, and ash-fusion temperatures for all assessed and nonassessed coals in the Illinois Basin as analyzed by the Illinois State Geological Survey, Indiana Geological Survey, Kentucky Geological Survey, and U.S. Geological Survey

Table 1. Number of samples, mean, median, range, and standard deviation of proximate and ultimate analyses, calorific value, forms-of-sulfur analyses, and ash-fusion temperatures for the Danville Coal Member in Illinois as analyzed by the Illinois State Geological Survey.

[All values are reported on an as-received basis and are in percent, except calorific value (Btu/lb) and ash-fusion temperatures (°F).]

	Number of samples	Mean	Median	Range		Standard deviation
				Minimum	Maximum	
Proximate and ultimate analyses						
Moisture	170	13.4	13.4	5.3	25.0	2.7
Volatile matter	162	35.9	36.7	25.2	44.5	3.4
Fixed carbon	162	38.6	38.8	26.5	48.4	2.8
Ash	170	12.2	11.0	4.3	44.2	4.4
Hydrogen	31	4.5	4.3	3.6	5.9	0.6
Carbon	31	60.2	61.3	52.7	67.6	4.0
Nitrogen	31	1.1	1.1	0.7	1.4	0.2
Oxygen	31	6.6	6.8	4.0	8.6	1.1
Sulfur	168	3.1	3.1	0.3	9.7	1.2
Calorific value						
Btu/lb	131	10,670	11,030	5,800	12,190	870
Forms of sulfur						
Sulfate	40	0.07	0.04	0.01	0.26	0.07
Pyritic	49	1.63	1.50	0.03	6.01	1.14
Organic	49	1.19	1.25	0.26	2.17	0.40
Ash-fusion temperatures (˚F)						
Initial deformation	20	2,075	2,010	1,920	2,330	120
Softening temperature	20	2,185	2,080	1,935	2,570	197
Fluid temperature	20	2,400	2,360	2,005	2,770	231

Table 2. Number of samples, mean, median, range, and standard deviation of proximate and ultimate analyses, calorific value, forms-of-sulfur analyses, and ash-fusion temperatures for the Danville Coal Member in Indiana as analyzed by the Indiana Geological Survey.

[All values are reported on an as-received basis and are in percent, except calorific value (Btu/lb) and ash-fusion temperatures (°F). G, greater than value shown.]

	Number of samples	Mean	Median	Range		Standard deviation
				Minimum	Maximum	
Proximate and ultimate analyses						
Moisture	115	10.9	10.9	1.9	28.2	4.2
Volatile matter	114	35.5	35.6	26.0	56.7	3.8
Fixed carbon	114	42.2	42.1	20.4	51.1	3.9
Ash	115	11.3	10.3	4.2	39.7	4.6
Hydrogen	90	5.5	5.6	3.3	6.3	0.5
Carbon	90	60.9	61.2	41.3	69.5	4.0
Nitrogen	88	1.4	1.3	1.1	1.9	0.1
Oxygen	88	18.1	18.7	9.4	24.4	3.5
Sulfur	115	2.5	2.6	0.4	6.7	1.3
Calorific value						
Btu/lb	115	10,970	10,970	7,400	12,630	790
Forms of sulfur						
Sulfate	10	0.27	0.09	0.05	1.68	0.50
Pyritic	10	1.35	1.15	0.61	2.74	0.70
Organic	10	0.99	0.84	0.39	1.82	0.44
Ash-fusion temperatures (˚F)						
Initial deformation	84	2,095	2,045	1,820	2,600	192
Softening temperature	101	2,240	2,230	1,905	2,710G	200
Fluid temperature	84	2,340	2,340	1,935	2,720G	198

Table 3. Number of samples, mean, median, range, and standard deviation of proximate and ultimate analyses, calorific value, forms-of-sulfur analyses, and ash-fusion temperatures for the Danville Coal Member in Indiana as analyzed by the U.S. Geological Survey.

[All values are reported on an as-received basis and are in percent, except calorific value (Btu/lb) and ash-fusion temperatures (°F). G, greater than value shown.]

	Number of samples	Mean	Median	Range		Standard deviation
				Minimum	Maximum	
Proximate and ultimate analyses						
Moisture	15	10.1	9.5	6.2	15.0	2.2
Volatile matter	15	33.8	33.1	28.4	37.2	2.5
Fixed carbon	15	44.7	44.8	35.0	52.3	4.9
Ash	15	11.5	10.8	6.4	21.5	4.4
Hydrogen	15	5.5	5.5	5.1	6.1	0.3
Carbon	18	59.0	61.8	36.9	68.1	7.9
Nitrogen	15	1.2	1.1	0.8	1.5	0.2
Oxygen	15	17.6	17.2	13.6	21.5	1.9
Sulfur	18	2.7	2.6	0.3	7.6	1.8
Calorific value						
Btu/lb	15	11,020	11,140	9,350	11,990	730
Forms of sulfur						
Sulfate	15	0.31	0.40	0.01	0.62	0.22
Pyritic	15	1.21	0.85	0.09	3.14	0.95
Organic	15	1.05	1.11	0.22	1.80	0.49
Ash-fusion temperatures (˚F)						
Initial deformation	14	2,135	2,115	1,900	2,745	207
Softening temperature	14	2,225	2,155	1,960	2,800G	215
Fluid temperature	14	2,325	2,315	1,995	2,800G	218

Table 4. Number of samples, mean, median, range, and standard deviation of proximate and ultimate analyses, calorific value, forms-of-sulfur analyses, and ash-fusion temperatures for the Baker coal in Kentucky as analyzed by the Kentucky Geological Survey.

[All values are reported on an as-received basis and are in percent, except calorific value (Btu/lb) and ash-fusion temperatures (°F). G, greater than value shown.]

	Number of samples	Mean	Median	Range		Standard deviation
				Minimum	Maximum	
Proximate and ultimate analyses						
Moisture	19	6.6	6.6	5.2	8.0	0.5
Volatile matter	19	33.8	34.1	25.7	37.3	3.0
Fixed carbon	19	46.5	46.7	34.5	54.7	4.8
Ash	19	13.2	11.6	6.5	27.6	5.4
Hydrogen	19	4.3	4.5	3.1	4.7	0.4
Carbon	19	65.3	66.7	52.7	72.7	5.7
Nitrogen	19	1.4	1.4	0.9	1.7	0.2
Oxygen	19	5.7	5.5	3.1	8.4	1.6
Sulfur	19	3.6	3.6	1.5	7.7	1.6
Calorific value						
Btu/lb	19	11,740	12,150	9,300	12,990	1,050
Forms of sulfur						
Sulfate	---	---	---	---	---	---
Pyritic	---	---	---	---	---	---
Organic	---	---	---	---	---	---
Ash-fusion temperatures (˚F)						
Initial deformation	---	---	---	---	---	---
Softening temperature	---	---	---	---	---	---
Fluid temperature	---	---	---	---	---	---

Table 5. Number of samples, mean, median, range, and standard deviation of proximate and ultimate analyses, calorific value, forms-of-sulfur analyses, and ash-fusion temperatures for the Baker coal in Kentucky as analyzed by the U.S. Geological Survey.

[All values are reported on an as-received basis and are in percent, except calorific value (Btu/lb) and ash-fusion temperatures (°F). G, greater than value shown.]

	Number of samples	Mean	Median	Range Minimum	Range Maximum	Standard deviation
Proximate and ultimate analyses						
Moisture	15	6.9	6.7	3.4	10.8	2.1
Volatile matter	15	36.0	35.8	31.3	40.8	3.0
Fixed carbon	15	45.1	44.1	40.0	50.5	3.1
Ash	15	12.0	11.7	7.9	17.9	2.7
Hydrogen	15	5.2	5.2	4.8	5.6	0.2
Carbon	15	64.2	64.8	58.6	70.3	3.4
Nitrogen	15	1.4	1.4	1.2	1.7	0.1
Oxygen	15	13.5	13.0	10.2	18.1	2.3
Sulfur	15	3.7	4.2	1.6	5.8	1.2
Calorific value						
Btu/lb	15	11,590	11,510	10,410	12,660	640
Forms of sulfur						
Sulfate	15	0.15	0.13	0.01	0.45	0.12
Pyritic	15	2.25	2.67	0.69	3.72	0.94
Organic	15	1.36	1.24	0.57	2.04	0.46
Ash-fusion temperatures (˚F)						
Initial deformation	15	2,080	2,030	1,930	2,610	169
Softening temperature	15	2,140	2,080	2,030	2,710	176
Fluid temperature	15	2,310	2,260	2,080	2,800	194

Table 6. Number of samples, mean, median, range, and standard deviation of proximate and ultimate analyses, calorific value, forms-of-sulfur analyses, and ash-fusion temperatures for the Herrin Coal Member in Illinois as analyzed by the Illinois State Geological Survey.

[All values are reported on an as-received basis and are in percent, except calorific value (Btu/lb) and ash-fusion temperatures (°F).]

	Number of samples	Mean	Median	Range		Standard deviation
				Minimum	Maximum	
Proximate and ultimate analyses						
Moisture	2,330	11.1	11.0	1.2	22.2	3.2
Volatile matter	2,160	34.6	34.6	19.5	45.2	2.8
Fixed carbon	2,160	43.4	42.6	25.3	58.2	4.6
Ash	2,327	10.9	10.4	2.7	43.6	3.6
Hydrogen	780	4.2	4.2	3.0	5.5	0.3
Carbon	780	60.8	60.5	41.4	73.6	5.2
Nitrogen	776	1.2	1.1	0.3	2.7	0.2
Oxygen	776	7.5	7.5	3.5	12.2	1.0
Sulfur	2,302	2.9	3.2	0.3	14.5	1.5
Calorific value						
Btu/lb	2,176	11,100	11,120	5,770	13,420	800
Forms of sulfur						
Sulfate	776	0.07	0.03	0.01	2.02	0.12
Pyritic	1,014	1.63	1.64	0.04	8.48	1.07
Organic	1,016	1.43	1.48	0.16	3.35	0.62
Ash-fusion temperatures (˚F)						
Initial deformation	437	2,110	2,080	1,680	2,700	168
Softening temperature	440	2,165	2,150	1,820	2,995	161
Fluid temperature	436	2,290	2,290	1,880	2,700	151

Table 7. Number of samples, mean, median, range, and standard deviation of proximate and ultimate analyses, calorific value, forms-of-sulfur analyses, and ash-fusion temperatures for the Herrin Coal Member in Illinois as analyzed by the U.S. Geological Survey.

[All values are reported on an as-received basis and are in percent, except calorific value (Btu/lb) and ash-fusion temperatures (°F). G, greater than value shown.]

	Number of samples	Mean	Median	Range		Standard deviation
				Minimum	Maximum	
Proximate and ultimate analyses						
Moisture	74	6.4	5.8	3.1	12.1	2.5
Volatile matter	74	34.8	34.9	27.3	40.9	2.6
Fixed carbon	74	48.1	48.3	40.1	58.5	3.9
Ash	74	10.7	10.2	2.4	24.3	4.1
Hydrogen	74	5.1	5.2	4.2	5.9	0.3
Carbon	74	64.6	65.2	55.1	73.6	4.9
Nitrogen	74	1.2	1.2	0.5	1.6	0.2
Oxygen	74	14.9	14.5	10.0	20.5	2.7
Sulfur	74	3.4	3.1	0.5	8.7	1.6
Calorific value						
Btu/lb	73	11,500	11,500	9,780	13,090	870
Forms of sulfur						
Sulfate	64	0.33	0.20	0.01	1.71	0.37
Pyritic	74	1.39	1.09	0.02	7.51	1.24
Organic	74	1.76	1.81	0.34	5.08	0.81
Ash-fusion temperatures (˚F)						
Initial deformation	74	2,060	2,035	1,780	2,800G	168
Softening temperature	74	2,130	2,125	1,820	2,910G	174
Fluid temperature	74	2,210	2,175	1,860	2,910G	191

Table 8. Number of samples, mean, median, range, and standard deviation of proximate and ultimate analyses, calorific value, forms-of-sulfur analyses, and ash-fusion temperatures for the Herrin coal in Kentucky as analyzed by the Kentucky Geological Survey.

[All values are reported on an as-received basis and are in percent, except calorific value (Btu/lb) and ash-fusion temperatures (°F). Leaders (---) indicate no data.]

	Number of samples	Mean	Median	Range Minimum	Range Maximum	Standard deviation
Proximate and ultimate analyses						
Moisture	121	6.5	6.5	3.8	9.4	0.9
Volatile matter	121	37.4	37.4	32.2	42.5	2.1
Fixed carbon	121	45.7	45.7	35.8	52.9	3.4
Ash	121	10.5	9.8	5.3	24.1	3.6
Hydrogen	65	4.3	4.3	2.9	5.0	0.5
Carbon	65	65.0	65.8	47.8	71.0	4.4
Nitrogen	65	1.2	1.3	0.7	1.7	0.2
Oxygen	65	7.3	7.8	2.3	16.7	2.4
Sulfur	121	3.8	3.8	1.0	7.0	1.1
Calorific value						
Btu/lb	121	11,990	12,070	9,540	13,100	690
Forms of sulfur						
Sulfate	---	---	---	---	---	---
Pyritic	---	---	---	---	---	---
Organic	---	---	---	---	---	---
Ash-fusion temperatures (˚F)						
Initial deformation	---	---	---	---	---	---
Softening temperature	---	---	---	---	---	---
Fluid temperature	---	---	---	---	---	---

Table 9. Number of samples, mean, median, range, and standard deviation of proximate and ultimate analyses, calorific value, forms-of-sulfur analyses, and ash-fusion temperatures for the Herrin coal in Kentucky as analyzed by the U.S. Geological Survey.

[All values are reported on an as-received basis and are in percent, except calorific value (Btu/lb) and ash-fusion temperatures (°F). G, greater than value shown.]

	Number of samples	Mean	Median	Range		Standard deviation
				Minimum	Maximum	
Proximate and ultimate analyses						
Moisture	20	6.0	6.2	2.3	9.7	2.0
Volatile matter	20	37.9	37.7	30.4	42.7	2.9
Fixed carbon	20	47.0	47.3	40.7	51.3	3.3
Ash	20	9.0	7.5	5.3	24.8	4.9
Hydrogen	20	5.4	5.5	4.3	5.8	0.3
Carbon	20	67.3	68.6	53.5	73.3	4.7
Nitrogen	20	1.4	1.4	1.2	1.5	0.1
Oxygen	20	13.3	13.5	8.7	16.8	2.2
Sulfur	20	3.6	3.6	2.9	5.0	0.6
Calorific value						
Btu/lb	20	12,240	12,540	9,710	13,390	850
Forms of sulfur						
Sulfate	20	0.09	0.07	0.01	0.26	0.09
Pyritic	20	1.83	1.65	0.77	3.56	0.77
Organic	20	1.69	1.85	0.51	2.40	0.48
Ash-fusion temperatures (˚F)						
Initial deformation	20	2,040	2,015	1,925	2,770	175
Softening temperature	20	2,125	2,085	2,030	2,800G	163
Fluid temperature	20	2,250	2,225	2,125	2,800G	139

Table 10. Number of samples, mean, median, range, and standard deviation of proximate and ultimate analyses, calorific value, forms-of-sulfur analyses, and ash-fusion temperatures for the Springfield Coal Member in Illinois as analyzed by the Illinois State Geological Survey.

[All values are reported on an as-received basis and are in percent, except calorific value (Btu/lb) and ash-fusion temperatures (°F).]

	Number of samples	Mean	Median	Range		Standard deviation
				Minimum	Maximum	
Proximate and ultimate analyses						
Moisture	1,171	10.7	10.5	0.9	24.2	4.2
Volatile matter	1,032	34.7	34.8	22.4	41.1	2.4
Fixed carbon	1,032	43.0	41.8	25.0	60.7	5.4
Ash	1,171	11.7	10.7	2.8	43.5	4.6
Hydrogen	472	4.3	4.2	2.7	5.5	0.4
Carbon	472	61.2	60.0	38.3	77.8	5.4
Nitrogen	472	1.2	1.2	0.3	2.2	0.2
Oxygen	472	6.5	6.7	0.2	12.8	1.3
Sulfur	1,163	3.5	3.4	0.6	17.7	1.5
Calorific value						
Btu/lb	1,109	11,140	10,980	4,810	13,910	1,070
Forms of sulfur						
Sulfate	505	0.06	0.03	0.01	1.18	0.09
Pyritic	584	2.01	1.79	0.11	18.28	1.29
Organic	585	1.57	1.65	0.29	5.11	0.50
Ash-fusion temperatures (˚F)						
Initial deformation	257	1,990	1,970	1,800	2,500	96
Softening temperature	257	2,030	2,010	1,835	2,550	102
Fluid temperature	257	2,130	2,105	1,845	2,700	139

Table 11. Number of samples, mean, median, range, and standard deviation of proximate and ultimate analyses, calorific value, forms-of-sulfur analyses, and ash-fusion temperatures for the Springfield Coal Member in Indiana as analyzed by the Indiana Geological Survey.

[All values are reported on an as-received basis and are in percent, except calorific value (Btu/lb) and ash-fusion temperatures (°F). G, greater than value shown.]

	Number of samples	Mean	Median	Range: Minimum	Range: Maximum	Standard deviation
Proximate and ultimate analyses						
Moisture	336	9.9	10.2	0.5	34.7	4.0
Volatile matter	335	37.0	37.3	17.7	55.0	3.9
Fixed carbon	335	42.1	42.2	14.0	62.7	4.9
Ash	336	10.9	9.7	4.3	49.7	5.3
Hydrogen	274	5.5	5.6	3.1	7.1	0.5
Carbon	273	62.0	62.9	34.7	72.5	5.3
Nitrogen	273	1.3	1.3	0.7	1.9	0.2
Oxygen	272	16.9	16.9	2.9	42.2	3.9
Sulfur	336	3.3	3.3	0.6	7.4	1.3
Calorific value						
Btu/lb	336	11,210	11,400	6,020	13,400	920
Forms of sulfur						
Sulfate	37	0.20	0.12	0.01	1.19	0.24
Pyritic	41	1.51	1.25	0.20	4.66	1.07
Organic	41	1.55	1.46	0.50	3.92	0.74
Ash-fusion temperatures (˚F)						
Initial deformation	237	2,001	1,959	1,795	2,700G	167
Softening temperature	293	2,130	2,080	1,860	2,810G	186
Fluid temperature	237	2,234	2,200	1,924	2,720G	194

Table 12. Number of samples, mean, median, range, and standard deviation of proximate and ultimate analyses, calorific value, forms-of-sulfur analyses, and ash-fusion temperatures for the Springfield Coal Member in Indiana as analyzed by the U.S. Geological Survey.

[All values are reported on an as-received basis and are in percent, except calorific value (Btu/lb) and ash-fusion temperatures (°F). G, greater than value shown.]

	Number of samples	Mean	Median	Range		Standard deviation
				Minimum	Maximum	
Proximate and ultimate analyses						
Moisture	35	8.8	8.9	4.6	15.3	2.2
Volatile matter	35	36.1	35.8	22.8	42.8	4.1
Fixed carbon	35	46.1	46.6	38.7	57.7	3.7
Ash	35	9.0	8.9	4.2	12.5	1.9
Hydrogen	35	5.5	5.5	5.1	5.9	0.2
Carbon	41	62.0	64.2	28.0	68.6	7.9
Nitrogen	35	1.2	1.2	0.9	1.6	0.2
Oxygen	35	16.3	16.5	12.0	22.9	2.4
Sulfur	41	4.2	3.4	0.5	19.5	3.3
Calorific value						
Btu/lb	35	11,603	11,590	10,800	12,460	377
Forms of sulfur						
Sulfate	35	0.29	0.15	0.01	1.28	0.34
Pyritic	35	1.51	1.42	0.06	3.41	0.83
Organic	35	1.68	1.73	0.42	2.65	0.50
Ash-fusion temperatures (˚F)						
Initial deformation	25	2,105	2,035	1,865	2,800	236
Softening temperature	25	2,205	2,145	1,935	2,910G	238
Fluid temperature	25	2,280	2,255	1,985	2,910G	235

Table 13. Number of samples, mean, median, range, and standard deviation of proximate and ultimate analyses, calorific value, forms-of-sulfur analyses, and ash-fusion temperatures for the Springfield coal in Kentucky as analyzed by the Kentucky Geological Survey.

[All values are reported on an as-received basis and are in percent, except calorific value (Btu/lb) and ash-fusion temperatures (°F). Leaders (---) indicate no data.]

	Number of samples	Mean	Median	Range		Standard deviation
				Minimum	Maximum	
Proximate and ultimate analyses						
Moisture	259	7.9	7.9	1.8	12.2	1.7
Volatile matter	259	36.2	36.4	31.6	41.4	1.5
Fixed carbon	259	45.7	45.5	40.0	52.1	2.3
Ash	259	10.2	10.1	5.0	16.4	1.6
Hydrogen	141	4.2	4.3	3.2	4.8	0.4
Carbon	141	65.2	65.4	50.5	72.6	2.4
Nitrogen	141	1.3	1.3	0.8	1.7	0.2
Oxygen	141	7.1	7.2	2.6	19.9	2.0
Sulfur	259	3.5	3.5	2.1	6.2	0.7
Calorific value						
Btu/lb	259	11,870	11,820	10,820	13,250	480
Forms of sulfur						
Sulfate	---	---	---	---	---	---
Pyritic	---	---	---	---	---	---
Organic	---	---	---	---	---	---
Ash-fusion temperatures (˚F)						
Initial deformation	---	---	---	---	---	---
Softening temperature	---	---	---	---	---	---
Fluid temperature	---	---	---	---	---	---

Table 14. Number of samples, mean, median, range, and standard deviation of proximate and ultimate analyses, calorific value, forms-of-sulfur analyses, and ash-fusion temperatures for the Springfield coal in Kentucky as analyzed by the U.S. Geological Survey.

[All values are reported on an as-received basis and are in percent, except calorific value (Btu/lb) and ash-fusion temperatures (°F).]

	Number of samples	Mean	Median	Range		Standard deviation
				Minimum	Maximum	
Proximate and ultimate analyses						
Moisture	31	7.2	7.0	2.5	12.4	2.2
Volatile matter	31	36.9	36.9	34.7	39.8	1.3
Fixed carbon	31	45.3	45.2	40.8	49.9	2.5
Ash	31	10.5	10.7	6.7	15.2	2.4
Hydrogen	31	5.3	5.3	4.8	5.7	0.2
Carbon	31	65.2	65.4	59.8	70.2	2.8
Nitrogen	31	1.4	1.4	1.0	1.6	0.1
Oxygen	31	13.6	13.5	7.6	20.3	2.7
Sulfur	31	3.9	3.7	2.5	8.0	1.1
Calorific value						
Btu/lb	31	11,840	11,930	10,820	12,770	530
Forms of sulfur						
Sulfate	31	0.12	0.06	0.01	0.53	0.13
Pyritic	31	2.09	1.90	0.71	4.10	0.85
Organic	31	1.74	1.67	1.08	3.94	0.52
Ash-fusion temperatures (˚F)						
Initial deformation	31	2,015	2,015	1,910	2,220	69
Softening temperature	31	2,100	2,105	1,950	2,250	77
Fluid temperature	31	2,205	2,205	2,050	2,360	78

Table 15. Number of samples, mean, median, range, and standard deviation of proximate and ultimate analyses, calorific value, forms-of-sulfur analyses, and ash-fusion temperatures for nonassessed coals from the McLeansboro Group in Kentucky as analyzed by the Kentucky Geological Survey.

[All values are reported on an as-received basis and are in percent, except calorific value (Btu/lb) and ash-fusion temperatures (°F). Leaders (---) indicate no data.]

	Number of samples	Mean	Median	Range		Standard deviation
				Minimum	Maximum	
Proximate and ultimate analyses						
Moisture	57	7.5	7.5	7.5	7.5	0.0
Volatile matter	57	34.6	34.4	29.8	38.2	2.1
Fixed carbon	57	43.2	43.0	34.0	50.6	4.0
Ash	57	14.7	14.6	6.0	28.7	4.4
Hydrogen	57	4.0	4.1	3.0	4.7	0.4
Carbon	57	62.0	62.2	51.8	69.9	3.9
Nitrogen	57	1.3	1.3	0.7	1.6	0.2
Oxygen	57	6.7	7.0	2.1	12.5	2.0
Sulfur	57	3.8	3.6	1.7	8.0	1.3
Calorific value						
Btu/lb	57	11,150	11,200	9,300	12,620	710
Forms of sulfur						
Sulfate	---	---	---	---	---	---
Pyritic	---	---	---	---	---	---
Organic	---	---	---	---	---	---
Ash-fusion temperatures (˚F)						
Initial deformation	---	---	---	---	---	---
Softening temperature	---	---	---	---	---	---
Fluid temperature	---	---	---	---	---	---

Table 16. Number of samples, mean, median, range, and standard deviation of proximate and ultimate analyses, calorific value, forms-of-sulfur analyses, and ash-fusion temperatures for nonassessed coals from the McLeansboro Group in Kentucky as analyzed by the U.S. Geological Survey.

[All values are reported on an as-received basis and are in percent, except calorific value (Btu/lb) and ash-fusion temperatures (°F).]

	Number of samples	Mean	Median	Range		Standard deviation
				Minimum	Maximum	
Proximate and ultimate analyses						
Moisture	25	6.7	7.0	3.8	12.6	1.9
Volatile matter	25	35.8	36.6	29.7	38.5	2.3
Fixed carbon	25	44.9	45.3	38.7	50.1	3.0
Ash	25	12.5	12.8	6.0	24.4	3.8
Hydrogen	25	5.2	5.2	4.6	5.5	0.2
Carbon	25	63.7	64.3	50.6	70.1	3.6
Nitrogen	25	1.4	1.4	1.2	1.6	0.1
Oxygen	25	13.8	13.4	11.1	20.5	2.0
Sulfur	25	3.4	3.2	1.8	5.7	1.0
Calorific value						
Btu/lb	25	11,530	11,530	9,080	12,660	660
Forms of sulfur						
Sulfate	24	0.13	0.08	0.01	0.70	0.17
Pyritic	24	1.83	1.69	0.84	4.04	0.89
Organic	24	1.42	1.51	0.50	1.92	0.43
Ash-fusion temperatures (˚F)						
Initial deformation	25	2,145	2,115	1,905	2,615	153
Softening temperature	25	2,240	2,190	2,015	2,710	153
Fluid temperature	25	2,380	2,340	2,130	2,800	172

Table 17. Number of samples, mean, median, range, and standard deviation of proximate and ultimate analyses, calorific value, forms-of-sulfur analyses, and ash-fusion temperatures for nonassessed coals from the Carbondale Group in Indiana as analyzed by the Indiana Geological Survey.

[All values are reported on an as-received basis and are in percent, except calorific value (Btu/lb) and ash-fusion temperatures (°F). G, greater than value shown.]

	Number of samples	Mean	Median	Range		Standard deviation
				Minimum	Maximum	
Proximate and ultimate analyses						
Moisture	312	10.8	11.3	0.8	37.1	5.0
Volatile matter	307	35.8	36.2	19.7	43.4	3.5
Fixed carbon	307	40.9	41.4	8.5	59.8	5.0
Ash	312	12.5	10.5	4.7	48.5	6.6
Hydrogen	235	5.4	5.5	3.1	6.8	0.6
Carbon	235	60.2	61.4	32.2	73.6	5.7
Nitrogen	229	1.3	1.3	0.9	2.1	0.2
Oxygen	228	17.6	18.1	6.2	32.0	4.5
Sulfur	312	2.8	2.5	0.3	11.1	1.6
Calorific value						
Btu/lb	312	10,800	11,100	5,440	13,200	1,170
Forms of sulfur						
Sulfate	20	0.28	0.21	0.02	1.02	0.28
Pyritic	20	1.77	1.61	0.59	3.80	0.92
Organic	20	1.55	1.24	0.68	5.78	1.21
Ash-fusion temperatures (˚F)						
Initial deformation	212	2,045	1,980	1,800	2,700G	191
Softening temperature	254	2,180	2,120	1,900	2,770G	193
Fluid temperature	212	2,295	2,260	1,930	2,805G	193

Table 18. Number of samples, mean, median, range, and standard deviation of proximate and ultimate analyses, calorific value, forms-of-sulfur analyses, and ash-fusion temperatures for nonassessed coals from the Carbondale Group in Indiana as analyzed by the U.S. Geological Survey.

[All values are reported on an as-received basis and are in percent, except calorific value (Btu/lb) and ash-fusion temperatures (°F). G, greater than value shown.]

	Number of samples	Mean	Median	Range		Standard deviation
				Minimum	Maximum	
Proximate and ultimate analyses						
Moisture	29	9.0	9.1	2.8	15.6	2.6
Volatile matter	29	34.6	34.8	25.0	40.7	3.2
Fixed carbon	29	44.4	44.7	27.3	52.7	4.5
Ash	29	12.0	10.5	6.3	44.9	7.1
Hydrogen	29	5.4	5.4	3.5	6.1	0.5
Carbon	36	59.4	61.5	24.0	69.6	9.1
Nitrogen	29	1.2	1.3	0.5	1.5	0.2
Oxygen	29	16.6	17.1	9.8	21.6	2.5
Sulfur	36	4.1	3.2	1.2	28.1	4.4
Calorific value						
Btu/lb	29	11,070	11,090	6,930	12,330	960
Forms of sulfur						
Sulfate	29	0.46	0.49	0.02	1.08	0.32
Pyritic	29	1.62	1.48	0.34	3.34	0.78
Organic	29	1.06	1.09	0.26	1.92	0.46
Ash-fusion temperatures (˚F)						
Initial deformation	26	2,090	2,030	1,885	2,800G	214
Softening temperature	26	2,180	2,120	1,985	2,800G	201
Fluid temperature	26	2,255	2,195	2,020	2,800G	199

Table 19. Number of samples, mean, median, range, and standard deviation of proximate and ultimate analyses, calorific value, forms-of-sulfur analyses, and ash-fusion temperatures for nonassessed coals from the Carbondale Formation in Kentucky as analyzed by the Kentucky Geological Survey.

[All values are reported on an as-received basis and are in percent, except calorific value (Btu/lb) and ash-fusion temperatures (°F). Leaders (---) indicate no data.]

	Number of samples	Mean	Median	Range		Standard deviation
				Minimum	Maximum	
Proximate and ultimate analyses						
Moisture	42	7.5	7.5	7.5	7.5	0.0
Volatile matter	42	36.0	36.0	26.2	42.5	3.2
Fixed carbon	42	41.5	41.1	30.4	53.1	4.9
Ash	42	15.0	13.8	3.6	30.9	6.4
Hydrogen	42	4.1	4.2	1.7	4.8	0.6
Carbon	42	60.9	62.1	47.0	69.7	5.8
Nitrogen	42	1.2	1.3	0.4	1.5	0.2
Oxygen	41	7.6	7.2	2.0	17.7	3.3
Sulfur	42	3.9	3.9	1.8	8.2	1.4
Calorific value						
Btu/lb	42	11,070	11,270	8,410	12,570	1,010
Forms of sulfur						
Sulfate	---	---	---	---	---	---
Pyritic	---	---	---	---	---	---
Organic	---	---	---	---	---	---
Ash-fusion temperatures (˚F)						
Initial deformation	---	---	---	---	---	---
Softening temperature	---	---	---	---	---	---
Fluid temperature	---	---	---	---	---	---

Table 20. Number of samples, mean, median, range, and standard deviation of proximate and ultimate analyses, calorific value, forms-of-sulfur analyses, and ash-fusion temperatures for nonassessed coals from the Carbondale Formation in Kentucky as analyzed by the U.S. Geological Survey.

[All values are reported on an as-received basis and are in percent, except calorific value (Btu/lb) and ash-fusion temperatures (°F).]

	Number of samples	Mean	Median	Range Minimum	Range Maximum	Standard deviation
Proximate and ultimate analyses						
Moisture	42	6.1	6.3	2.4	16.3	2.4
Volatile matter	42	37.6	37.4	32.1	44.3	2.8
Fixed carbon	42	42.9	42.9	33.2	52.2	4.1
Ash	42	13.4	12.3	6.1	27.1	5.1
Hydrogen	42	5.2	5.3	4.0	5.8	0.4
Carbon	42	63.3	63.7	45.5	73.6	6.2
Nitrogen	42	1.4	1.4	1.0	1.6	0.2
Oxygen	42	12.2	12.1	6.5	25.3	2.8
Sulfur	42	4.6	4.0	1.4	15.9	2.6
Calorific value						
Btu/lb	42	11,590	11,630	8,950	13,200	1,010
Forms of sulfur						
Sulfate	42	0.16	0.11	0.01	0.64	0.15
Pyritic	42	2.74	2.24	0.30	12.10	2.13
Organic	42	1.66	1.58	0.64	4.37	0.70
Ash-fusion temperatures (˚F)						
Initial deformation	42	2,065	2,035	1,930	2,440	101
Softening temperature	42	2,130	2,105	2,000	2,530	113
Fluid temperature	42	2,255	2,225	2,070	2,650	139

Table 21. Number of samples, mean, median, range, and standard deviation of proximate and ultimate analyses, calorific value, forms-of-sulfur analyses, and ash-fusion temperatures for nonassessed coals from the Raccoon Creek Group in Indiana as analyzed by the Indiana Geological Survey.

[All values are reported on an as-received basis and are in percent, except calorific value (Btu/lb) and ash-fusion temperatures (°F). G, greater than value shown.]

	Number of samples	Mean	Median	Range		Standard deviation
				Minimum	Maximum	
Proximate and ultimate analyses						
Moisture	586	12.0	12.1	0.7	52.8	5.8
Volatile Matter	584	35.3	35.2	16.5	54.0	3.9
Fixed carbon	584	42.2	42.9	7.9	58.7	6.1
Ash	586	10.5	8.7	1.7	48.7	6.4
Hydrogen	390	5.6	5.7	2.4	8.2	0.6
Carbon	390	61.8	62.8	30.2	75.7	6.3
Nitrogen	390	1.3	1.3	0.7	1.8	0.2
Oxygen	387	18.3	17.8	5.7	51.2	5.8
Sulfur	586	2.9	2.6	0.1	14.1	2.0
Calorific value						
Btu/lb	583	10,980	11,290	4,540	13,540	1,300
Forms of sulfur						
Sulfate	50	0.34	0.27	0.02	2.31	0.37
Pyritic	50	1.76	1.13	0.15	7.46	1.79
Organic	51	1.43	1.32	0.05	5.43	1.00
Ash-fusion temperatures (˚F)						
Initial deformation	444	2,135	2,020	1,760	2,860G	275
Softening temperature	507	2,265	2,200	1,810	2,895G	256
Fluid temperature	444	2,360	2,360	1,900	2,895G	231

Table 22. Number of samples, mean, median, range, and standard deviation of proximate and ultimate analyses, calorific value, forms-of-sulfur analyses, and ash-fusion temperatures for nonassessed coals from the Raccoon Creek Group in Indiana as analyzed by the U.S. Geological Survey.

[All values are reported on an as-received basis and are in percent, except calorific value (Btu/lb) and ash-fusion temperatures (°F). G, greater than value shown.]

	Number of samples	Mean	Median	Range		Standard deviation
				Minimum	Maximum	
Proximate and ultimate analyses						
Moisture	62	10.9	11.0	2.1	21.4	3.8
Volatile matter	62	33.9	34.3	22.4	43.5	4.2
Fixed carbon	62	46.7	47.3	39.2	57.8	4.0
Ash	62	8.5	8.1	2.0	15.0	3.1
Hydrogen	62	5.6	5.6	4.8	6.3	0.3
Carbon	85	62.2	63.3	27.7	82.9	8.0
Nitrogen	62	1.1	1.2	0.6	1.6	0.2
Oxygen	62	18.4	18.2	7.9	31.3	4.0
Sulfur	85	3.1	2.5	0.4	30.1	3.5
Calorific value						
Btu/lb	62	11,360	11,405	9,020	13,010	730
Forms of sulfur						
Sulfate	62	0.29	0.26	0.01	0.92	0.26
Pyritic	62	1.70	1.24	0.06	6.10	1.50
Organic	62	1.09	0.93	0.15	2.15	0.53
Ash-fusion temperatures (˚F)						
Initial deformation	54	2,215	2,065	1,895	2,800G	289
Softening temperature	54	2,305	2,205	1,960	2,910G	291
Fluid temperature	54	2,390	2,340	2,000	2,910G	276

Table 23. Number of samples, mean, median, range, and standard deviation of proximate and ultimate analyses, calorific value, forms-of-sulfur analyses, and ash-fusion temperatures for nonassessed coals from the Raccoon Creek Group in Kentucky as analyzed by the Kentucky Geological Survey.

[All values are reported on an as-received basis and are in percent, except calorific value (Btu/lb) and ash-fusion temperatures (°F). Leaders (---) indicate no data.]

	Number of samples	Mean	Median	Range		Standard deviation
				Minimum	Maximum	
Proximate and ultimate analyses						
Moisture	87	7.5	7.5	7.5	7.5	0.0
Volatile matter	87	36.5	36.1	24.2	44.9	3.5
Fixed carbon	87	46.9	47.0	24.4	55.9	5.5
Ash	87	9.1	7.6	1.5	43.9	6.9
Hydrogen	87	4.2	4.2	2.4	5.1	0.5
Carbon	87	67.1	68.6	35.9	75.7	7.2
Nitrogen	87	1.3	1.4	0.6	1.8	0.3
Oxygen	87	8.3	8.1	4.3	12.8	1.7
Sulfur	87	2.6	2.4	0.6	7.3	1.6
Calorific value						
Btu/lb	87	11,960	12,310	6,180	13,620	1,270
Forms of sulfur						
Sulfate	---	---	---	---	---	---
Pyritic	---	---	---	---	---	---
Organic	---	---	---	---	---	---
Ash-fusion temperatures (˚F)						
Initial deformation	---	---	---	---	---	---
Softening temperature	---	---	---	---	---	---
Fluid temperature	---	---	---	---	---	---

Table 24. Number of samples, mean, median, range, and standard deviation of proximate and ultimate analyses, calorific value, forms-of-sulfur analyses, and ash-fusion temperatures for nonassessed coals from the Raccoon Creek Group in Kentucky as analyzed by the U.S. Geological Survey.

[All values are reported on an as-received basis and are in percent, except calorific value (Btu/lb) and ash-fusion temperatures (°F). G, greater than value shown.]

	Number of samples	Mean	Median	Range		Standard deviation
				Minimum	Maximum	
Proximate and ultimate analyses						
Moisture	43	8.9	8.7	4.1	15.2	2.5
Volatile matter	43	36.5	36.3	30.7	42.6	2.6
Fixed carbon	43	47.7	47.4	40.4	53.5	3.3
Ash	43	6.8	6.4	1.5	13.9	3.4
Hydrogen	43	5.6	5.7	4.7	6.1	0.3
Carbon	43	67.9	69.0	60.6	74.4	3.5
Nitrogen	43	1.5	1.4	1.1	2.5	0.2
Oxygen	43	15.6	15.5	10.4	21.4	2.8
Sulfur	43	2.5	2.2	0.5	8.1	1.8
Calorific value						
Btu/lb	43	12,220	12,340	10,970	13,330	570
Forms of sulfur						
Sulfate	43	0.11	0.05	0.01	0.45	0.13
Pyritic	43	1.49	1.40	0.03	4.57	1.23
Organic	43	0.95	0.72	0.34	3.13	0.63
Ash-fusion temperatures (˚F)						
Initial deformation	43	2,240	2,120	1,915	2,800G	270
Softening temperature	43	2,325	2,205	2,030	2,800G	262
Fluid temperature	43	2,430	2,350	2,080	2,800G	239

Appendix 3. Summary descriptive statistics of ash yields and contents of selected elements for all assessed and nonassessed coals in the Illinois Basin.

Table 1. Number of samples, mean, median, range, and standard deviation of ash yield and contents of elements for all assessed coals (Springfield, Herrin, Danville, and Baker Coals) in the Illinois Basin.

[All analyses are in percent or parts per million and are reported on an as-received, whole-coal basis. L, less than value shown. A common problem in statistical summaries of trace-element data arises when element values are below the limits of analytical detection. This results in a censored distribution. To compute unbiased estimates of the means for censored data, we adopted the protocol of reducing all "less than" values by 50 percent before summary statistics were generated.]

	Number of samples	Mean	Median	Range		Standard deviation
				Minimum	Maximum	
Percent						
Ash	211	12.4	11.0	2.8	47.0	6.7
Si	574	2.2	1.9	0.018	13	1.2
Al	574	1.1	0.93	0.17	5.8	0.57
Ca	574	0.52	0.40	0.015	11	0.62
Mg	575	0.054	0.043	0.0044L	0.47	0.043
Na	587	0.053	0.038	0.0018	0.42	0.049
K	592	0.18	0.15	0.003L	1.4	0.13
Fe	574	2.0	1.7	0.096	27	1.5
Ti	574	0.058	0.051	0.004L	0.37	0.03
Parts per million						
As	400	9.4	4.4	0.20L	140	15
B	352	99	89	5.7L	390	48
Ba	332	100	35	5.5	2,500	280
Be	389	1.8	1.5	0.36L	8.5	1.1
Cd	370	0.99	0.16	0.01L	54	4.2
Co	566	4.0	3.3	0.78	17	2.3
Cr	568	18	14	2.8L	190	16
Cu	355	11	8.6	2.7	77	8.3
F	345	71	52	10L	600	75
Ge	338	7.8	5.8	0.045L	63	8.1
Hg	368	0.12	0.09	0.01L	1.2	0.11
La	316	5.8	5.0	0.84L	31	4.2
Li	284	11	7.3	0.94L	89	13
Mn	558	52	36	0.58	1,200	64
Mo	335	7.6	5.0	0.16L	190	12
Nb	210	1.8	1.6	0.26L	12	1.4
Ni	580	16	12	1.0	190	15
P	399	90	45	2.8L	2,200	160
Pb	389	16	6.3	0.019L	350	30
Sb	399	0.9	0.6	0.1	15	1.4
Sc	313	2.7	2.3	0.38	16	1.5
Se	380	2.2	1.8	0.4L	13	1.6
Sr	332	33	23	2.7L	980	60
Th	334	2.0	1.5	0.3L	17	1.7
U	351	2.2	1.2	0.15L	26	3.1
V	358	24	19	1.2	130	19
Y	211	5.6	4.9	1.1	27	3.3
Yb	299	0.55	0.5	0.065L	3.2	0.33
Zn	373	170	36	3.7	4,500	510
Zr	346	26	20	0.51L	270	24

Table 2. Number of samples, mean, median, range, and standard deviation of ash yield and contents of elements for the Danville Coal Member in Illinois and Indiana.

[All analyses are in percent or parts per million and are reported on an as-received, whole-coal basis. L, less than value shown. G, greater than value shown. A common problem in statistical summaries of trace-element data arises when element values are below the limits of analytical detection. This results in a censored distribution. To compute unbiased estimates of the means for censored data, we adopted the protocol of reducing all "less than" values by 50 percent before summary statistics were generated. Leaders (---) indicate statistics could not be calculated owing to no data or to an insufficient number of analyses above the lower detection limit.]

	Number of samples	Mean	Median	Range		Standard deviation
				Minimum	Maximum	
Percent						
Ash	19	16.2	13.0	6.7	47.0	11
Si	22	3.3	2.2	1.4	13	2.7
Al	22	1.6	1.1	0.55	5.8	1.2
Ca	22	0.37	0.33	0.029	1.2	0.34
Mg	22	0.12	0.079	0.029	0.47	0.10
Na	22	0.075	0.058	0.013	0.24	0.061
K	22	0.35	0.23	0.11	1.4	0.33
Fe	22	2.0	1.7	0.2.0	7.5	1.5
Ti	22	0.089	0.062	0.044	0.37	0.073
Parts per million						
As	22	12	10	0.50	43	10
B	22	110	110	31	190G	40
Ba	21	67	46	20	290	62
Be	22	3.2	3.2	1.2	6.0	1.2
Cd	22	0.40	0.12	0.01L	4.5	0.98
Co	22	6.3	6.2	2.5	12	2.5
Cr	22	19	17	9.5	46	9.5
Cu	22	10	9.9	5.5	24	4.0
F	22	110	66	22	450	120
Ge	22	12	14	1.1L	19	5.5
Hg	22	0.10	0.09	0.01	0.32	0.07
La	21	8.7	6.5	3.0	26	5.8
Li	21	19	10	5.5	89	20
Mn	22	55	48	10	230	48
Mo	21	2.6	2.3	0.16L	10	2.1
Nb	19	2.9	2.1	0.61L	12	2.5
Ni	22	24	27	5.5	48	15
P	---	---	---	---	---	---
Pb	22	17	13	1.5L	48	15
Sb	22	2.3	1.5	0.2	15	3.2
Sc	21	3.9	3.2	1.9	8.9	1.8
Se	22	1.3	1.2	0.7	2.1	0.4
Sr	21	35	31	13	130	26
Th	20	2.5	1.8	1.0	8.3	1.7
U	21	1.3	1.4	0.35L	3.5	0.73
V	22	25	20	10	85	17
Y	19	6.8	6.4	3.3	18	3.5
Yb	21	0.70	0.60	0.27	1.6	0.39
Zn	22	250	36	8.2	3,300	710
Zr	21	49	29	13	270	61

Table 3. Number of samples, mean, median, range, and standard deviation of ash yield and contents of elements for the Baker coal in western Kentucky.

[All analyses are in percent or parts per million and are reported on an as-received, whole-coal basis. L, less than value shown. A common problem in statistical summaries of trace-element data arises when element values are below the limits of analytical detection. This results in a censored distribution. To compute unbiased estimates of the means for censored data, we adopted the protocol of reducing all "less than" values by 50 percent before summary statistics were generated.]

	Number of samples	Mean	Median	Range		Standard deviation
				Minimum	Maximum	
Percent						
Ash	15	13.1	13.0	7.7	20.0	3.2
Si	34	2.2	1.9	1.3	6.6	1.0
Al	34	1.3	1.1	0.63	4.4	0.7
Ca	34	0.47	0.27	0.044	1.6	0.45
Mg	34	0.063	0.049	0.019	0.19	0.04
Na	33	0.041	0.039	0.0047	0.12	0.025
K	34	0.21	0.17	0.065	0.87	0.16
Fe	34	2.6	2.5	0.65	5.7	1.3
Ti	34	0.061	0.051	0.033	0.18	0.03
Parts per million						
As	17	27	22	4.6	70	19
B	15	77	75	52	110	15
Ba	15	87	43	17	400	120
Be	17	2.2	2.1	1.6	3.7	0.52
Cd	17	0.19	0.12	0.02	0.55	0.16
Co	33	5.2	4.0	2.0	17	3.3
Cr	33	19	17	9.5	50	7.4
Cu	15	16	14	8.8	46	9.2
F	15	94	60	10L	300	86
Ge	15	18	14	4.6	52	13
Hg	17	0.13	0.07	0.02L	0.32	0.11
La	15	7.4	6.3	2.0	22	5.4
Li	15	12	11	2.9	24	7.1
Mn	33	62	36	5.8	240	53
Mo	7	4.6	3.6	1.8	10	2.8
Nb	15	2.0	2.0	0.77	3.6	0.77
Ni	33	36	31	4.6	120	25
P	31	170	100	22L	740	180
Pb	17	20	15	4.7	70	18
Sb	17	1.5	1.4	0.2	3.7	1.0
Sc	15	4.4	4.2	2.7	7.1	1.0
Se	17	1.8	1.9	0.8	3.0	0.8
Sr	15	65	38	15	200	57
Th	17	2.0	1.9	1.0	3.3	0.72
U	17	2.5	2.1	0.94	7.0	1.5
V	15	26	25	14	70	13
Y	15	7.9	6.5	3.5	18	4.3
Yb	15	0.99	0.8	0.58	2.8	0.57
Zn	15	56	39	13	130	39
Zr	15	25	24	7.7	39	8.4

Table 4. Number of samples, mean, median, range, and standard deviation of ash yield and contents of elements for the Danville-Baker Coals in the Illinois Basin.

[All analyses are in percent or parts per million and are reported on an as-received, whole-coal basis. L, less than value shown. G, greater than value shown. A common problem in statistical summaries of trace-element data arises when element values are below the limits of analytical detection. This results in a censored distribution. To compute unbiased estimates of the means for censored data, we adopted the protocol of reducing all "less than" values by 50 percent before summary statistics were generated.]

	Number of samples	Mean	Median	Range: Minimum	Range: Maximum	Standard deviation
Percent						
Ash	34	14.8	13.0	6.7	47.0	8.3
Si	56	2.7	2.1	1.3	13	1.9
Al	56	1.4	1.1	0.55	5.8	0.95
Ca	56	0.43	0.27	0.029	1.6	0.41
Mg	56	0.083	0.061	0.019	0.47	0.076
Na	55	0.055	0.044	0.0047	0.24	0.046
K	56	0.27	0.19	0.065	1.4	0.25
Fe	56	2.4	2.2	0.2.0	7.5	1.4
Ti	56	0.072	0.055	0.033	0.37	0.053
Parts per million						
As	39	19	14	0.50	70	16
B	37	97	93	31	190G	36
Ba	36	75	45	17	400	90
Be	39	2.7	2.4	1.2	6.0	1.1
Cd	39	0.31	0.12	0.01L	4.5	0.74
Co	55	5.6	5.3	2.0	17	3.0
Cr	55	19	17	9.5	50	8.2
Cu	37	12	11	5.5	46	7.1
F	37	100	60	10L	450	110
Ge	37	14	14	1.1L	52	9.7
Hg	39	0.11	0.09	0.01L	0.32	0.09
La	36	8.2	6.4	2.0	26	5.6
Li	36	16	11	2.9	89	16
Mn	55	59	39	5.8	240	51
Mo	28	3.1	2.5	0.16L	10	2.4
Nb	34	2.5	2.0	0.61L	12	2.0
Ni	55	31	30	4.6	120	22
P	34	160	96	15L	740	180
Pb	39	18	14	1.5L	70	16
Sb	39	1.9	1.4	0.2	15	2.5
Sc	36	4.1	3.8	1.9	8.9	1.6
Se	39	1.5	1.3	0.7	3.0	0.7
Sr	36	48	33	13	200	44
Th	37	2.2	1.8	1.0	8.3	1.4
U	38	1.9	1.4	0.35L	7.0	1.3
V	37	25	21	10	85	16
Y	34	7.3	6.5	3.3	18	3.8
Yb	36	0.82	0.7	0.27	2.8	0.49
Zn	37	170	37	8.2	3,300	550
Zr	36	39	28	7.7	270	48

Table 5. Number of samples, mean, median, range, and standard deviation of ash yield and contents of elements for the Herrin Coal in the Illinois Basin.

[All analyses are in percent or parts per million and are reported on an as-received, whole-coal basis. L, less than value shown. A common problem in statistical summaries of trace-element data arises when element values are below the limits of analytical detection. This results in a censored distribution. To compute unbiased estimates of the means for censored data, we adopted the protocol of reducing all "less than" values by 50 percent before summary statistics were generated.]

	Number of samples	Mean	Median	Range		Standard deviation
				Minimum	Maximum	
Percent						
Ash	97	11.7	11.0	2.8	46.0	5.9
Si	269	2.3	1.9	0.46	9.3	1.2
Al	269	1.1	1.0	0.29	4.2	0.54
Ca	269	0.55	0.42	0.02	11	0.77
Mg	270	0.055	0.045	0.0044L	0.31	0.04
Na	270	0.071	0.054	0.0019	0.42	0.059
K	269	0.17	0.15	0.003L	0.75	0.098
Fe	269	1.8	1.6	0.096	11	1.2
Ti	269	0.06	0.054	0.004L	0.20	0.029
Parts per million						
As	216	5.8	3.0	0.2L	140	12
B	207	110	97	22	390	54
Ba	201	120	36	5.5	2,000	300
Be	226	1.6	1.3	0.36	8.5	1.1
Cd	209	1.3	0.14	0.02L	54	5.5
Co	267	4.0	3.2	0.78	17	2.4
Cr	268	19	15	2.8	190	21
Cu	209	10	9.0	2.7	58	6.7
F	199	66	51	10L	570	65
Ge	196	6.4	3.3	0.045L	63	8.5
Hg	206	0.12	0.10	0.01L	0.70	0.09
La	176	5.3	4.5	0.84L	28	3.8
Li	158	12	7.6	0.94L	80	13
Mn	256	58	39	1.6	1,200	85
Mo	206	8.4	5.2	0.42L	190	15
Nb	97	1.7	1.4	0.28L	10	1.4
Ni	275	17	13	1.0	190	17
P	182	110	46	2.8L	2,200	210
Pb	226	18	5.4	0.019L	350	36
Sb	216	0.8	0.4	0.1	7.6	1.0
Sc	190	2.5	2.3	0.38	16	1.4
Se	214	2.1	1.7	0.4L	13	1.5
Sr	201	33	24	2.7L	980	73
Th	196	2.1	1.6	0.35L	17	1.8
U	203	2.0	0.92	0.15L	26	3.5
V	213	22	18	1.2	110	15
Y	97	5.2	4.5	1.1	27	3.7
Yb	178	0.5	0.45	0.065L	3.2	0.28
Zn	209	200	39	3.7	4,500	600
Zr	203	25	19	0.51L	110	19

Table 6. Number of samples, mean, median, range, and standard deviation of ash yield and contents of elements for the Springfield Coal in the Illinois Basin.

[All analyses are in percent or parts per million and are reported on an as-received, whole-coal basis. L, less than value shown. A common problem in statistical summaries of trace-element data arises when element values are below the limits of analytical detection. This results in a censored distribution. To compute unbiased estimates of the means for censored data, we adopted the protocol of reducing all "less than" values by 50 percent before summary statistics were generated.]

	Number of samples	Mean	Median	Range Minimum	Range Maximum	Standard deviation
Percent						
Ash	80	12.1	10.0	5.5	46.0	6.7
Si	249	1.9	1.9	0.018	9.0	0.73
Al	249	0.94	0.88	0.17	5.8	0.45
Ca	249	0.5	0.4.0	0.015	3.9	0.46
Mg	249	0.047	0.04	0.0047L	0.31	0.03
Na	262	0.033	0.027	0.0018	0.2	0.026
K	267	0.16	0.15	0.004	1.3	0.11
Fe	249	2.0	1.8	0.25	27	1.9
Ti	249	0.052	0.049	0.022	0.26	0.021
Parts per million						
As	145	12	5.9	0.27	130	18
B	108	85	81.5	5.7L	210	35
Ba	95	73	26	8.3	2,500	280
Be	124	1.9	1.7	0.44	6.0	0.9.0
Cd	122	0.61	0.20	0.02L	9.0	1.1
Co	244	3.6	3.3	0.90	12	1.7
Cr	245	16	13	3.1	86	9.8
Cu	109	10	7.4	3.5	77	11
F	109	71	50	10L	600	77
Ge	105	8.0	7.2	0.43L	38	5.1
Hg	123	0.12	0.09	0.01L	1.2	0.13
La	104	5.9	5.0	1.8	31	4.0
Li	90	8.9	5.8	2.3L	89	11
Mn	247	43	34	0.58	210	34
Mo	101	7.3	5.4	0.76L	46	7.1
Nb	79	1.8	1.6	0.26L	4.6	0.94
Ni	250	12	10	1.8	41	6.6
P	183	54	39	4.2L	740	75
Pb	124	13	5.7	0.49L	110	20
Sb	144	1.1	0.8	0.1	13	1.2
Sc	87	2.4	2.1	0.47	12	1.5
Se	127	2.5	2.0	0.9L	13	1.8
Sr	95	26	18	3.4	160	25
Th	101	1.7	1.3	0.30	10	1.3
U	110	2.6	1.6	0.17L	15	2.7
V	108	28	19	3.2	130	24
Y	80	5.3	4.8	1.2	13	2.2
Yb	85	0.53	0.48	0.19L	1.9	0.27
Zn	127	110	33	6.5	3,300	310
Zr	107	23	17	1.8L	130	18

Table 7. Number of samples, mean, median, range, and standard deviation of ash yield and contents of elements for all nonassessed coals in the Illinois Basin.

[All analyses are in percent or parts per million and are reported on an as-received, whole-coal basis. L, less than value shown. A common problem in statistical summaries of trace-element data arises when element values are below the limits of analytical detection. This results in a censored distribution. To compute unbiased estimates of the means for censored data, we adopted the protocol of reducing all "less than" values by 50 percent before summary statistics were generated.]

	Number of samples	Mean	Median	Range		Standard deviation
				Minimum	Maximum	
Percent						
Ash	260	12.4	10.0	1.5	48.0	8.5
Si	437	2.3	1.8	0.019	13	2.0
Al	437	1.3	1.0	0.11	7.8	1.1
Ca	435	0.23	0.065	0.0093	3.5	0.39
Mg	446	0.065	0.04	0.002L	4.6	0.22
Na	417	0.034	0.019	0.001L	0.28	0.042
K	436	0.21	0.14	0.007	1.3	0.21
Fe	437	2.2	1.9	0.0093	25	2.1
Ti	437	0.068	0.054	0.002	0.46	0.058
Parts per million						
As	298	23	11	0.30L	950	60
B	259	81	77	12	210	38
Ba	260	44	24	1.9	560	60
Be	302	3.4	3.3	0.25	9.2	1.4
Cd	298	0.35	0.11	0.01L	6.2	0.81
Co	402	7.8	5.5	0.20	110	9.4
Cr	411	17	15	3.0L	86	12
Cu	260	17	13	2.1L	140	16
F	260	82	56	10L	780	84
Ge	258	13	12	0.31L	59	9.3
Hg	290	0.12	0.07	0.01L	2.4	0.18
La	253	9.6	6.7	0.97	72	10
Li	260	17	8.9	0.67L	210	25
Mn	403	35	22	1.0	360	42
Mo	234	3.5	1.9	0.16L	56	6.0
Nb	256	2.3	1.7	0.051L	14	2.1
Ni	411	31	25	3.3	190	25
P	236	140	69	5.6L	6,700	450
Pb	298	23	16	0.37L	230	26
Sb	298	1.4	1.0	0.1L	13	1.6
Sc	260	3.9	3.3	0.39	18	2.6
Se	298	3.4	2.8	0.5L	14	2.2
Sr	260	54	26	1.3	490	72
Th	290	2.2	1.6	0.15L	18	2.1
U	302	2.2	1.3	0.055L	17	2.3
V	260	23	17	0.60	98	20
Y	255	8.4	6.7	0.96L	64	6.9
Yb	249	0.91	0.7	0.15L	8.1	0.77
Zn	260	80	30	1.8	2,600	230
Zr	260	25	16	0.83L	210	26

Table 8. Number of samples, mean, median, range, and standard deviation of ash yield and contents of elements for all nonassessed coals from the McLeansboro Group in the Illinois Basin.

[All analyses are in percent or parts per million and are reported on an as-received, whole-coal basis. L, less than value shown. A common problem in statistical summaries of trace-element data arises when element values are below the limits of analytical detection. This results in a censored distribution. To compute unbiased estimates of the means for censored data, we adopted the protocol of reducing all "less than" values by 50 percent before summary statistics were generated.]

	Number of samples	Mean	Median	Range		Standard deviation
				Minimum	Maximum	
			Percent			
Ash	25	13.6	14.0	8.1	26.0	3.9
Si	82	2.9	3.0	0.028	5.9	1.2
Al	82	1.5	1.5	0.67	2.8	0.45
Ca	82	0.27	0.15	0.037	2.4	0.34
Mg	82	0.073	0.07	0.015	0.29	0.042
Na	74	0.038	0.022	0.006	0.17	0.035
K	82	0.29	0.29	0.065	0.81	0.13
Fe	82	2.3	2.1	0.0093	6.4	1.2
Ti	82	0.081	0.082	0.031	0.14	0.025
			Parts per million			
As	44	9.5	3.5	0.30L	65	13
B	25	86	84	55	130	18
Ba	25	40	35	8.9	98	22
Be	48	2.2	2.0	1.1	5.5	0.96
Cd	44	0.14	0.09	0.03	0.65	0.13
Co	76	5.3	4.2	1.6	19	3.2
Cr	81	20	18	7.8	40	7.2
Cu	25	14	10	6.7	50	9.6
F	25	97	86	33	260	49
Ge	25	4.8	4.0	1.7	14	3.1
Hg	43	0.09	0.05	0.01L	0.33	0.09
La	25	8.1	7.0	2.8	21	4.8
Li	25	14	11	6.6	39	7.5
Mn	81	56	41	7.5	360	64
Mo	25	3.1	2.0	0.42	14	3.2
Nb	25	1.8	1.7	0.52	5.4	1.1
Ni	81	20	15	3.6	75	14
P	64	160	110	10L	1,300	180
Pb	44	7.7	5.2	2.2	49	7.6
Sb	44	0.7	0.3	0.1	3.6	1.0
Sc	25	3.3	3.0	1.9	7.9	1.1
Se	44	2.1	2.1	0.7	3.5	0.6
Sr	25	44	33	14	150	33
Th	44	2.1	2.0	1.0	5.1	0.76
U	48	1.6	0.98	0.35	7.4	1.3
V	25	21	17	9.8	57	10
Y	25	6.0	5.8	2.0	20	3.8
Yb	25	0.70	0.64	0.32	1.4	0.28
Zn	25	39	32	13	140	30
Zr	25	16	14	5.5	41	9.3

Table 9. Number of samples, mean, median, range, and standard deviation of ash yield and contents of elements for all nonassessed coals from the Carbondale Group or Formation in the Illinois Basin.

[All analyses are in percent or parts per million and are reported on an as-received, whole-coal basis. L, less than value shown. G, greater than value shown. A common problem in statistical summaries of trace-element data arises when element values are below the limits of analytical detection. This results in a censored distribution. To compute unbiased estimates of the means for censored data, we adopted the protocol of reducing all "less than" values by 50 percent before summary statistics were generated.]

	Number of samples	Mean	Median	Range		Standard deviation
				Minimum	Maximum	
			Percent			
Ash	86	14.3	12.0	5.4	48.0	7.6
Si	128	2.6	2.2	0.34	12	1.7
Al	128	1.4	1.2	0.15	6.4	0.88
Ca	127	0.4	0.18	0.023	3.5	0.56
Mg	128	0.11	0.055	0.009	4.6	0.40
Na	124	0.043	0.033	0.0028	0.22	0.035
K	128	0.25	0.19	0.027	1.2	0.20
Fe	128	2.8	2.5	0.32	25	2.6
Ti	128	0.071	0.063	0.005	0.33	0.045
			Parts per million			
As	90	34	14	0.50L	950	100
B	86	89	88	13	190G	36
Ba	86	41	30	7.5	170	33
Be	90	3.5	3.3	1.2	7.3	1.3
Cd	90	0.45	0.11	0.01L	6.2	1.0
Co	121	7.1	5.4	1.1	110	11
Cr	121	20	17	4.1	86	12
Cu	86	16	14	4.4	96	12
F	86	98	60	10L	780	110
Ge	86	14	13	0.31L	59	11
Hg	90	0.14	0.08	0.01L	2.4	0.26
La	84	7.5	5.4	1.0	55	7.1
Li	86	16	9.4	0.76	210	24
Mn	120	51	37	1.1	220	42
Mo	67	6.2	3.0	0.46L	56	9.7
Nb	86	2.6	2.4	0.39L	8.6	1.5
Ni	121	28	24	3.3	190	23
P	74	210	83	20L	6,700	770
Pb	90	27	17	0.46L	230	35
Sb	90	1.5	1.0	0.1L	7.1	1.6
Sc	86	4.2	3.5	0.70	18	2.6
Se	90	3.3	2.7	0.5L	12	2.1
Sr	86	43	25	8.4	300	45
Th	88	2.1	1.7	0.20L	15	1.8
U	90	3.3	2.1	0.44L	13	2.9
V	86	26	23	3.8	84	17
Y	86	8.9	7.0	0.96L	64	7.7
Yb	83	1.1	0.80	0.20L	8.1	1.1
Zn	86	69	25	1.8	1,100	150
Zr	86	28	24	3.9	140	21

Table 10. Number of samples, mean, median, range, and standard deviation of ash yield and contents of elements for all nonassessed coals from the Raccoon Creek Group in the Illinois Basin.

[All analyses are in percent or parts per million and are reported on an as-received, whole-coal basis. L, less than value shown. A common problem in statistical summaries of trace-element data arises when element values are below the limits of analytical detection. This results in a censored distribution. To compute unbiased estimates of the means for censored data, we adopted the protocol of reducing all "less than" values by 50 percent before summary statistics were generated.]

	Number of samples	Mean	Median	Range		Standard deviation
				Minimum	Maximum	
Percent						
Ash	149	11.2	8.1	1.5	48.0	9.3
Si	227	2.0	1.2	0.019	13	2.3
Al	227	1.2	0.75	0.11	7.8	1.3
Ca	226	0.11	0.046	0.0093	1.2	0.20
Mg	236	0.04	0.023	0.002L	0.35	0.049
Na	219	0.028	0.011	0.001L	0.28	0.047
K	226	0.16	0.081	0.007	1.3	0.22
Fe	227	1.9	1.5	0.068	24	2.0
Ti	227	0.061	0.04	0.002	0.46	0.071
Parts per million						
As	164	20	11	0.40	180	28
B	148	75	70	12	210	41
Ba	149	46	16	1.9	560	74
Be	164	3.7	3.5	0.25	9.2	1.4
Cd	164	0.35	0.12	0.01L	4.7	0.79
Co	205	9.2	7.0	0.20	110	10
Cr	209	15	11	3.0L	65	13
Cu	149	19	14	2.1L	140	19
F	149	70	49	10L	420	71
Ge	147	14	13	0.82L	39	8.5
Hg	157	0.12	0.07	0.01L	1.2	0.14
La	144	11	7.9	0.97	72	12
Li	149	18	8.0	0.67L	140	27
Mn	202	17	11	1.0	94	16
Mo	142	2.4	1.6	0.16L	25	3.0
Nb	145	2.2	1.4	0.051L	14	2.4
Ni	209	38	30	4.4	170	27
P	98	79	42	5.6L	520	97
Pb	164	24	19	0.37L	190	22
Sb	164	1.5	1.1	0.1L	13	1.7
Sc	149	3.8	3.1	0.39	13	2.7
Se	164	3.7	3.3	0.6L	14	2.4
Sr	149	61	27	1.3	490	87
Th	158	2.2	1.4	0.15L	18	2.5
U	164	1.8	1.2	0.055L	17	2.0
V	149	22	14	0.60	98	22
Y	144	8.6	6.6	1.5	41	6.7
Yb	141	0.84	0.70	0.15L	4.1	0.60
Zn	149	94	31	5.5	2,600	280
Zr	149	24	13	0.83	210	30

Table 11. Number of samples, mean, median, range, and standard deviation of ash yield and contents of elements for all coals (assessed and nonassessed) in the Illinois Basin.

[All analyses are in percent or parts per million and are reported on an as-received, whole-coal basis. L, less than value shown. A common problem in statistical summaries of trace-element data arises when element values are below the limits of analytical detection. This results in a censored distribution. To compute unbiased estimates of the means for censored data, we adopted the protocol of reducing all "less than" values by 50 percent before summary statistics were generated.]

	Number of samples	Mean	Median	Range		Standard deviation
				Minimum	Maximum	
			Percent			
Ash	471	12.4	10.0	1.5	48.0	7.7
Si	1011	2.2	1.9	0.018	13	1.6
Al	1011	1.2	0.96	0.11	7.8	0.85
Ca	1009	0.39	0.24	0.0093	11	0.55
Mg	1021	0.059	0.042	0.002L	4.6	0.15
Na	1004	0.045	0.03	0.001L	0.42	0.047
K	1028	0.19	0.15	0.003L	1.4	0.17
Fe	1011	2.1	1.8	0.0093L	27	1.8
Ti	1011	0.062	0.052	0.002L	0.46	0.044
			Parts per million			
As	698	15	5.9	0.20L	950	41
B	611	91	84	5.7L	390	45
Ba	592	76	31	1.9	2,500	220
Be	691	2.5	2.2	0.25L	9.2	1.5
Cd	668	0.71	0.13	0.01L	54	3.2
Co	968	5.6	3.9	0.20	110	6.6
Cr	979	17	14	2.8L	190	14
Cu	615	14	10	2.1L	140	13
F	605	76	54	10L	780	79
Ge	596	10	7.5	0.045L	63	9.0
Hg	658	0.12	0.08	0.01L	2.4	0.15
La	569	7.5	5.2	0.84L	72	7.7
Li	544	14	8.1	0.67L	210	20
Mn	961	45	29	0.58	1,200	57
Mo	569	5.9	3.3	0.16L	190	10
Nb	466	2.1	1.7	0.051L	14	1.8
Ni	991	22	15	1.0	190	21
P	635	110	49	2.8L	6,700	300
Pb	687	19	9.8	0.019L	350	29
Sb	697	1.2	0.7	0.1L	15	1.5
Sc	573	3.2	2.6	0.38	18	2.2
Se	678	2.7	2.1	0.4L	14	2.0
Sr	592	42	24	1.3L	980	66
Th	624	2.1	1.5	0.15L	18	1.9
U	653	2.2	1.3	0.055L	26	2.8
V	618	24	18	0.60	130	19
Y	466	7.1	5.8	0.96L	64	5.7
Yb	548	0.71	0.58	0.065L	8.1	0.6
Zn	633	130	33	1.8	4,500	420
Zr	606	25	18	0.51L	270	25

Appendix 4. Summary descriptive statistics of ash yields and contents of selected elements for all assessed and non-assessed coals in the Illinois Basin as analyzed by the Illinois State Geological Survey, Indiana Geological Survey, Kentucky Geological Survey, and U.S. Geological Survey.

Table 1. Number of samples, mean, median, range, and standard deviation of ash yield and contents of elements for the Danville Coal Member in Illinois as analyzed by the Illinois State Geological Survey.

[All analyses are in percent or parts per million and are reported on an as-received, whole-coal basis. Leaders (---) indicate statistics could not be calculated owing to no data or to an insufficient number of analyses above the lower detection limit.]

	Number of samples	Mean	Median	Range		Standard deviation
				Minimum	Maximum	
Percent						
Ash	170	12.2	11.0	4.3	44.2	4.4
Si	3	1.9	1.9	1.7	2.0	0.15
Al	3	0.82	0.91	0.55	1.0	0.24
Ca	3	0.78	0.73	0.72	0.88	0.09
Mg	3	0.10	0.10	0.044	0.16	0.058
Na	3	0.073	0.072	0.072	0.075	0.0017
K	3	0.16	0.16	0.15	0.18	0.015
Fe	3	1.7	1.7	1.3	2.0	0.35
Ti	3	0.047	0.046	0.044	0.052	0.0042
Parts per million						
As	3	4.6	5.1	2.8	6.0	1.7
B	3	110	95	90	130	22
Ba	---	---	---	---	---	---
Be	3	1.3	1.3	1.2	1.5	0.15
Cd	---	---	---	---	---	---
Co	3	3.6	3.5	2.5	4.8	1.2
Cr	3	12	10	10	16	3.5
Cu	3	6.8	7.0	5.5	7.8	1.2
F	3	39	39	36	41	2.5
Ge	3	6.7	6.6	4.8	8.7	2.0
Hg	3	0.09	0.09	0.07	0.11	0.02
La	---	---	---	---	---	---
Li	---	---	---	---	---	---
Mn	3	73	73	67	80	6.5
Mo	3	6.1	4.4	3.9	10	3.4
Nb	---	---	---	---	---	---
Ni	3	7.9	6.1	5.5	12	3.6
P	---	---	---	---	---	---
Pb	---	---	---	---	---	---
Sb	3	1.1	1.4	0.4	1.5	0.6
Sc	---	---	---	---	---	---
Se	3	1.3	1.0	0.8	2.1	0.7
Sr	---	---	---	---	---	---
Th	---	---	---	---	---	---
U	---	---	---	---	---	---
V	3	14	11	10	22	6.7
Y	---	---	---	---	---	---
Yb	---	---	---	---	---	---
Zn	3	17	8.7	8.2	33	14
Zr	---	---	---	---	---	---

Table 2. Number of samples, mean, median, range, and standard deviation of ash yield and contents of elements for the Danville Coal Member in Indiana as analyzed by the U.S. Geological Survey.

[All analyses are in percent or parts per million and are reported on an as-received, whole-coal basis. L, less than value shown. G, greater than value shown. A common problem in statistical summaries of trace-element data arises when element values are below the limits of analytical detection. This results in a censored distribution. To compute unbiased estimates of the means for censored data, we adopted the protocol of reducing all "less than" values by 50 percent before summary statistics were generated. Leaders (---) indicate statistics could not be calculated owing to no data or to an insufficient number of analyses above the lower detection limit.]

	Number of samples	Mean	Median	Range		Standard deviation
				Minimum	Maximum	
			Percent			
Ash	19	16.2	13.0	6.7	47.0	11
Si	19	3.5	2.5	1.4	13	2.8
Al	19	1.7	1.1	0.68	5.8	1.3
Ca	19	0.3	0.21	0.029	1.2	0.32
Mg	19	0.12	0.072	0.029	0.47	0.11
Na	19	0.075	0.051	0.013	0.24	0.066
K	19	0.38	0.23	0.11	1.4	0.35
Fe	19	2.0	1.7	0.20	7.5	1.6
Ti	19	0.096	0.064	0.044	0.37	0.077
			Parts per million			
As	19	13	12	0.50	43	11
B	19	110	110	31	190G	43
Ba	19	67	44	20	290	65
Be	19	3.5	3.2	2.0	6.0	1.1
Cd	19	0.44	0.12	0.01L	4.5	1.1
Co	19	6.7	6.7	3.0	12	2.4
Cr	19	20	17	9.5	46	9.7
Cu	19	11	10	6.6	24	4.0
F	19	120	72	22	450	120
Ge	19	13	15	1.1L	19	5.5
Hg	19	0.10	0.09	0.01	0.32	0.08
La	19	8.9	6.5	3.0	26	6.0
Li	19	20	12	5.5	89	21
Mn	19	52	36	10	230	51
Mo	18	2.0	2.2	0.16L	4.5	1.2
Nb	19	2.9	2.1	0.61L	12	2.5
Ni	19	26	30	5.6	48	14
P	---	---	---	---	---	---
Pb	19	19	14	1.5	48	15
Sb	19	2.4	1.5	0.2	15	3.5
Sc	19	4.0	3.3	2.1	8.9	1.9
Se	19	1.3	1.2	0.7	2.0	0.4
Sr	19	36	31	13	130	27
Th	18	2.6	1.8	1.0	8.3	1.8
U	19	1.4	1.4	0.35	3.5	0.73
V	19	26	21	11	85	18
Y	19	6.8	6.4	3.3	18	3.5
Yb	19	0.73	0.6	0.30	1.6	0.39
Zn	19	280	44	9.2	3,300	760
Zr	19	52	30	13	270	63

Table 3. Number of samples, mean, median, range, and standard deviation of ash yield and contents of elements for the Baker coal in Kentucky as analyzed by the Kentucky Geological Survey.

[All analyses are in percent or parts per million and are reported on an as-received, whole-coal basis. Leaders (---) indicate statistics could not be calculated owing to no data or to an insufficient number of analyses above the lower detection limit.]

	Number of samples	Mean	Median	Range Minimum	Range Maximum	Standard deviation
Percent						
Ash	19	13.2	11.6	6.5	27.6	5.4
Si	19	2.3	1.9	1.3	6.6	1.3
Al	19	1.4	1.1	0.70	4.4	0.88
Ca	19	0.39	0.21	0.075	1.4	0.38
Mg	19	0.062	0.04	0.019	0.19	0.049
Na	18	0.041	0.037	0.0047	0.12	0.026
K	19	0.22	0.15	0.065	0.87	0.20
Fe	19	2.5	2.4	0.68	5.7	1.4
Ti	19	0.062	0.049	0.034	0.18	0.036
Parts per million						
As	---	---	---	---	---	---
B	---	---	---	---	---	---
Ba	---	---	---	---	---	---
Be	---	---	---	---	---	---
Cd	---	---	---	---	---	---
Co	18	3.8	3.3	2.0	7.7	1.7
Cr	18	21	20	11	50	8.7
Cu	---	---	---	---	---	---
F	---	---	---	---	---	---
Ge	---	---	---	---	---	---
Hg	---	---	---	---	---	---
La	---	---	---	---	---	---
Li	---	---	---	---	---	---
Mn	18	56	34	5.8	140	45
Mo	---	---	---	---	---	---
Nb	---	---	---	---	---	---
Ni	18	44	43	4.6	120	29
P	19	210	130	27	740	210
Pb	---	---	---	---	---	---
Sb	---	---	---	---	---	---
Sc	---	---	---	---	---	---
Se	---	---	---	---	---	---
Sr	---	---	---	---	---	---
Th	---	---	---	---	---	---
U	---	---	---	---	---	---
V	---	---	---	---	---	---
Y	---	---	---	---	---	---
Yb	---	---	---	---	---	---
Zn	---	---	---	---	---	---
Zr	---	---	---	---	---	---

Table 4. Number of samples, mean, median, range, and standard deviation of ash yield and contents of elements for the Baker coal in Kentucky as analyzed by the U.S. Geological Survey.

[All analyses are in percent or parts per million and are reported on an as-received, whole-coal basis. L, less than value shown. A common problem in statistical summaries of trace-element data arises when element values are below the limits of analytical detection. This results in a censored distribution. To compute unbiased estimates of the means for censored data, we adopted the protocol of reducing all "less than" values by 50 percent before summary statistics were generated.]

	Number of Samples	Mean	Median	Range		Standard deviation
				Minimum	Maximum	
Percent						
Ash	15	13.1	13.0	7.7	20.0	3.2
Si	15	2.1	2.1	1.3	4.1	0.68
Al	15	1.2	1.1	0.63	2.2	0.40
Ca	15	0.56	0.33	0.044	1.6	0.53
Mg	15	0.064	0.053	0.03	0.11	0.026
Na	15	0.042	0.044	0.008	0.11	0.026
K	15	0.20	0.18	0.082	0.45	0.085
Fe	15	2.8	2.9	0.65	5.4	1.3
Ti	15	0.059	0.057	0.033	0.12	0.022
Parts per million						
As	15	28	22	4.6	70	19
B	15	77	75	52	110	15
Ba	15	87	43	17	400	120
Be	15	2.2	2.1	1.7	3.7	0.53
Cd	15	0.19	0.12	0.02	0.55	0.17
Co	15	6.9	5.6	2.1	17	3.9
Cr	15	16	16	9.5	26	4.4
Cu	15	16	14	8.8	46	9.2
F	15	94	60	10L	300	86
Ge	15	18	14	4.6	52	13
Hg	15	0.14	0.10	0.02L	0.32	0.11
La	15	7.4	6.3	2.0	22	5.4
Li	15	12	11	2.9	24	7.1
Mn	15	69	48	12	240	61
Mo	7	4.6	3.6	1.8	10	2.8
Nb	15	2.0	2.0	0.77	3.6	0.77
Ni	15	26	25	5.1	58	15
P	12	110	81	22L	320	95
Pb	15	21	15	4.7	70	18
Sb	15	1.5	1.4	0.2	3.7	1.1
Sc	15	4.4	4.2	2.7	7.1	1.0
Se	15	1.8	1.9	0.8	3.0	0.8
Sr	15	65	38	15	200	57
Th	15	2.0	1.9	1.0	3.3	0.71
U	15	2.6	2.1	0.94	7.0	1.6
V	15	26	25	14	70	13
Y	15	7.9	6.5	3.5	18	4.3
Yb	15	0.99	0.80	0.58	2.8	0.57
Zn	15	56	39	13	130	39
Zr	15	25	24	7.7	39	8.4

Table 5. Number of samples, mean, median, range, and standard deviation of ash yield and contents of elements for the Herrin Coal Member in Illinois as analyzed by the Illinois State Geological Survey.

[All analyses are in percent or parts per million and are reported on an as-received, whole-coal basis. L, less than value shown. A common problem in statistical summaries of trace-element data arises when element values are below the limits of analytical detection. This results in a censored distribution. To compute unbiased estimates of the means for censored data, we adopted the protocol of reducing all "less than" values by 50 percent before summary statistics were generated. Leaders (---) indicate statistics could not be calculated owing to no data or to an insufficient number of analyses above the lower detection limit.]

	Number of samples	Mean	Median	Range		Standard deviation
				Minimum	Maximum	
Percent						
Ash	2,327	10.9	10.4	2.7	43.6	3.6
Si	108	2.4	2.2	0.46	9.3	1.3
Al	108	1.2	1.1	0.33	3.1	0.50
Ca	108	0.7	0.61	0.045	2.5	0.47
Mg	108	0.063	0.052	0.0044L	0.31	0.05
Na	114	0.083	0.081	0.009	0.42	0.069
K	108	0.17	0.15	0.017	0.75	0.11
Fe	108	1.6	1.5	0.28	3.8	0.70
Ti	108	0.06	0.054	0.0089	0.18	0.028
Parts per million						
As	107	5.7	3.4	0.36	140	14
B	110	110	99	33	280	47
Ba	104	90	47	5.5	1,300	160
Be	116	1.3	1.2	0.36L	3.3	0.55
Cd	100	1.6	0.17	0.04L	54	6.7
Co	107	4.7	4.0	1.0	17	2.9
Cr	107	18	15	5.5	54	9.0
Cu	112	11	10	3.3	58	6.3
F	102	64	49	13	570	71
Ge	114	4.4	2.5	0.045L	23	4.4
Hg	100	0.15	0.12	0.03	0.47	0.09
La	93	5.3	4.5	0.84	28	3.4
Li	61	16	13	1.7	80	15
Mn	100	78	61	11	270	56
Mo	116	8.5	6.5	0.42L	45	7.5
Nb	---	---	---	---	---	---
Ni	114	16	14	1.8	84	10
P	108	73	44	4.1L	740	100
Pb	116	21	11	0.32L	170	28
Sb	107	0.7	0.5	0.1	3.5	0.7
Sc	93	2.4	2.3	0.89	5.8	0.92
Se	107	2.1	1.8	0.8	6.6	1.0
Sr	104	29	25	4.2L	220	25
Th	95	1.9	1.6	0.46	5.7	0.95
U	93	1.7	0.98	0.20L	26	3.1
V	116	23	20	3.0	110	15
Y	---	---	---	---	---	---
Yb	93	0.48	0.45	0.065L	1.4	0.19
Zn	112	260	51	4.2	4,500	720
Zr	106	28	21	2.8	110	20

Table 6. Number of samples, mean, median, range, and standard deviation of ash yield and contents of elements for the Herrin Coal Member in Illinois as analyzed by the U.S. Geological Survey.

[All analyses are in percent or parts per million and are reported on an as-received, whole-coal basis. L, less than value shown. A common problem in statistical summaries of trace-element data arises when element values are below the limits of analytical detection. This results in a censored distribution. To compute unbiased estimates of the means for censored data, we adopted the protocol of reducing all "less than" values by 50 percent before summary statistics were generated. Leaders (---) indicate statistics could not be calculated owing to no data or to an insufficient number of analyses above the lower detection limit.]

	Number of Samples	Mean	Median	Range		Standard deviation
				Minimum	Maximum	
			Percent			
Ash	77	12.2	11.0	2.8	46.0	6.0
Si	76	2.2	1.9	0.46	7.0	1.3
Al	76	1.0	0.90	0.29	3.4	0.6
Ca	76	0.63	0.38	0.02	11	1.3
Mg	77	0.057	0.047	0.012	0.18	0.037
Na	77	0.094	0.088	0.029	0.36	0.049
K	76	0.17	0.14	0.003L	0.59	0.11
Fe	76	1.7	1.3	0.096	11	1.6
Ti	76	0.06	0.05	0.004L	0.19	0.034
			Parts per million			
As	77	5.3	2.8	0.20L	44	7.6
B	77	120	110	22	390	62
Ba	77	180	33	6.2	2,000	440
Be	77	1.8	1.3	0.40	8.5	1.5
Cd	77	1.5	0.14	0.02L	30	4.9
Co	77	3.2	2.4	0.78	11	2.2
Cr	77	18	12	2.8L	190	27
Cu	77	9.9	8.2	2.7	30	6.0
F	77	69	60	10L	420	59
Ge	62	9.4	5.1	0.085L	47	11
Hg	77	0.09	0.07	0.03	0.39	0.06
La	63	5.1	4.2	1.0L	26	3.8
Li	77	9.7	6.7	0.94	69	12
Mn	77	62	43	8.4	1,200	140
Mo	77	6.4	3.3	0.56	43	8.0
Nb	77	1.7	1.4	0.28L	10	1.5
Ni	77	14	9.4	1.0	67	13
P	---	---	---	---	---	---
Pb	77	19	4.3	0.64L	350	49
Sb	77	0.9	0.3	0.1	7.6	1.4
Sc	77	2.5	2.1	0.38	6.2	1.2
Se	77	2.2	1.7	0.4L	13	1.8
Sr	77	30	25	8.3	290	32
Th	69	2.8	2.1	0.35L	17	2.6
U	77	1.9	0.75	0.15L	20	3.8
V	77	20	17	1.2	86	16
Y	77	5.5	5.0	1.1	27	3.6
Yb	65	0.50	0.50	0.20L	1.3	0.22
Zn	77	160	26	3.7	2,600	460
Zr	77	23	17	0.51L	110	18

Table 7. Number of samples, mean, median, range, and standard deviation of ash yield and contents of elements for the Herrin coal in Kentucky as analyzed by the Kentucky Geological Survey.

[All analyses are in percent or parts per million and are reported on an as-received, whole-coal basis. Leaders (---) indicate statistics could not be calculated owing to no data or to an insufficient number of analyses above the lower detection limit.]

	Number of samples	Mean	Median	Range Minimum	Range Maximum	Standard deviation
Percent						
Ash	121	10.5	9.8	5.3	24.1	3.6
Si	65	2.2	2.0	0.95	4.9	0.89
Al	65	1.1	1.1	0.51	2.2	0.39
Ca	65	0.30	0.21	0.028	1.2	0.27
Mg	65	0.044	0.039	0.019	0.12	0.021
Na	59	0.033	0.026	0.0019	0.10	0.022
K	65	0.18	0.16	0.094	0.38	0.066
Fe	65	2.3	2.1	0.40	5.1	1.0
Ti	65	0.061	0.056	0.032	0.14	0.022
Parts per million						
As	12	6.2	2.0	0.92	52	14
B	---	---	---	---	---	---
Ba	---	---	---	---	---	---
Be	13	1.7	1.7	0.46	2.5	0.59
Cd	12	0.24	0.10	0.04	1.2	0.35
Co	63	4.0	3.6	1.4	9.2	1.7
Cr	64	19	18	9.9	61	7.9
Cu	---	---	---	---	---	---
F	---	---	---	---	---	---
Ge	---	---	---	---	---	---
Hg	9	0.02	0.01	0.01	0.12	0.04
La	---	---	---	---	---	---
Li	---	---	---	---	---	---
Mn	59	30	27	1.6	100	20
Mo	---	---	---	---	---	---
Nb	---	---	---	---	---	---
Ni	64	21	17	2.9	80	16
P	65	180	94	2.8	2,200	310
Pb	13	3.1	2.0	0.019	9.3	2.5
Sb	12	0.2	0.1	0.1	0.8	0.2
Sc	---	---	---	---	---	---
Se	10	1.3	1.3	1.0	2.0	0.3
Sr	---	---	---	---	---	---
Th	12	1.2	1.2	0.95	1.5	0.18
U	13	1.9	1.8	0.83	3.8	1.0
V	---	---	---	---	---	---
Y	---	---	---	---	---	---
Yb	---	---	---	---	---	---
Zn	---	---	---	---	---	---
Zr	---	---	---	---	---	---

Table 8. Number of samples, mean, median, range, and standard deviation of ash yield and contents of elements for the Herrin coal in Kentucky as analyzed by the U.S. Geological Survey.

[All analyses are in percent or parts per million and are reported on an as-received, whole-coal basis. L, less than value shown. G, greater than value shown. A common problem in statistical summaries of trace-element data arises when element values are below the limits of analytical detection. This results in a censored distribution. To compute unbiased estimates of the means for censored data, we adopted the protocol of reducing all "less than" values by 50 percent before summary statistics were generated.]

	Number of samples	Mean	Median	Range		Standard deviation
				Minimum	Maximum	
			Percent			
Ash	20	10.0	7.9	5.9	26.0	5.2
Si	20	1.9	1.5	1.0	6.2	1.3
Al	20	0.97	0.75	0.56	4.2	0.79
Ca	20	0.22	0.17	0.025	0.84	0.22
Mg	20	0.036	0.03	0.02	0.11	0.021
Na	20	0.025	0.023	0.005	0.055	0.017
K	20	0.15	0.13	0.10	0.29	0.052
Fe	20	1.8	1.5	0.43	4.2	1.0
Ti	20	0.058	0.046	0.032	0.20	0.037
			Parts per million			
As	20	8.6	3.0	1.3	55	13
B	20	60	57	38	94	17
Ba	20	33	18	7.5	190	43
Be	20	2.0	1.5	0.39	7.9	1.7
Cd	20	0.20	0.08	0.03	1.2	0.30
Co	20	3.6	3.0	2.1	8.8	1.7
Cr	20	29	14	10	190	47
Cu	20	9.5	7.0	3.5	53	10
F	20	62	48	10L	290	58
Ge	20	8.9	5.0	0.60	63	14
Hg	20	0.14	0.08	0.03L	0.70	0.15
La	20	5.4	3.6	1.7	27	5.6
Li	20	6.8	4.7	2.6	42	8.6
Mn	20	26	21	9.4	95	21
Mo	13	19	4.4	0.55	190G	51
Nb	20	1.5	1.4	0.31	4.5	1.1
Ni	20	20	7.7	2.4	190	43
P	9	97	22	22L	440	140
Pb	20	6.1	3.3	0.84	36	8.0
Sb	20	0.6	0.2	0.1	5.7	1.2
Sc	20	3.3	2.4	2.1	16	3.0
Se	20	2.6	1.7	0.8L	11	2.7
Sr	20	68	14	2.7	980	220
Th	20	1.8	1.2	1.1	10	2.0
U	20	3.3	1.7	0.37	22	5.4
V	20	20	13	5.1	82	19
Y	20	4.3	3.4	1.1	19	3.8
Yb	20	0.61	0.43	0.35	3.2	0.62
Zn	20	31	23	8.8	170	36
Zr	20	17	12	3.7	67	15

Table 9. Number of samples, mean, median, range, and standard deviation of ash yield and contents of elements for the Springfield Coal Member in Illinois as analyzed by the Illinois State Geological Survey.

[All analyses are in percent or parts per million and are reported on an as-received, whole-coal basis. L, less than value shown. A common problem in statistical summaries of trace-element data arises when element values are below the limits of analytical detection. This results in a censored distribution. To compute unbiased estimates of the means for censored data, we adopted the protocol of reducing all "less than" values by 50 percent before summary statistics were generated. Leaders (---) indicate statistics could not be calculated owing to no data or to an insufficient number of analyses above the lower detection limit.]

	Number of samples	Mean	Median	Range		Standard deviation
				Minimum	Maximum	
			Percent			
Ash	1,171	11.7	10.7	2.8	43.5	4.6
Si	28	2.2	2.1	1.6	3.6	0.45
Al	28	1.0	0.95	0.59	2.5	0.41
Ca	28	0.77	0.69	0.22	2.1	0.47
Mg	28	0.04	0.036	0.0047L	0.16	0.031
Na	50	0.048	0.04	0.011	0.20	0.041
K	46	0.15	0.14	0.03	0.46	0.069
Fe	28	1.8	1.8	0.65	3.9	0.64
Ti	28	0.055	0.056	0.028	0.094	0.013
			Parts per million			
As	50	20	8.8	0.27	130	26
B	28	90	82	14	180	40
Ba	15	230	46	22	2,500	630
Be	28	1.2	1.1	0.58	2.5	0.38
Cd	27	0.96	0.26	0.05L	6.9	1.4
Co	32	5.1	4.7	1.7	12	2.6
Cr	32	12	11	6.9	28	5.2
Cu	29	9.6	8.5	4.1	30	4.9
F	29	55	48	28	130	23
Ge	28	5.2	4.8	0.43L	15	3.5
Hg	28	0.13	0.11	0.03	0.47	0.10
La	33	5.4	5.3	1.8	11	2.4
Li	10	9.7	7.8	4.4	27	6.8
Mn	32	62	56	18	150	39
Mo	28	7.8	6.5	1.4L	22	5.1
Nb	---	---	---	---	---	---
Ni	29	15	15	1.8	28	7.2
P	28	62	46	4.2L	290	60
Pb	29	34	27	3.6	110	30
Sb	49	1.2	0.8	0.1	13	1.9
Sc	15	2.2	2.4	1.3	3.4	0.62
Se	32	2.1	1.8	0.9	5.5	1.0
Sr	15	29	23	13	59	13
Th	15	1.5	1.3	1.1	2.9	0.50
U	15	0.95	0.94	0.46L	1.6	0.40
V	28	29	28	7.0	75	17
Y	---	---	---	---	---	---
Yb	15	0.41	0.38	0.19	0.57	0.094
Zn	47	210	58	9.0	3,300	500
Zr	27	30	22	6.5	130	25

Table 10. Number of samples, mean, median, range, and standard deviation of ash yield and contents of elements for the Springfield Coal Member in Indiana as analyzed by the U.S. Geological Survey.

[All analyses are in percent or parts per million and are reported on an as-received, whole-coal basis. L, less than value shown. A common problem in statistical summaries of trace-element data arises when element values are below the limits of analytical detection. This results in a censored distribution. To compute unbiased estimates of the means for censored data, we adopted the protocol of reducing all "less than" values by 50 percent before summary statistics were generated. Leaders (---) indicate statistics could not be calculated owing to no data or to an insufficient number of analyses above the lower detection limit.]

	Number of samples	Mean	Median	Range		Standard deviation
				Minimum	Maximum	
			Percent			
Ash	49	12.8	9.8	5.5	46.0	8.3
Si	49	2.1	1.7	1.0	9.0	1.4
Al	49	1.1	0.92	0.17	5.8	0.90
Ca	49	0.37	0.24	0.015	3.9	0.58
Mg	49	0.059	0.044	0.016	0.31	0.051
Na	49	0.033	0.028	0.006	0.1	0.02
K	49	0.22	0.15	0.004	1.3	0.22
Fe	49	2.5	1.7	0.25	27	3.9
Ti	49	0.061	0.052	0.027	0.26	0.042
			Parts per million			
As	49	9.7	5.0	1.4	50	11
B	49	87	85	5.7L	210	38
Ba	49	35	26	8.3	160	28
Be	49	2.4	2.4	0.83	6.0	0.93
Cd	49	0.75	0.26	0.02L	9.0	1.4
Co	41	4.4	3.6	0.90	12	2.6
Cr	41	18	12	3.1	75	16
Cu	49	14	7.7	4.1	77	15
F	49	88	56	10L	600	110
Ge	46	8.9	8.5	1.5L	38	6.2
Hg	49	0.14	0.1	0.02	1.2	0.17
La	40	7.4	6.0	2.0	31	5.6
Li	49	10	5.7	2.3L	89	14
Mn	49	35	26	5.1	180	31
Mo	48	8.0	5.3	0.76	46	9.3
Nb	48	1.9	1.8	0.61L	4.6	1.0
Ni	49	14	12	5,0	40	8.6
P	---	---	---	---	---	---
Pb	49	7.3	3.9	0.49L	60	9.8
Sb	49	1.0	0.9	0.2	3.0	0.6
Sc	41	2.8	2.1	0.47	12	2.1
Se	49	3.1	2.2	0.9L	13	2.5
Sr	49	28	17	3.4	160	32
Th	40	2.2	1.6	0.30	10	1.9
U	49	3.1	1.7	0.17	15	3.2
V	49	27	17	3.2	120	24
Y	49	6.2	6.0	1.8	13	2.2
Yb	39	0.63	0.55	0.20L	1.9	0.35
Zn	49	51	28	6.5	300	63
Zr	49	23	19	1.8L	69	15

Table 11. Number of samples, mean, median, range, and standard deviation of ash yield and contents of elements for the Springfield coal in Kentucky as analyzed by the Kentucky Geological Survey.

[All analyses are in percent or parts per million and are reported on an as-received, whole-coal basis. Leaders (---) indicate statistics could not be calculated owing to no data or to an insufficient number of analyses above the lower detection limit.]

	Number of samples	Mean	Median	Range: Minimum	Range: Maximum	Standard deviation
Percent						
Ash	259	10.2	10.1	5.0	16.4	1.6
Si	141	1.9	1.9	0.018	3.1	0.37
Al	141	0.88	0.87	0.38	1.4	0.16
Ca	141	0.47	0.41	0.028	2.0	0.33
Mg	141	0.044	0.041	0.017	0.10	0.014
Na	132	0.028	0.025	0.0018	0.11	0.019
K	141	0.15	0.15	0.064	0.26	0.037
Fe	141	1.9	1.9	0.69	3.7	0.62
Ti	141	0.048	0.047	0.022	0.11	0.0097
Parts per million						
As	15	4.8	4.7	1.8	11	2.5
B	---	---	---	---	---	---
Ba	---	---	---	---	---	---
Be	16	1.8	1.5	0.44	4.7	0.96
Cd	15	0.27	0.17	0.04	0.97	0.27
Co	140	3.2	3.3	1.5	5.2	0.80
Cr	141	16	14	4.1	86	8.8
Cu	---	---	---	---	---	---
F	---	---	---	---	---	---
Ge	---	---	---	---	---	---
Hg	15	0.02	0.02	0.01	0.03	0.01
La	---	---	---	---	---	---
Li	---	---	---	---	---	---
Mn	135	39	35	0.58	160	24
Mo	---	---	---	---	---	---
Nb	---	---	---	---	---	---
Ni	141	10	9.6	2.2	41	5.5
P	141	52	37	4.6	740	80
Pb	15	3.8	2.6	1.0	9.0	2.5
Sb	15	1.0	0.8	0.2	2.4	0.7
Sc	---	---	---	---	---	---
Se	15	2.0	1.9	1.2	3.6	0.7
Sr	---	---	---	---	---	---
Th	15	1.3	1.2	0.95	2.4	0.45
U	15	2.5	1.6	0.52	9.1	2.3
V	---	---	---	---	---	---
Y	---	---	---	---	---	---
Yb	---	---	---	---	---	---
Zn	---	---	---	---	---	---
Zr	---	---	---	---	---	---

Table 12. Number of samples, mean, median, range, and standard deviation of ash yield and contents of elements for the Springfield coal in Kentucky as analyzed by the U.S. Geological Survey.

[All analyses are in percent or parts per million and are reported on an as-received, whole-coal basis. L, less than value shown. G, greater than value shown. A common problem in statistical summaries of trace-element data arises when element values are below the limits of analytical detection. This results in a censored distribution. To compute unbiased estimates of the means for censored data, we adopted the protocol of reducing all "less than" values by 50 percent before summary statistics were generated. Leaders (---) indicate statistics could not be calculated owing to no data or to an insufficient number of analyses above the lower detection limit.]

	Number of Samples	Mean	Median	Range		Standard deviation
				Minimum	Maximum	
			Percent			
Ash	31	11.1	11.0	7.3	17.0	2.8
Si	31	1.8	1.8	1.4	2.3	0.23
Al	31	0.83	0.80	0.65	1.1	0.13
Ca	31	0.63	0.35	0.038	2.3	0.63
Mg	31	0.044	0.037	0.018	0.23	0.036
Na	31	0.027	0.018	0.007	0.072	0.02
K	31	0.14	0.14	0.10	0.22	0.029
Fe	31	2.2	2.0	0.75	5.8	1.0
Ti	31	0.051	0.049	0.04	0.069	0.0071
			Parts per million			
As	31	7.9	4.9	1.8	37	7.6
B	31	76	71	42	130G	24
Ba	31	58	18	9.6	1,100	190
Be	31	1.8	1.7	0.56	3.8	0.69
Cd	31	0.26	0.14	0.04	1.4	0.31
Co	31	2.5	2.4	1.5	4.2	0.67
Cr	31	13	11	7.7	35	6.6
Cu	31	5.9	5.8	3.5	10	1.5
F	31	59	47	10L	260	44
Ge	31	9.2	8.4	3.9	16	3.3
Hg	31	0.14	0.13	0.01L	0.39	0.1
La	31	4.4	4.0	2.8	6.8	0.93
Li	31	6.4	5.8	2.6	16	2.7
Mn	31	54	31	2.7	210	55
Mo	25	5.5	5.2	1.9	13	2.5
Nb	31	1.5	1.5	0.26L	3.8	0.78
Ni	31	8.8	9.1	2.4	18	4.3
P	14	63	59	22L	180	44
Pb	31	5.7	4.2	0.77	17	4.3
Sb	31	1.0	0.8	0.2	2.4	0.7
Sc	31	2.0	1.9	1.5	3.1	0.4
Se	31	2.4	2.1	1.1	6.3	1.2
Sr	31	21	18	3.9	81	16
Th	31	1.3	1.2	0.98	2.5	0.29
U	31	2.7	1.9	0.51	9.8	2.2
V	31	30	13	5.8	130	31
Y	31	4.0	3.9	1.2	7.8	1.5
Yb	31	0.45	0.41	0.25	0.71	0.10
Zn	31	45	27	6.9	390	69
Zr	31	16	15	5.1	45	8.1

Table 13. Number of samples, mean, median, range, and standard deviation of ash yield and contents of elements for nonassessed coals from the McLeansboro Group in Kentucky as analyzed by the Kentucky Geological Survey.

[All analyses are in percent or parts per million and are reported on an as-received, whole-coal basis. Leaders (---) indicate statistics could not be calculated owing to no data or to an insufficient number of analyses above the lower detection limit.]

	Number of samples	Mean	Median	Range		Standard deviation
				Minimum	Maximum	
Percent						
Ash	57	14.7	14.6	6.0	28.7	4.4
Si	57	3.0	3.0	0.028	5.9	1.3
Al	57	1.5	1.5	0.67	2.7	0.45
Ca	57	0.27	0.13	0.037	2.4	0.36
Mg	57	0.077	0.071	0.015	0.29	0.047
Na	49	0.041	0.031	0.0065	0.17	0.037
K	57	0.30	0.29	0.065	0.81	0.14
Fe	57	2.4	2.1	0.0093	6.4	1.2
Ti	57	0.081	0.081	0.031	0.14	0.025
Parts per million						
As	19	9.0	3.7	0.43	37	10
B	---	---	---	---	---	---
Ba	---	---	---	---	---	---
Be	23	2.1	1.9	1.1	5.3	0.83
Cd	19	0.14	0.09	0.03	0.65	0.16
Co	51	5.3	4.7	1.6	15	2.6
Cr	56	21	20	7.8	40	7.7
Cu	---	---	---	---	---	---
F	---	---	---	---	---	---
Ge	---	---	---	---	---	---
Hg	18	0.02	0.01	0.01	0.04	0.01
La	---	---	---	---	---	---
Li	---	---	---	---	---	---
Mn	56	60	37	7.5	360	75
Mo	---	---	---	---	---	---
Nb	---	---	---	---	---	---
Ni	56	22	18	3.6	51	14
P	57	170	110	10	1,300	190
Pb	19	6.9	4.8	2.2	20	4.8
Sb	19	0.8	0.3	0.1	3.3	1.0
Sc	---	---	---	---	---	---
Se	19	2.0	2.0	0.7	3.1	0.6
Sr	---	---	---	---	---	---
Th	19	2.0	2.0	1.0	3.6	0.70
U	23	1.6	0.88	0.35	7.4	1.6
V	---	---	---	---	---	---
Y	---	---	---	---	---	---
Yb	---	---	---	---	---	---
Zn	---	---	---	---	---	---
Zr	---	---	---	---	---	---

Table 14. Number of samples, mean, median, range, and standard deviation of ash yield and contents of elements for nonassessed coals from the McLeansboro Group in Kentucky as analyzed by the U.S. Geological Survey.

[All analyses are in percent or parts per million and are reported on an as-received, whole-coal basis. L, less than value shown. A common problem in statistical summaries of trace-element data arises when element values are below the limits of analytical detection. This results in a censored distribution. To compute unbiased estimates of the means for censored data, we adopted the protocol of reducing all "less than" values by 50 percent before summary statistics were generated.]

	Number of samples	Mean	Median	Range		Standard deviation
				Minimum	Maximum	
Percent						
Ash	25	13.6	14.0	8.1	26.0	3.9
Si	25	2.8	3.0	0.94	4.9	1.1
Al	25	1.4	1.5	0.73	2.8	0.44
Ca	25	0.27	0.18	0.054	1.4	0.29
Mg	25	0.064	0.069	0.016	0.14	0.027
Na	25	0.03	0.019	0.006	0.15	0.032
K	25	0.28	0.29	0.072	0.59	0.12
Fe	25	2.1	1.8	0.87	4.6	1.0
Ti	25	0.08	0.084	0.035	0.14	0.026
Parts per million						
As	25	9.9	3.2	0.30L	65	15
B	25	86	84	55	130	18
Ba	25	40	35	8.9	98	22
Be	25	2.3	2.1	1.1	5.5	1.1
Cd	25	0.14	0.10	0.03	0.49	0.12
Co	25	5.3	3.7	2.5	19	4.2
Cr	25	16	16	9.2	31	4.5
Cu	25	14	10	6.7	50	9.6
F	25	97	86	33	260	49
Ge	25	4.8	4.0	1.7	14	3.1
Hg	25	0.13	0.11	0.03L	0.33	0.09
La	25	8.1	7.0	2.8	21	4.8
Li	25	14	11	6.6	39	7.5
Mn	25	48	44	18	140	27
Mo	25	3.1	2.0	0.42	14	3.2
Nb	25	1.8	1.7	0.52	5.4	1.1
Ni	25	16	12	5.5	75	14
P	7	91	79	22L	260	81
Pb	25	8.2	5.2	3.5	49	9.2
Sb	25	0.7	0.3	0.1	3.6	1.0
Sc	25	3.3	3.0	1.9	7.9	1.1
Se	25	2.2	2.1	1.2	3.5	0.6
Sr	25	44	33	14	150	33
Th	25	2.1	2.0	1.2	5.1	0.81
U	25	1.5	0.99	0.49	4.8	1.1
V	25	21	17	9.8	57	10
Y	25	6.0	5.8	2.0	20	3.8
Yb	25	0.70	0.64	0.32	1.4	0.28
Zn	25	39	32	13	140	30
Zr	25	16	14	5.5	41	9.3

Table 15. Number of samples, mean, median, range, and standard deviation of ash yield and contents of elements for the nonassessed coals from the Carbondale Group in Indiana as analyzed by the U.S. Geological Survey.

[All analyses are in percent or parts per million and are reported on an as-received, whole-coal basis. L, less than value shown. G, greater than value shown. A common problem in statistical summaries of trace-element data arises when element values are below the limits of analytical detection. This results in a censored distribution. To compute unbiased estimates of the means for censored data, we adopted the protocol of reducing all "less than" values by 50 percent before summary statistics were generated. Leaders (---) indicate statistics could not be calculated owing to no data or to an insufficient number of analyses above the lower detection limit.]

	Number of samples	Mean	Median	Range		Standard deviation
				Minimum	Maximum	
			Percent			
Ash	44	14.0	12.0	5.4	48.0	9.2
Si	44	2.4	2.0	0.34	12	2.1
Al	44	1.2	0.95	0.15	6.4	1.1
Ca	43	0.41	0.18	0.023	3.5	0.7
Mg	44	0.071	0.053	0.009	0.35	0.063
Na	44	0.04	0.032	0.006	0.22	0.039
K	44	0.23	0.15	0.027	1.2	0.24
Fe	44	2.7	2.2	0.32	25	3.6
Ti	44	0.069	0.054	0.019	0.33	0.058
			Parts per million			
As	44	43	14	2.4	950	140
B	44	100	100	27	190G	41
Ba	44	41	27	11	170	37
Be	44	3.3	3.1	1.4	7.0	1.2
Cd	44	0.46	0.11	0.01L	5.7	1.0
Co	44	6.5	5.3	1.4	26	4.4
Cr	44	16	12	4.1	72	11
Cu	44	16	12	4.4	96	15
F	44	100	58	10L	780	120
Ge	44	12	9.9	0.31L	59	11
Hg	44	0.19	0.11	0.02	2.4	0.36
La	42	7.6	4.3	1.0	55	8.9
Li	44	17	8.5	0.76	210	33
Mn	44	48	30	7.6	150	40
Mo	44	4.7	2.6	0.46L	45	8.2
Nb	44	2.4	1.9	0.39L	8.6	1.7
Ni	44	23	21	3.3	81	16
P	---	---	---	---	---	---
Pb	44	30	15	0.46L	230	44
Sb	44	1.9	1.2	0.3	7.1	1.8
Sc	44	3.8	3.2	0.70	18	2.8
Se	44	2.7	2.2	0.5L	11	2.1
Sr	44	42	23	8.4	190	45
Th	42	2.2	1.5	0.2L	15	2.5
U	44	2.1	1.7	0.44L	7.6	1.8
V	44	22	18	3.8	84	16
Y	44	7.5	6.4	0.96L	64	9.2
Yb	41	0.98	0.6	0.20L	8.1	1.3
Zn	44	67	23	4.3	1,100	170
Zr	44	28	24	3.9	140	23

Table 16. Number of samples, mean, median, range, and standard deviation of ash yield and contents of elements for nonassessed coals from the Carbondale Formation in Kentucky as analyzed by the Kentucky Geological Survey.

[All analyses are in percent or parts per million and are reported on an as-received, whole-coal basis. Leaders (---) indicate statistics could not be calculated owing to no data or to an insufficient number of analyses above the lower detection limit.]

	Number of samples	Mean	Median	Range Minimum	Range Maximum	Standard deviation
			Percent			
Ash	42	15.0	13.8	3.6	30.9	6.4
Si	42	2.9	2.5	0.75	8.6	1.7
Al	42	1.6	1.5	0.41	4.5	0.88
Ca	42	0.29	0.12	0.037	1.9	0.38
Mg	42	0.19	0.081	0.019	4.6	0.70
Na	38	0.054	0.043	0.0028	0.15	0.038
K	42	0.32	0.29	0.065	0.97	0.20
Fe	42	2.6	2.6	0.46	6.3	1.3
Ti	42	0.079	0.075	0.021	0.23	0.043
			Parts per million			
As	4	16	10	3.8	38	15
B	---	---	---	---	---	---
Ba	---	---	---	---	---	---
Be	4	2.9	2.1	1.5	5.9	2.1
Cd	4	0.33	0.26	0.08	0.71	0.28
Co	35	4.8	4.6	1.3	11	2.2
Cr	35	24	22	5.3	55	12
Cu	---	---	---	---	---	---
F	---	---	---	---	---	---
Ge	---	---	---	---	---	---
Hg	4	0.02	0.02	0.01	0.05	0.02
La	---	---	---	---	---	---
Li	---	---	---	---	---	---
Mn	34	45	32	1.1	140	34
Mo	---	---	---	---	---	---
Nb	---	---	---	---	---	---
Ni	35	26	24	7.4	64	14
P	42	280	96	20	6,700	1000
Pb	4	20	18	11	35	10
Sb	4	0.9	0.4	0.3	2.4	1.0
Sc	---	---	---	---	---	---
Se	4	3.1	2.6	2.0	5.1	1.4
Sr	---	---	---	---	---	---
Th	4	2.2	2.4	1.1	2.9	0.81
U	4	2.9	2.0	1.2	6.3	2.3
V	---	---	---	---	---	---
Y	---	---	---	---	---	---
Yb	---	---	---	---	---	---
Zn	---	---	---	---	---	---
Zr	---	---	---	---	---	---

Table 17. Number of samples, mean, median, range, and standard deviation of ash yield and contents of elements for nonassessed coals from the Carbondale Formation in Kentucky as analyzed by the U.S. Geological Survey.

[All analyses are in percent or parts per million and are reported on an as-received, whole-coal basis. L, less than value shown. G, greater than value shown. A common problem in statistical summaries of trace-element data arises when element values are below the limits of analytical detection. This results in a censored distribution. To compute unbiased estimates of the means for censored data, we adopted the protocol of reducing all "less than" values by 50 percent before summary statistics were generated.]

	Number of samples	Mean	Median	Range Minimum	Range Maximum	Standard deviation
Percent						
Ash	42	14.7	14.0	6.2	28.0	5.6
Si	42	2.4	2.2	0.87	5.9	1.1
Al	42	1.3	1.2	0.51	3.1	0.58
Ca	42	0.5	0.34	0.037	2.4	0.56
Mg	42	0.058	0.046	0.015	0.15	0.034
Na	42	0.036	0.029	0.009	0.11	0.025
K	42	0.21	0.18	0.051	0.52	0.11
Fe	42	3.2	2.6	0.67	12	2.2
Ti	42	0.065	0.063	0.005	0.17	0.03
Parts per million						
As	42	27	15	0.50L	130	30
B	42	78	74	13	140G	25
Ba	42	40	31	7.5	130	28
Be	42	3.7	3.7	1.2	7.3	1.3
Cd	42	0.45	0.11	0.02L	6.2	1.1
Co	42	9.6	5.8	1.1	110	17
Cr	42	20	17	9.7	86	13
Cu	42	16	15	6.6	33	7.1
F	42	97	65	10L	460	88
Ge	42	16	15	1.8	41	10
Hg	42	0.10	0.08	0.02L	0.45	0.09
La	42	7.3	6.0	2.0	28	4.7
Li	42	15	11	2.7	46	11
Mn	42	59	50	8.1	220	47
Mo	23	8.9	5.3	0.96	56	12
Nb	42	2.8	2.6	0.74	6.3	1.4
Ni	42	34	28	3.7	190	33
P	32	110	74	22L	810	140
Pb	42	25	20	2.2	120	24
Sb	42	1.2	1.0	0.1L	7.1	1.2
Sc	42	4.7	4.2	2.0	12	2.2
Se	42	3.9	3.3	1.7	12	2.0
Sr	42	44	33	9.5	300	46
Th	42	2.1	1.9	0.71	6.4	0.99
U	42	4.6	3.7	0.59	13	3.4
V	42	31	28	7.8	82	17
Y	42	10	9.2	5.1	34	5.5
Yb	42	1.2	1.0	0.57	4.4	0.67
Zn	42	71	29	1.8	670	130
Zr	42	28	24	9.9	110	18

Table 18. Number of samples, mean, median, range, and standard deviation of ash yield and contents of elements for nonassessed coals in the Raccoon Creek Group in Indiana as analyzed by the U.S. Geological Survey.

[All analyses are in percent or parts per million and are reported on an as-received, whole-coal basis. L, less than value shown. A common problem in statistical summaries of trace-element data arises when element values are below the limits of analytical detection. This results in a censored distribution. To compute unbiased estimates of the means for censored data, we adopted the protocol of reducing all "less than" values by 50 percent before summary statistics were generated. Leaders (---) indicate statistics could not be calculated owing to no data or to an insufficient number of analyses above the lower detection limit.]

	Number of samples	Mean	Median	Range		Standard deviation
				Minimum	Maximum	
Percent						
Ash	106	12.7	8.9	1.7	48.0	10
Si	105	2.5	1.5	0.40	13	2.8
Al	105	1.5	0.89	0.14	7.8	1.7
Ca	105	0.084	0.046	0.018	1.0	0.16
Mg	106	0.05	0.029	0.002L	0.25	0.055
Na	106	0.036	0.012	0.002	0.28	0.06
K	104	0.20	0.085	0.007	1.3	0.28
Fe	105	1.9	1.4	0.11	24	2.5
Ti	105	0.081	0.047	0.002	0.46	0.092
Parts per million						
As	106	16	9.0	0.40	95	17
B	105	83	77	12	210	45
Ba	106	59	23	1.9	560	85
Be	106	3.7	3.5	0.25	9.2	1.5
Cd	106	0.30	0.12	0.01L	3.5	0.57
Co	106	12	8.8	1.0	110	12
Cr	106	19	13	3.1L	65	15
Cu	106	22	16	2.1L	140	21
F	106	79	55	10L	420	80
Ge	104	12	13	0.82L	37	8.3
Hg	106	0.13	0.08	0.01L	1.2	0.16
La	101	13	9.0	1.0	72	13
Li	106	22	8.8	0.67L	140	31
Mn	106	18	13	2.2	94	17
Mo	106	2.4	1.6	0.16L	25	3.1
Nb	102	2.5	1.5	0.051L	14	2.8
Ni	106	39	31	4.4	170	30
P	---	---	---	---	---	---
Pb	106	23	19	0.37L	190	24
Sb	106	1.3	1.1	0.1	7.4	1.2
Sc	106	4.4	3.5	0.47	13	3.0
Se	106	4.2	3.6	0.6L	14	2.6
Sr	106	75	33	2.0	490	99
Th	100	2.7	1.5	0.15L	18	3.0
U	106	1.9	1.2	0.055L	17	2.2
V	106	26	15	0.60	98	25
Y	101	9.3	6.7	1.5	41	7.8
Yb	98	0.92	0.70	0.15L	4.1	0.69
Zn	106	88	33	5.5	1,600	210
Zr	106	30	14	0.83L	210	34

Table 19. Number of samples, mean, median, range, and standard deviation of ash yield and contents of elements for nonassessed coals from the Raccoon Creek Group in Kentucky as analyzed by the Kentucky Geological Survey.

[All analyses are in percent or parts per million and are reported on an as-received, whole-coal basis. Leaders (---) indicate statistics could not be calculated owing to no data or to an insufficient number of analyses above the lower detection limit.]

	Number of samples	Mean	Median	Range		Standard deviation
				Minimum	Maximum	
Percent						
Ash	87	9.1	7.6	1.5	43.9	6.9
Si	83	1.7	1.1	0.019	12	1.8
Al	83	1.0	0.71	0.11	5.9	0.92
Ca	82	0.13	0.037	0.0093	1.1	0.21
Mg	87	0.036	0.019	0.0028	0.35	0.049
Na	70	0.024	0.011	0.0019	0.17	0.028
K	83	0.13	0.065	0.0093	1.2	0.18
Fe	83	1.8	1.6	0.093	5.4	1.3
Ti	83	0.047	0.034	0.0037	0.29	0.044
Parts per million						
As	15	26	11	2.0	180	44
B	---	---	---	---	---	---
Ba	---	---	---	---	---	---
Be	15	3.8	3.5	2.4	7.3	1.2
Cd	15	0.72	0.15	0.01	4.4	1.4
Co	56	5.3	3.7	0.20	18	4.9
Cr	60	13	11	3.2	56	9.0
Cu	---	---	---	---	---	---
F	---	---	---	---	---	---
Ge	---	---	---	---	---	---
Hg	8	0.01	0.01	0.01	0.03	0.01
La	---	---	---	---	---	---
Li	---	---	---	---	---	---
Mn	53	14	9.4	1	81	15
Mo	---	---	---	---	---	---
Nb	---	---	---	---	---	---
Ni	60	43	40	5.3	120	25
P	83	79	42	5.6	520	99
Pb	15	22	17	6.2	65	16
Sb	15	2.4	1.4	0.2	13	3.2
Sc	---	---	---	---	---	---
Se	15	2.6	2.0	1.1	5.1	1.3
Sr	---	---	---	---	---	---
Th	15	1.2	1.0	0.48	2.7	0.70
U	15	2.0	1.2	0.76	7.8	1.9
V	---	---	---	---	---	---
Y	---	---	---	---	---	---
Yb	---	---	---	---	---	---
Zn	---	---	---	---	---	---
Zr	---	---	---	---	---	---

Table 20. Number of samples, mean, median, range, and standard deviation of ash yield and contents of elements for nonassessed coals from the Raccoon Creek Group in Kentucky as analyzed by the U.S. Geological Survey.

[All analyses are in percent or parts per million and are reported on an as-received, whole-coal basis. L, less than value shown. G, greater than value shown. A common problem in statistical summaries of trace-element data arises when element values are below the limits of analytical detection. This results in a censored distribution. To compute unbiased estimates of the means for censored data, we adopted the protocol of reducing all "less than" values by 50 percent before summary statistics were generated.]

	Number of samples	Mean	Median	Range		Standard deviation
				Minimum	Maximum	
Percent						
Ash	43	7.2	6.8	1.5	15.0	3.7
Si	39	1.2	0.98	0.41	2.8	0.61
Al	39	0.73	0.65	0.14	2.3	0.42
Ca	39	0.16	0.051	0.013	1.2	0.28
Mg	43	0.022	0.021	0.006	0.052	0.01
Na	43	0.015	0.008	0.001	0.16	0.026
K	39	0.088	0.083	0.013	0.21	0.048
Fe	39	1.8	1.5	0.068	6.4	1.6
Ti	39	0.038	0.033	0.011	0.088	0.021
Parts per million						
As	43	29	17	1.3	170	39
B	43	56	58	15	100G	24
Ba	43	15	13	3.8	59	9.9
Be	43	3.7	3.6	1.9	8.0	0.99
Cd	43	0.34	0.11	0.01L	4.7	0.92
Co	43	8.4	7.3	1.2	30	6.0
Cr	43	8.7	7.5	3.0L	18	4.0
Cu	43	12	12	4.8	27	5.1
F	43	49	41	10L	160	35
Ge	43	17	16	3.4	39	8.2
Hg	43	0.12	0.08	0.01	0.44	0.11
La	43	5.8	4.4	0.97	20	4.6
Li	43	7.4	4.3	1.1	30	6.9
Mn	43	16	9.8	1.4	74	17
Mo	36	2.2	1.5	0.37	17	2.9
Nb	43	1.4	1.1	0.24	3.2	0.79
Ni	43	26	22	6.4	65	15
P	15	76	22	22L	300	91
Pb	43	26	20	1.5	90	22
Sb	43	1.7	1.2	0.1L	13	2.1
Sc	43	2.5	2.2	0.4	5.0	1.2
Se	43	2.9	2.5	0.9L	8.5	1.7
Sr	43	28	17	1.3	170	31
Th	43	1.3	1.1	0.36L	2.7	0.65
U	43	1.7	1.2	0.17L	7.7	1.5
V	43	12	11	3.2	30	6.4
Y	43	6.8	6.5	3.4	14	2.6
Yb	43	0.67	0.6	0.30	1.3	0.26
Zn	43	110	28	5.8	2,600	390
Zr	43	11	8.4	3.2	28	7.0

Appendix 5. Minimum, maximum, percentile, and median values of ash yield, sulfur content, calorific value, and elements of environmental concern for assessed and nonassessed coals, grouped by assessed coal or stratigraphic unit in the Illinois Basin.

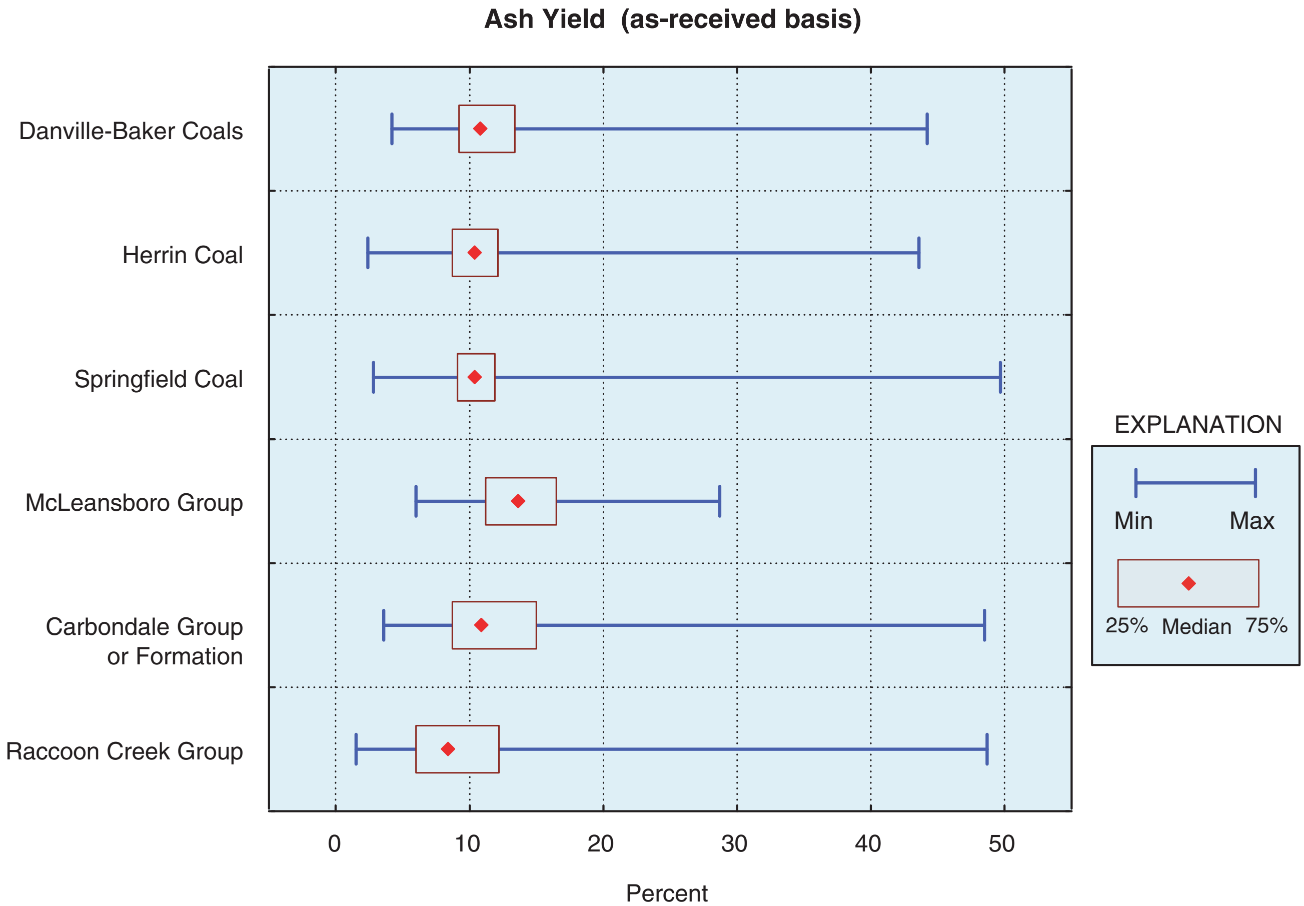

Figure 1. Minimum, maximum, percentile, and median values for ash yield (percent, as-received basis) of coals, grouped by assessed coal or stratigraphic unit in the Illinois Basin.

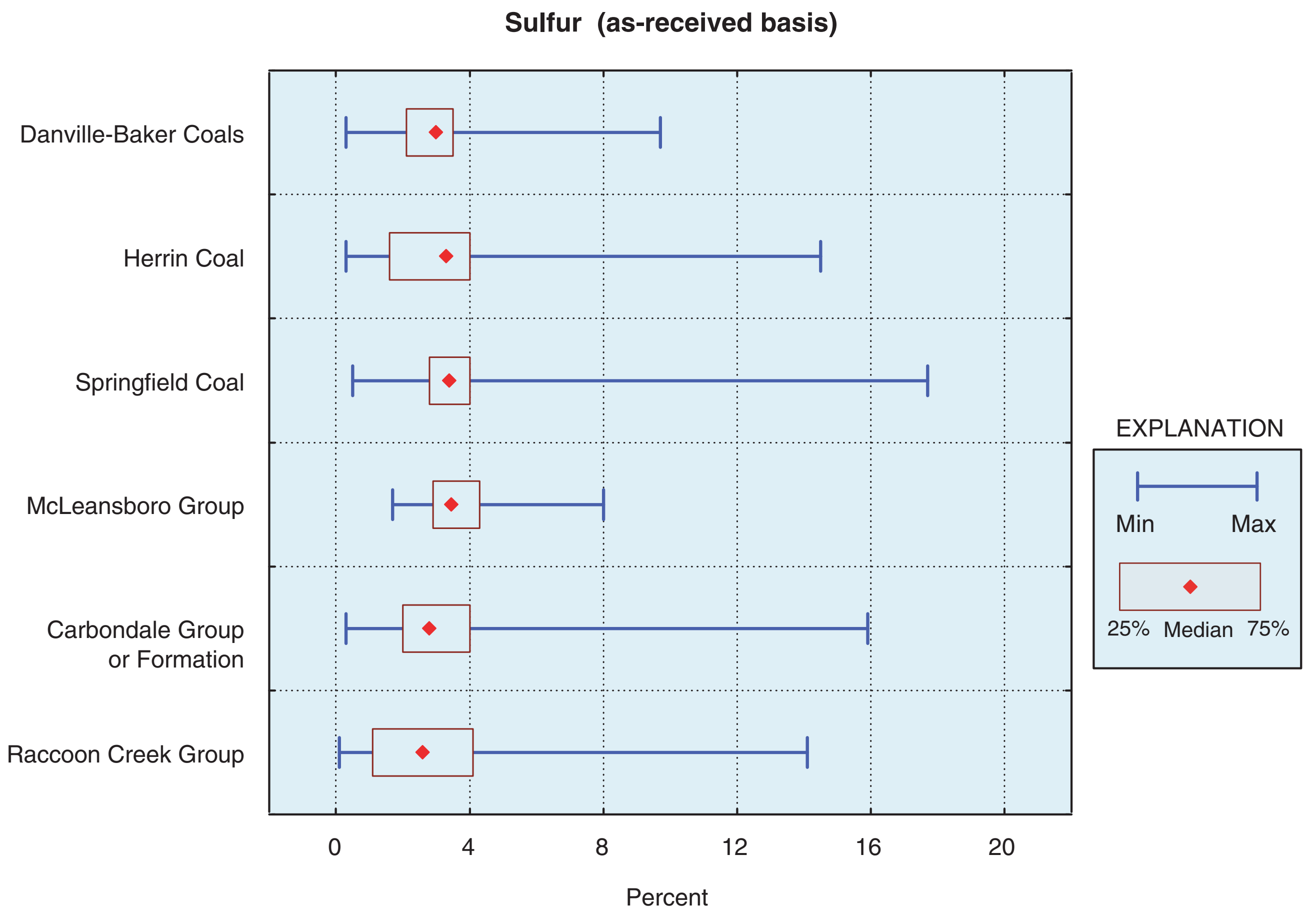

Figure 2. Minimum, maximum, percentile, and median values for sulfur content (percent, as-received basis) of coals, grouped by assessed coal or stratigraphic unit in the Illinois Basin.

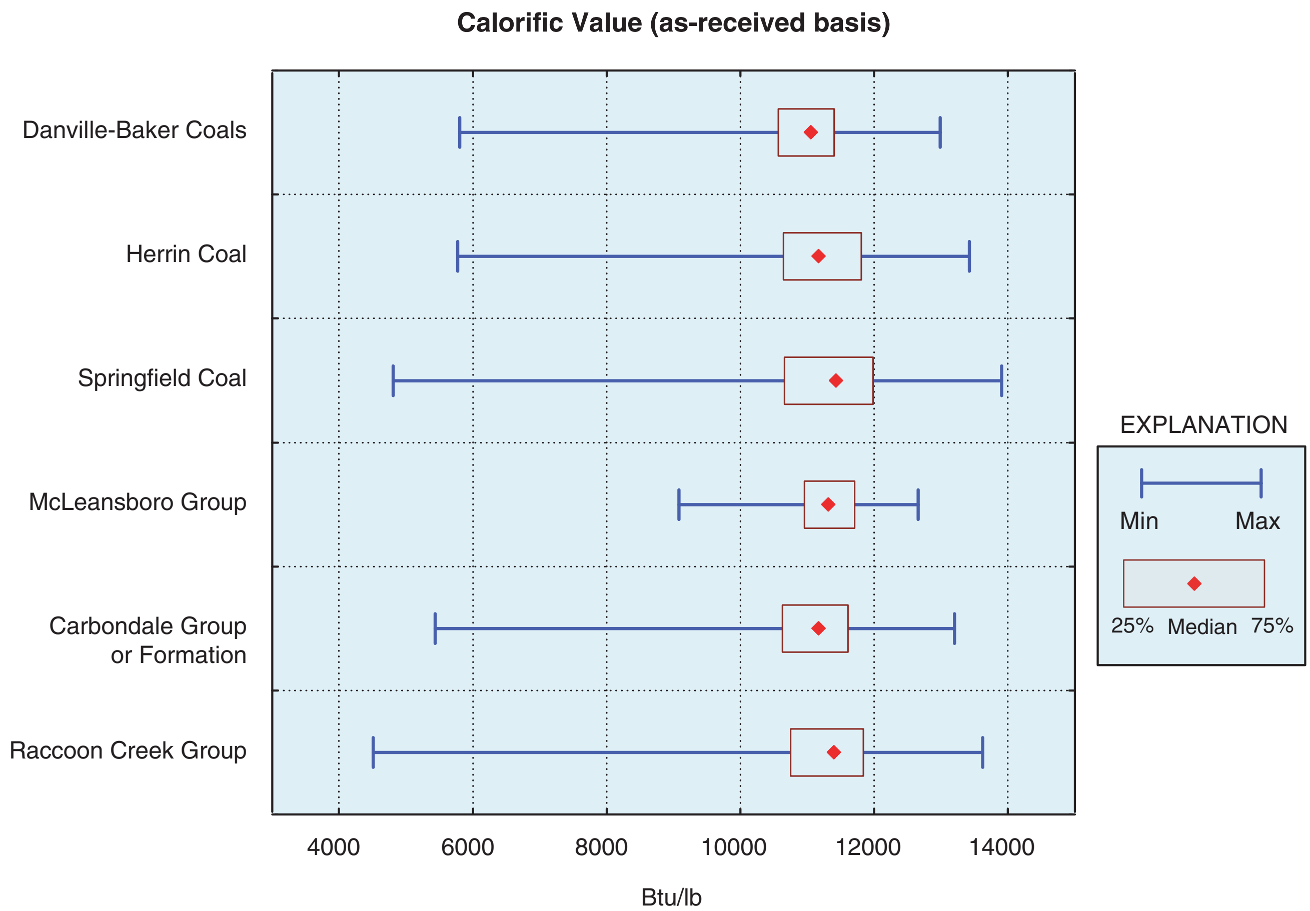

Figure 3. Minimum, maximum, percentile, and median values for calorific value (Btu/lb, as-received basis) of coals, grouped by assessed coal or stratigraphic unit in the Illinois Basin.

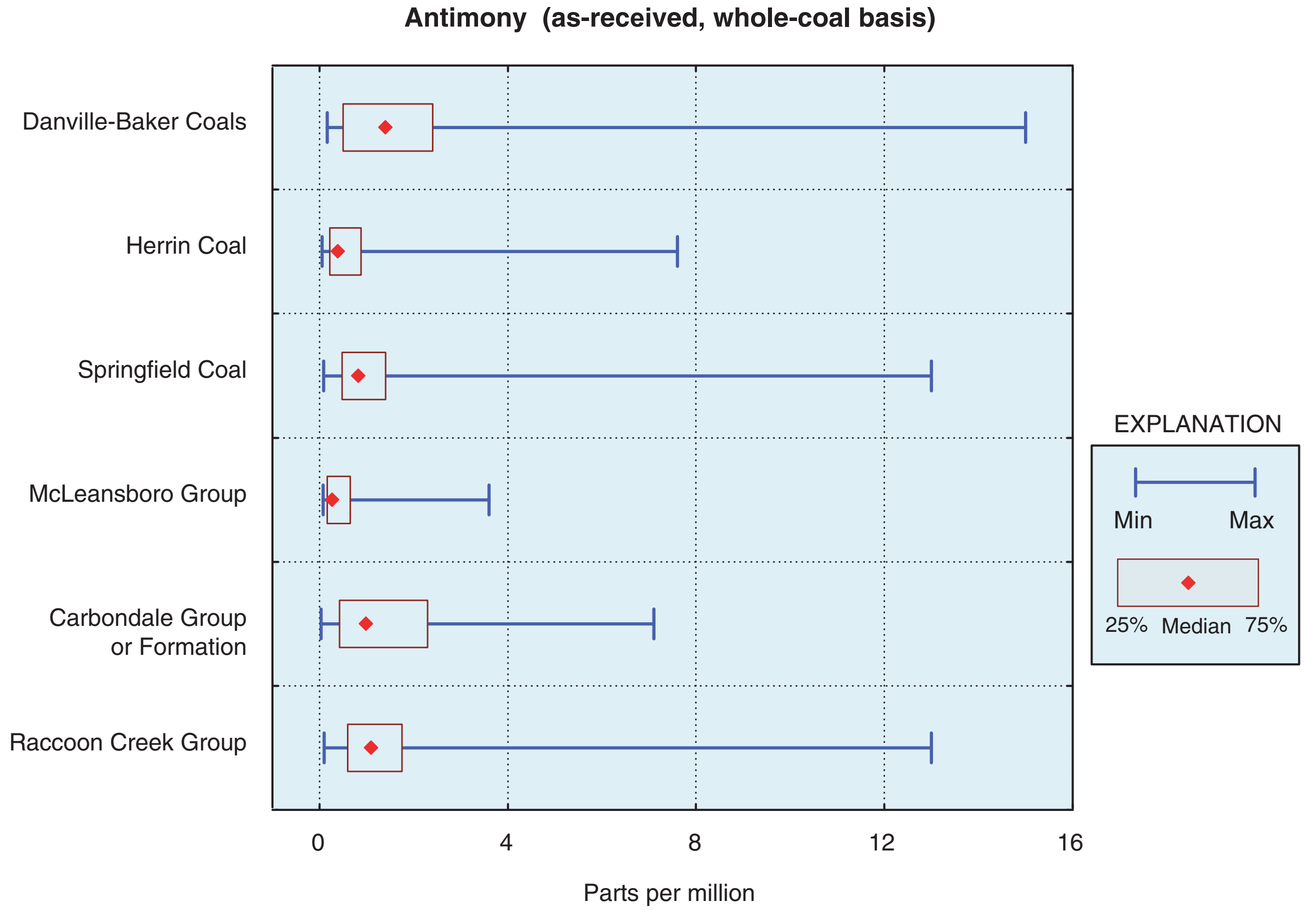

Figure 4. Minimum, maximum, percentile, and median values for antimony content (parts per million, as-received, whole-coal basis) of coals, grouped by assessed coal or stratigraphic unit in the Illinois Basin.

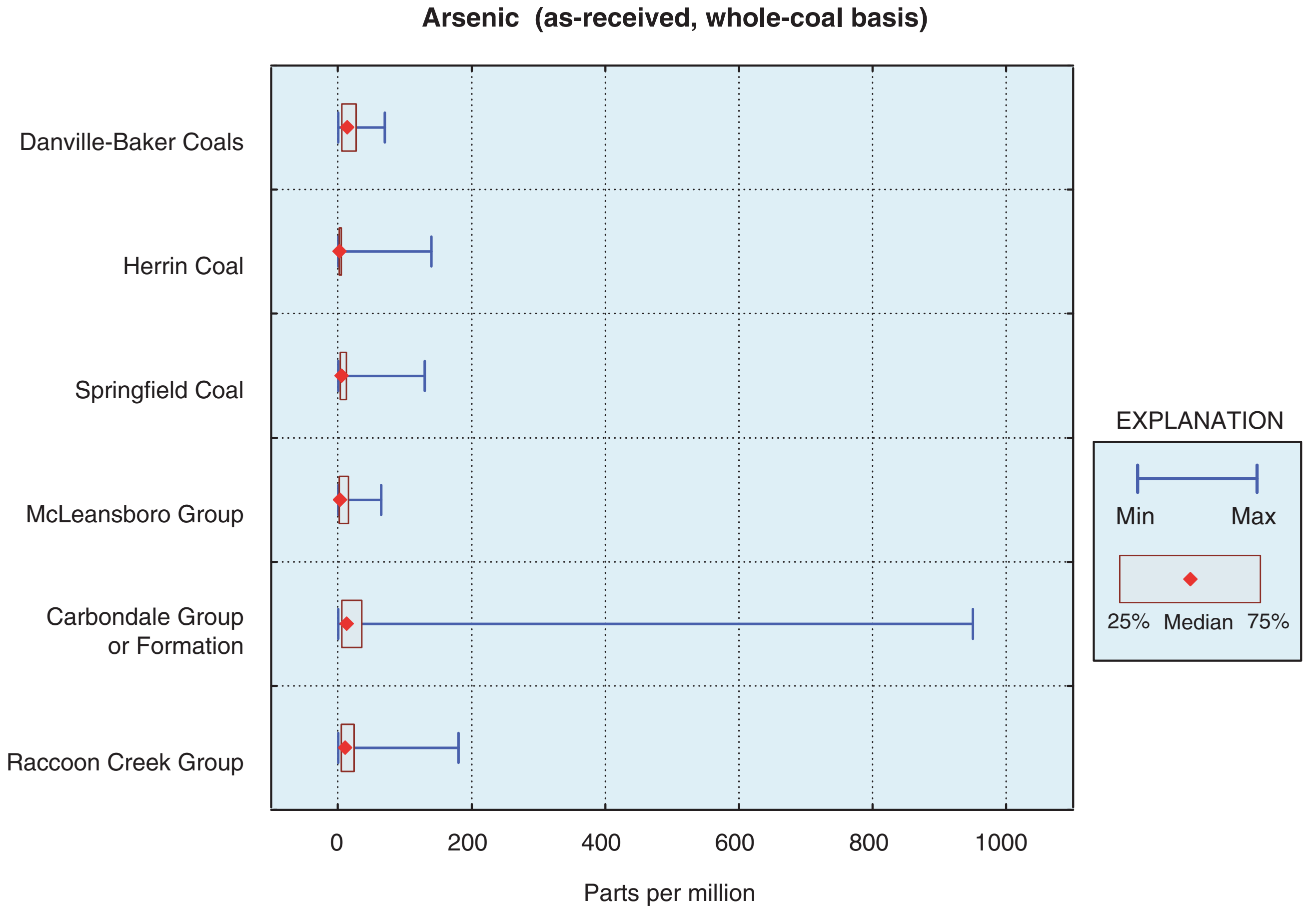

Figure 5. Minimum, maximum, percentile, and median values for arsenic content (parts per million, as-received, whole-coal basis) of coals, grouped by assessed coal or stratigraphic unit in the Illinois Basin.

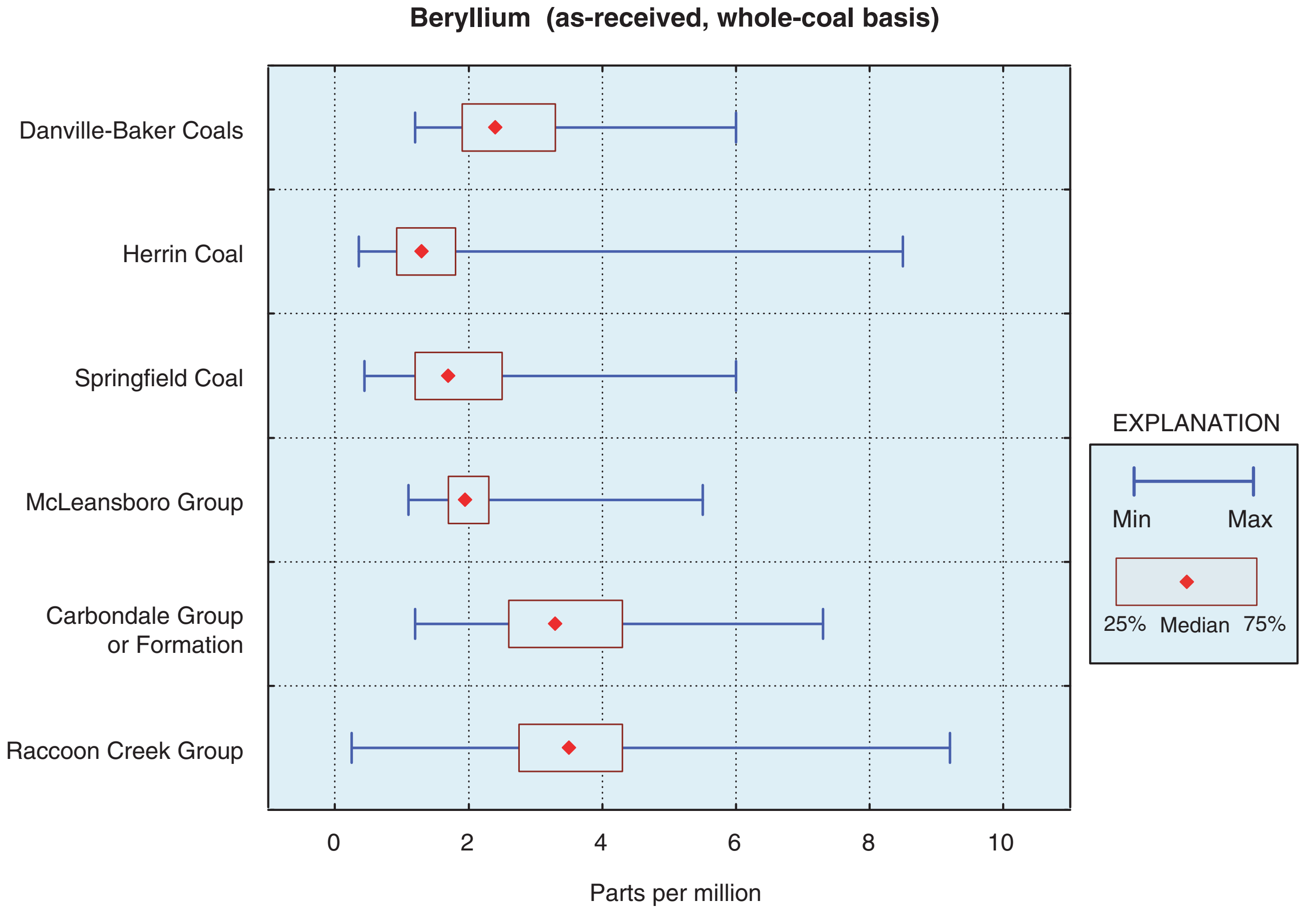

Figure 6. Minimum, maximum, percentile, and median values for beryllium content (parts per million, as-received, whole-coal basis) of coals, grouped by assessed coal or stratigraphic unit in the Illinois Basin.

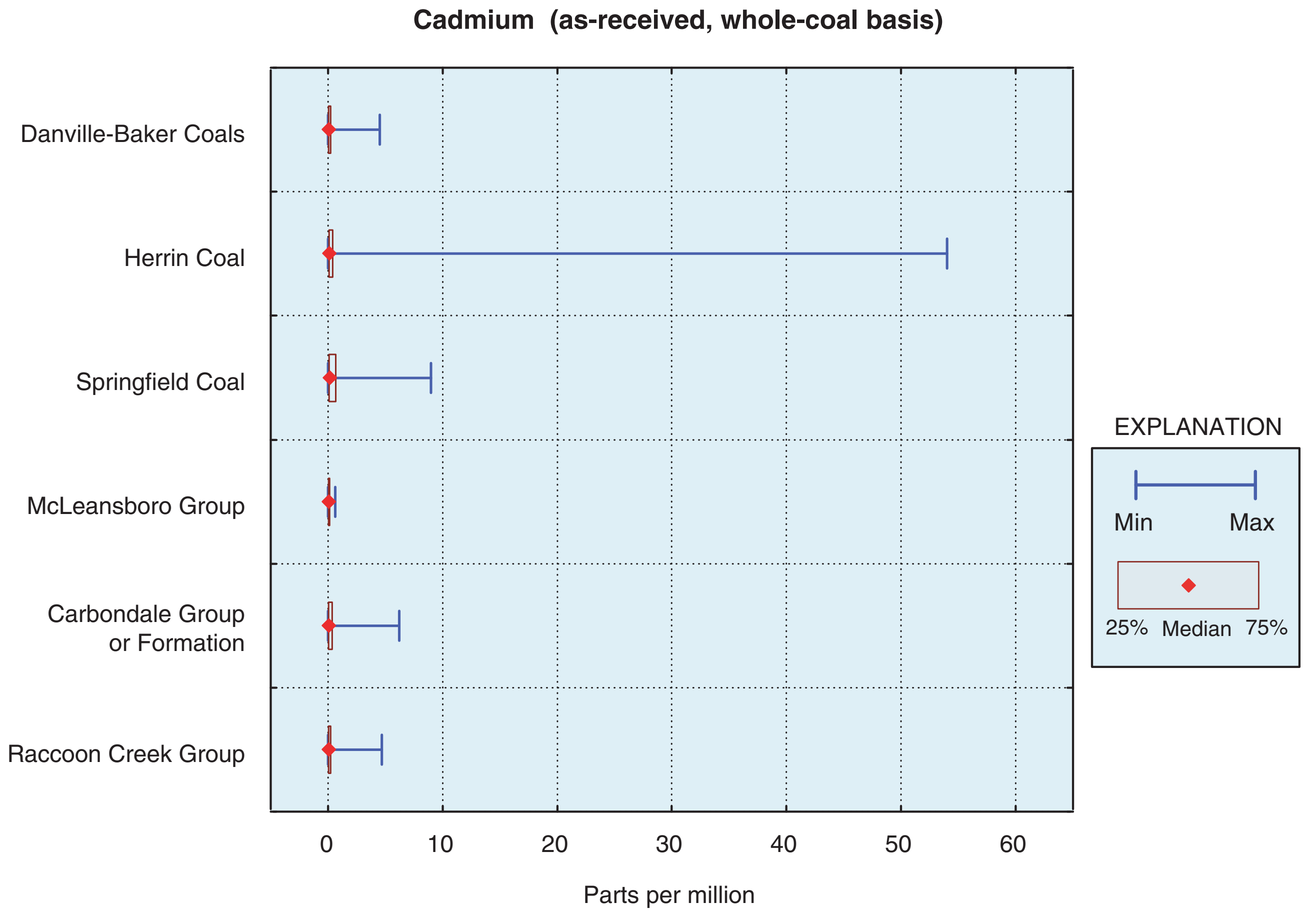

Figure 7. Minimum, maximum, percentile, and median values for cadmium content (parts per million, as-received, whole-coal basis) of coals, grouped by assessed coal or stratigraphic unit in the Illinois Basin.

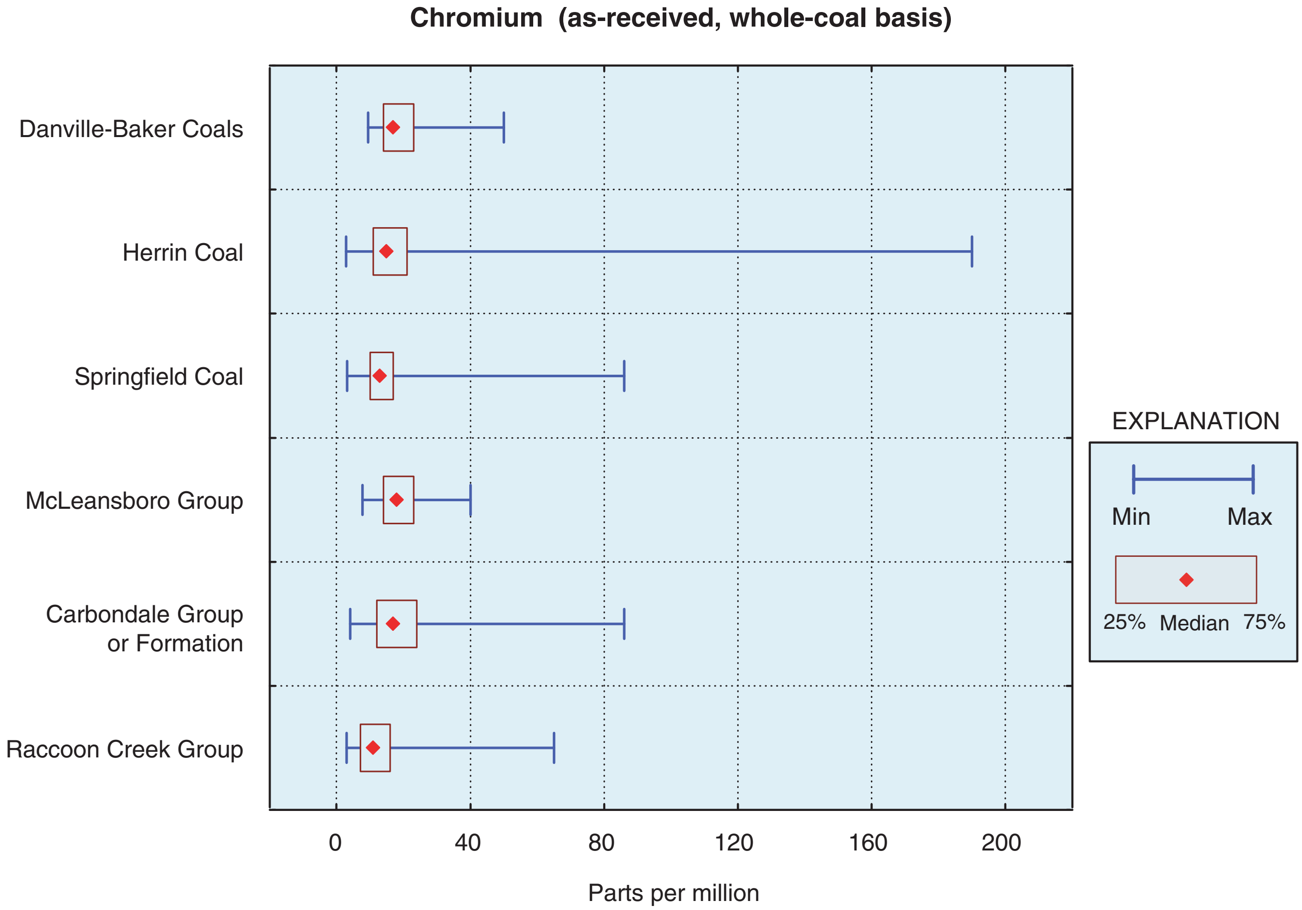

Figure 8. Minimum, maximum, percentile, and median values for chromium content (parts per million, as-received, whole-coal basis) of coals, grouped by assessed coal or stratigraphic unit in the Illinois Basin.

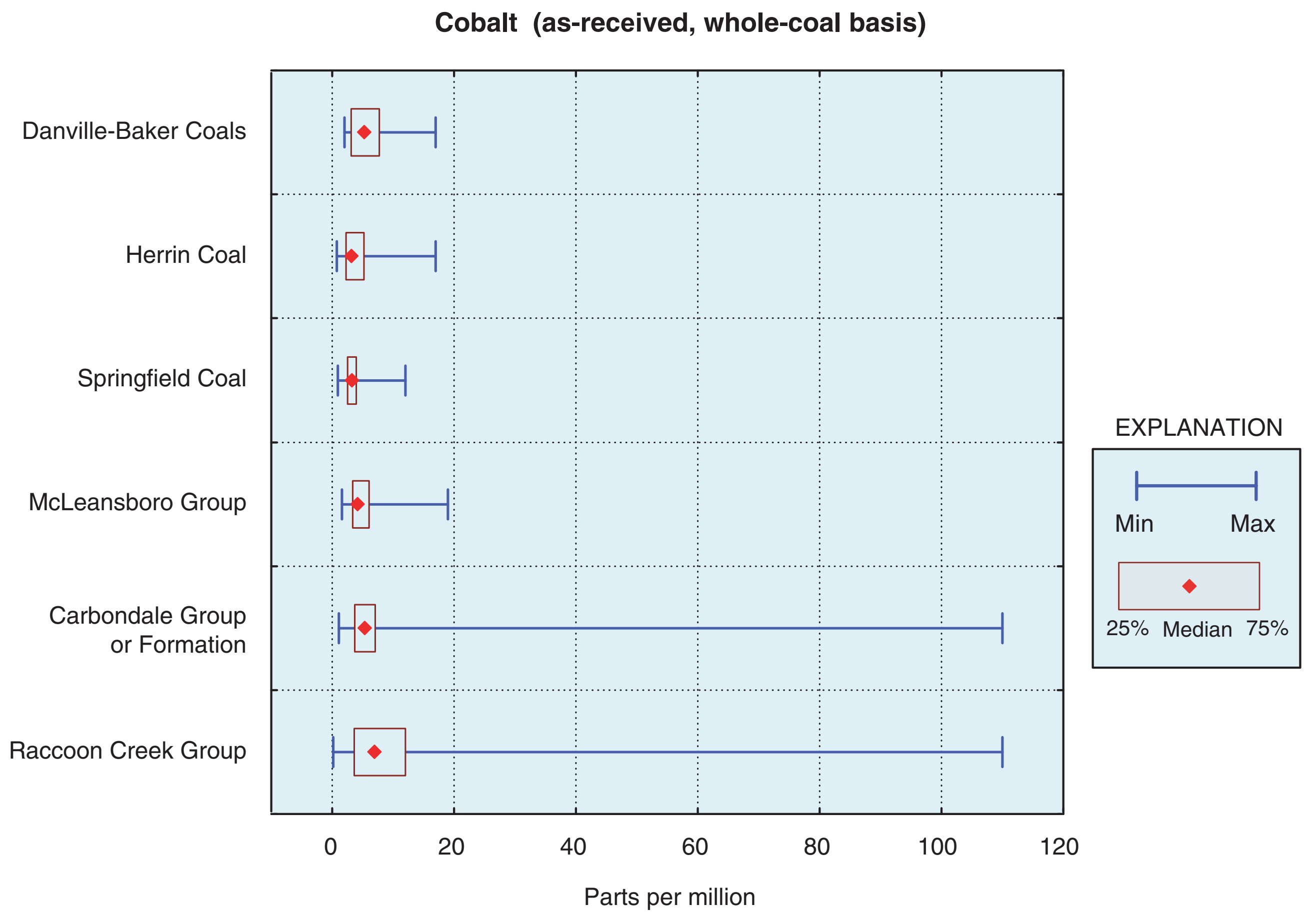

Figure 9. Minimum, maximum, percentile, and median values for cobalt content (parts per million, as-received, whole-coal basis) of coals, grouped by assessed coal or stratigraphic unit in the Illinois Basin.

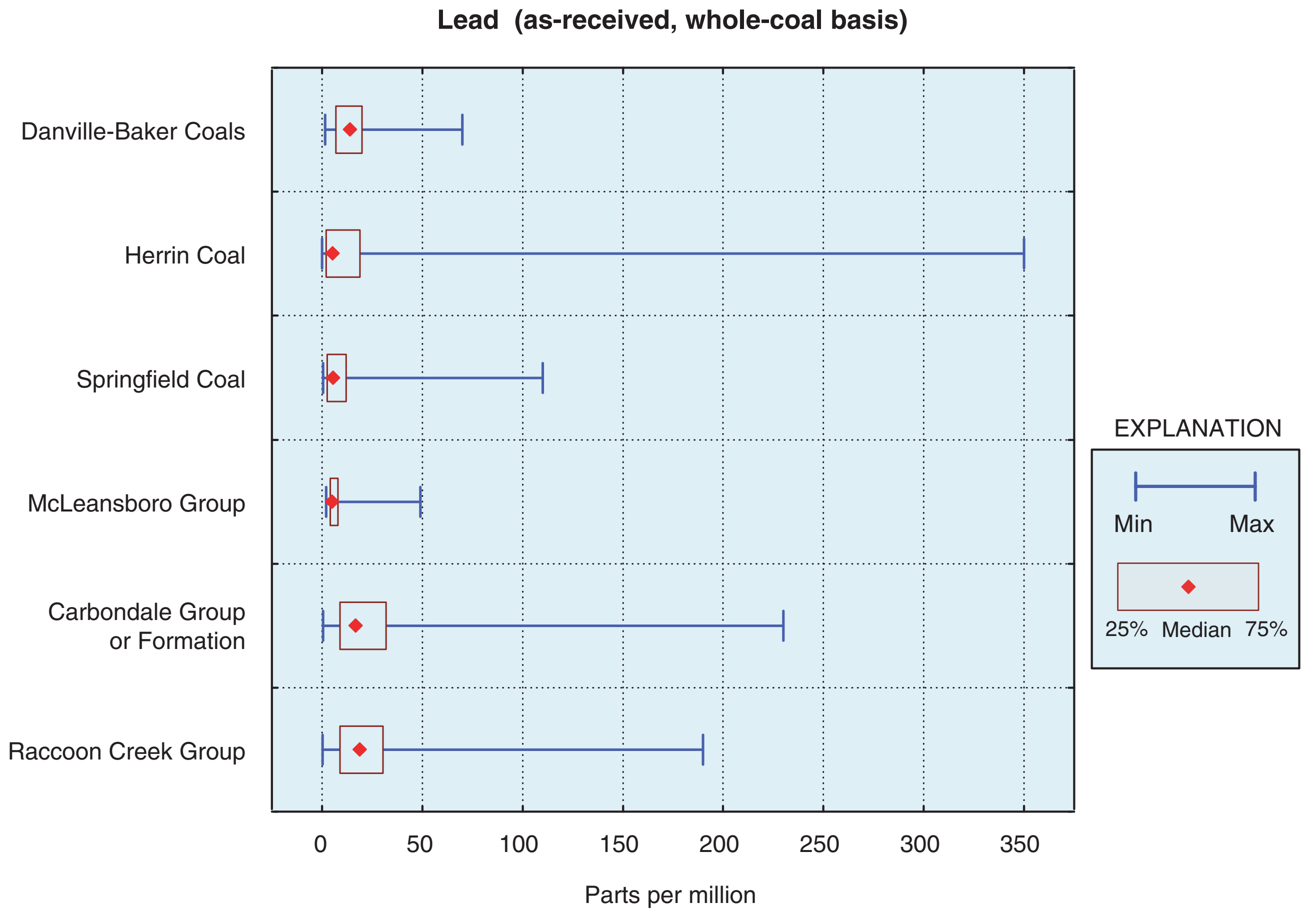

Figure 10. Minimum, maximum, percentile, and median values for lead content (parts per million, as-received, whole-coal basis) of coals, grouped by assessed coal or stratigraphic unit in the Illinois Basin.

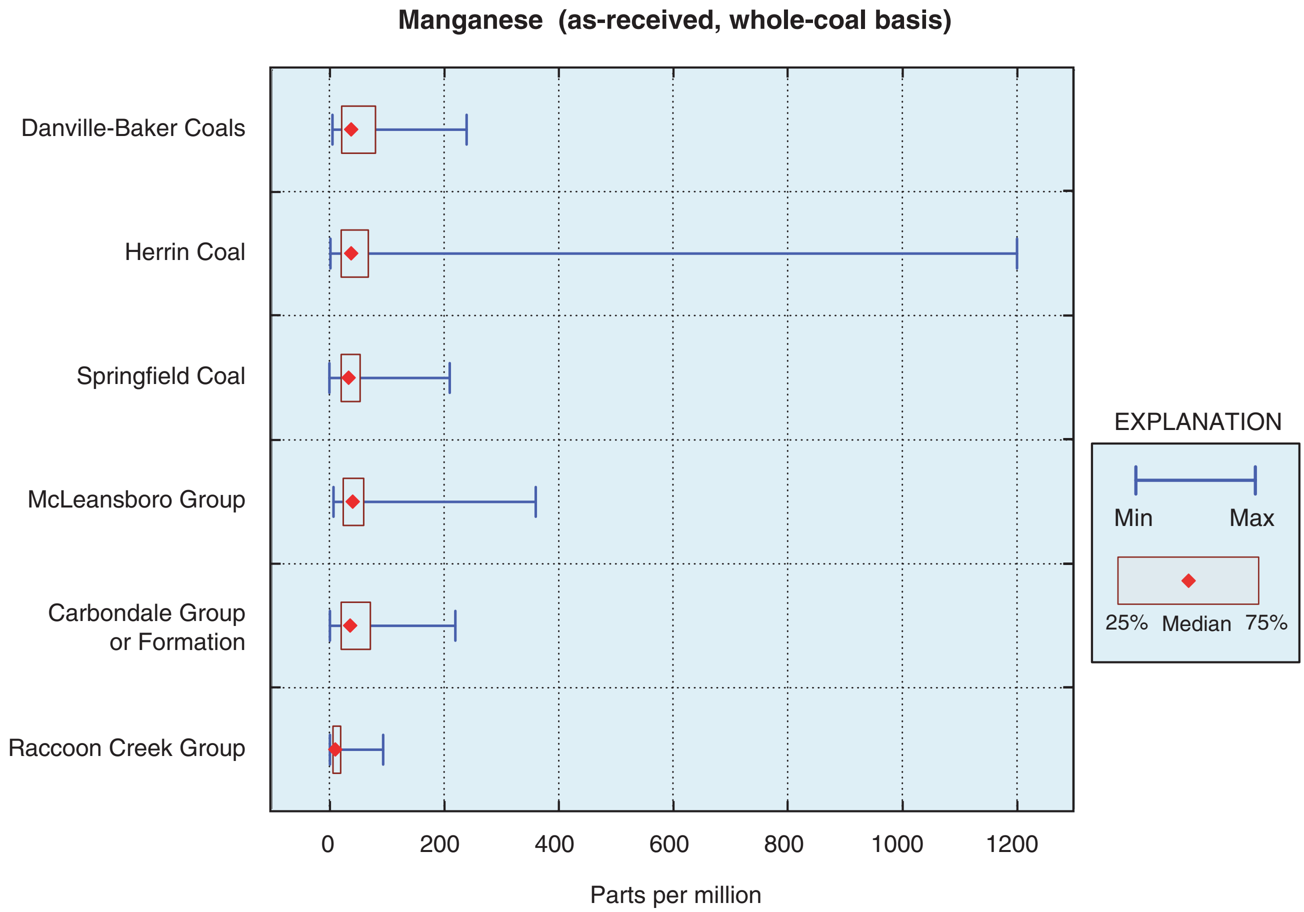

Figure 11. Minimum, maximum, percentile, and median values for manganese content (parts per million, as-received, whole-coal basis) of coals, grouped by assessed coal or stratigraphic unit in the Illinois Basin.

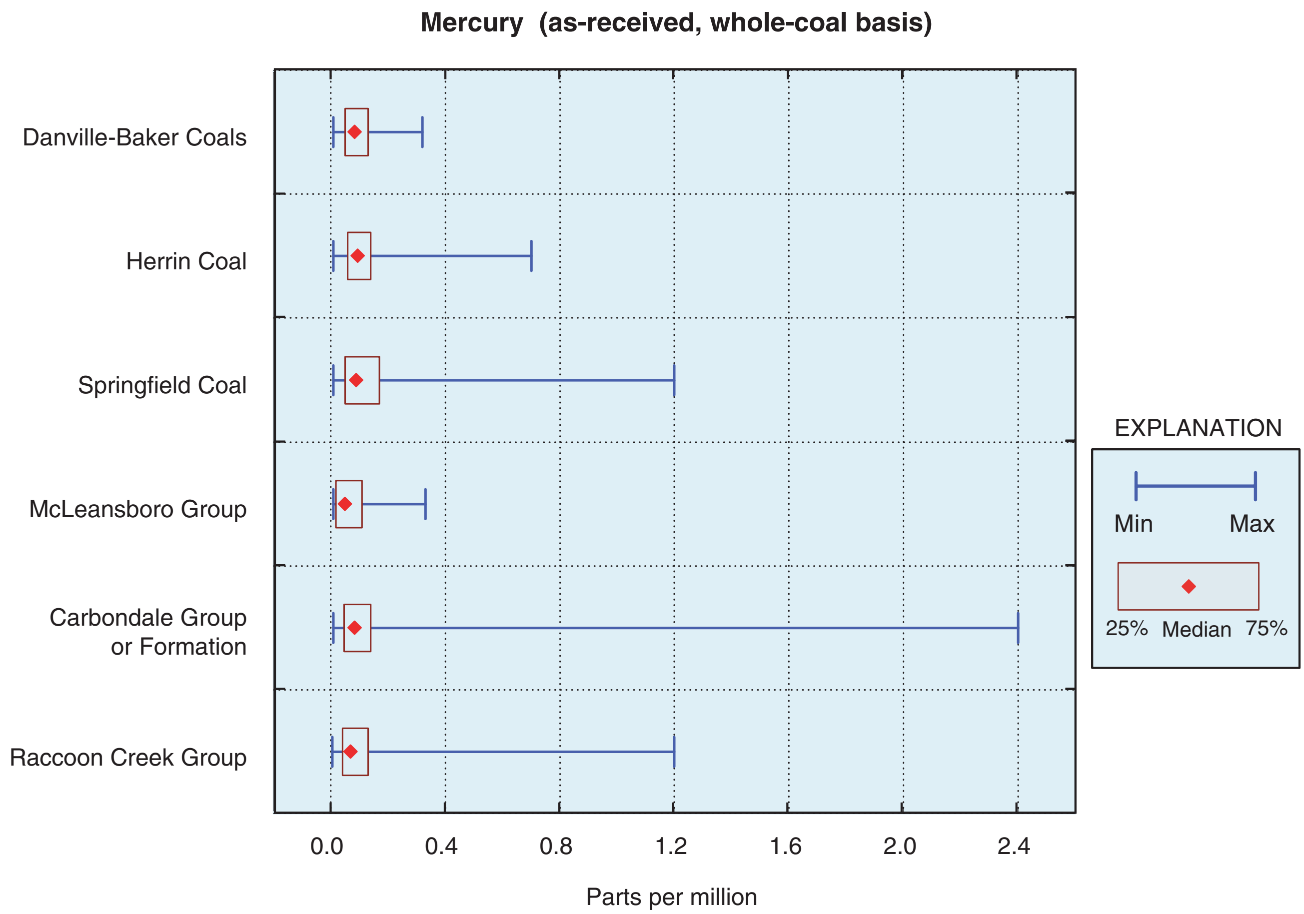

Figure 12. Minimum, maximum, percentile, and median values for mercury content (parts per million, as-received, whole-coal basis) of coals, grouped by assessed coal or stratigraphic unit in the Illinois Basin.

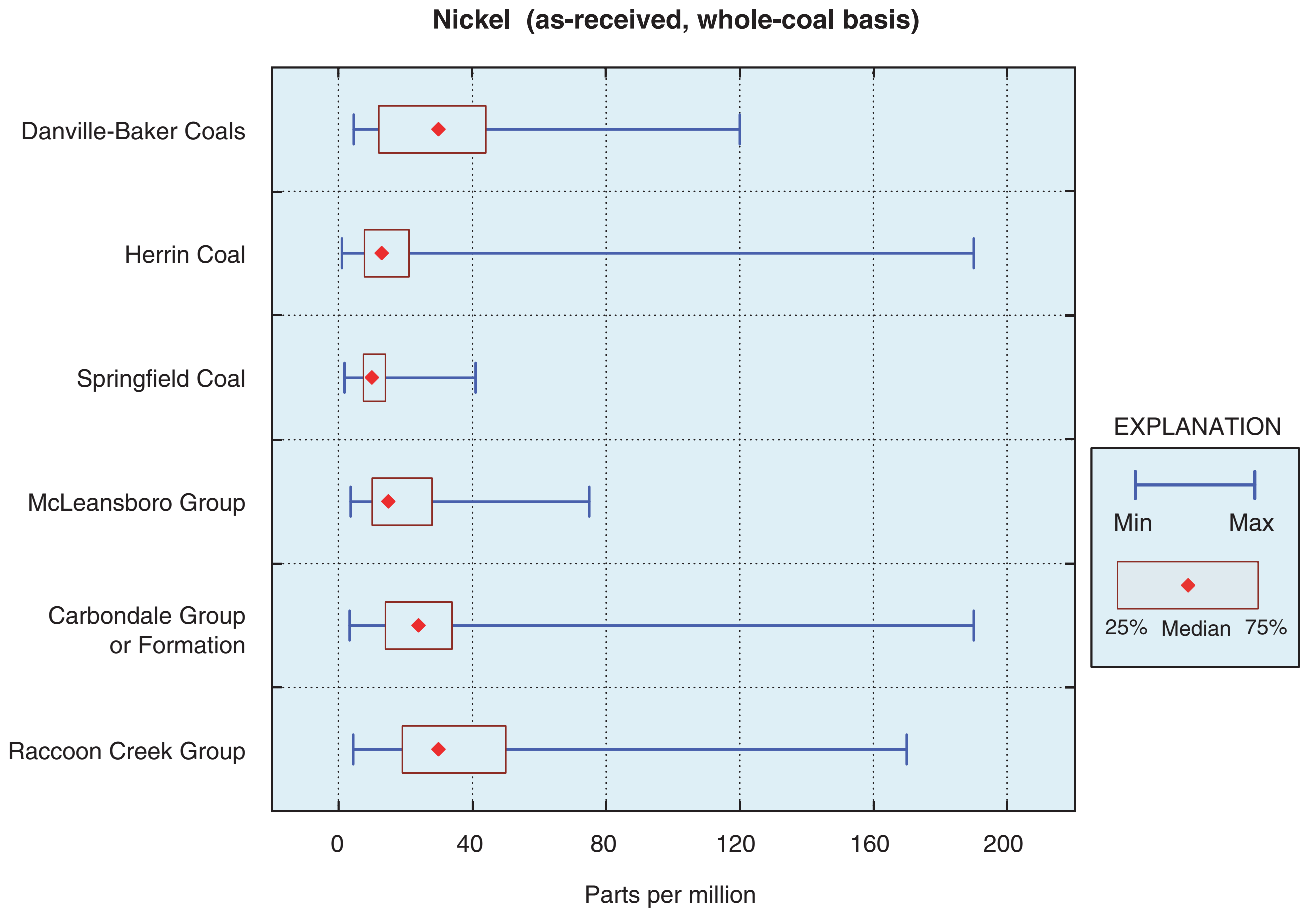

Figure 13. Minimum, maximum, percentile, and median values for nickel content (parts per million, as-received, whole-coal basis) of coals, grouped by assessed coal or stratigraphic unit in the Illinois Basin.

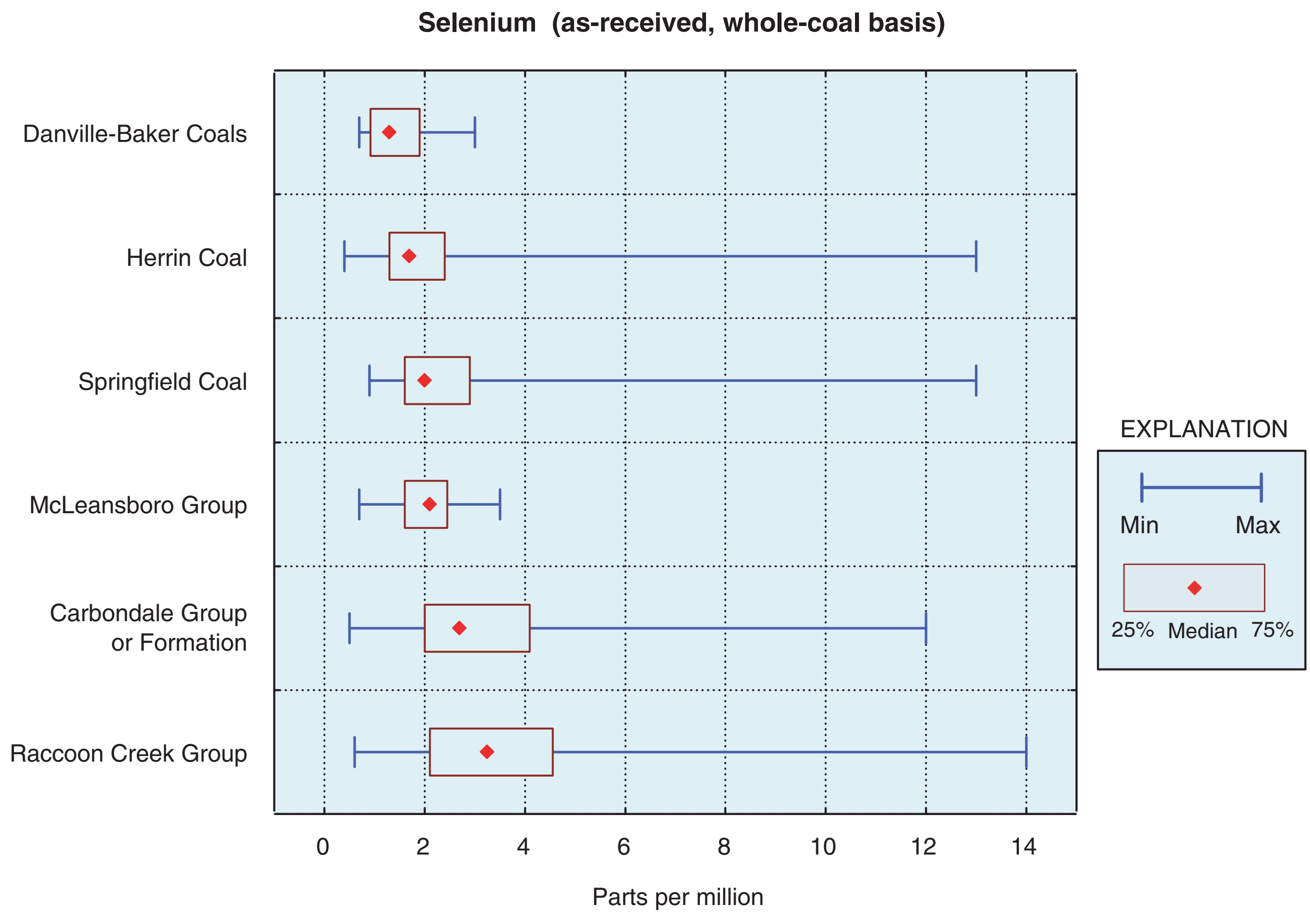

Figure 14. Minimum, maximum, percentile, and median values for selenium content (parts per million, as-received, whole-coal basis) of coals, grouped by assessed coal or stratigraphic unit in the Illinois Basin.

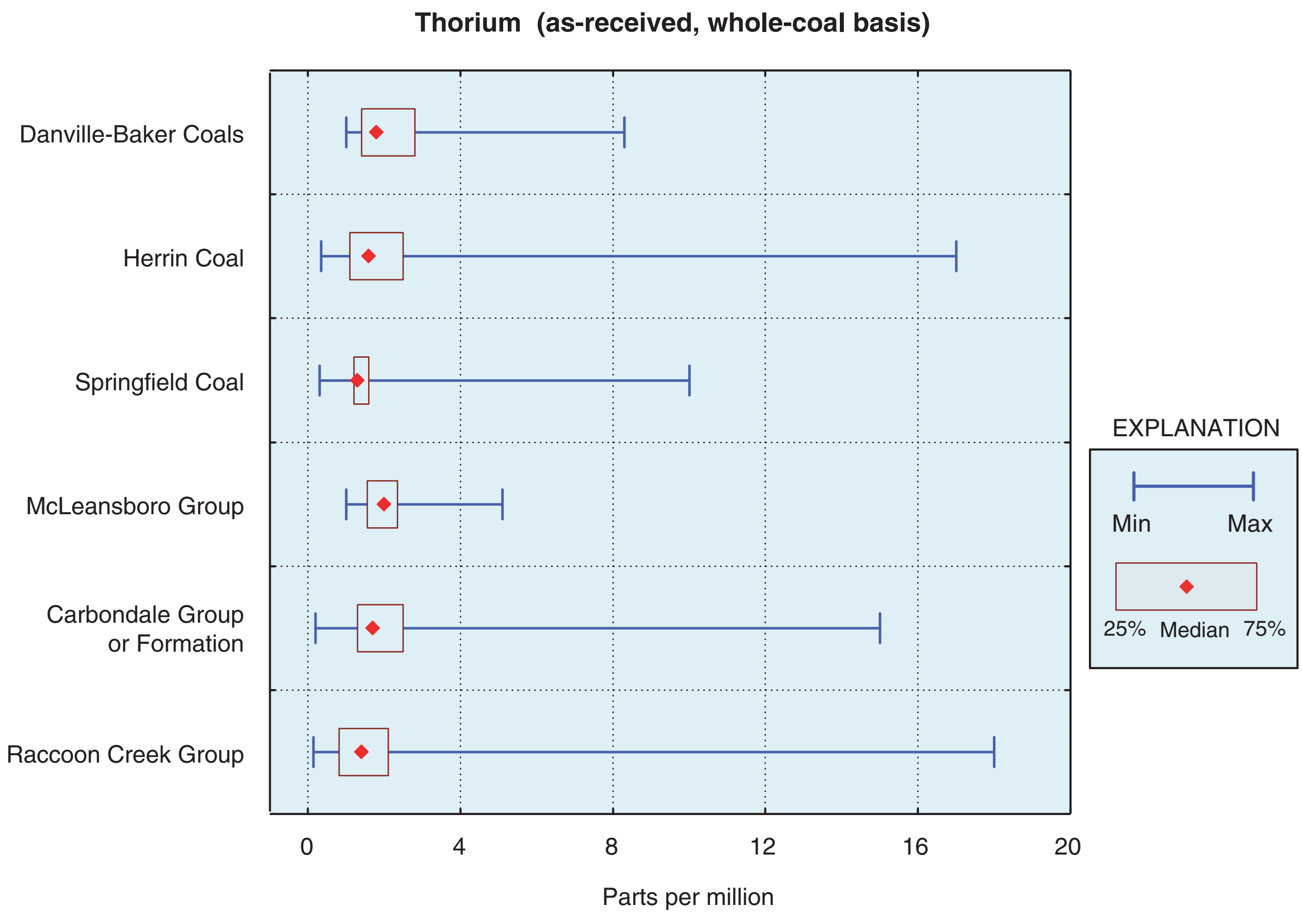

Figure 15. Minimum, maximum, percentile, and median values for thorium content (parts per million, as-received, whole-coal basis) of coals, grouped by assessed coal or stratigraphic unit in the Illinois Basin.

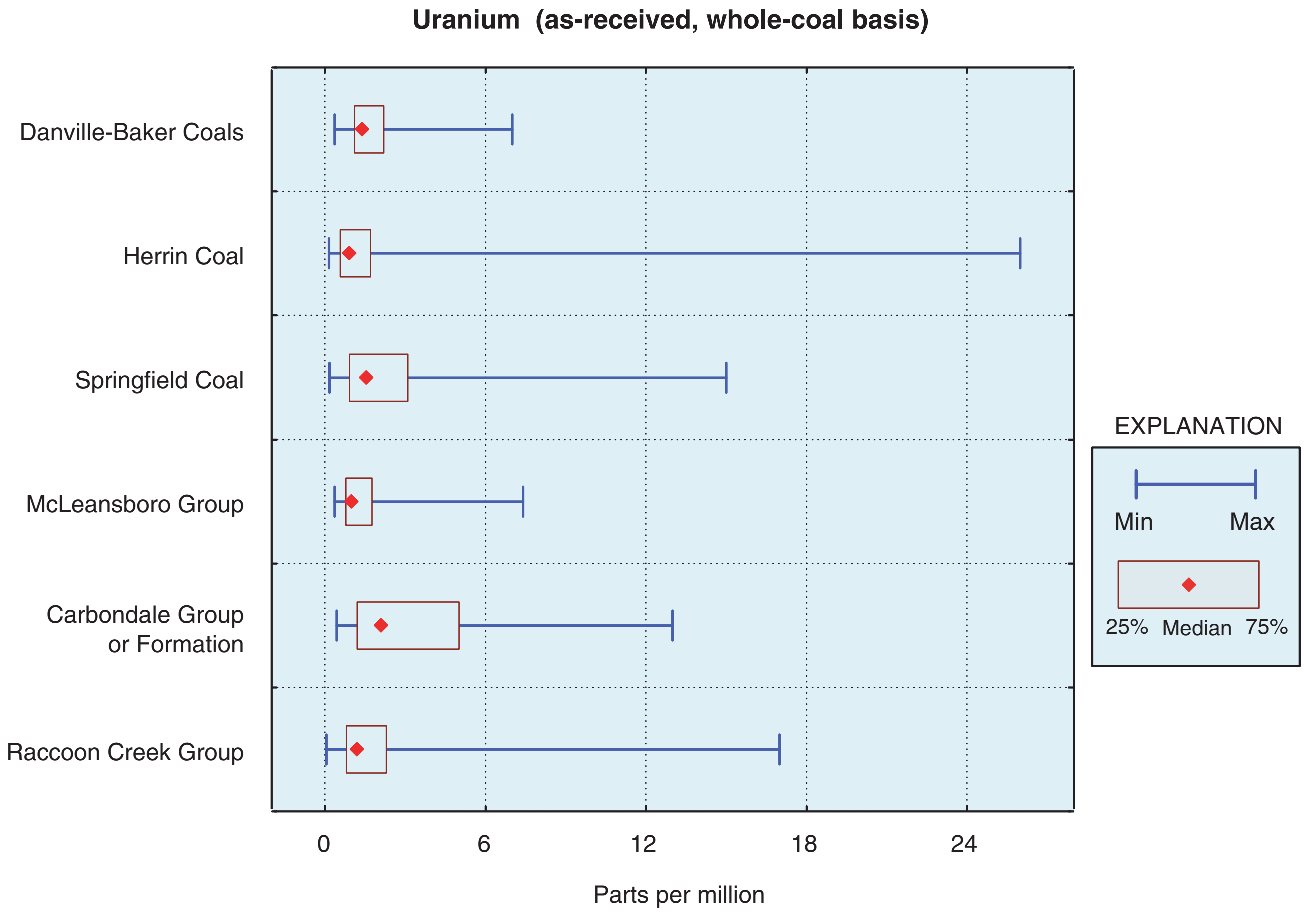

Figure 16. Minimum, maximum, percentile, and median values for uranium content (parts per million, as-received, whole-coal basis) of coals, grouped by assessed coal or stratigraphic unit in the Illinois Basin.

Appendix 6. Histograms of ash yield, sulfur content, calorific value, and elements of environmental concern for the Springfield, Herrin, and Danville-Baker Coals in the Illinois Basin.

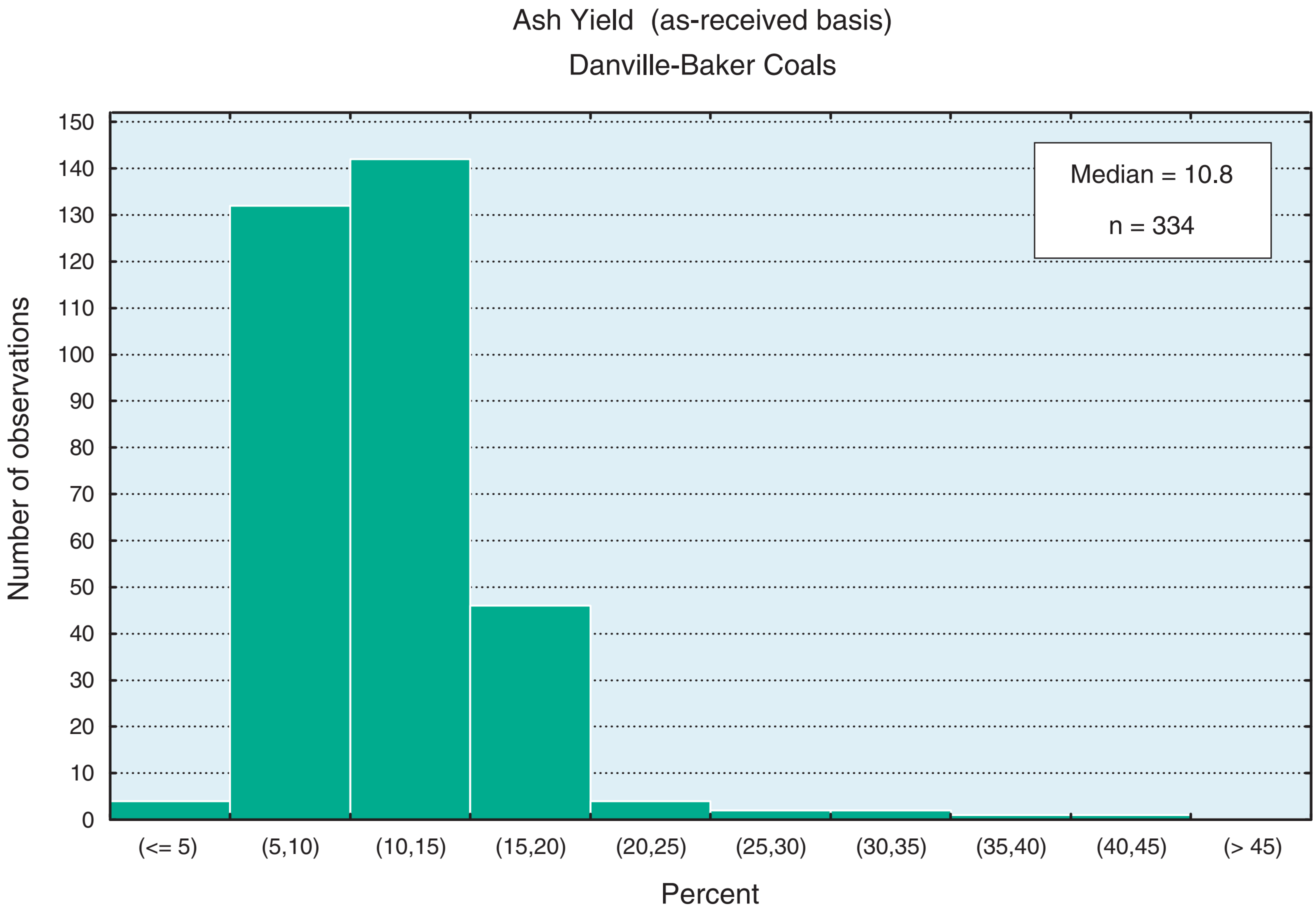

Figure 1. Histogram of ash yield (percent, as-received basis) of the Danville-Baker Coals in the Illinois Basin. Intervals on the x-axis are shown in parentheses.

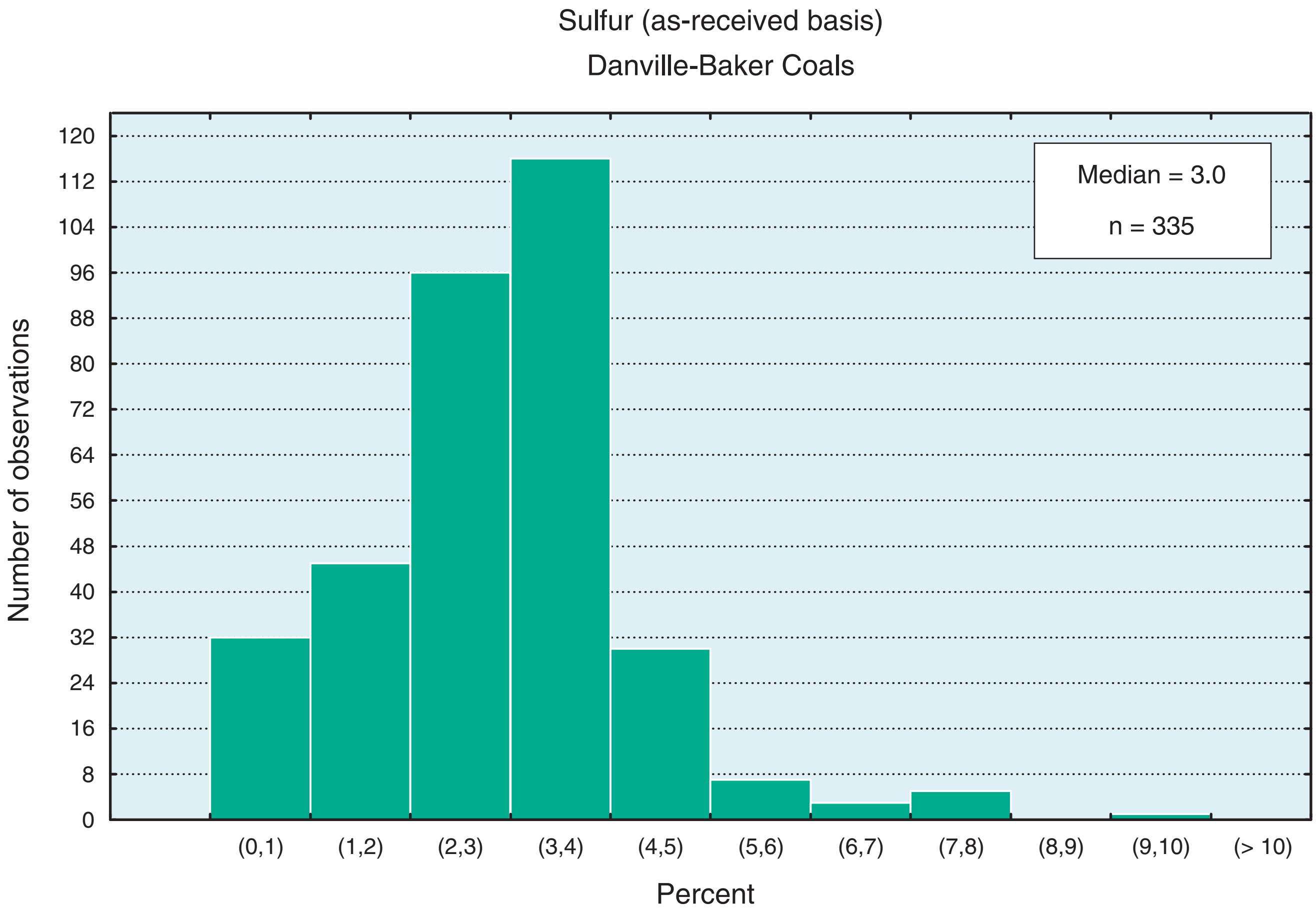

Figure 2. Histogram of sulfur content (percent, as-received basis) of the Danville-Baker Coals in the Illinois Basin. Intervals on the x-axis are shown in parentheses.

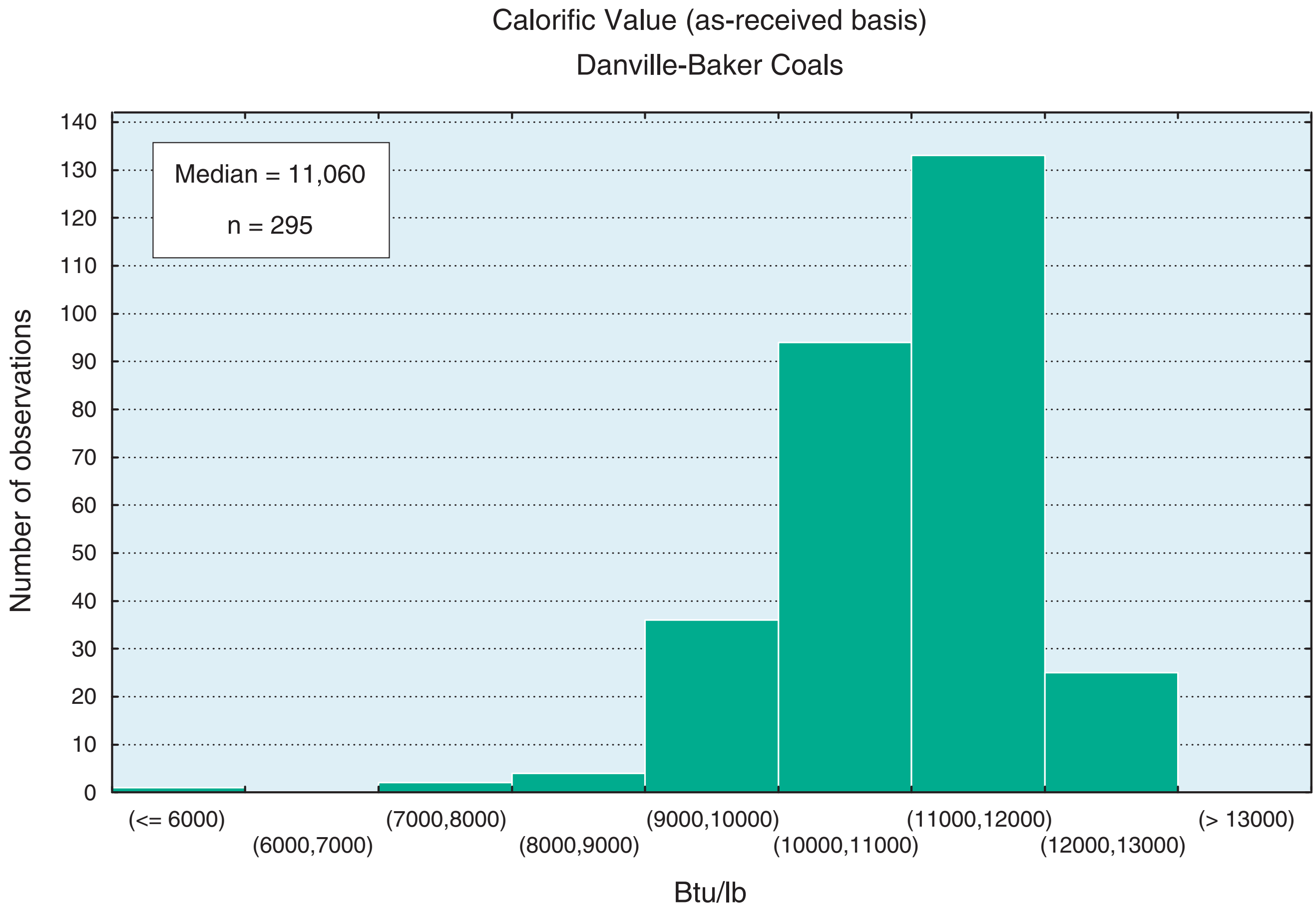

Figure 3. Histogram of calorific values (Btu/lb, as-received basis) of the Danville-Baker Coals in the Illinois Basin. Intervals on the x-axis are shown in parentheses

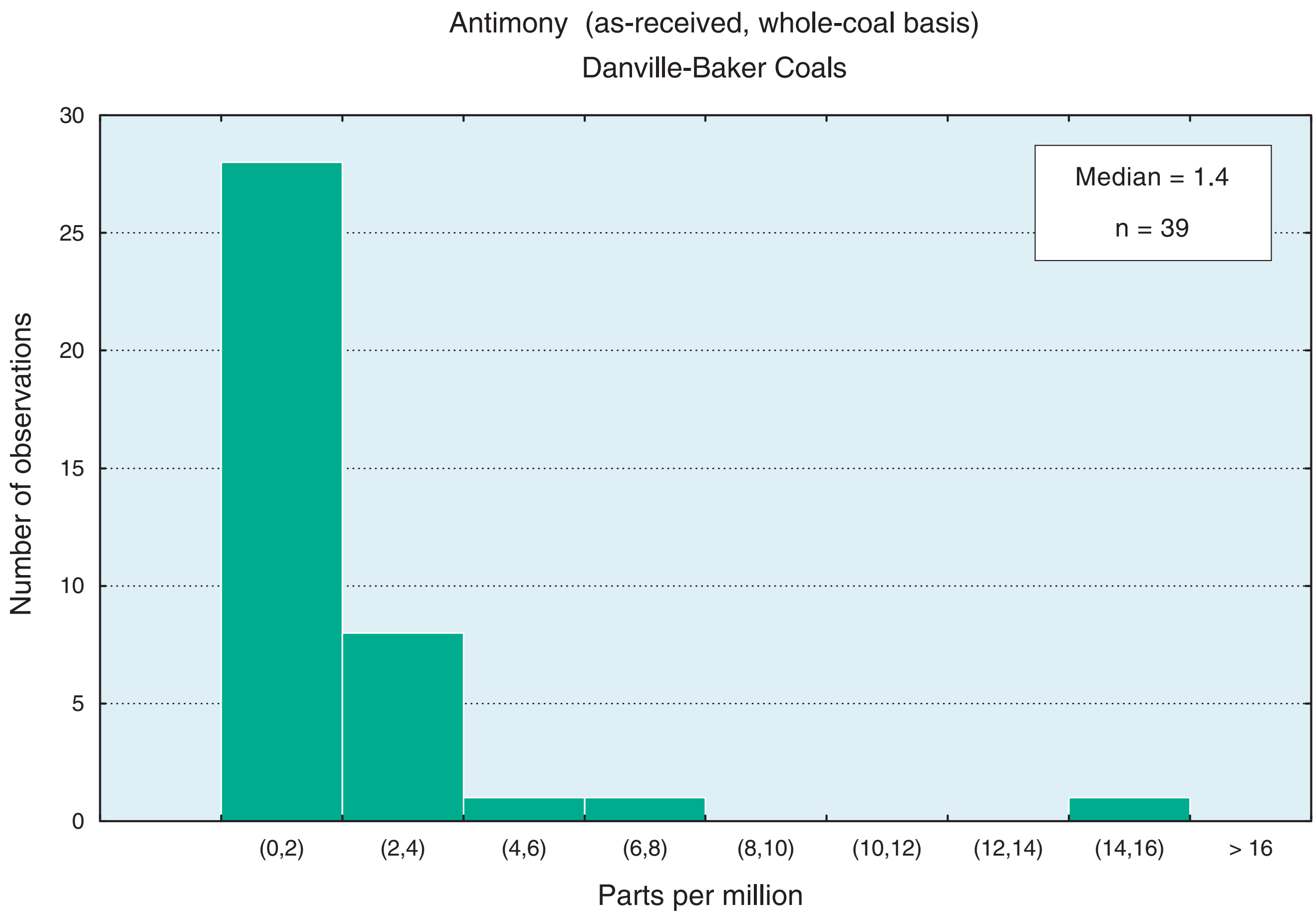

Figure 4. Histogram of antimony content (parts per million, as-received, whole-coal basis) of the Danville-Baker Coals in the Illinois Basin. Intervals on the x-axis are shown in parentheses.

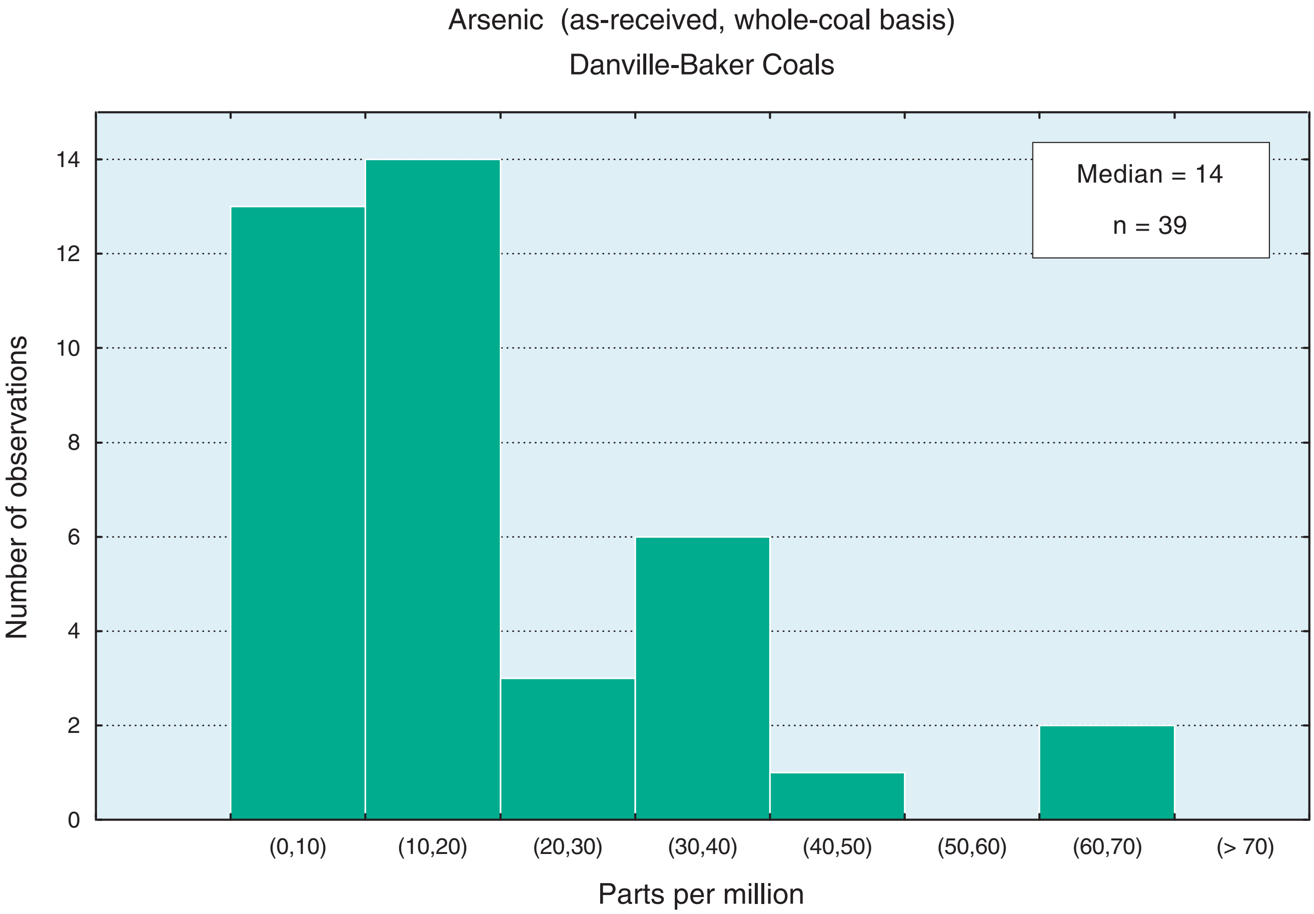

Figure 5. Histogram of arsenic content (parts per million, as-received, whole-coal basis) of the Danville-Baker Coals in the Illinois Basin. Intervals on the x-axis are shown in parentheses.

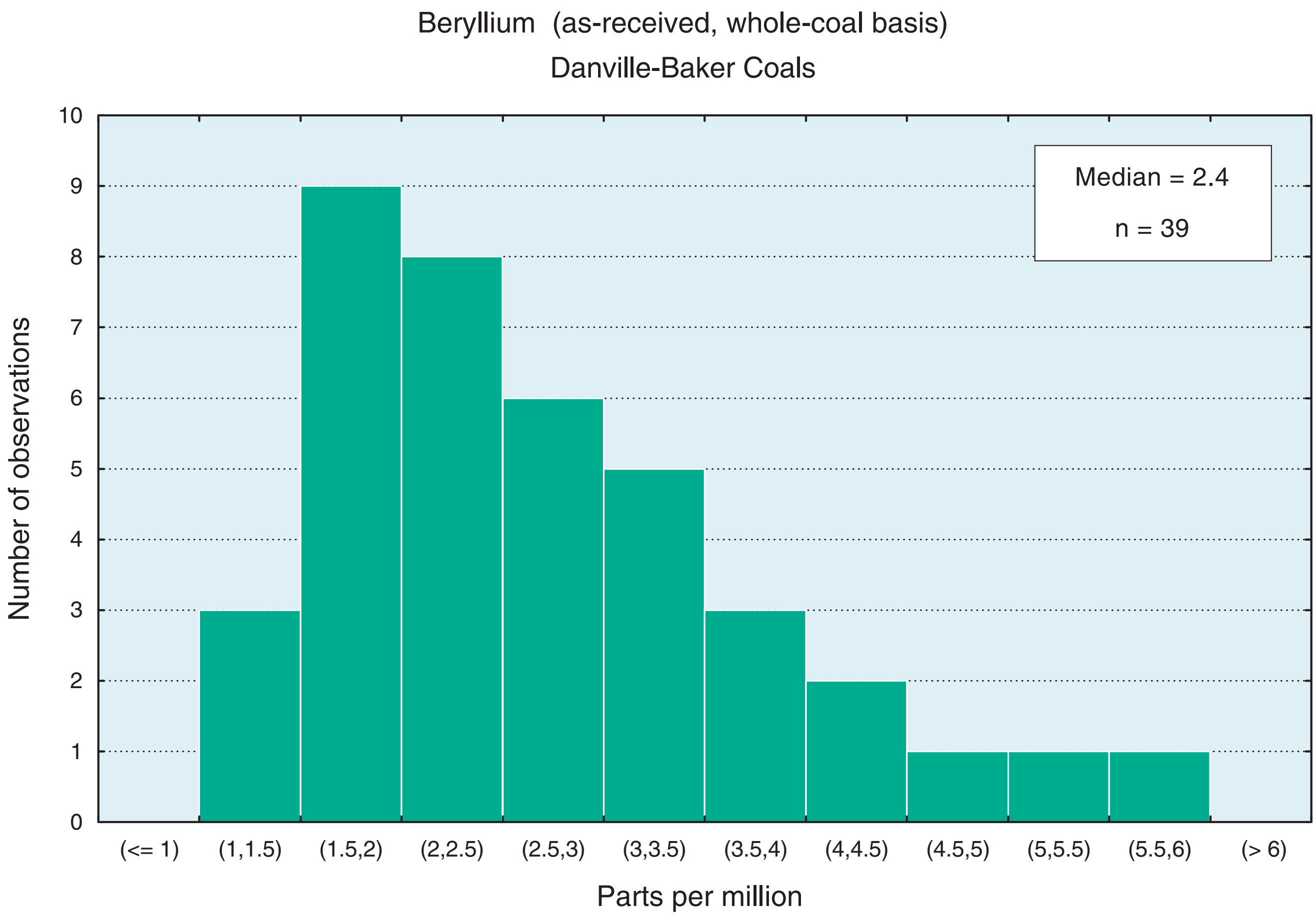

Figure 6. Histogram of beryllium content (parts per million, as-received, whole-coal basis) of the Danville-Baker Coals in the Illinois Basin. Intervals on the x-axis are shown in parentheses.

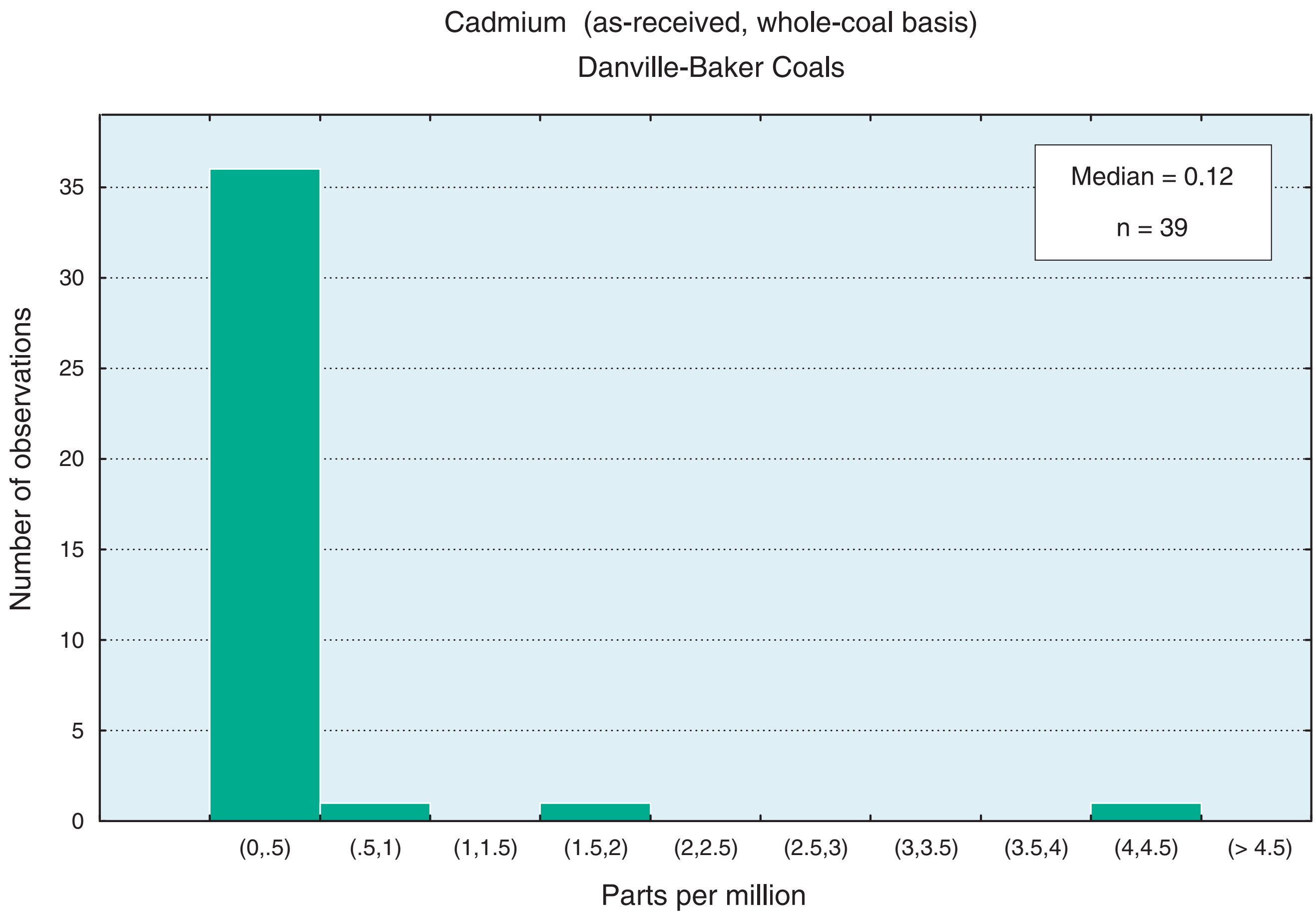

Figure 7. Histogram of cadmium content (parts per million, as-received, whole-coal basis) of the Danville-Baker Coals in the Illinois Basin. Intervals on the x-axis are shown in parentheses.

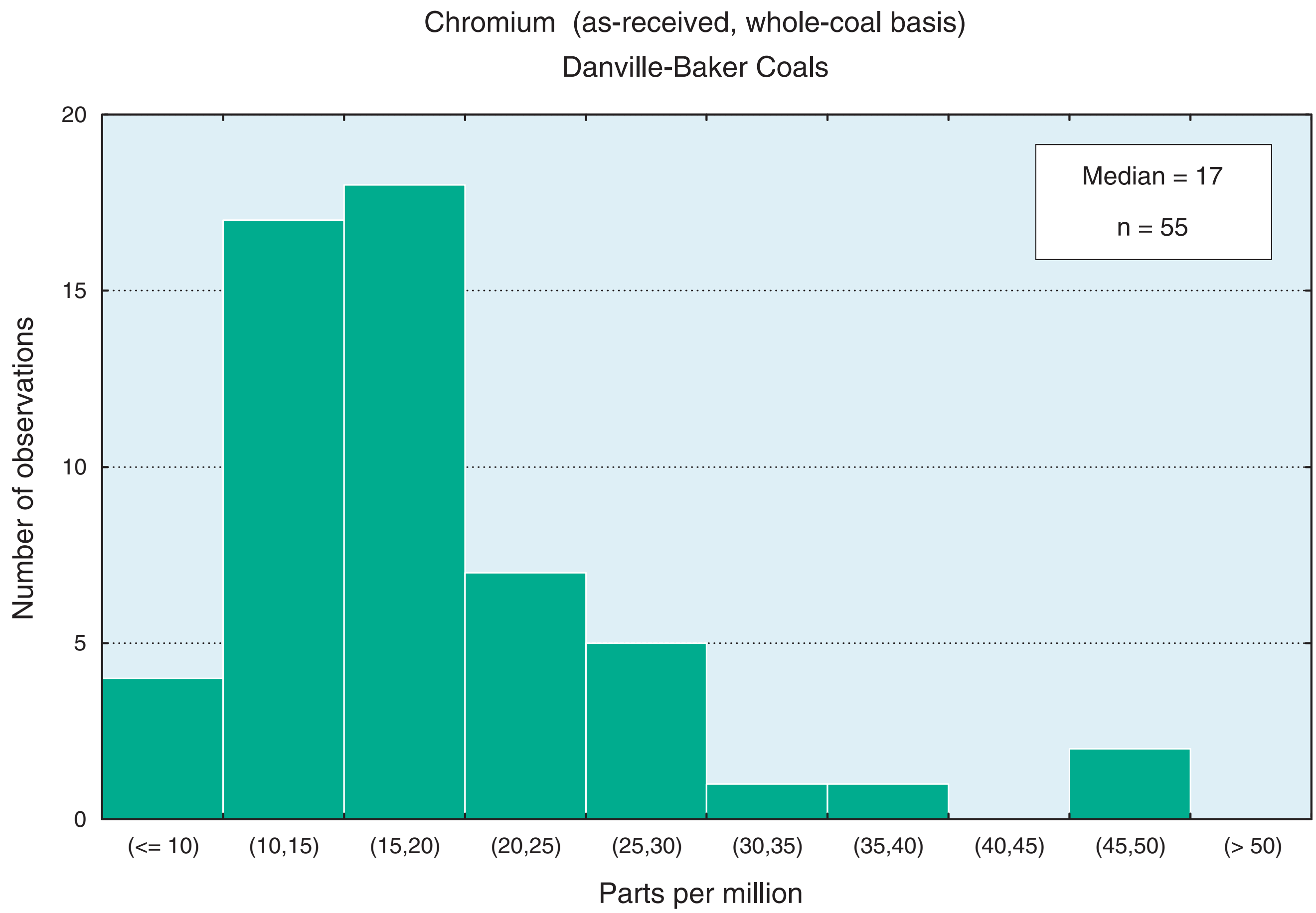

Figure 8. Histogram of chromium content (parts per million, as-received, whole-coal basis) of the Danville-Baker Coals in the Illinois Basin. Intervals on the x-axis are shown in parentheses.

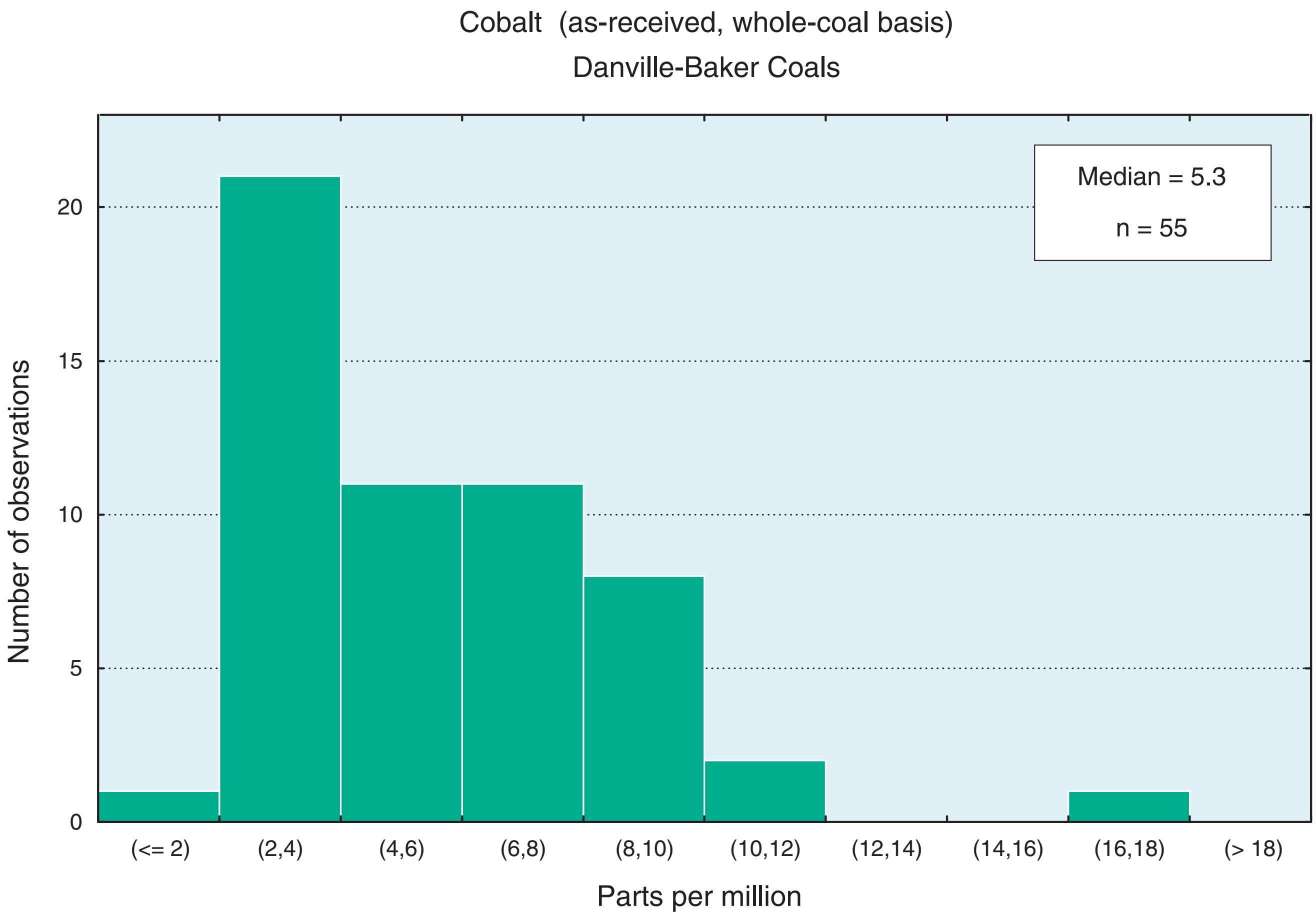

Figure 9. Histogram of cobalt content (parts per million, as-received, whole-coal basis) of the Danville-Baker Coals in the Illinois Basin. Intervals on the x-axis are shown in parentheses.

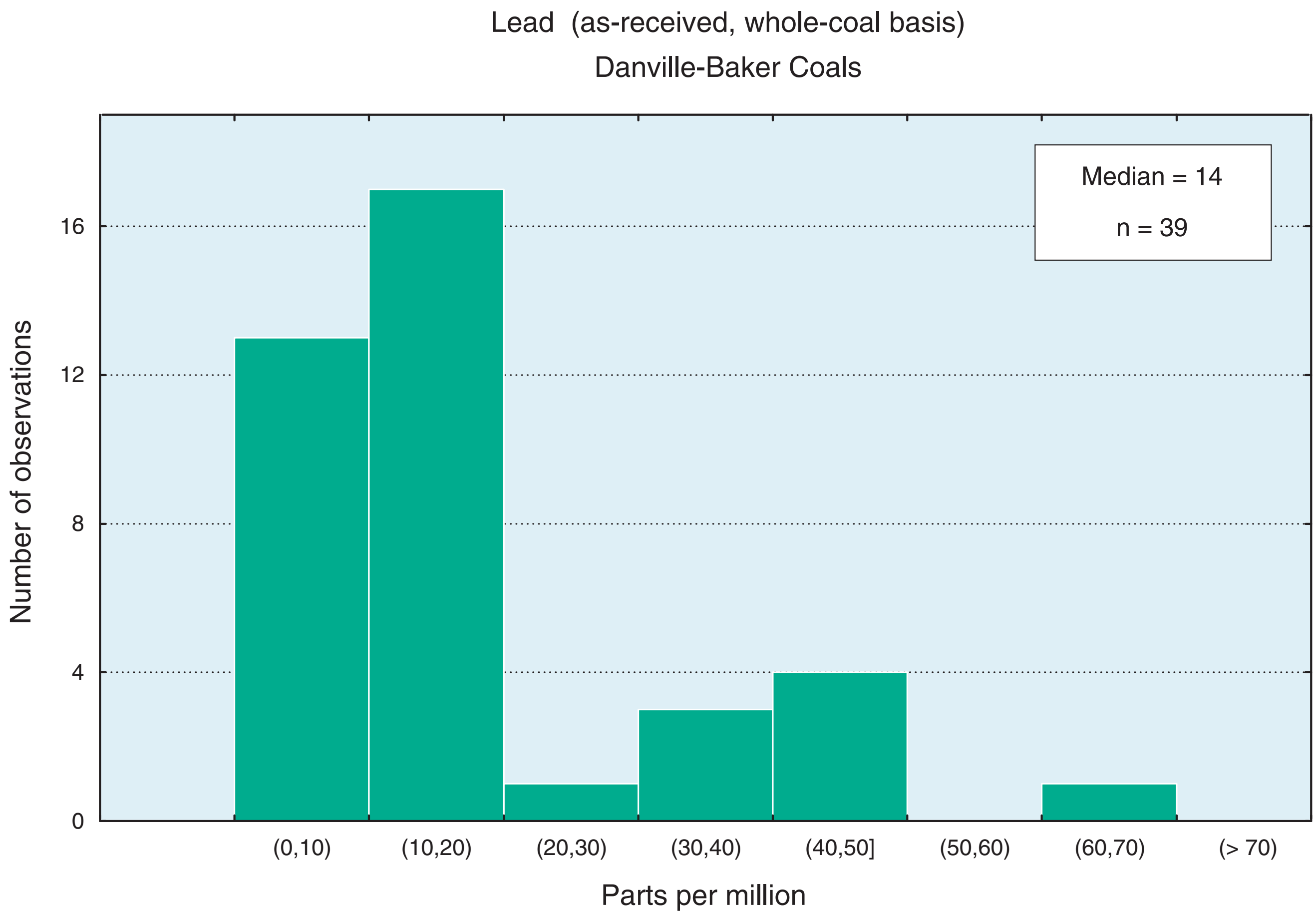

Figure 10. Histogram of lead content (parts per million, as-received, whole-coal basis) of the Danville-Baker Coals in the Illinois Basin. Intervals on the x-axis are shown in parentheses.

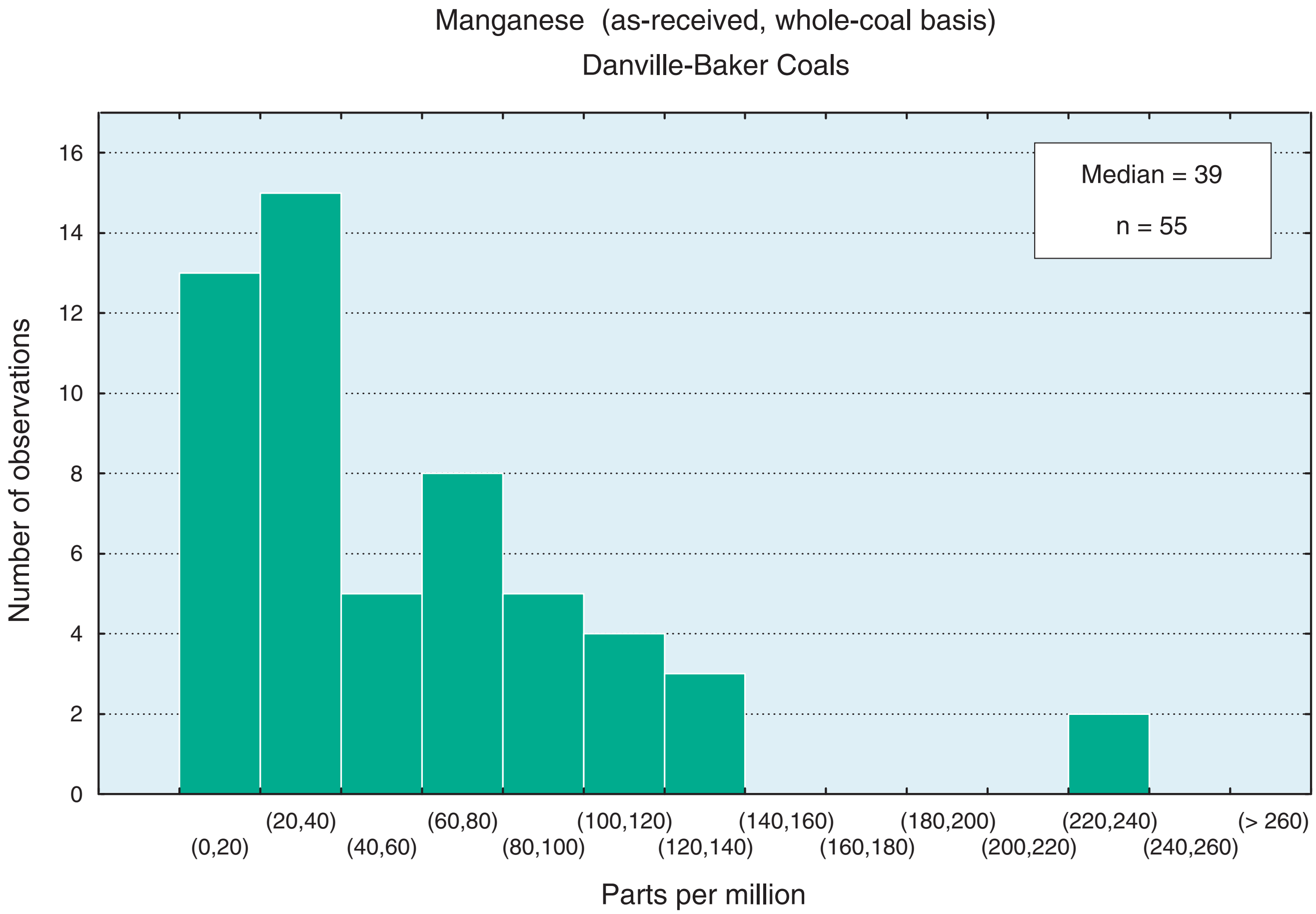

Figure 11. Histogram of manganese content (parts per million, as-received, whole-coal basis) of the Danville-Baker Coals in the Illinois Basin. Intervals on the x-axis are shown in parentheses.

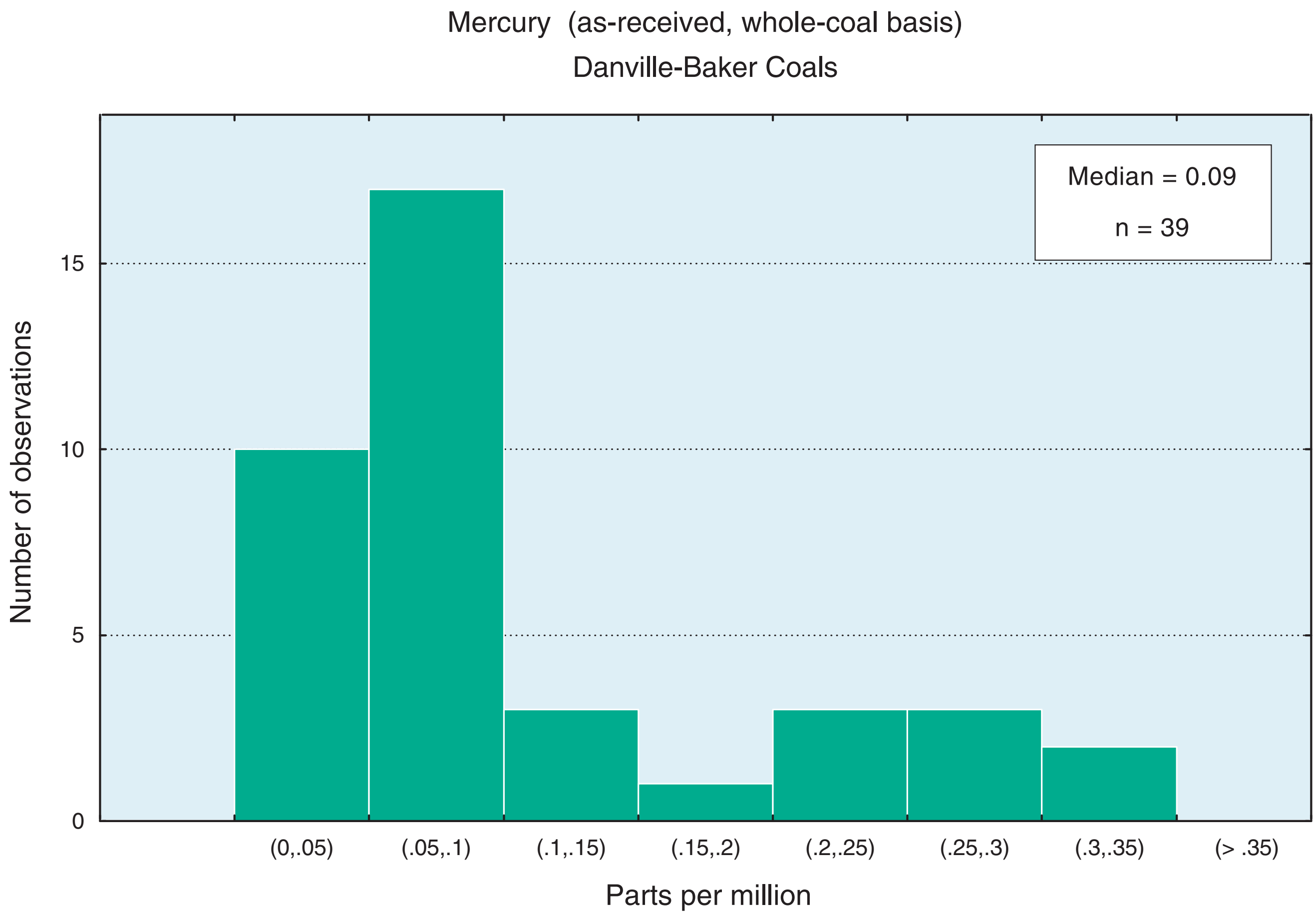

Figure 12. Histogram of mercury content (parts per million, as-received, whole-coal basis) of the Danville-Baker Coals in the Illinois Basin. Intervals on the x-axis are shown in parentheses.

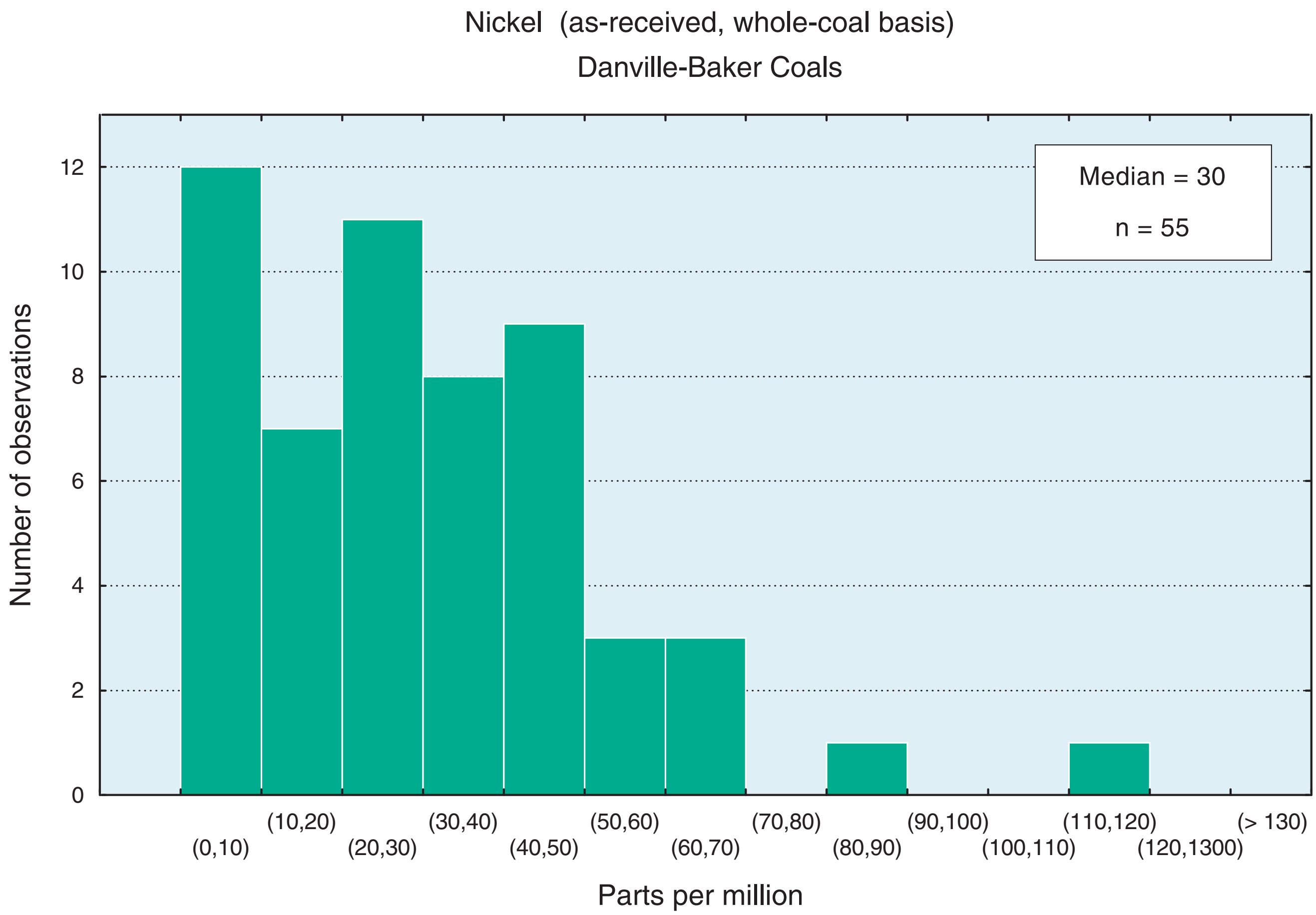

Figure 13. Histogram of nickel content (parts per million, as-received, whole-coal basis) of the Danville-Baker Coals in the Illinois Basin. Intervals on the x-axis are shown in parentheses.

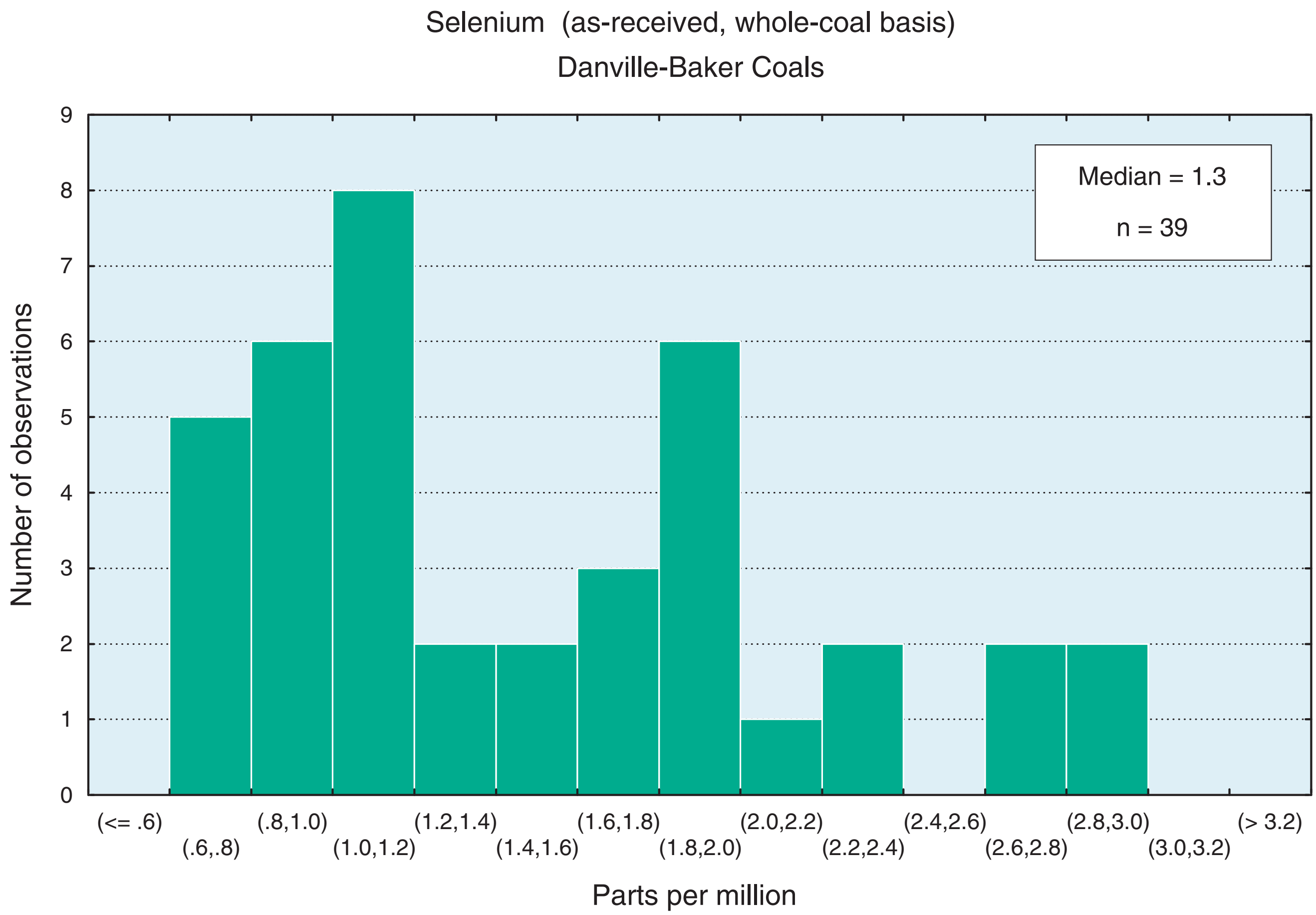

Figure 14. Histogram of selenium content (parts per million, as-received, whole-coal basis) of the Danville-Baker Coals in the Illinois Basin. Intervals on the x-axis are shown in parentheses.

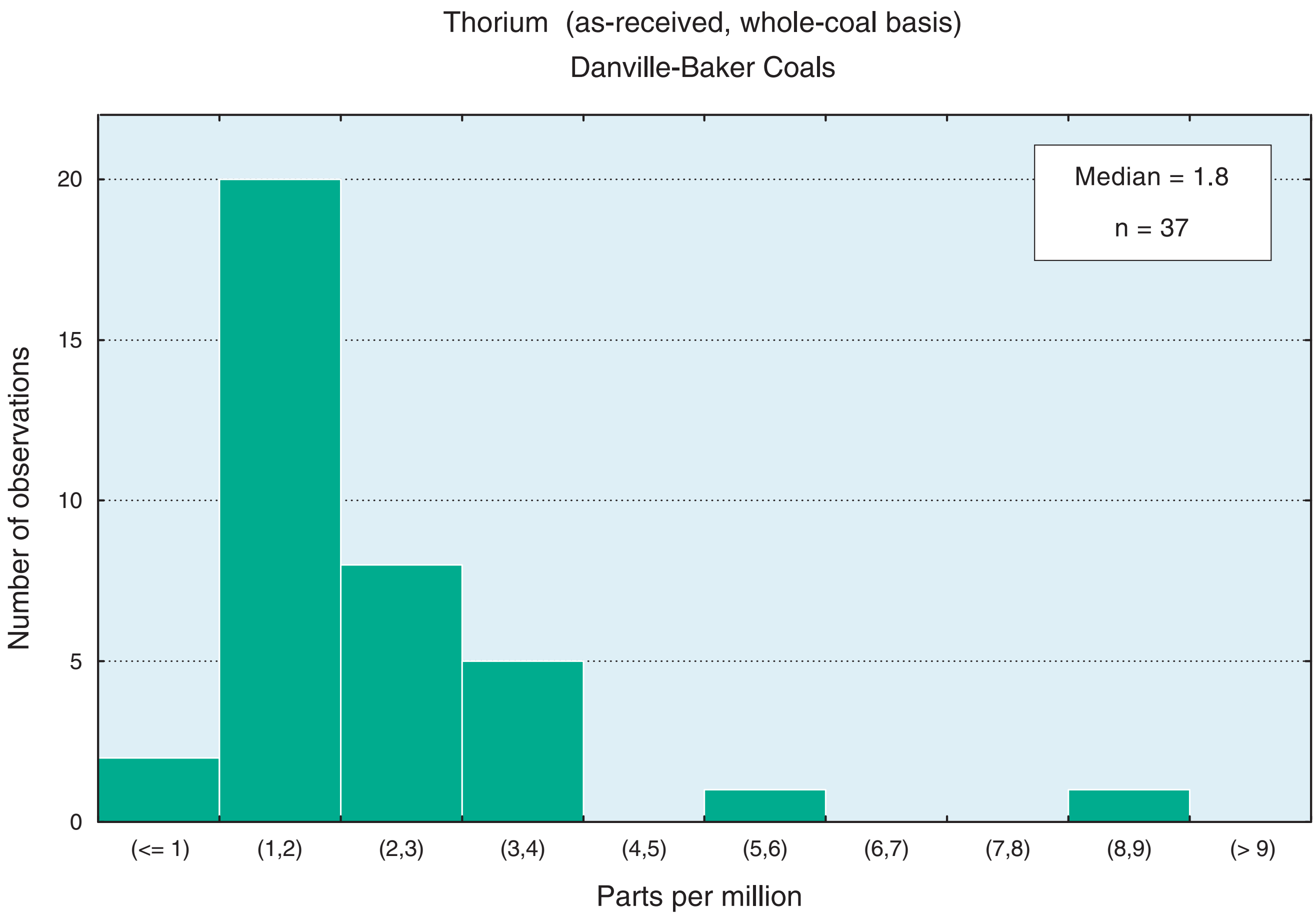

Figure 15. Histogram of thorium content (parts per million, as-received, whole-coal basis) of the Danville-Baker Coals in the Illinois Basin. Intervals on the x-axis are shown in parentheses.

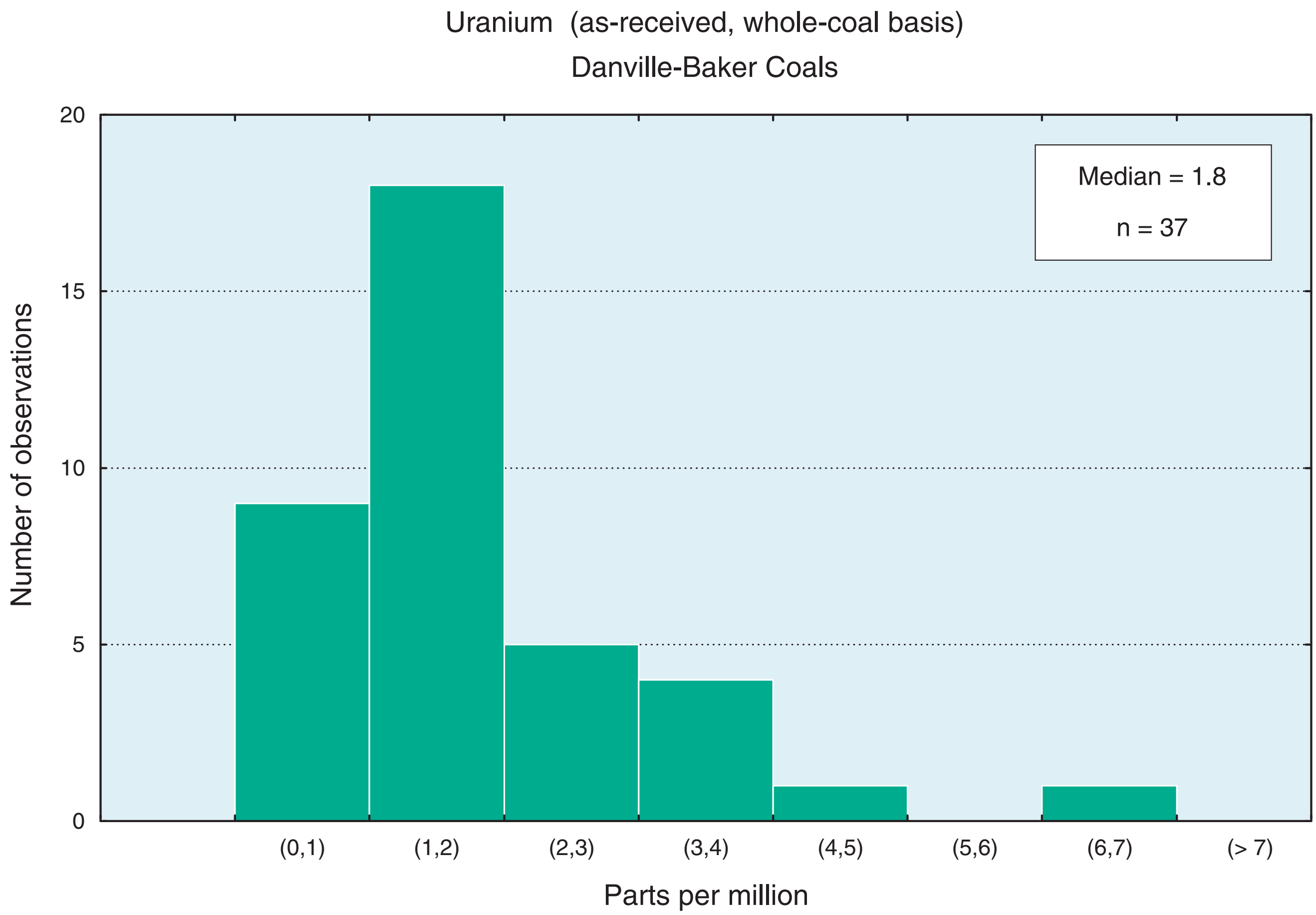

Figure 16. Histogram of uranium content (parts per million, as-received, whole-coal basis) of the Danville-Baker Coals in the Illinois Basin. Intervals on the x-axis are shown in parentheses.

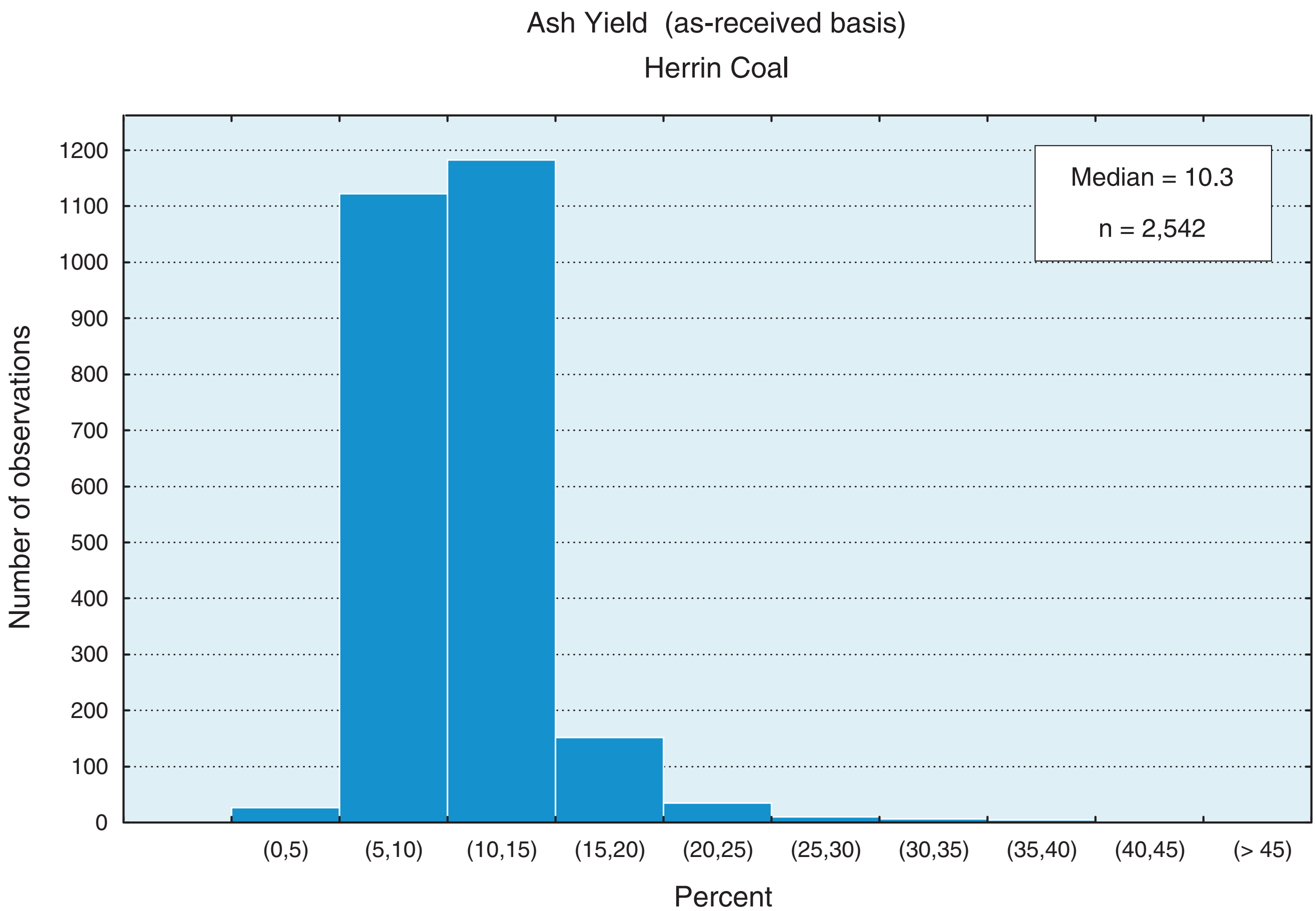

Figure 17. Histogram of ash yield (percent, as-received basis) of the Herrin Coal in the Illinois Basin. Intervals on the x-axis are shown in parentheses.

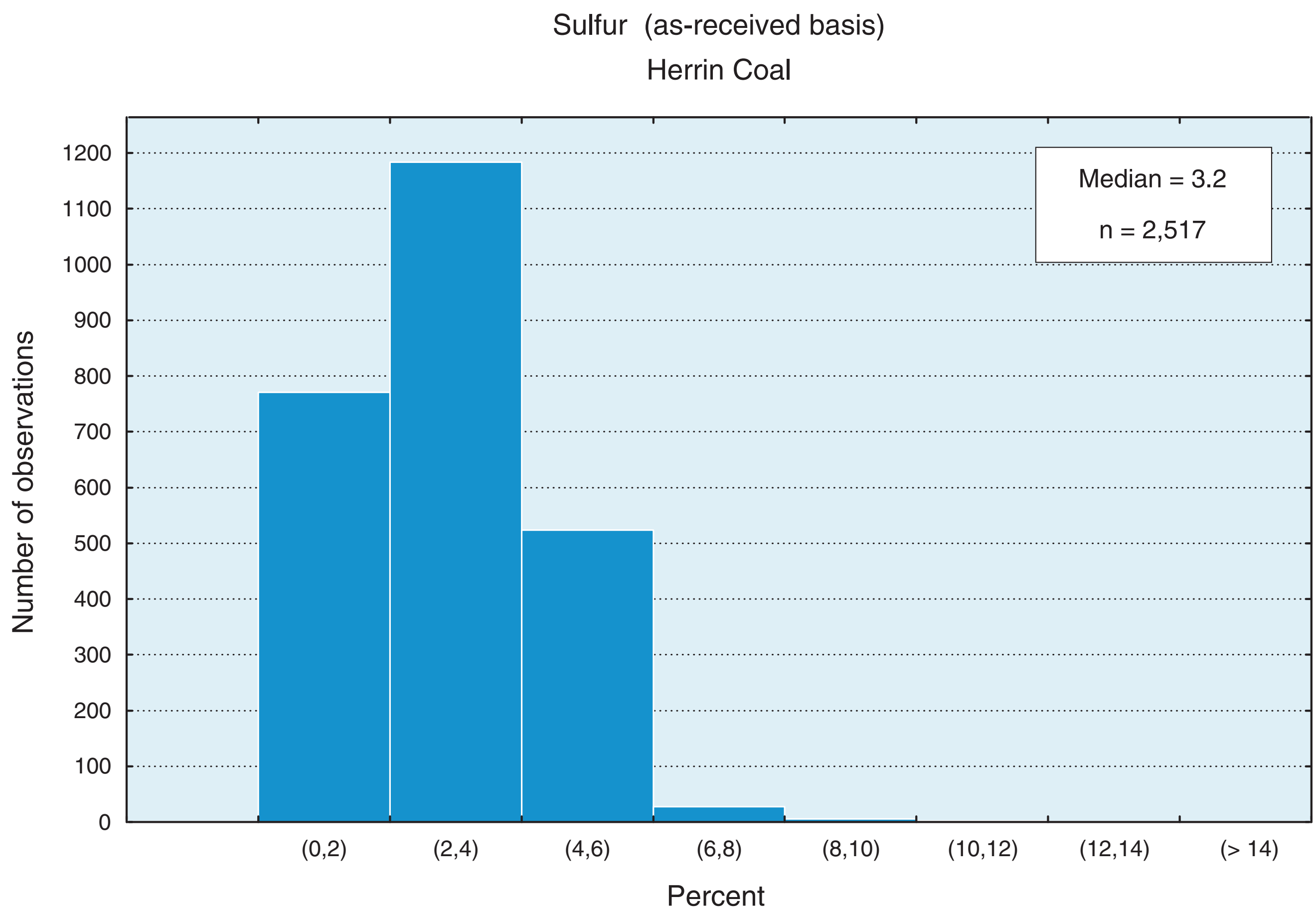

Figure 18. Histogram of sulfur content (percent, as-received basis) of the Herrin Coal in the Illinois Basin. Intervals on the x-axis are shown in parentheses.

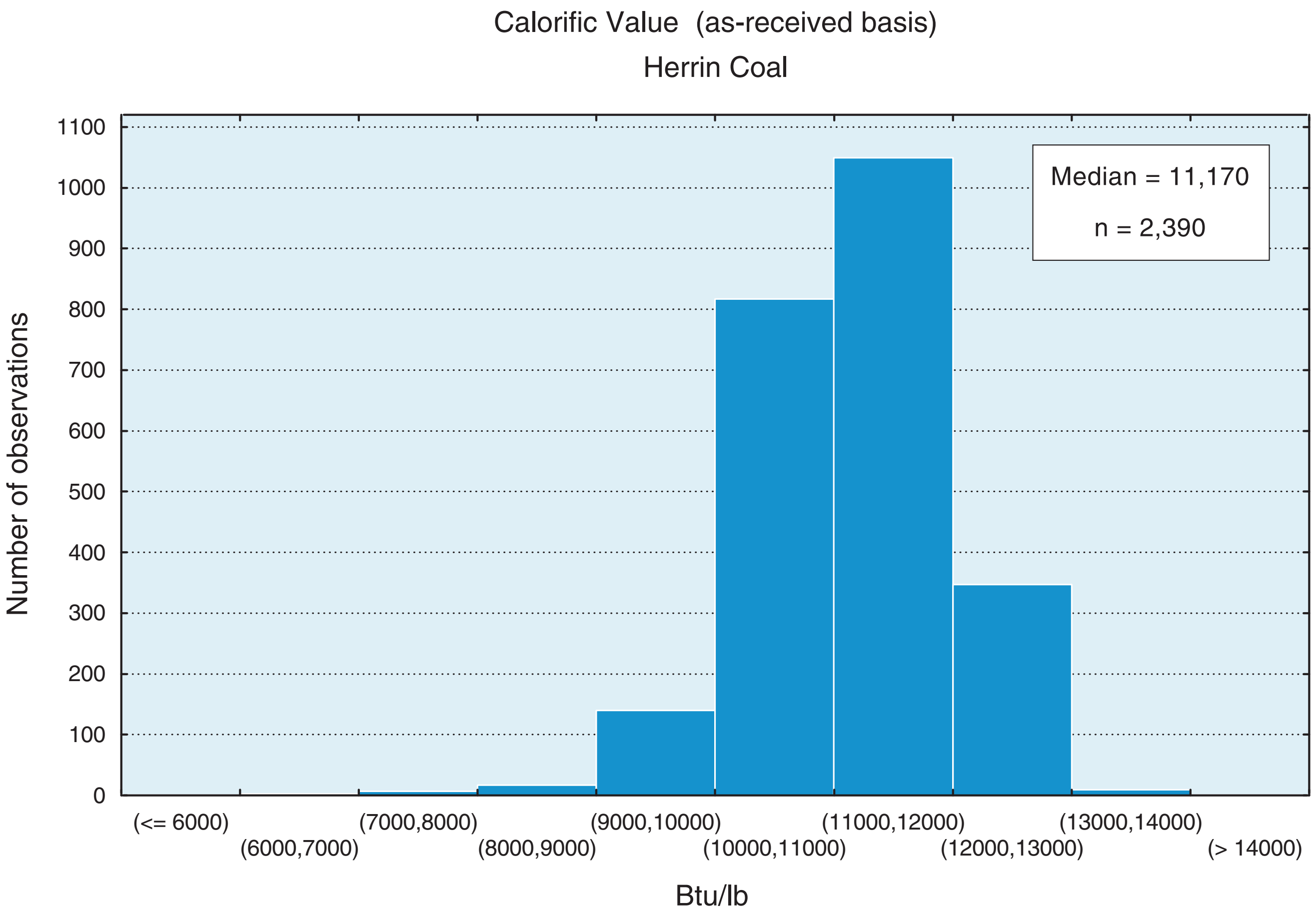

Figure 19. Histogram of calorific values (Btu/lb, as-received basis) of the Herrin Coal in the Illinois Basin. Intervals on the x-axis are shown in parentheses.

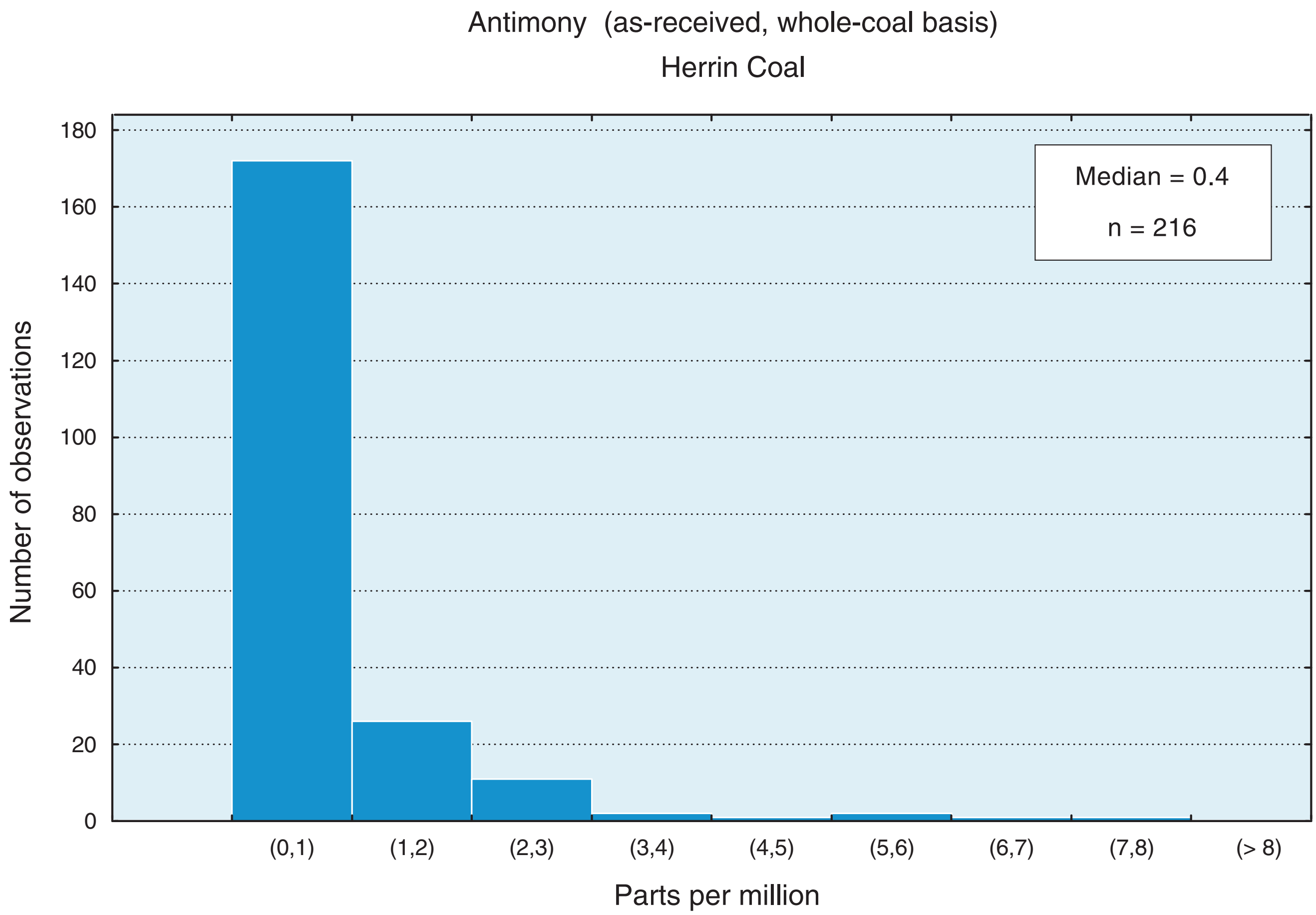

Figure 20. Histogram of antimony content (parts per million, as-received, whole-coal basis) of the Herrin Coal in the Illinois Basin. Intervals on the x-axis are shown in parentheses.

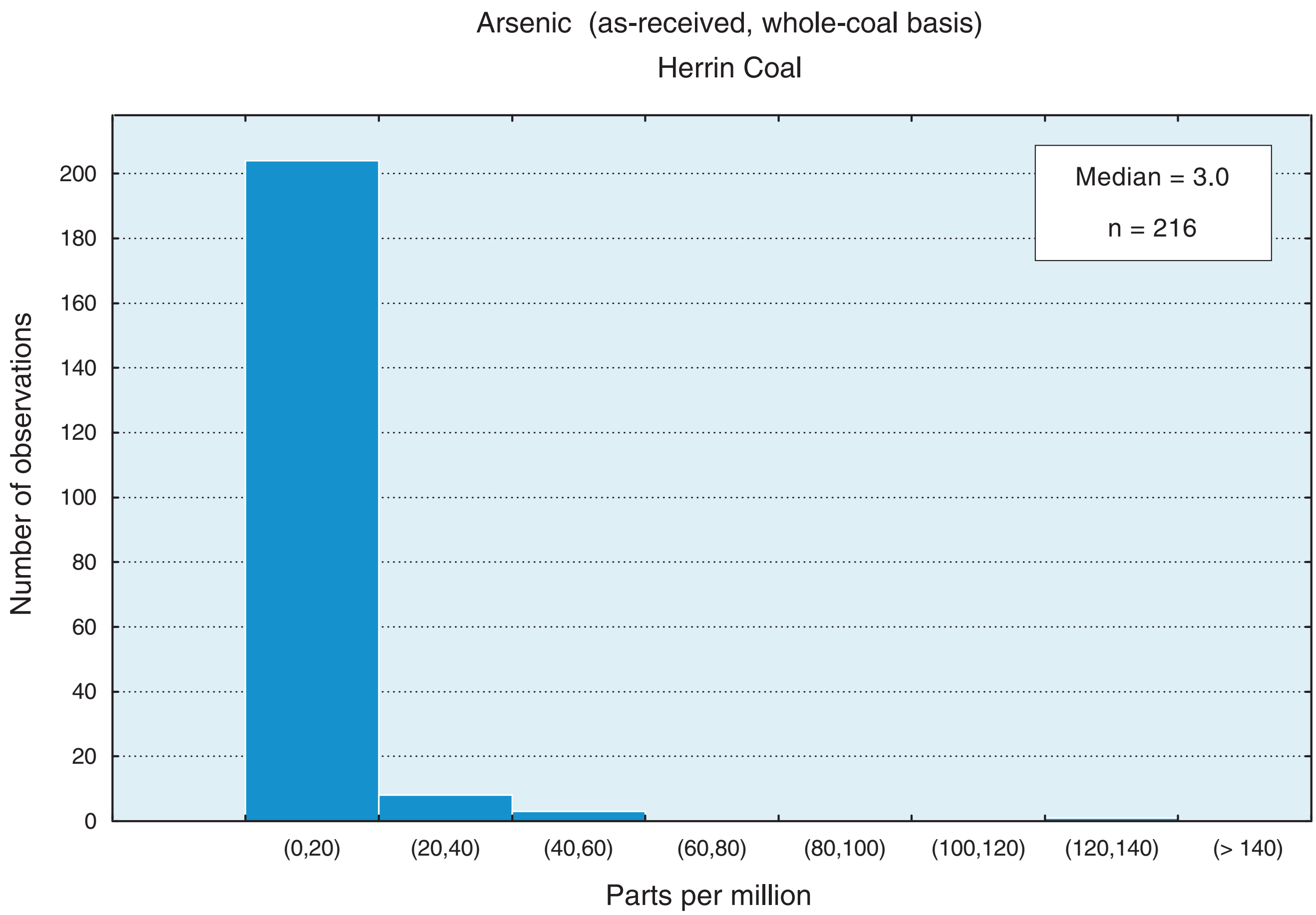

Figure 21. Histogram of arsenic content (parts per million, as-received, whole-coal basis) of the Herrin Coal in the Illinois Basin. Intervals on the x-axis are shown in parentheses.

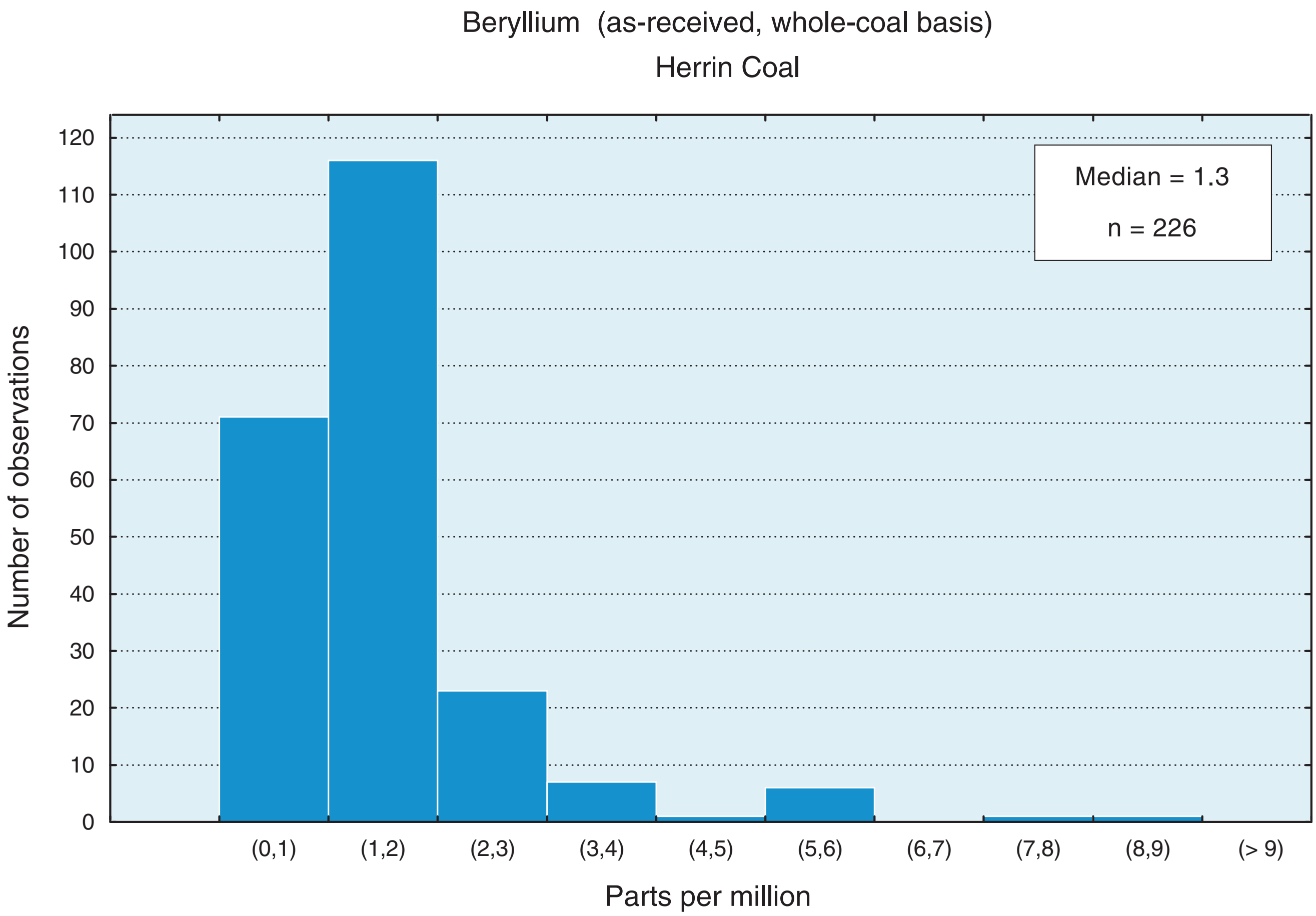

Figure 22. Histogram of beryllium content (parts per million, as-received, whole-coal basis) of the Herrin Coal in the Illinois Basin. Intervals on the x-axis are shown in parentheses.

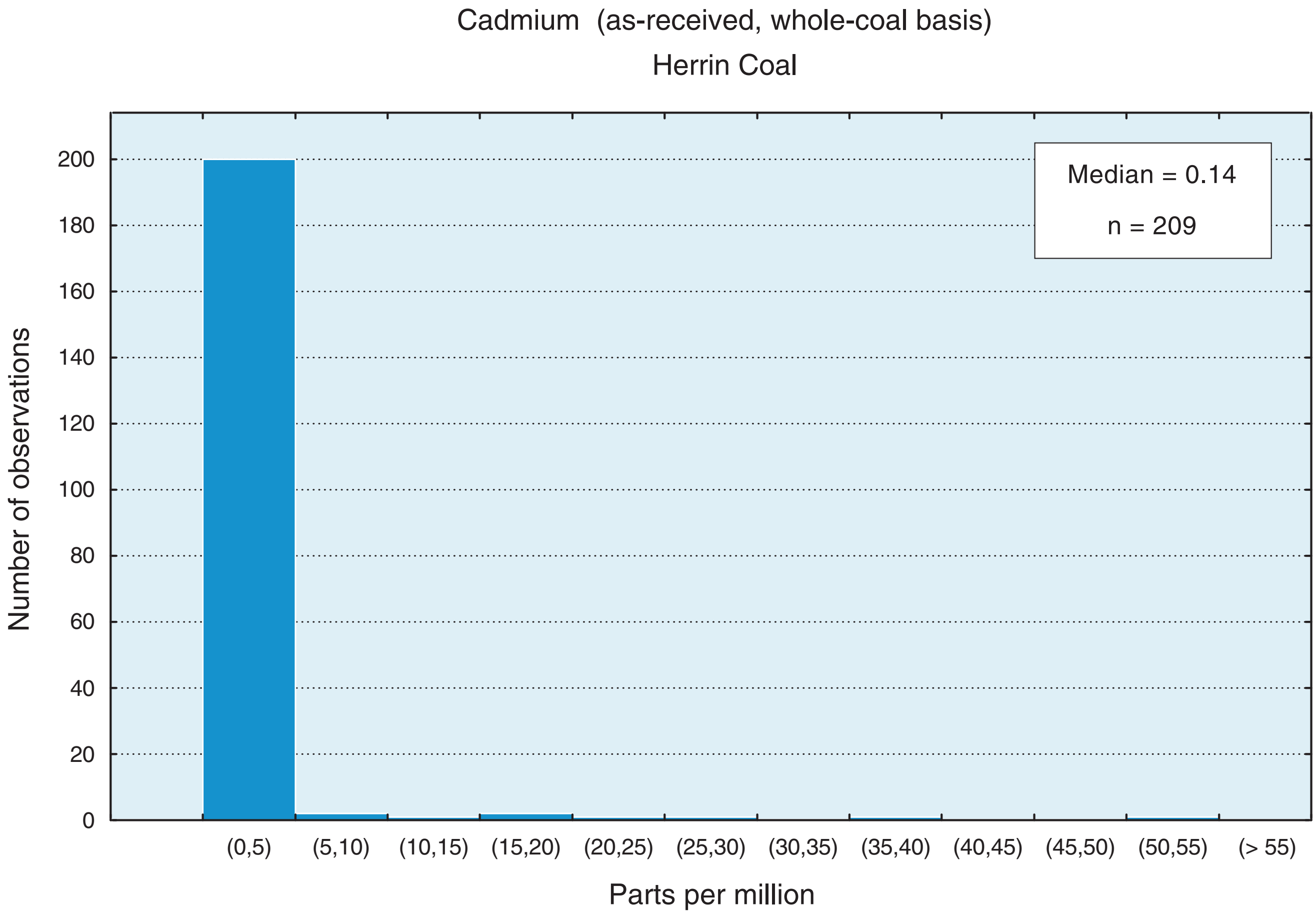

Figure 23. Histogram of cadmium content (parts per million, as-received, whole-coal basis) of the Herrin Coal in the Illinois Basin. Intervals on the x-axis are shown in parentheses.

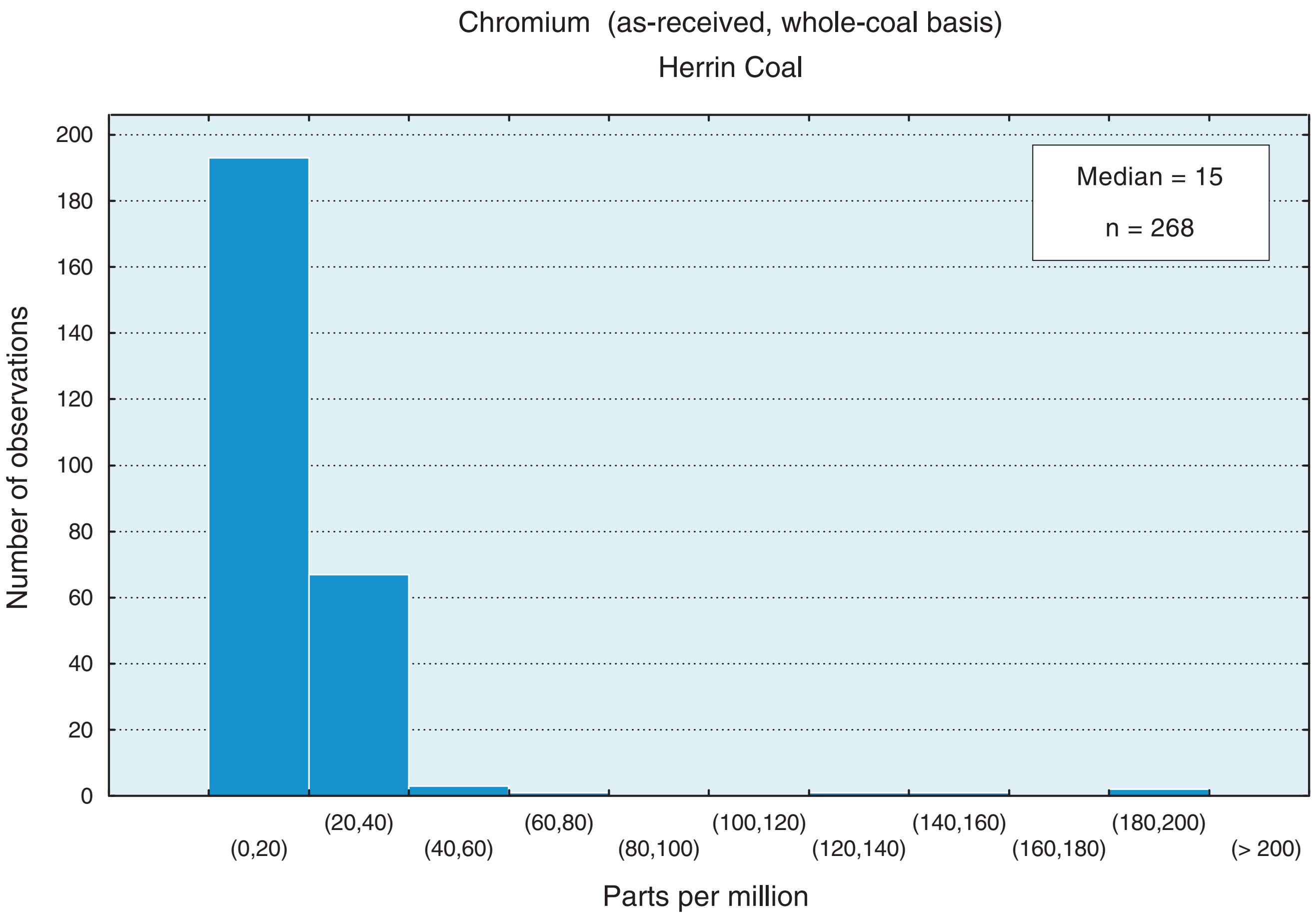

Figure 24. Histogram of chromium content (parts per million, as-received, whole-coal basis) of the Herrin Coal in the Illinois Basin. Intervals on the x-axis are shown in parentheses.

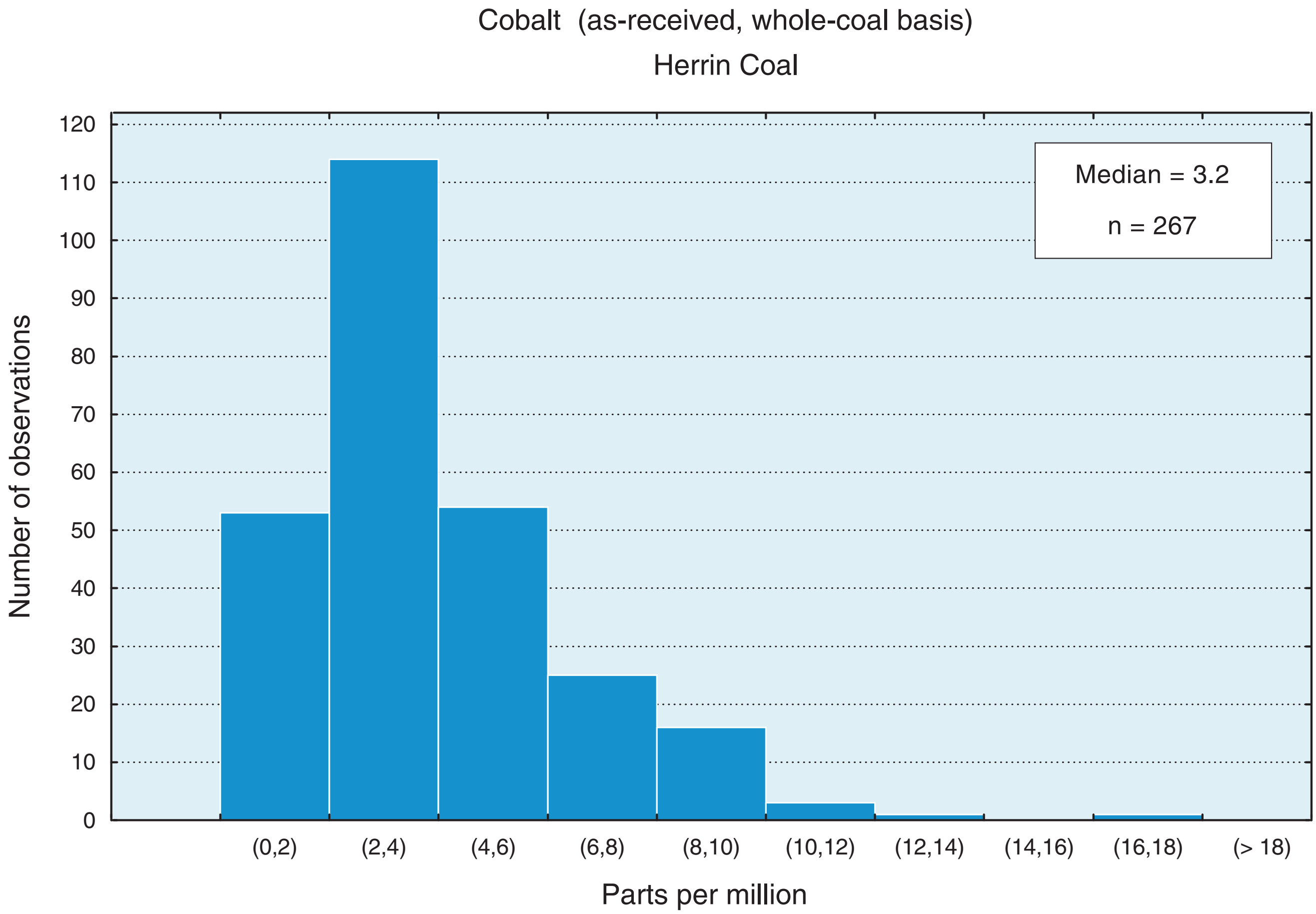

Figure 25. Histogram of cobalt content (parts per million, as-received, whole-coal basis) of the Herrin Coal in the Illinois Basin. Intervals on the x-axis are shown in parentheses.

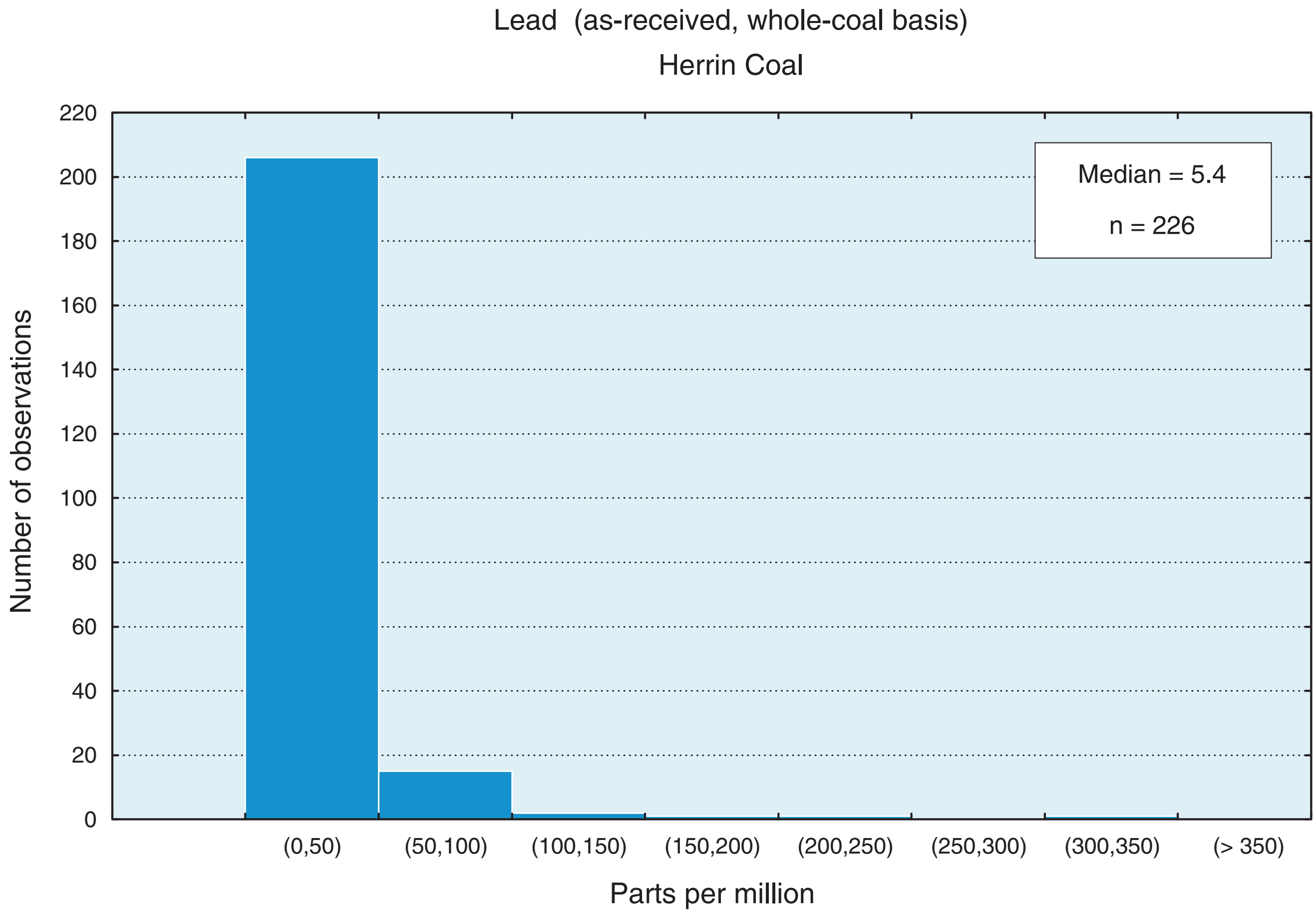

Figure 26. Histogram of lead content (parts per million, as-received, whole-coal basis) of the Herrin Coal in the Illinois Basin. Intervals on the x-axis are shown in parentheses.

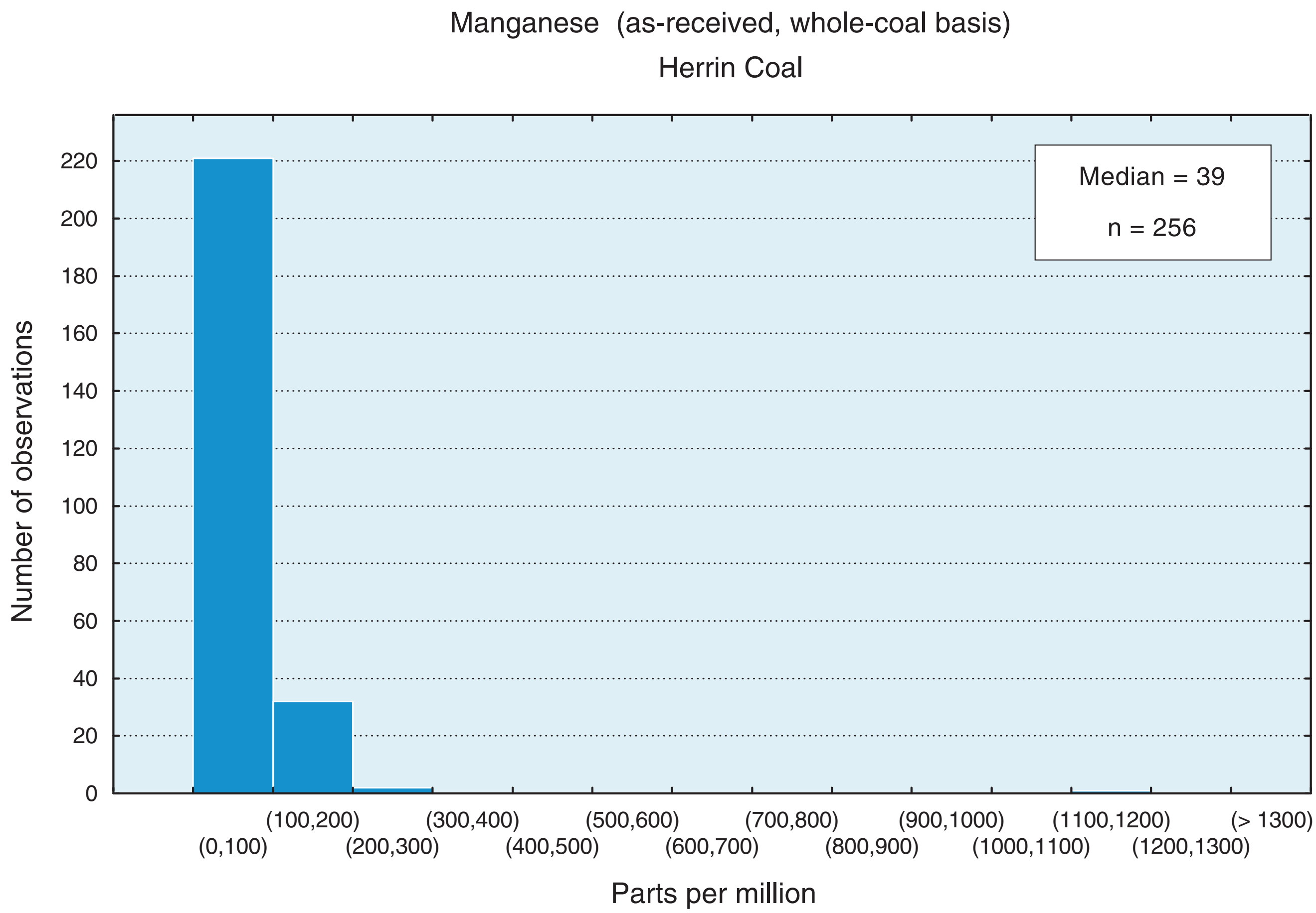

Figure 27. Histogram of manganese content (parts per million, as-received, whole-coal basis) of the Herrin Coal in the Illinois Basin. Intervals on the x-axis are shown in parentheses.

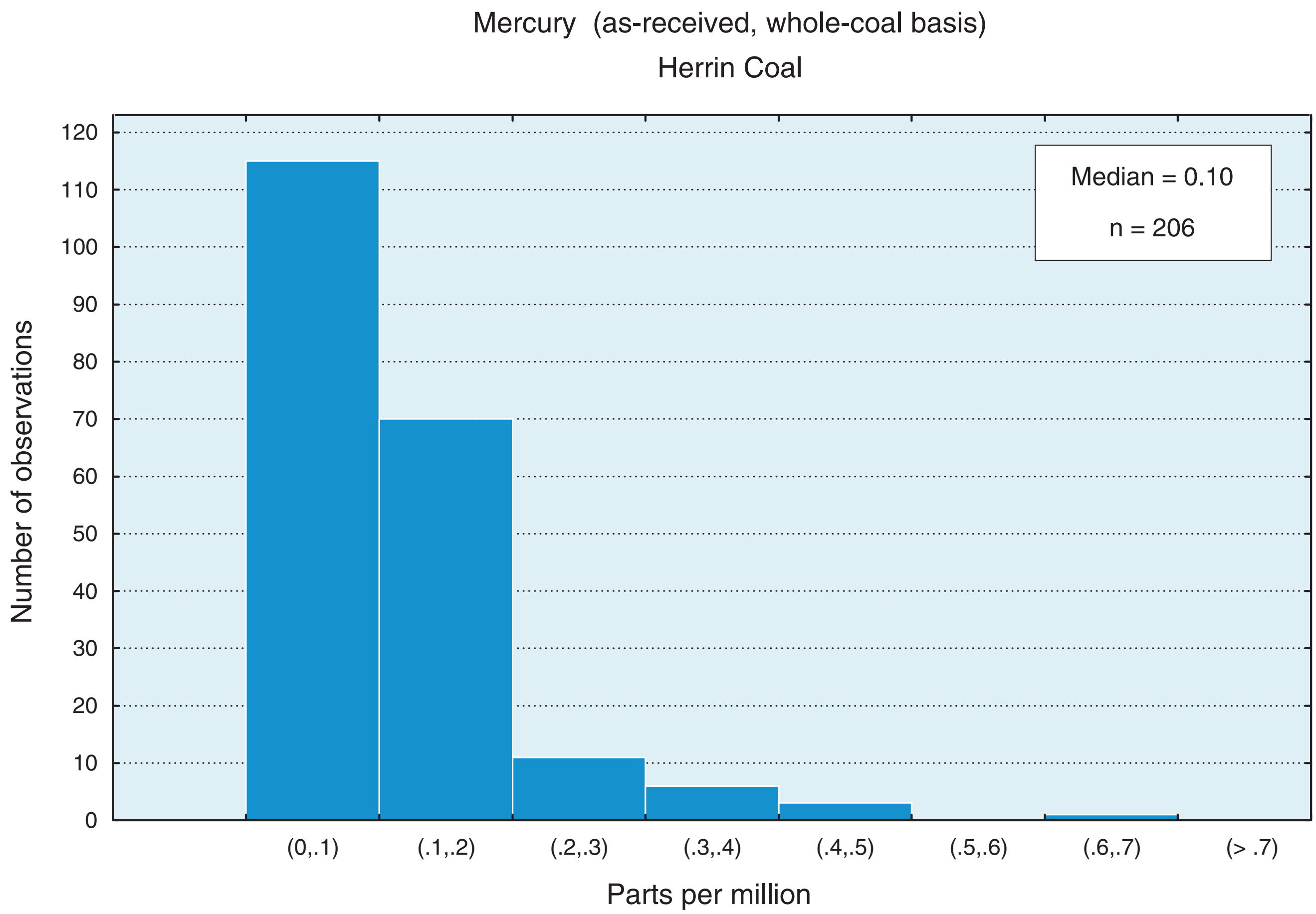

Figure 28. Histogram of mercury content (parts per million, as-received, whole-coal basis) of the Herrin Coal in the Illinois Basin. Intervals on the x-axis are shown in parentheses.

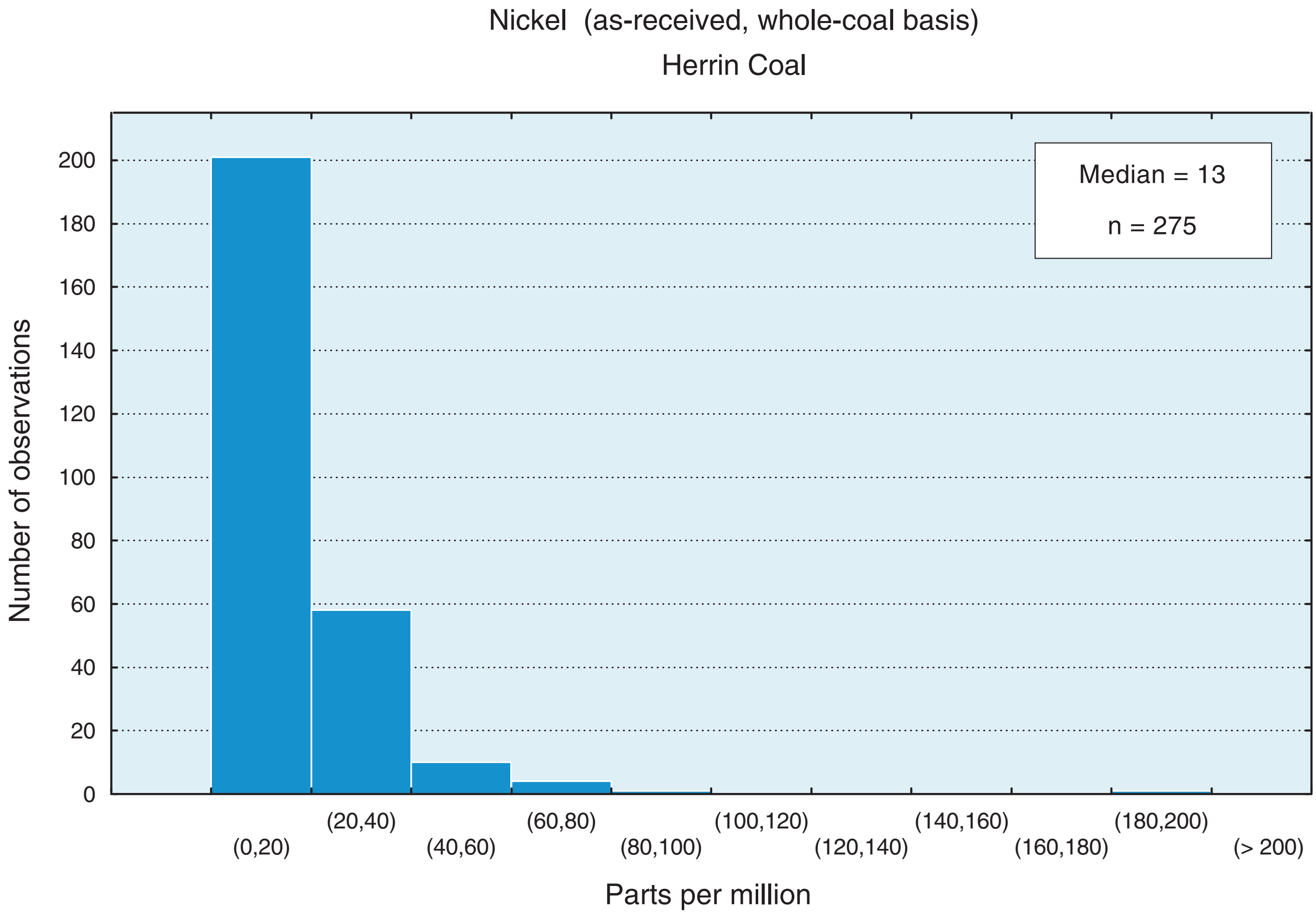

Figure 29. Histogram of nickel content (parts per million, as-received, whole-coal basis) of the Herrin Coal in the Illinois Basin. Intervals on the x-axis are shown in parentheses.

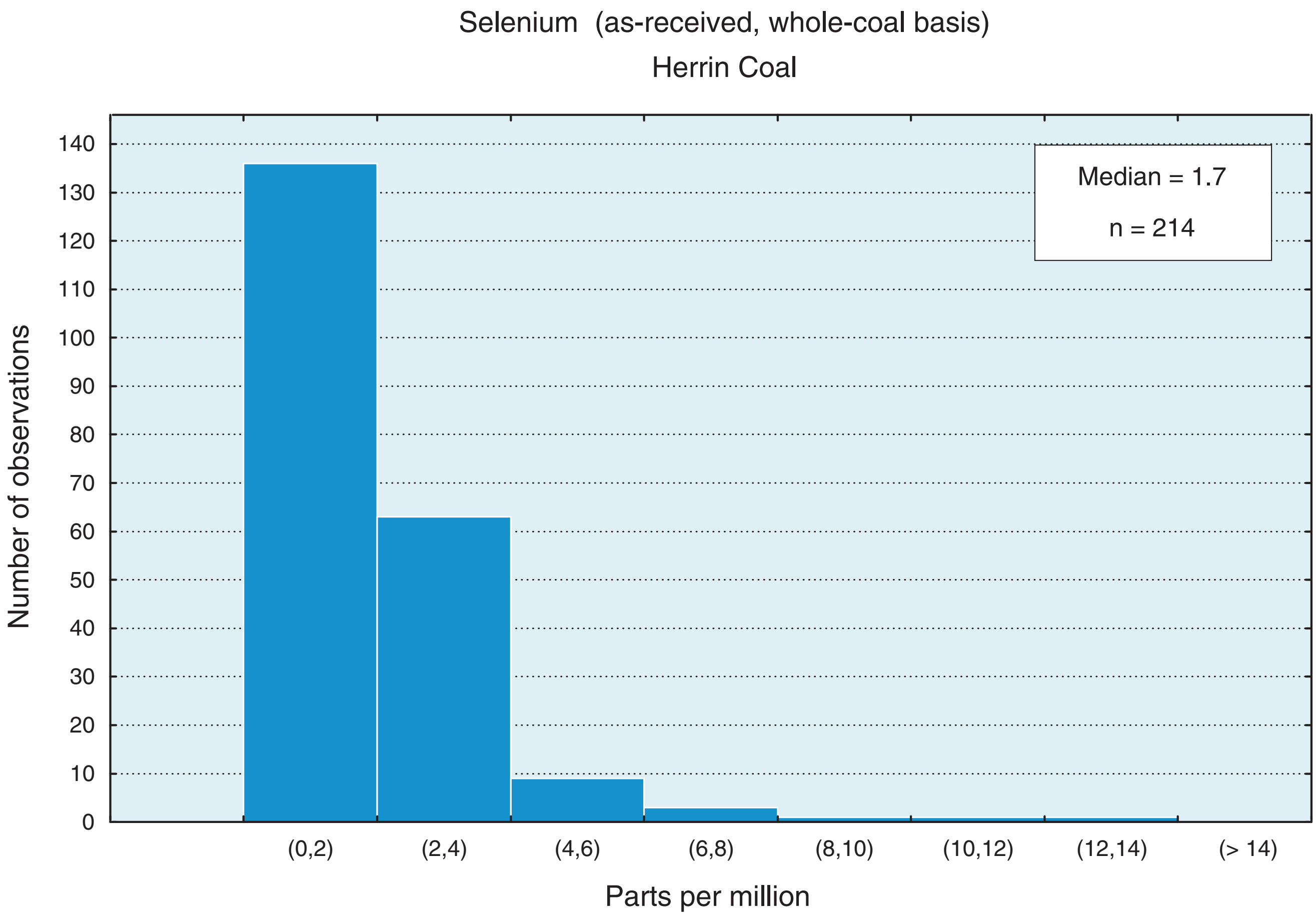

Figure 30. Histogram of selenium content (parts per million, as-received, whole-coal basis) of the Herrin Coal in the Illinois Basin. Intervals on the x-axis are shown in parentheses.

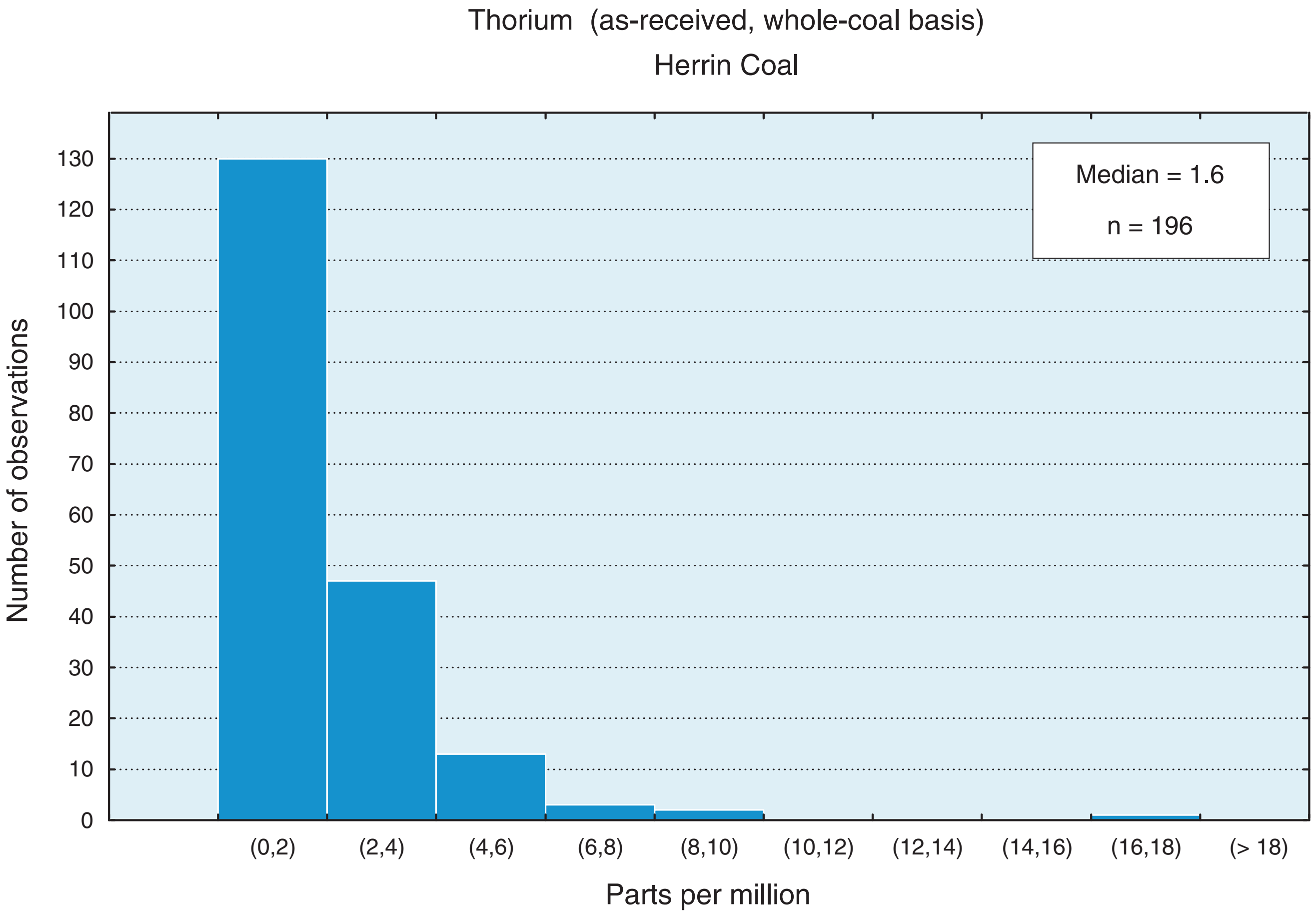

Figure 31. Histogram of thorium content (parts per million, as-received, whole-coal basis) of the Herrin Coal in the Illinois Basin. Intervals on the x-axis are shown in parentheses.

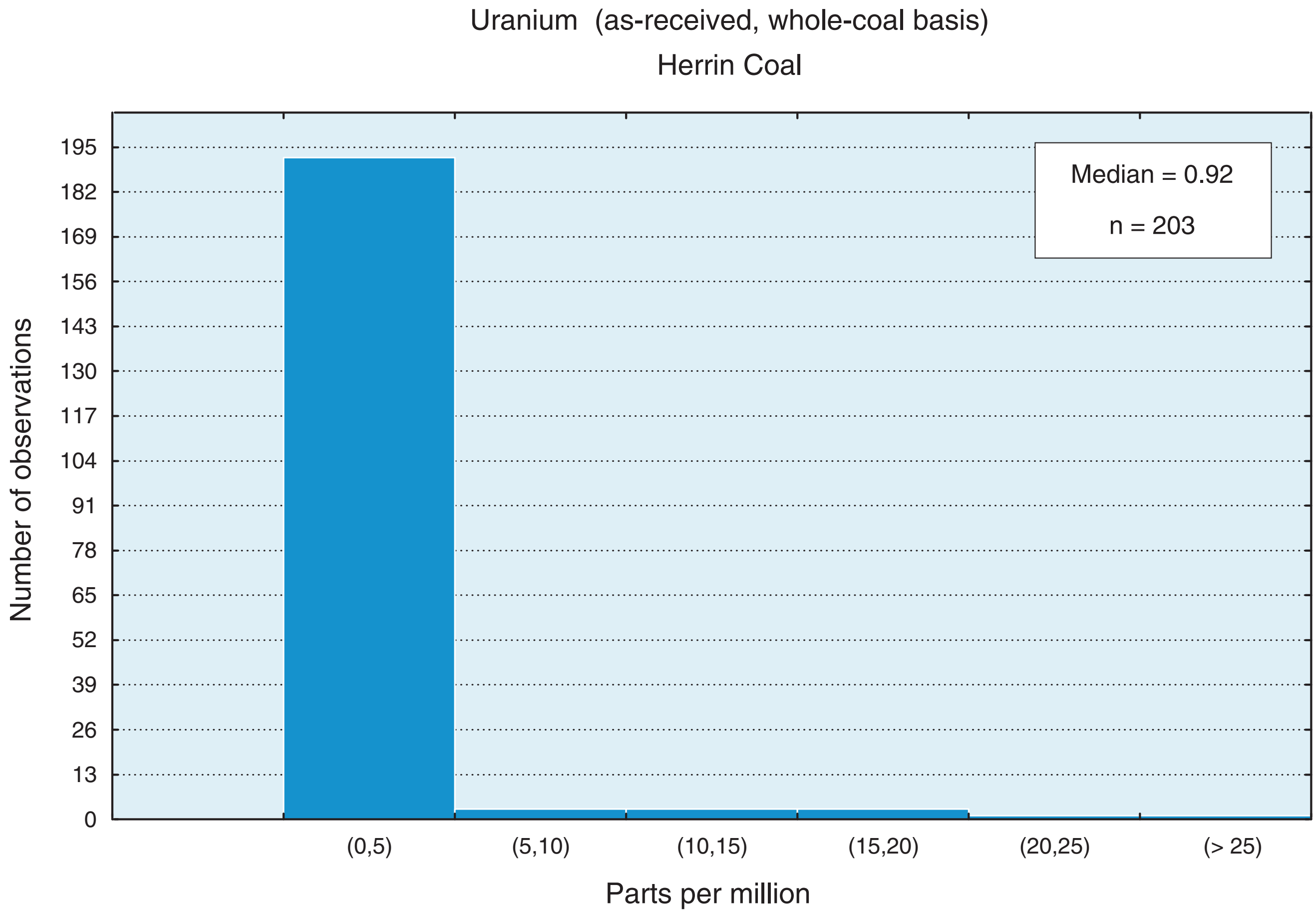

Figure 32. Histogram of uranium content (parts per million, as-received, whole-coal basis) of the Herrin Coal in the Illinois Basin. Intervals on the x-axis are shown in parentheses.

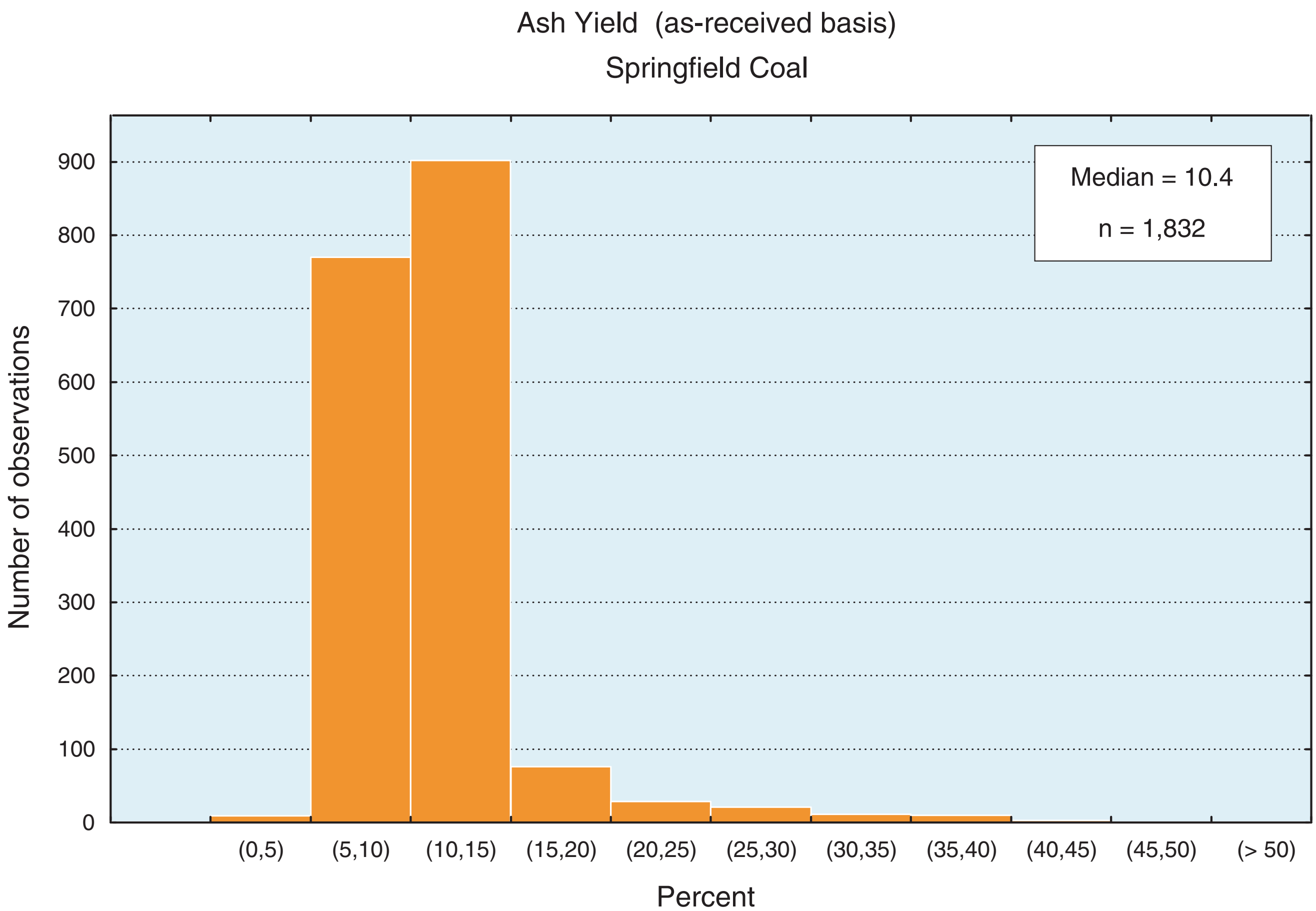

Figure 33. Histogram of ash yield (percent, as-received basis) of the Springfield Coal in the Illinois Basin. Intervals on the x-axis are shown in parentheses.

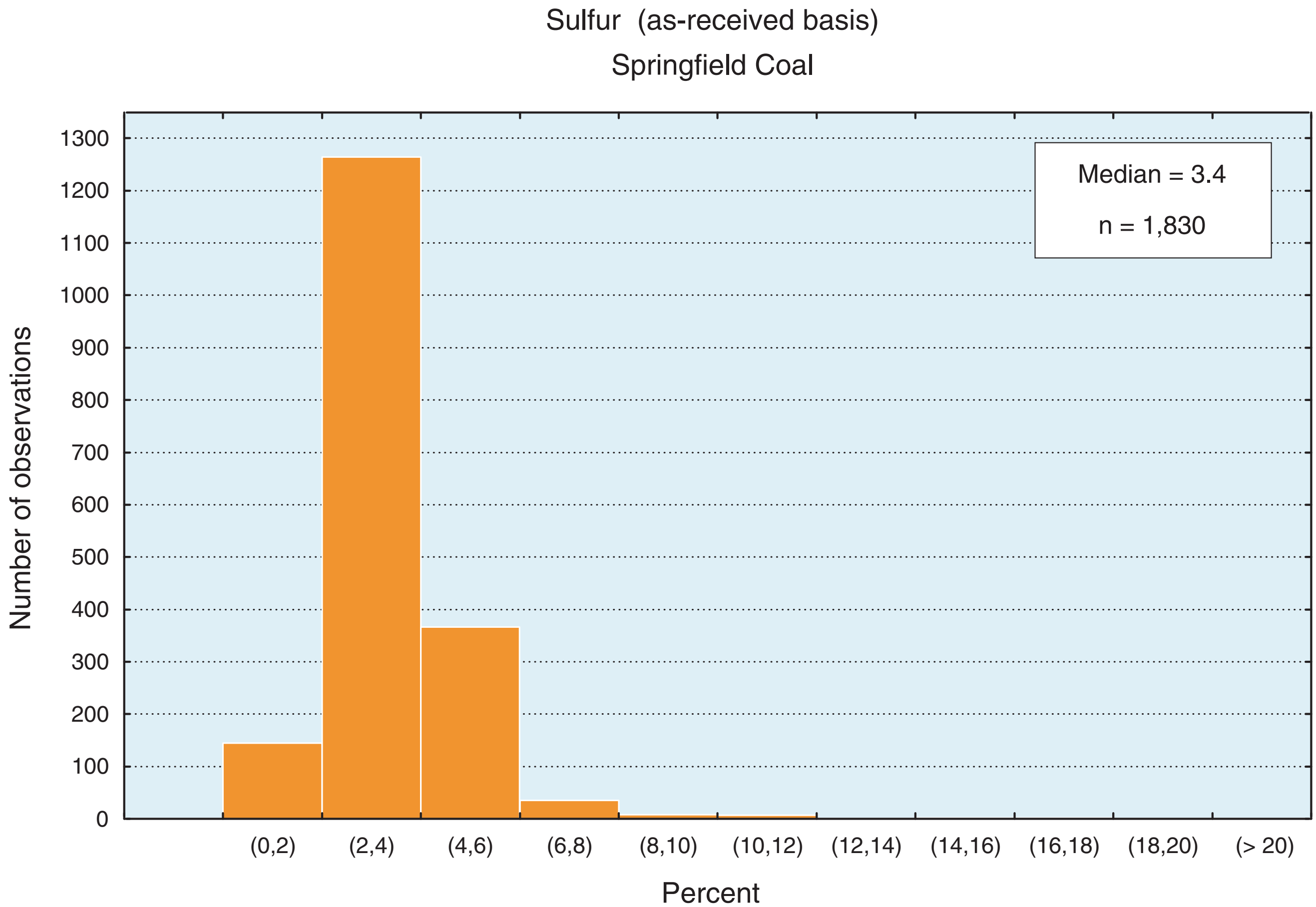

Figure 34. Histogram of sulfur content (percent, as-received basis) of the Springfield Coal in the Illinois Basin. Intervals on the x-axis are shown in parentheses.

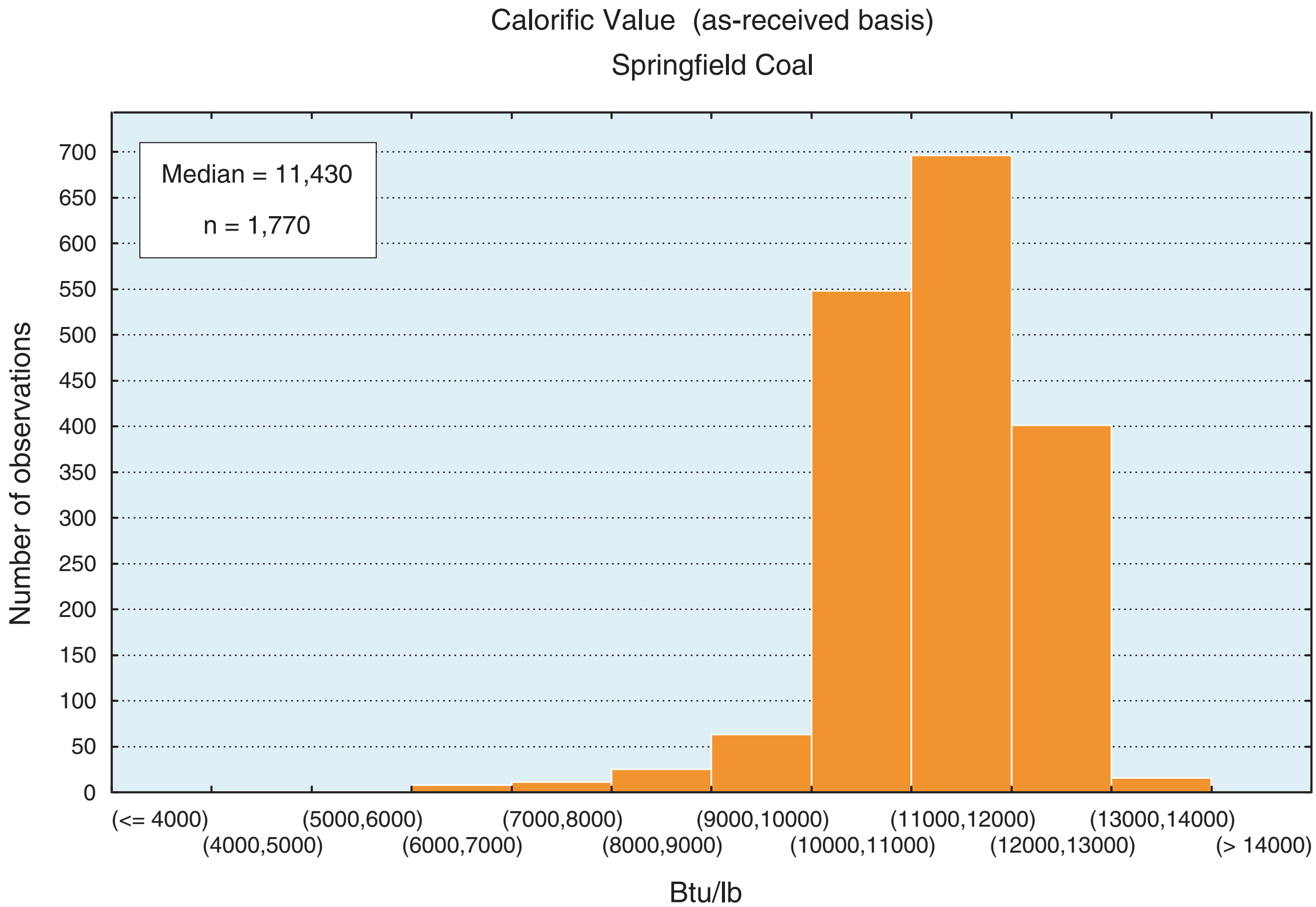

Figure 35. Histogram of calorific values (Btu/lb, as-received basis) of the Springfield Coal in the Illinois Basin. Intervals on the x-axis are shown in parentheses.

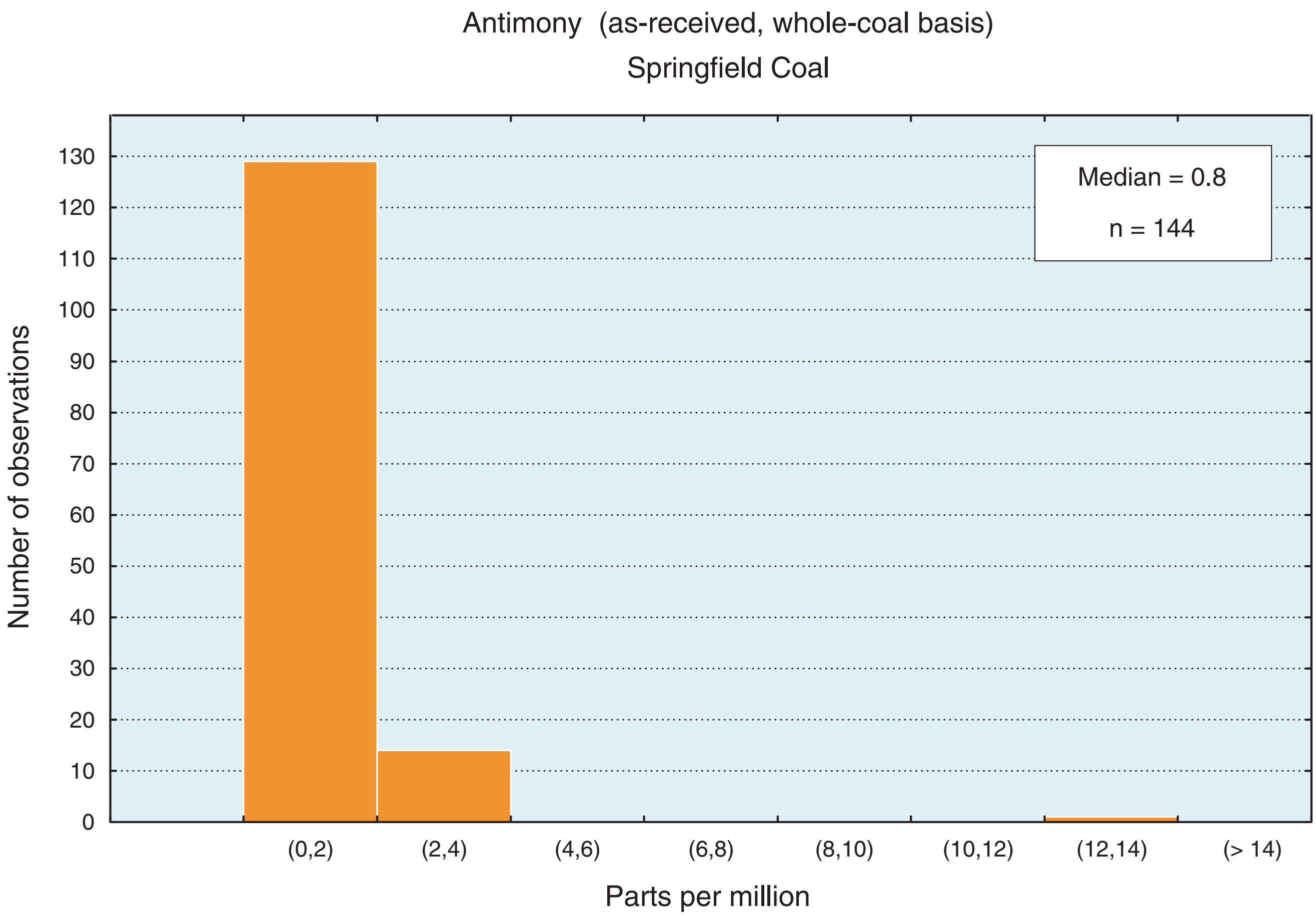

Figure 36. Histogram of antimony content (parts per million, as-received, whole-coal basis) of the Springfield Coal in the Illinois Basin. Intervals on the x-axis are shown in parentheses.

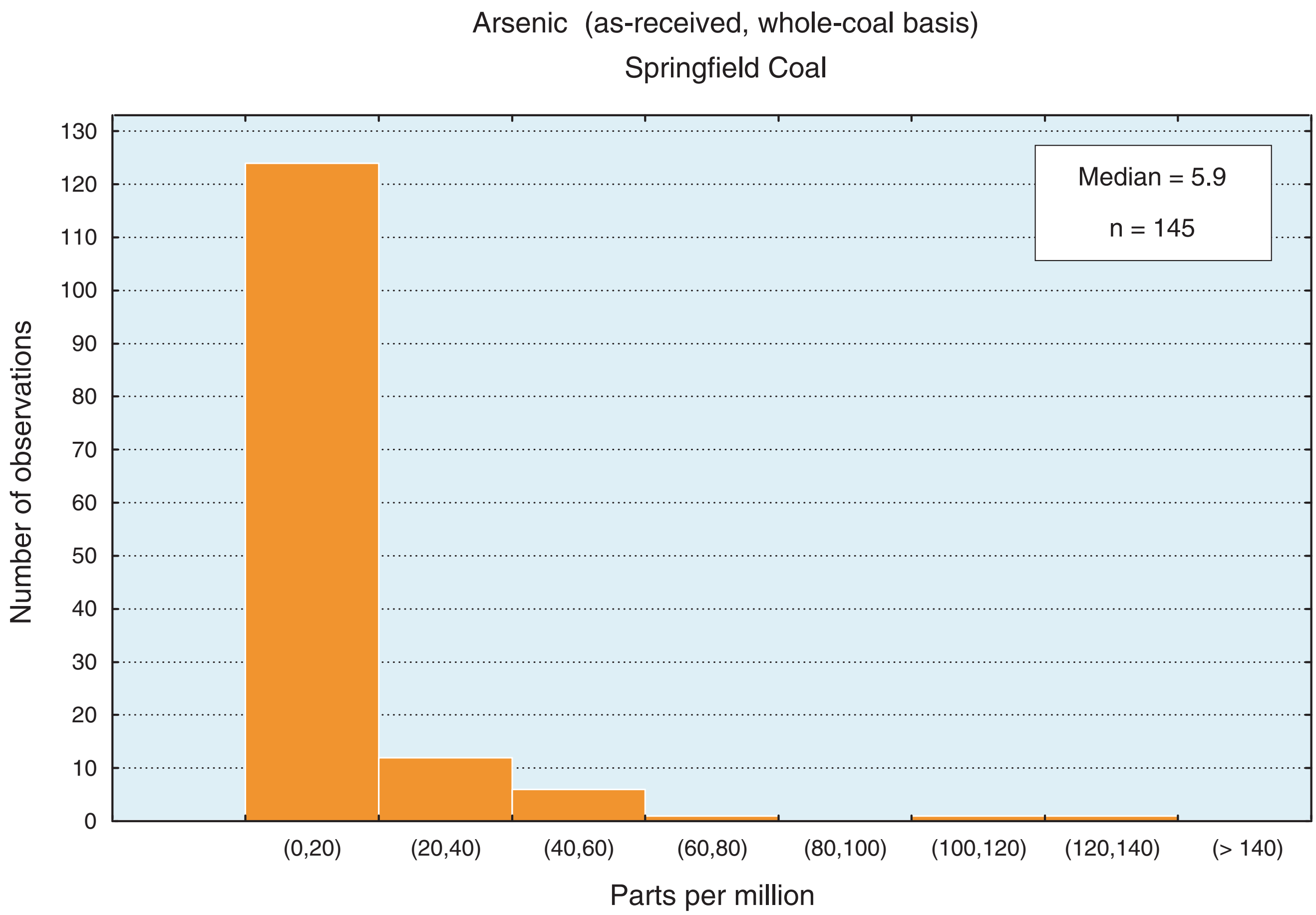

Figure 37. Histogram of arsenic content (parts per million, as-received, whole-coal basis) of the Springfield Coal in the Illinois Basin. Intervals on the x-axis are shown in parentheses.

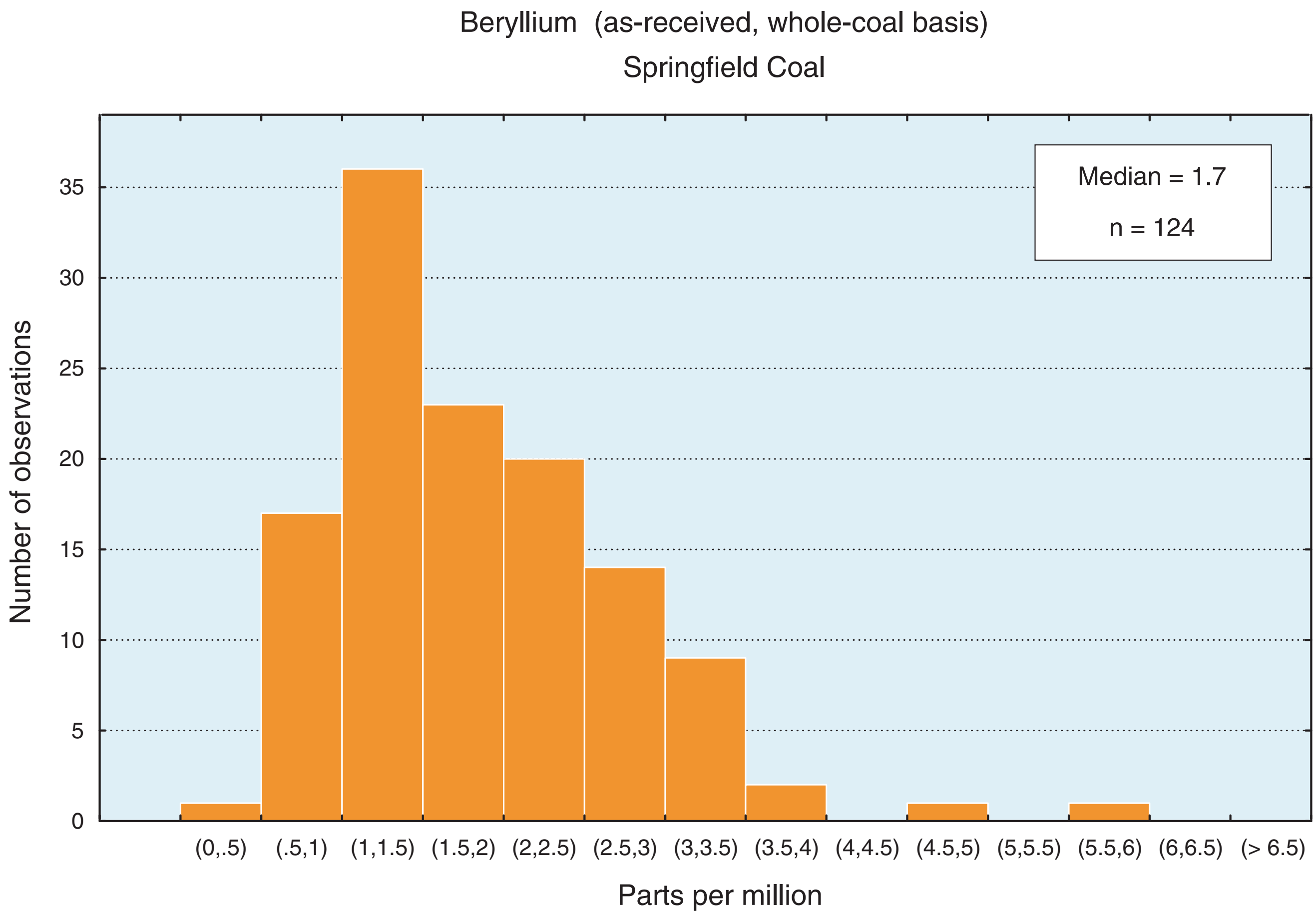

Figure 38. Histogram of beryllium content (parts per million, as-received, whole-coal basis) of the Springfield Coal in the Illinois Basin. Intervals on the x-axis are shown in parentheses.

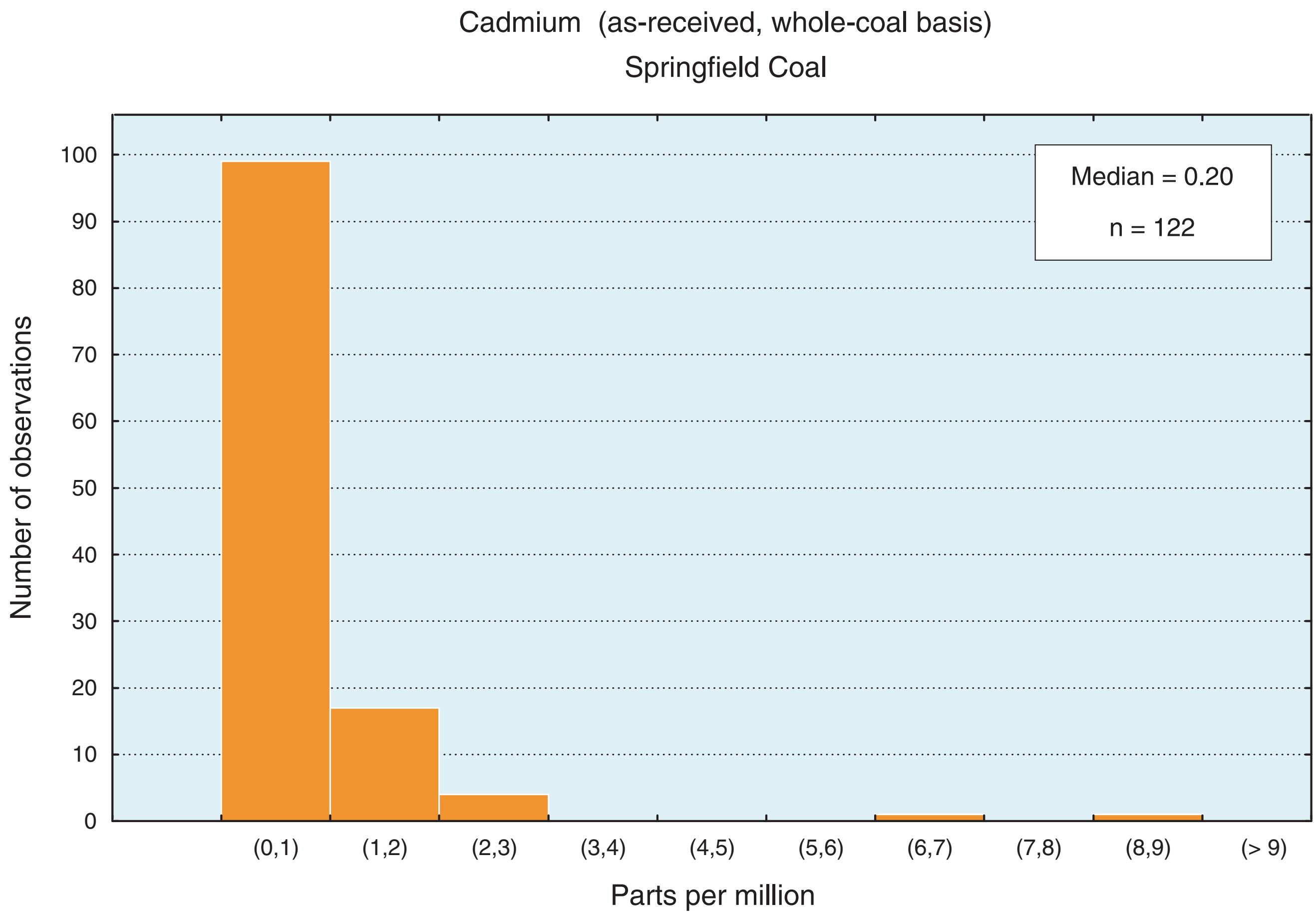

Figure 39. Histogram of cadmium content (parts per million, as-received, whole-coal basis) of the Springfield Coal in the Illinois Basin. Intervals on the x-axis are shown in parentheses.

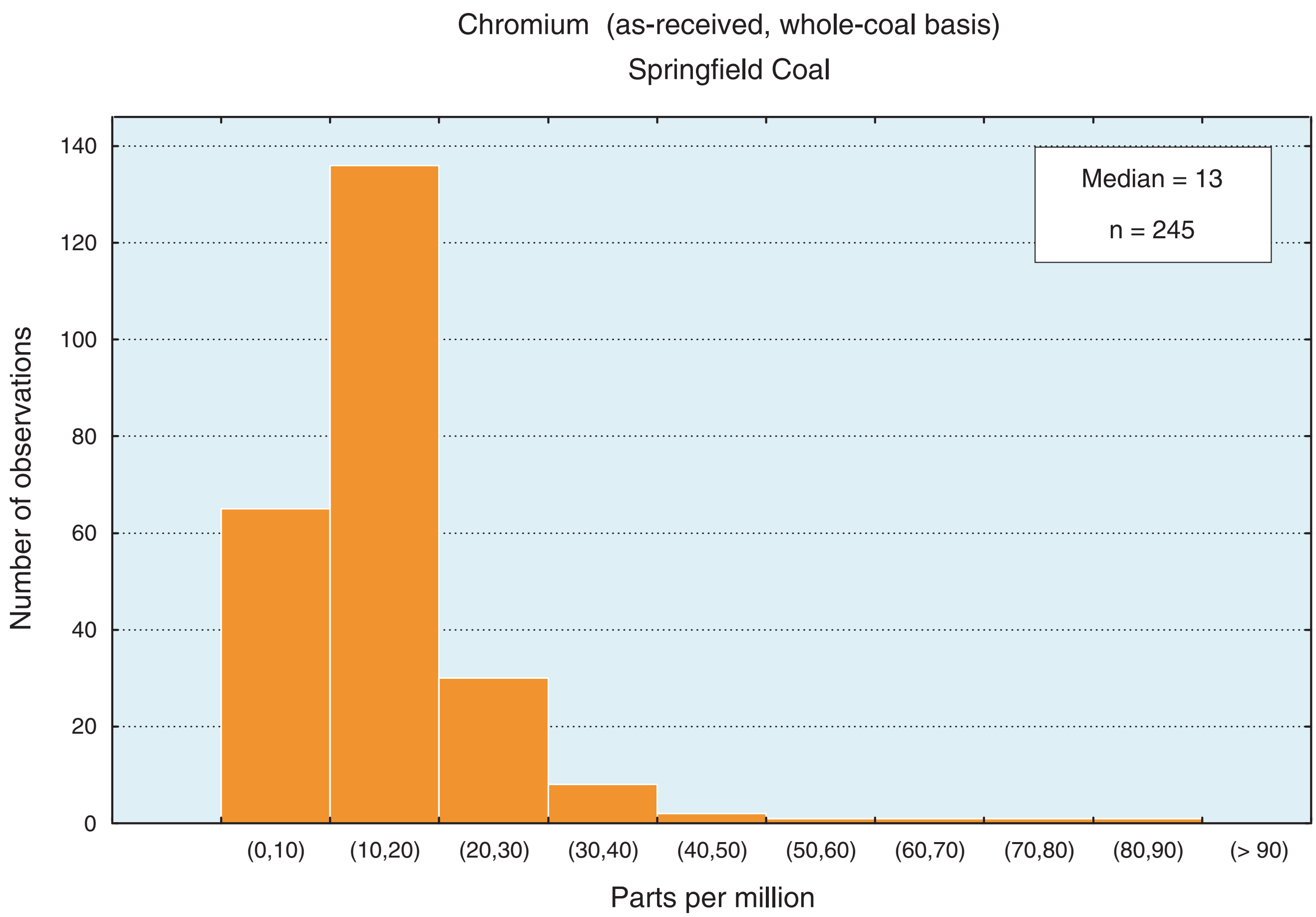

Figure 40. Histogram of chromium content (parts per million, as-received, whole-coal basis) of the Springfield Coal in the Illinois Basin. Intervals on the x-axis are shown in parentheses.

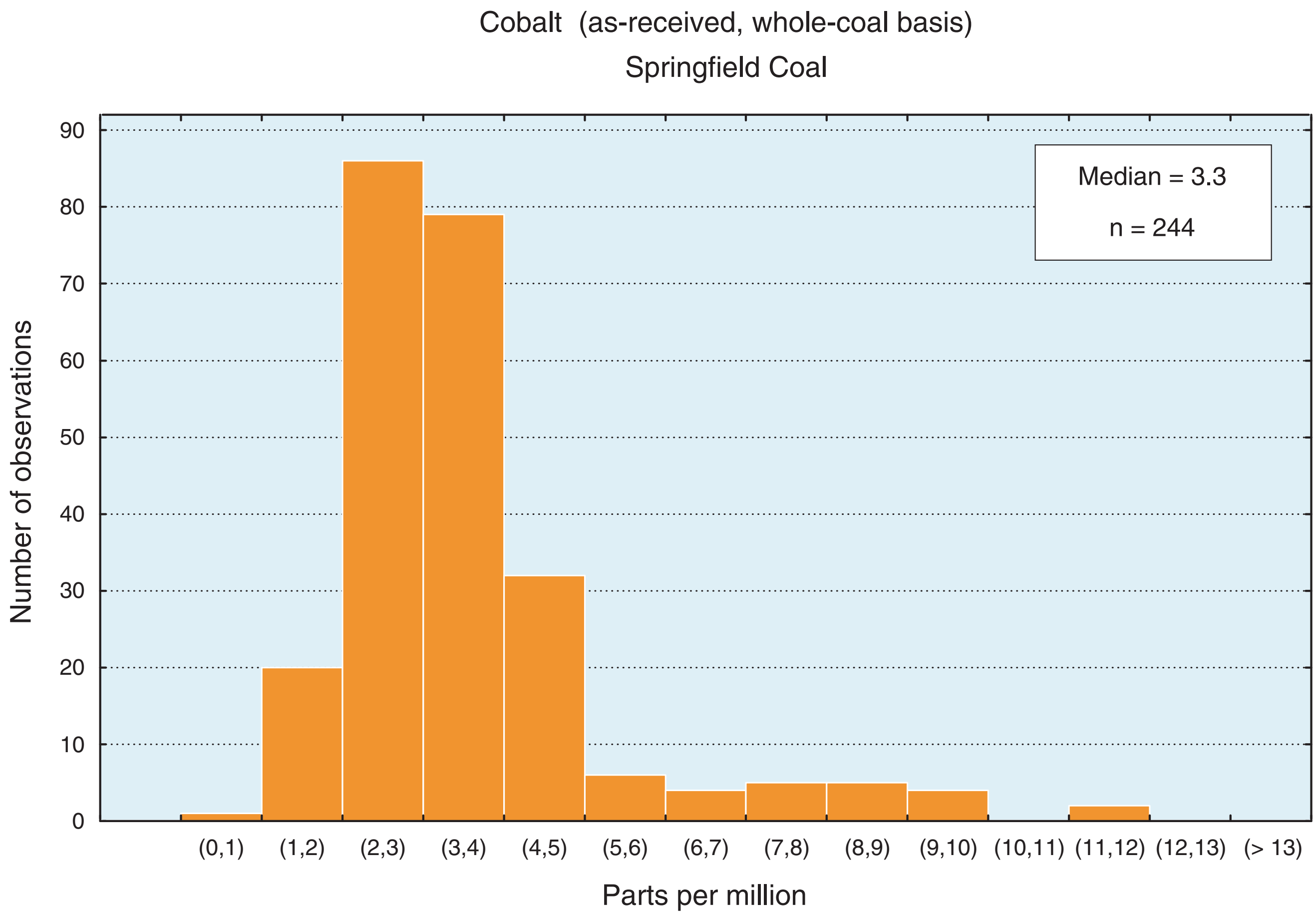

Figure 41. Histogram of cobalt content (parts per million, as-received, whole-coal basis) of the Springfield Coal in the Illinois Basin. Intervals on the x-axis are shown in parentheses.

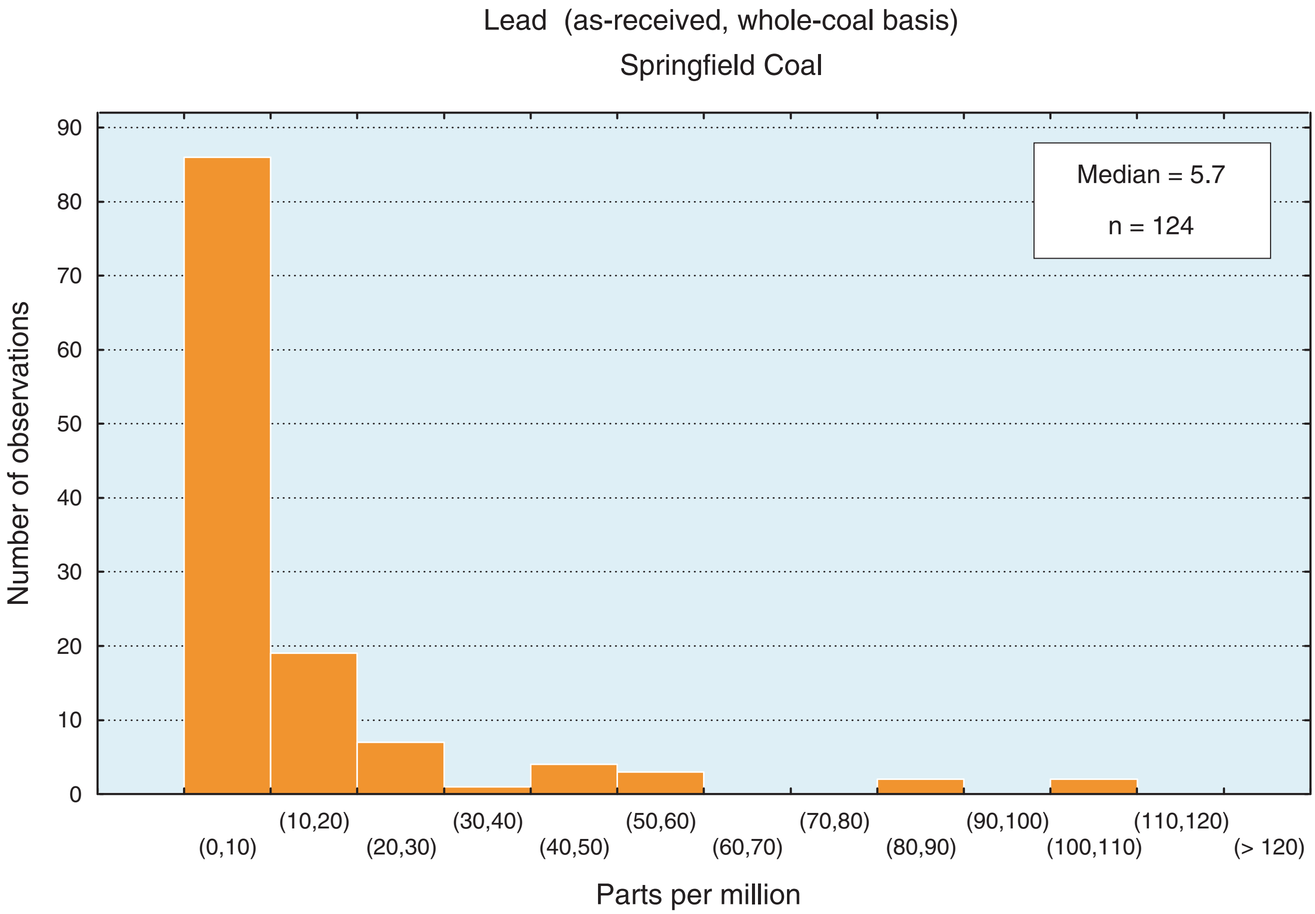

Figure 42. Histogram of lead content (parts per million, as-received, whole-coal basis) of the Springfield Coal in the Illinois Basin. Intervals on the x-axis are shown in parentheses.

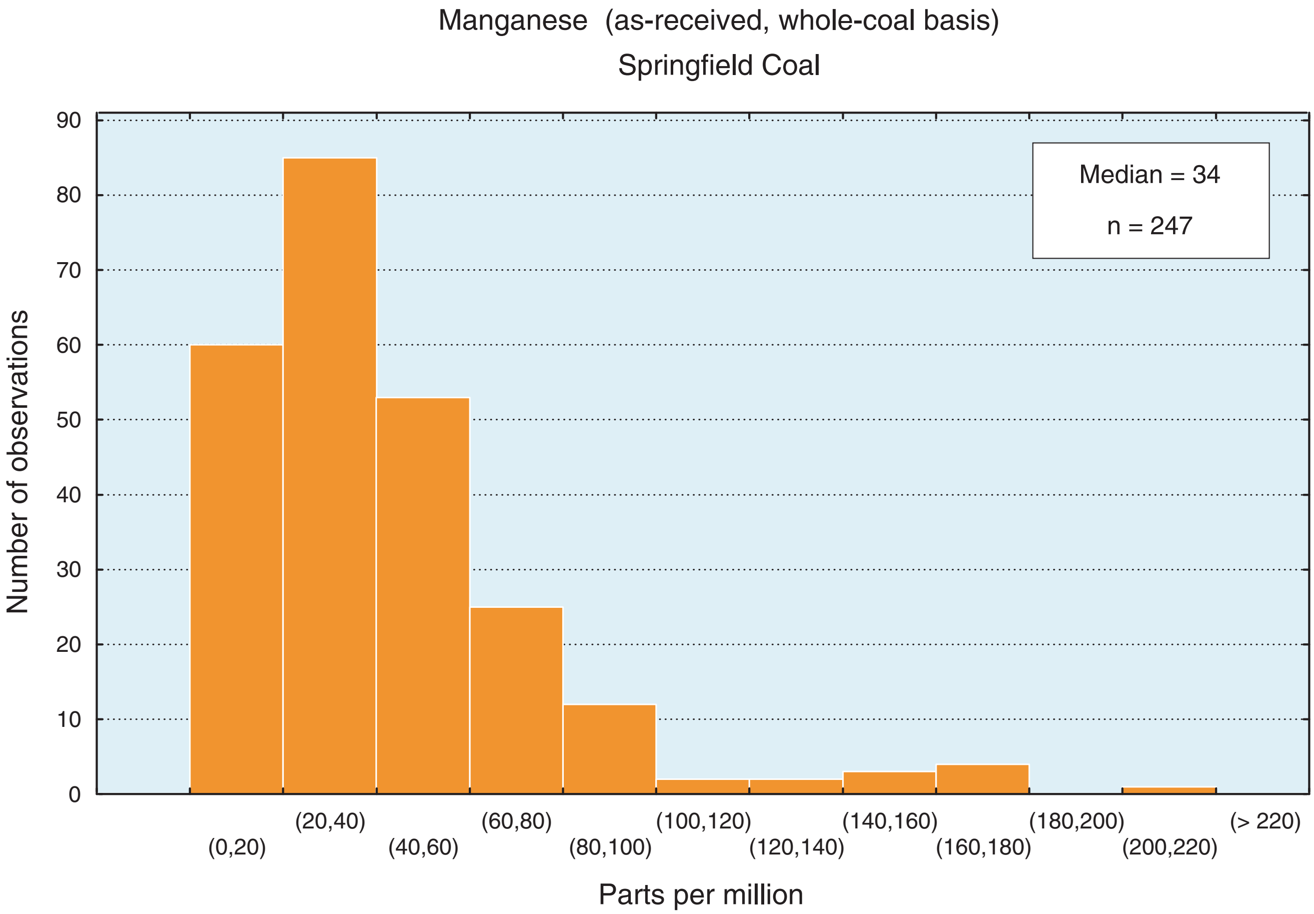

Figure 43. Histogram of manganese content (parts per million, as-received, whole-coal basis) of the Springfield Coal in the Illinois Basin. Intervals on the x-axis are shown in parentheses.

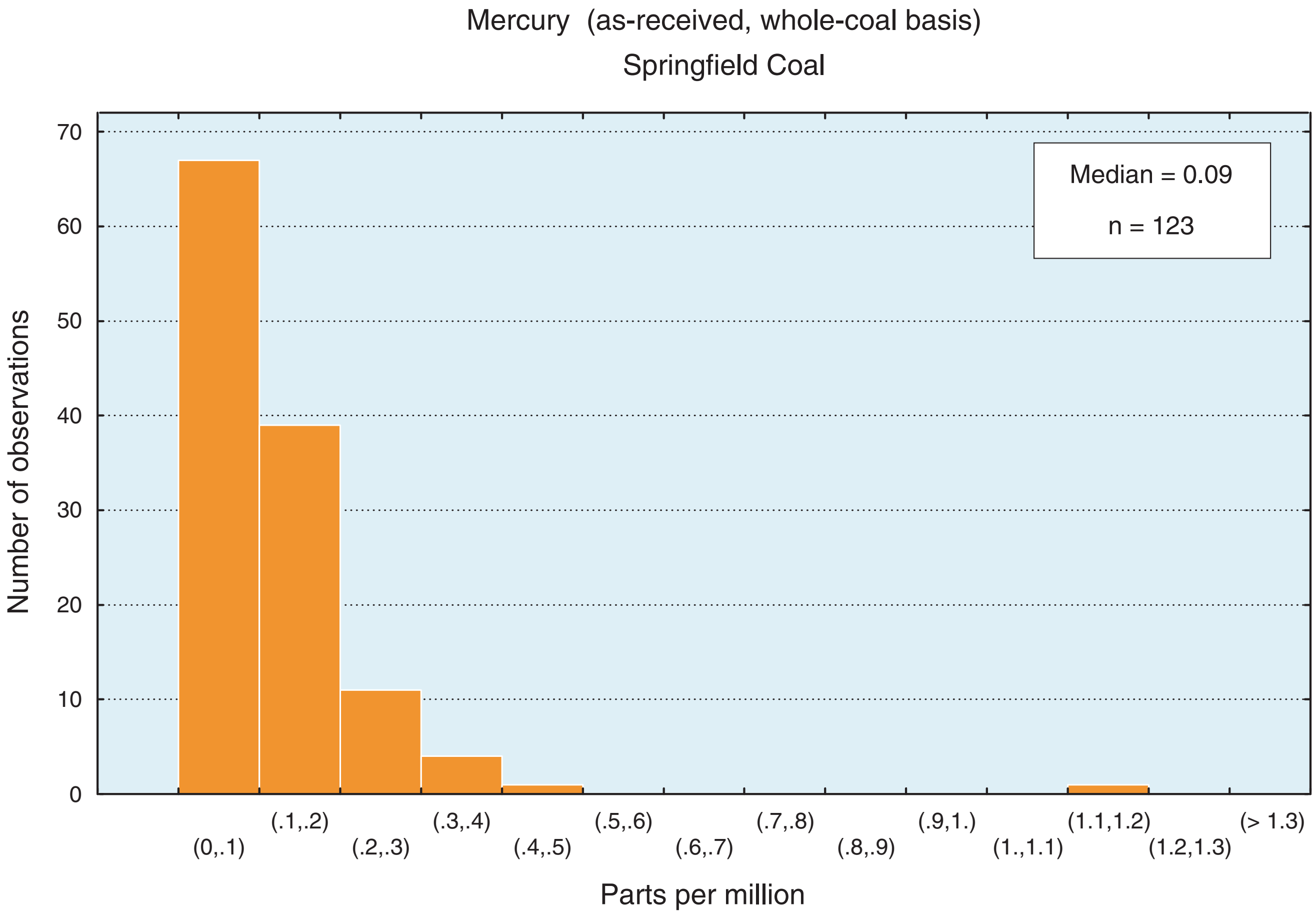

Figure 44. Histogram of mercury content (parts per million, as-received, whole-coal basis) of the Springfield Coal in the Illinois Basin. Intervals on the x-axis are shown in parentheses.

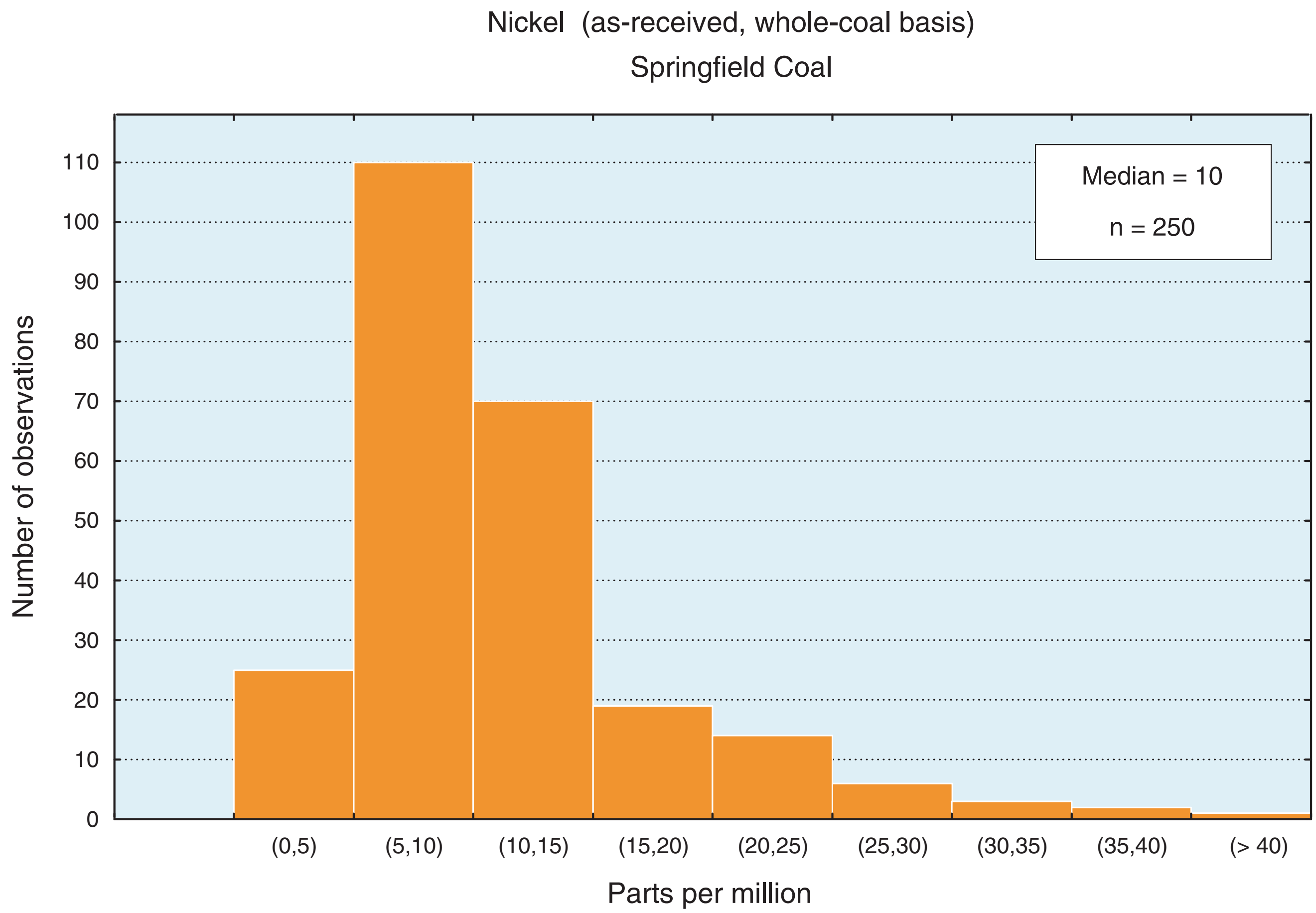

Figure 45. Histogram of nickel content (parts per million, as-received, whole-coal basis) of the Springfield Coal in the Illinois Basin. Intervals on the x-axis are shown in parentheses.

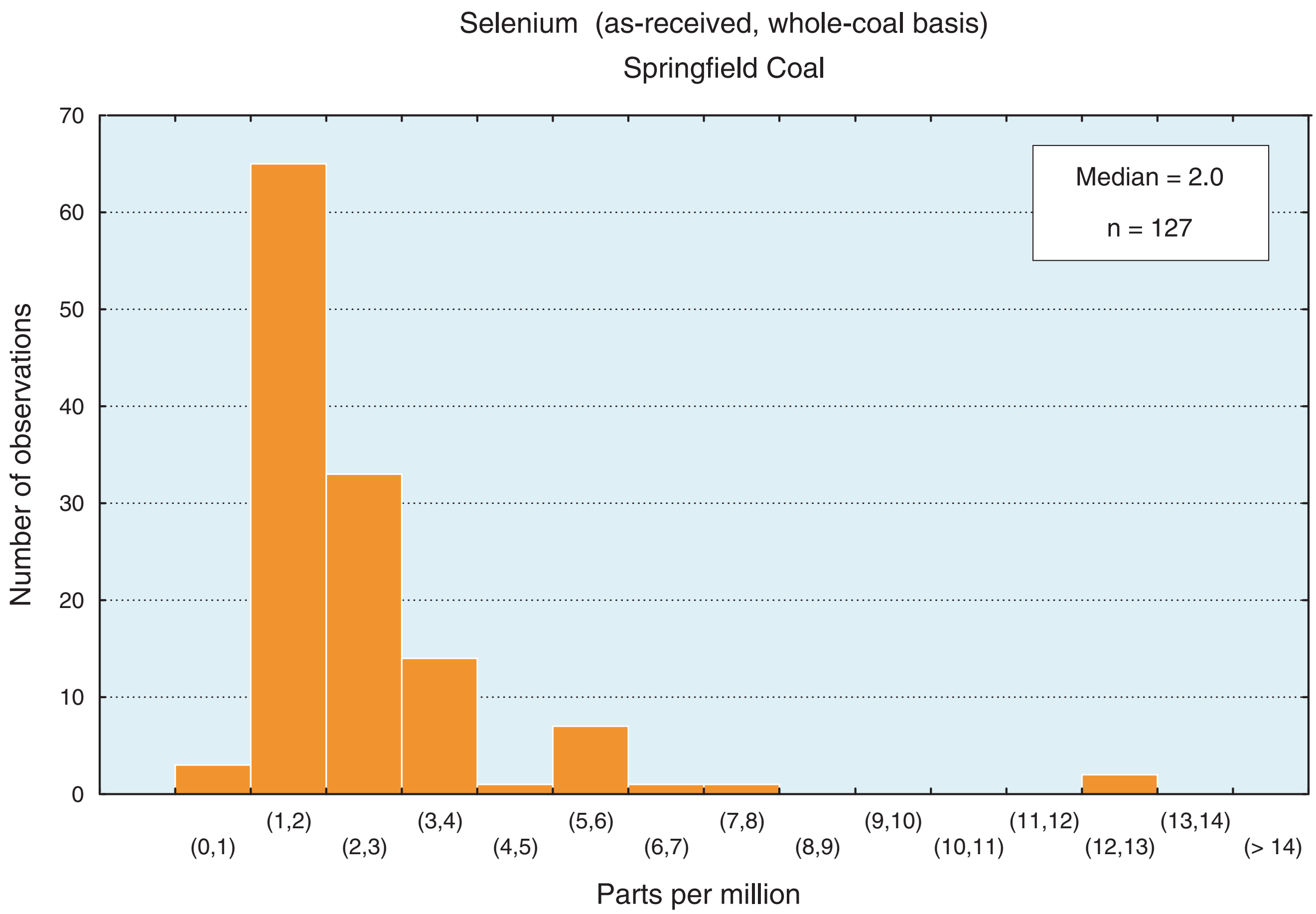

Figure 46. Histogram of selenium content (parts per million, as-received, whole-coal basis) of the Springfield Coal in the Illinois Basin. Intervals on the x-axis are shown in parentheses.

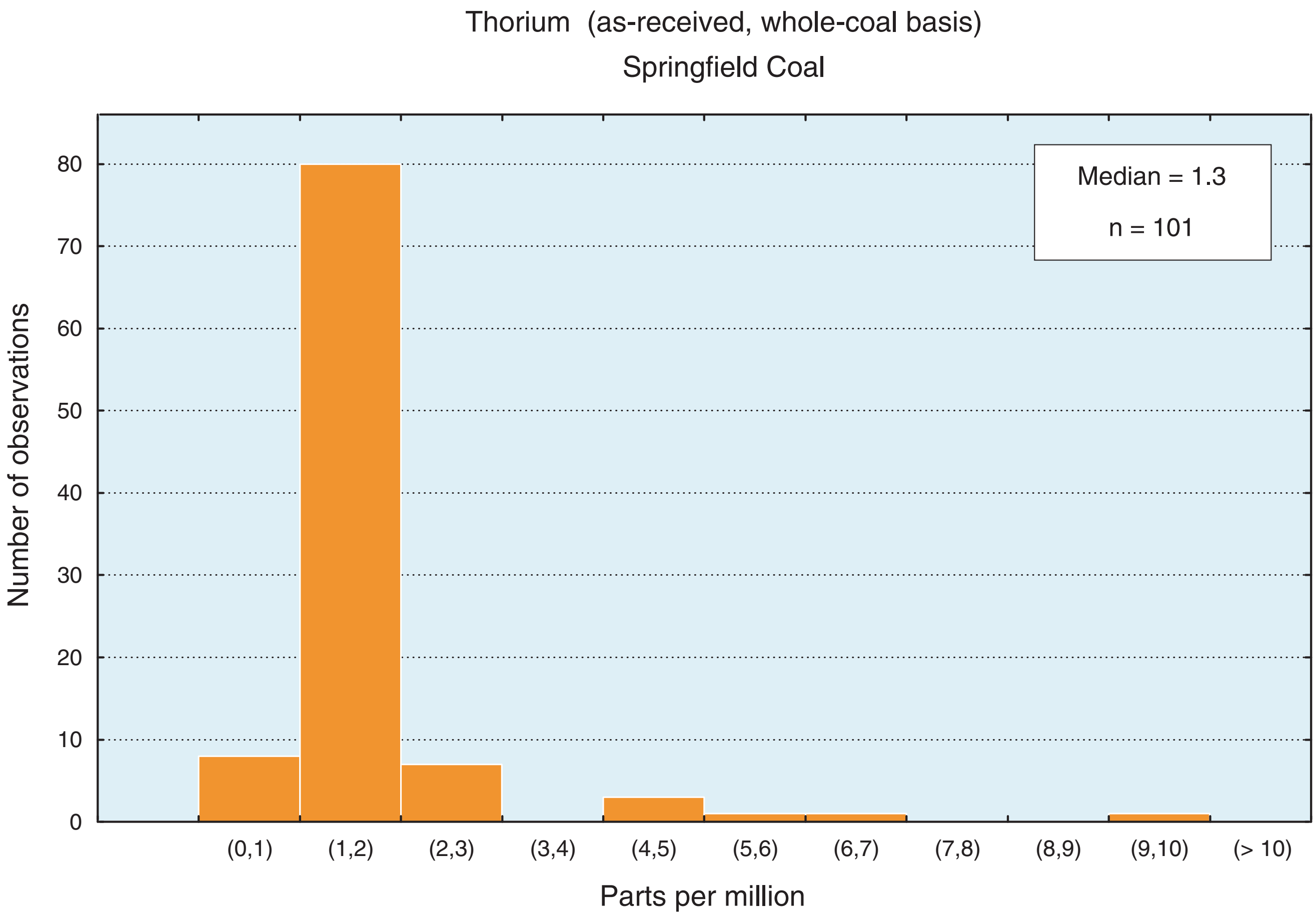

Figure 47. Histogram of thorium content (parts per million, as-received, whole-coal basis) of the Springfield Coal in the Illinois Basin. Intervals on the x-axis are shown in parentheses.

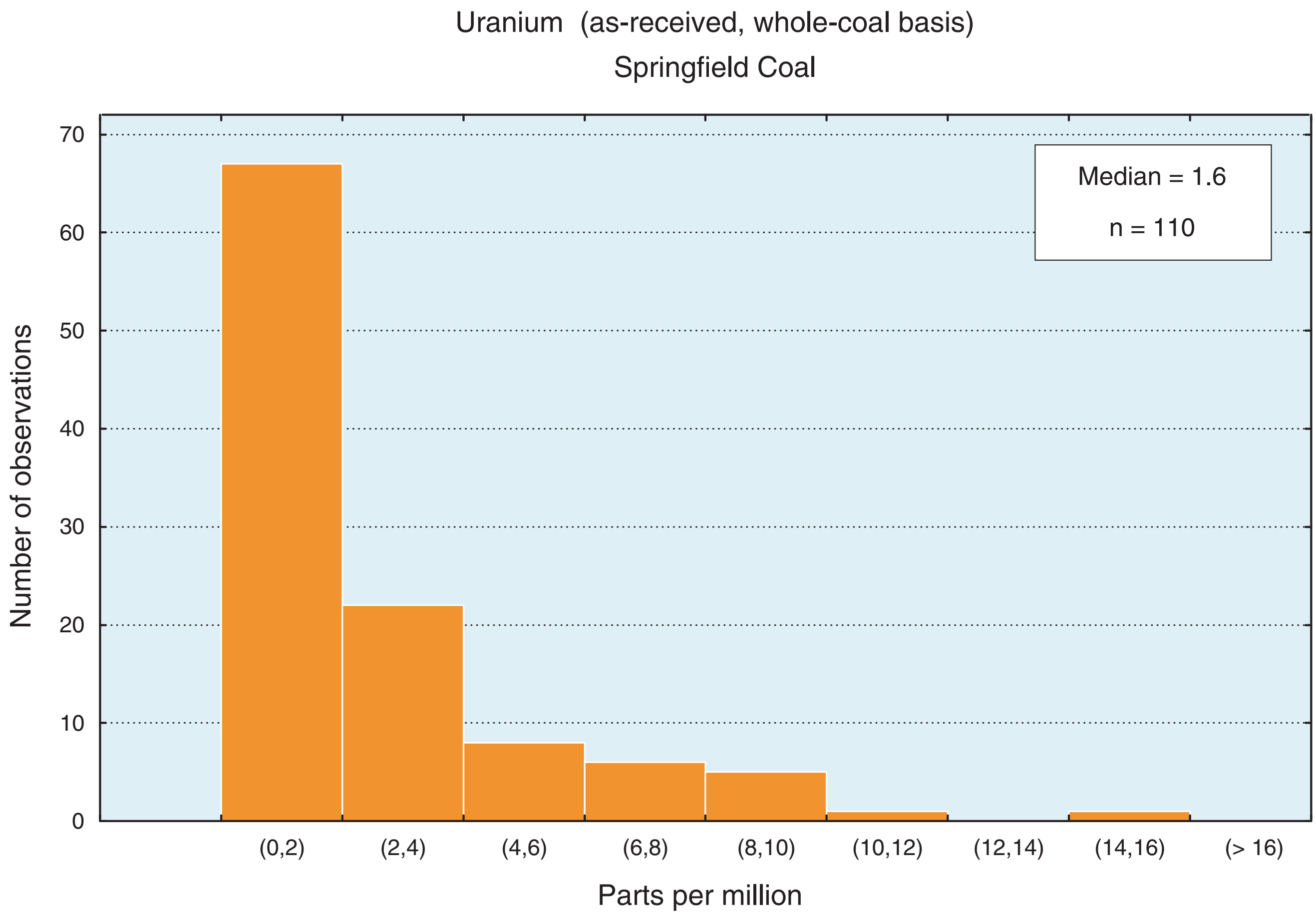

Figure 48. Histogram of uranium content (parts per million, as-received, whole-coal basis) of the Springfield Coal in the Illinois Basin. Intervals on the x-axis are shown in parentheses.

Appendix 7. Graduated-symbol maps for ash yield, sulfur content, calorific value, and elements of environmental concern for the Springfield, Herrin, and Danville-Baker Coals in the Illinois Basin.

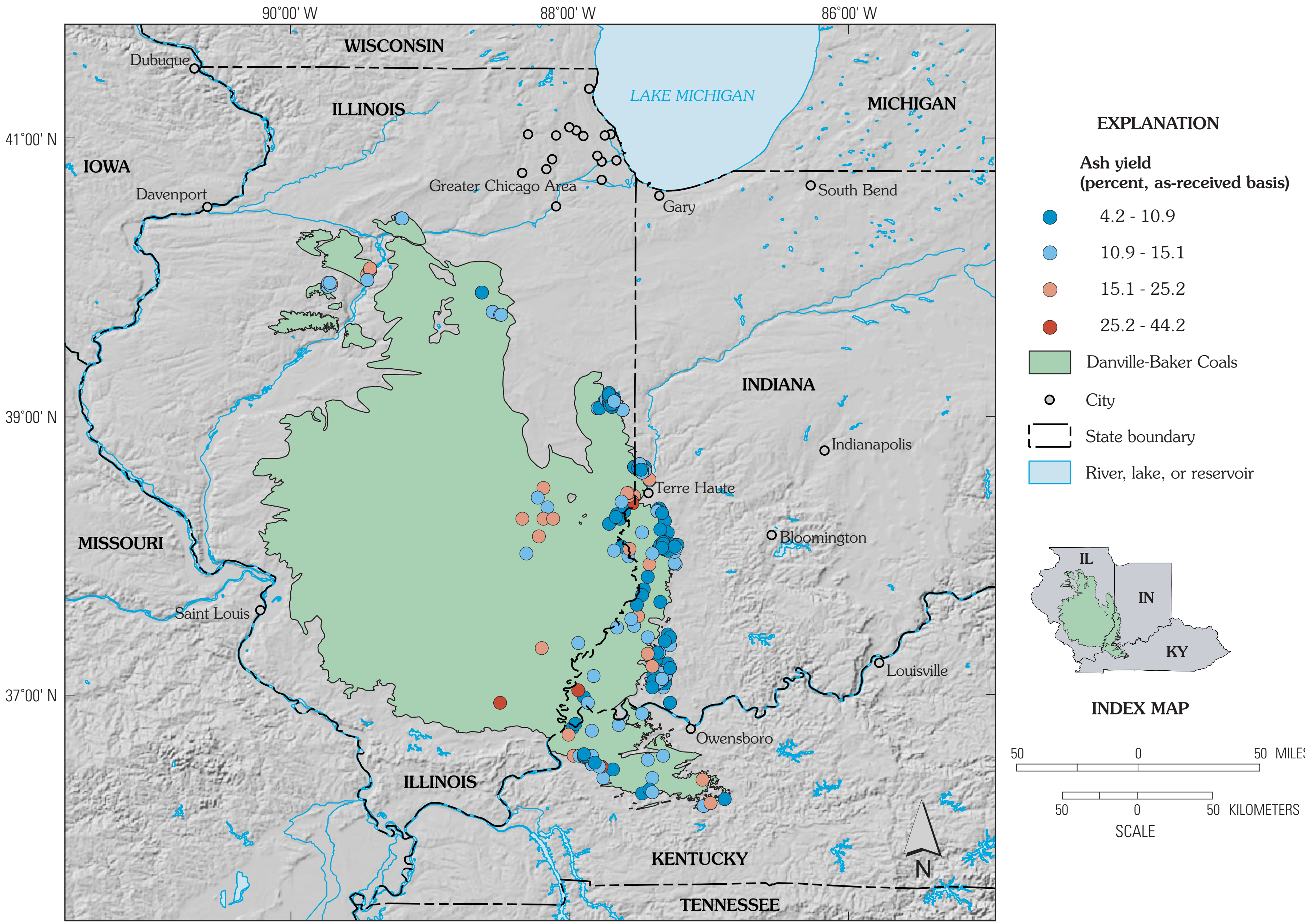

Figure 1. Graduated-symbol map for ash yield (percent, as-received basis) of the Danville-Baker Coals in the Illinois Basin.

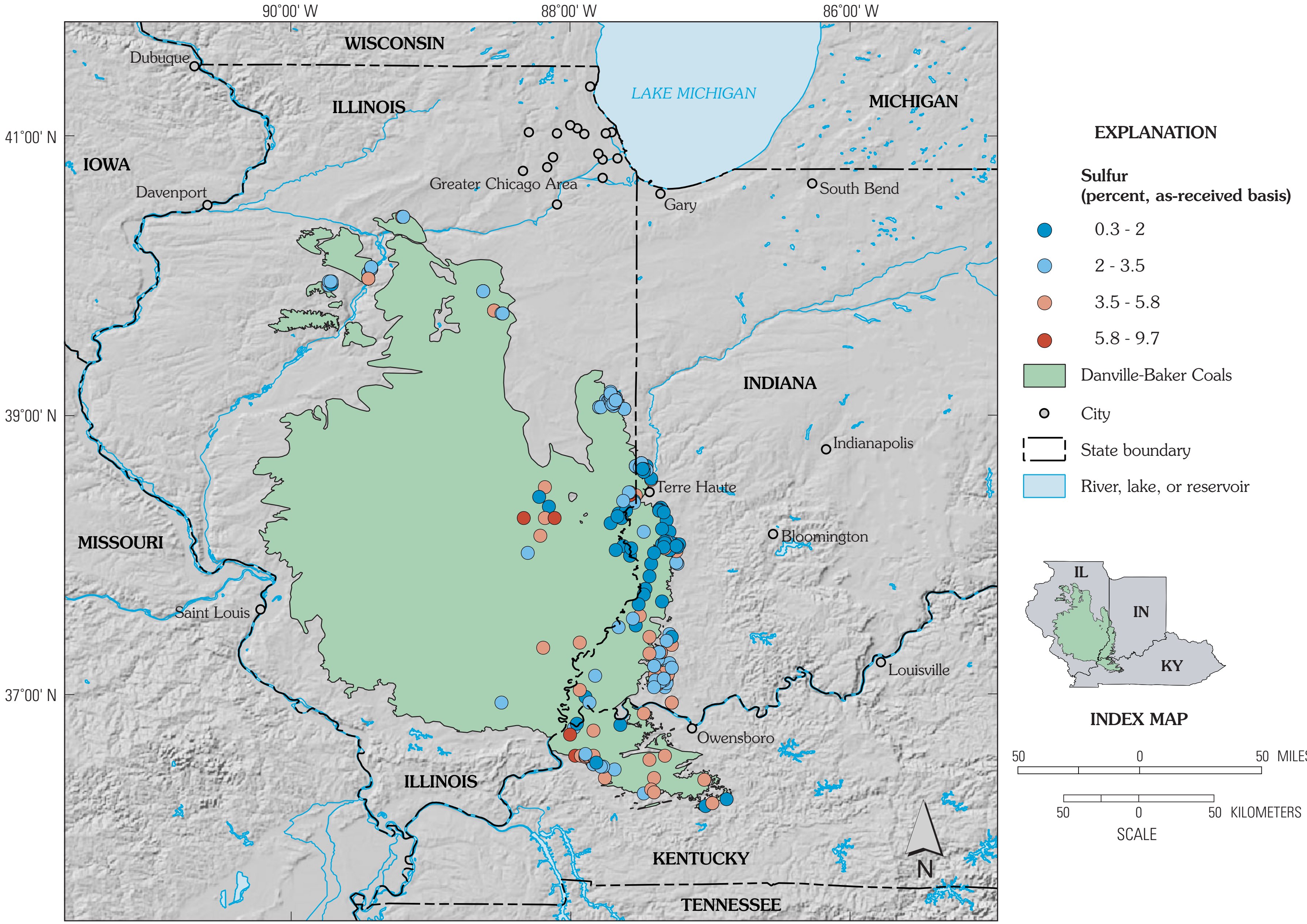

Figure 2. Graduated-symbol map for sulfur content (percent, as-received basis) of the Danville-Baker Coals in the Illinois Basin.

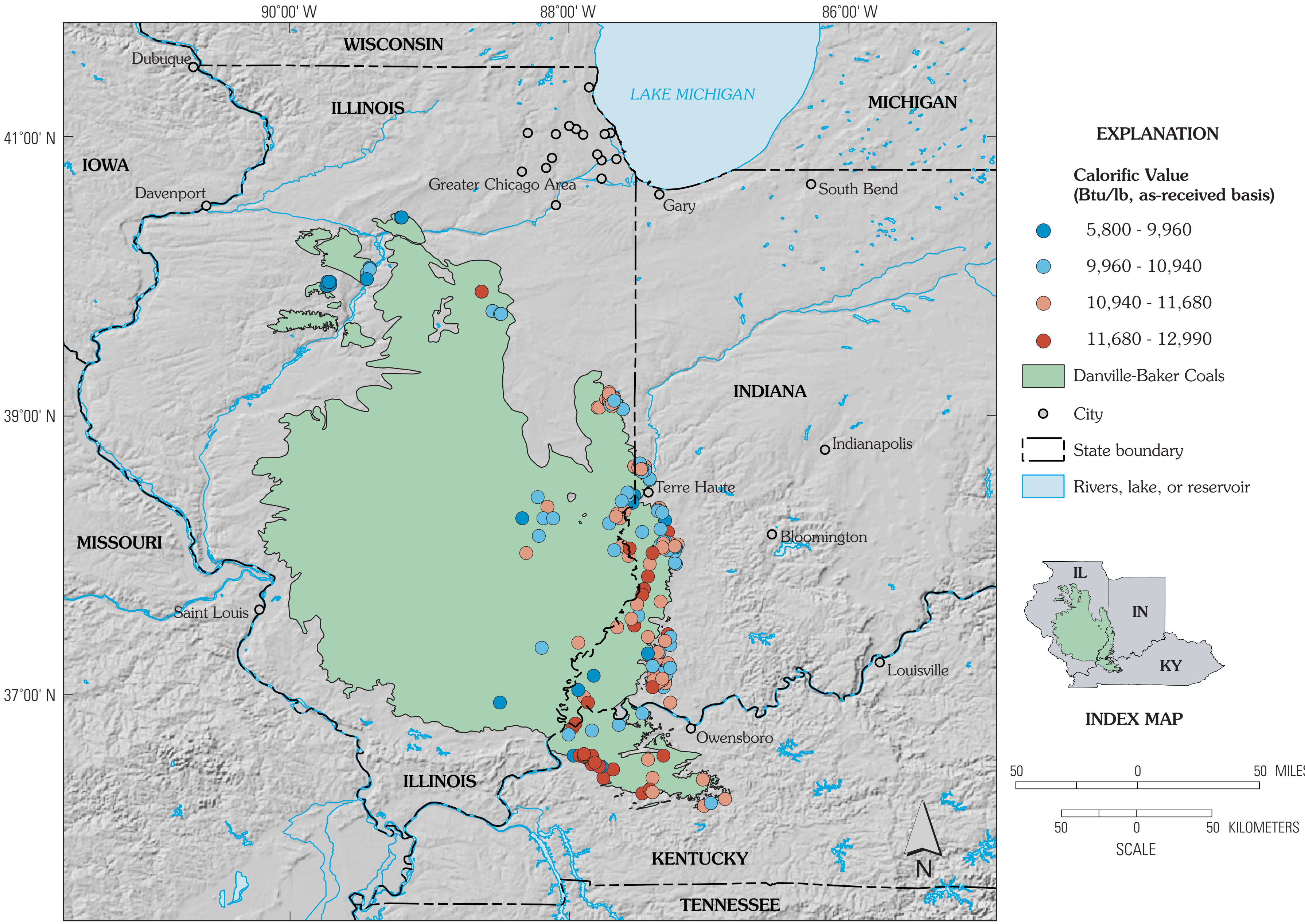

Figure 3. Graduated-symbol map for calorific values (Btu/lb, as-received basis) of the Danville-Baker Coals in the Illinois Basin.

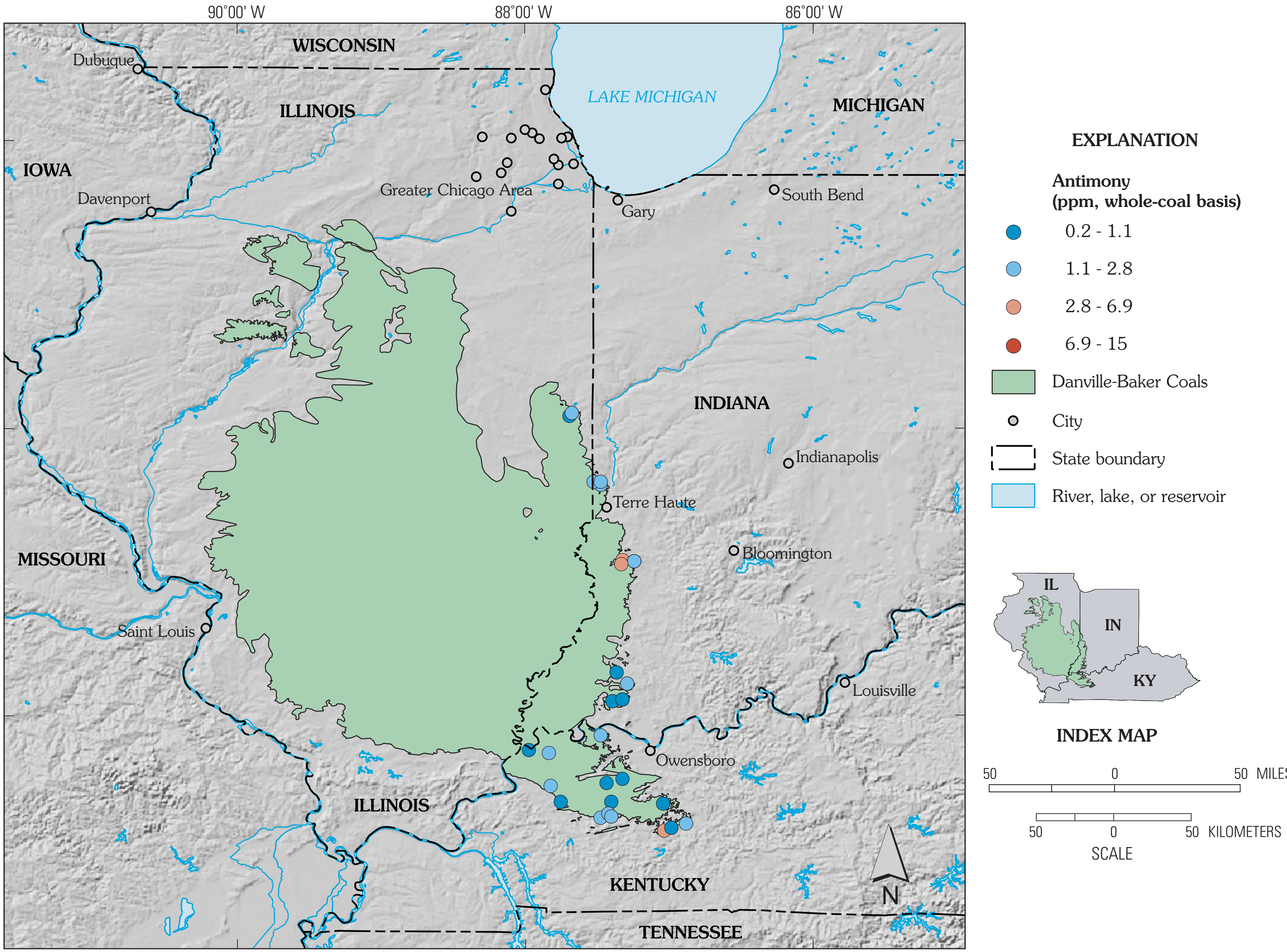

Figure 4. Graduated-symbol map for antimony content (parts per million, as-received, whole-coal basis) of the Danville-Baker Coals in the Illinois Basin.

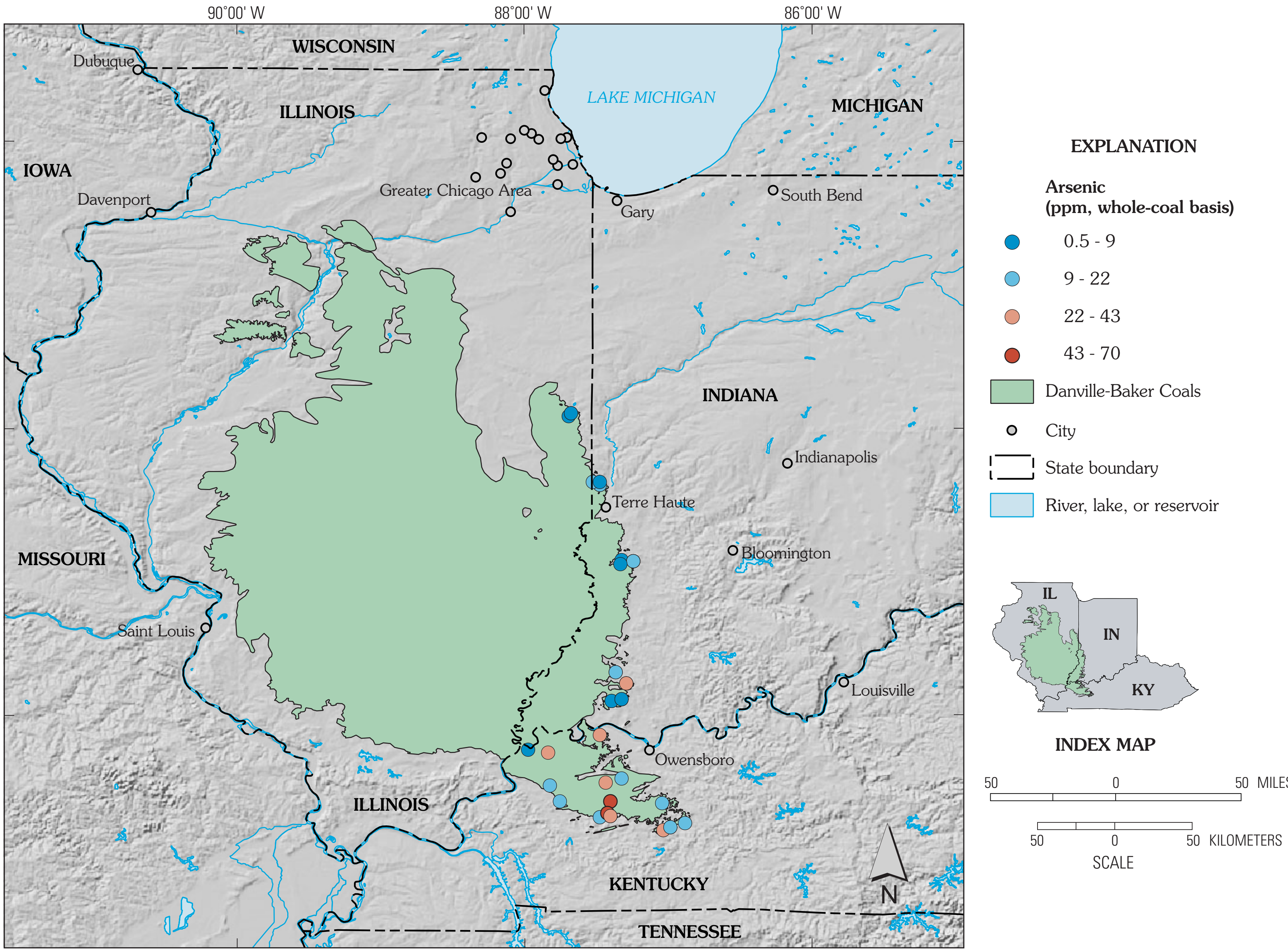

Figure 5. Graduated-symbol map for arsenic content (parts per million, as-received, whole-coal basis) of the Danville-Baker Coals in the Illinois Basin.

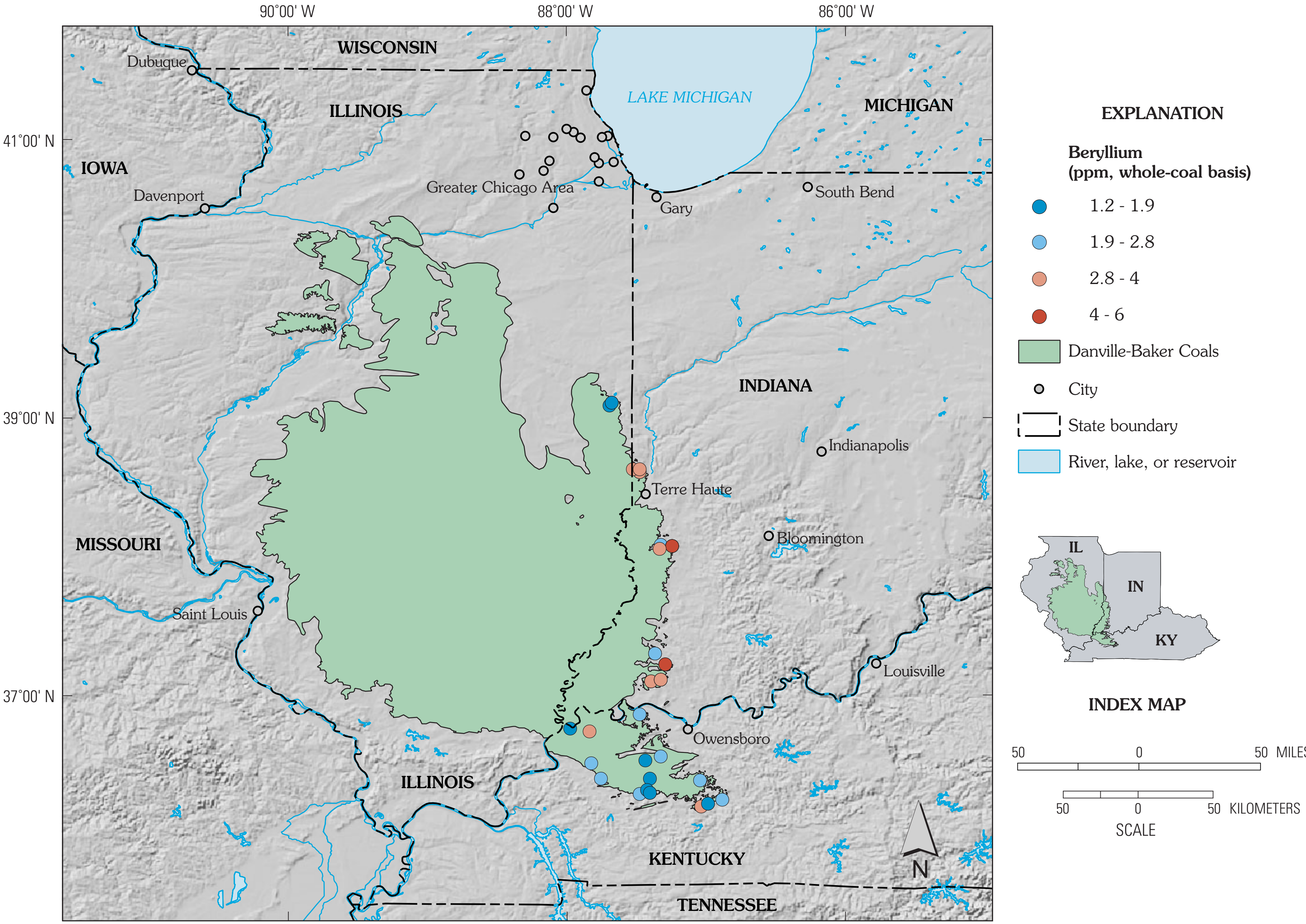

Figure 6. Graduated-symbol map for beryllium content (parts per million, as-received, whole-coal basis) of the Danville-Baker Coals in the Illinois Basin.

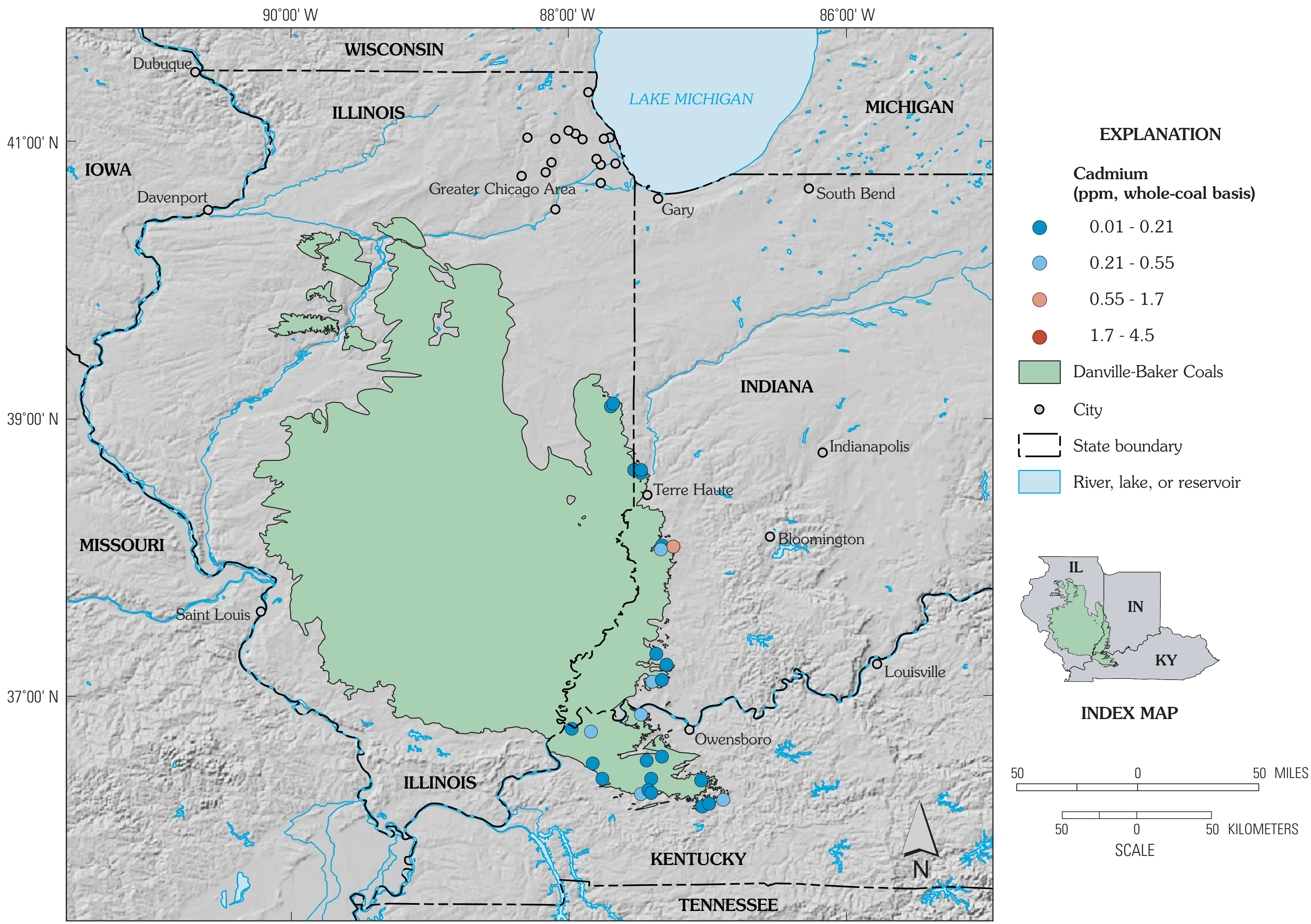

Figure 7. Graduated-symbol map for cadmium content (parts per million, as-received, whole-coal basis) of the Danville-Baker Coals in the Illinois Basin.

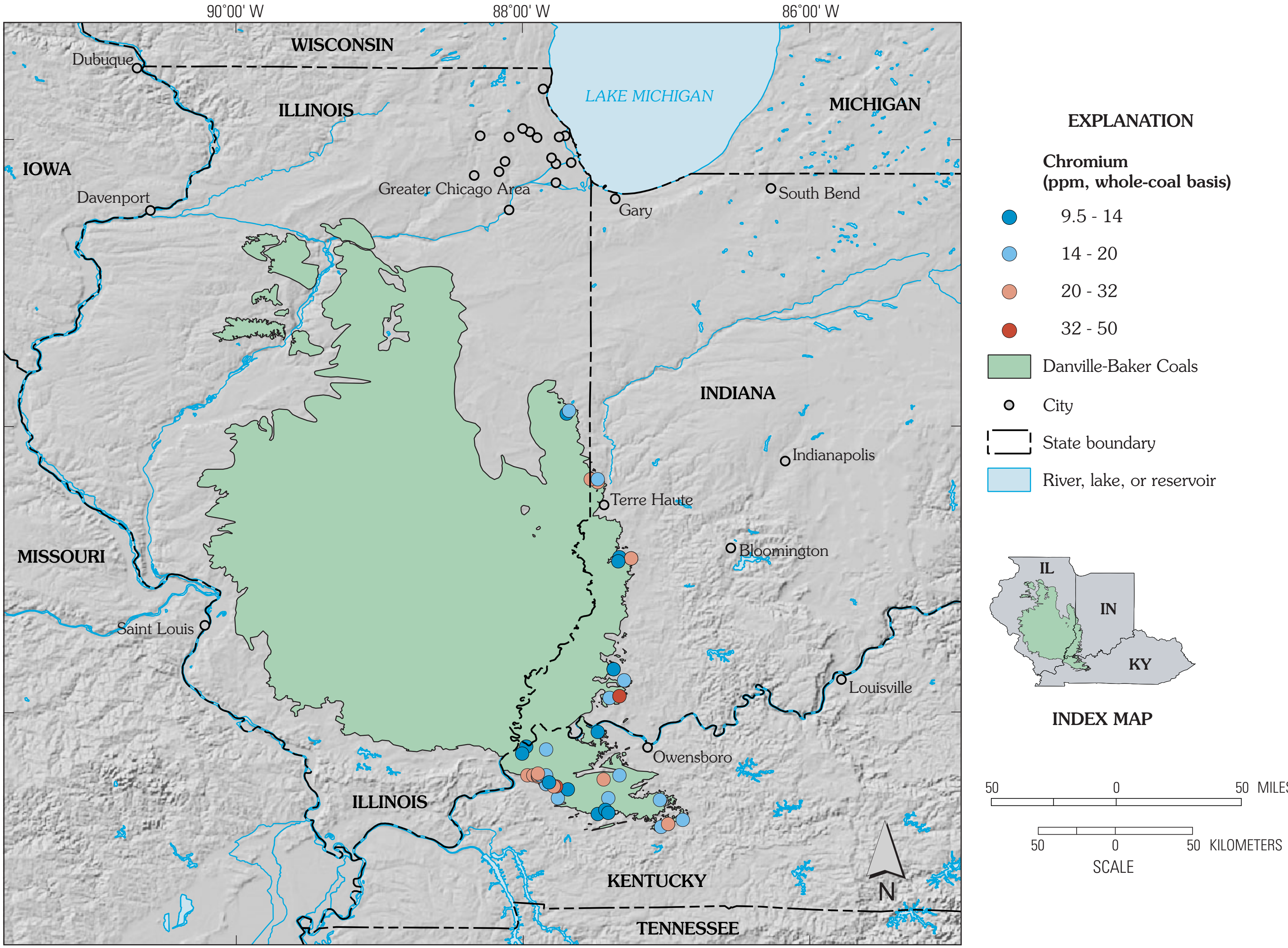

Figure 8. Graduated-symbol map for chromium content (parts per million, as-received, whole-coal basis) of the Danville-Baker Coals in the Illinois Basin.

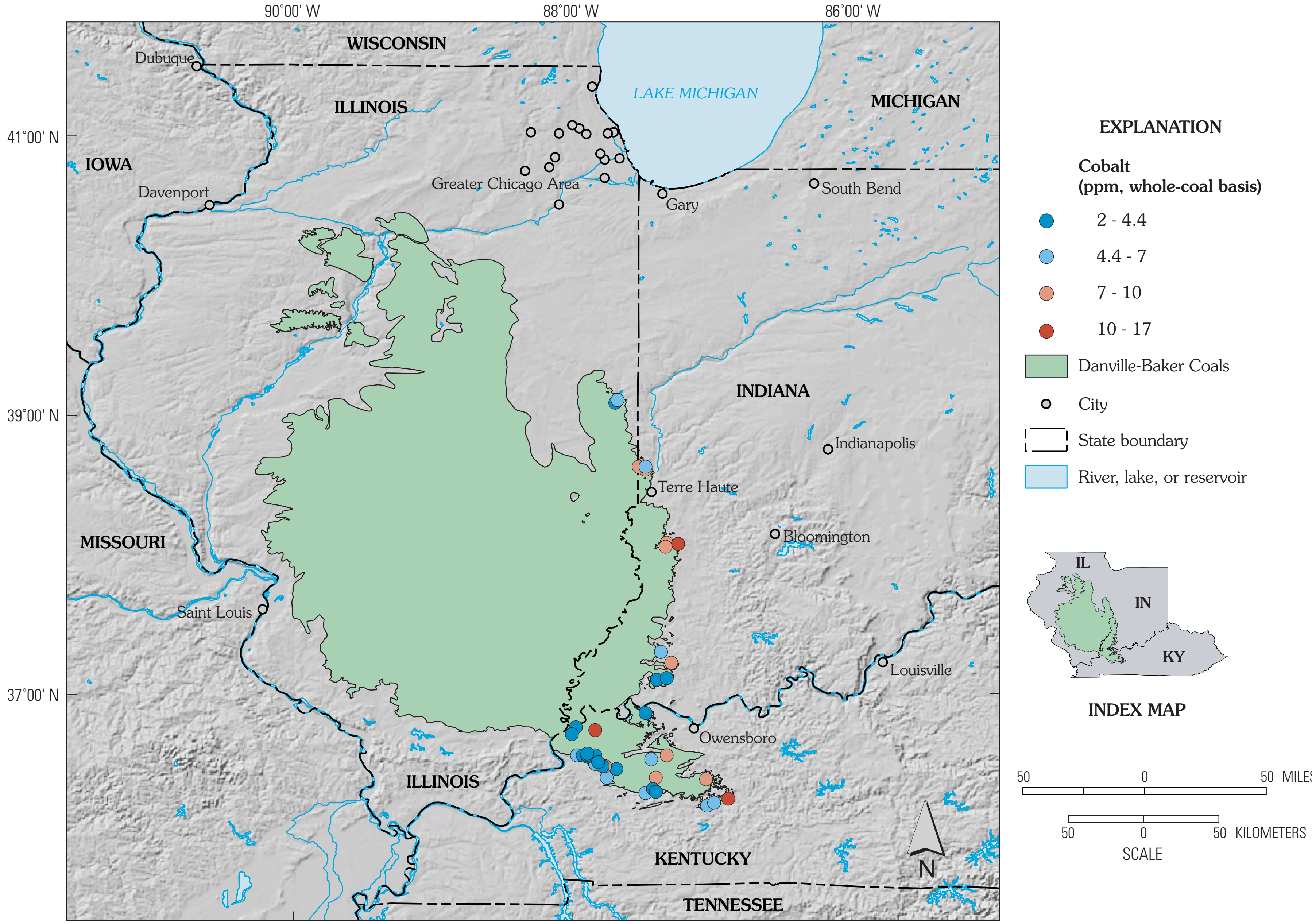

Figure 9. Graduated-symbol map for cobalt content (parts per million, as-received, whole-coal basis) of the Danville-Baker Coals in the Illinois Basin.

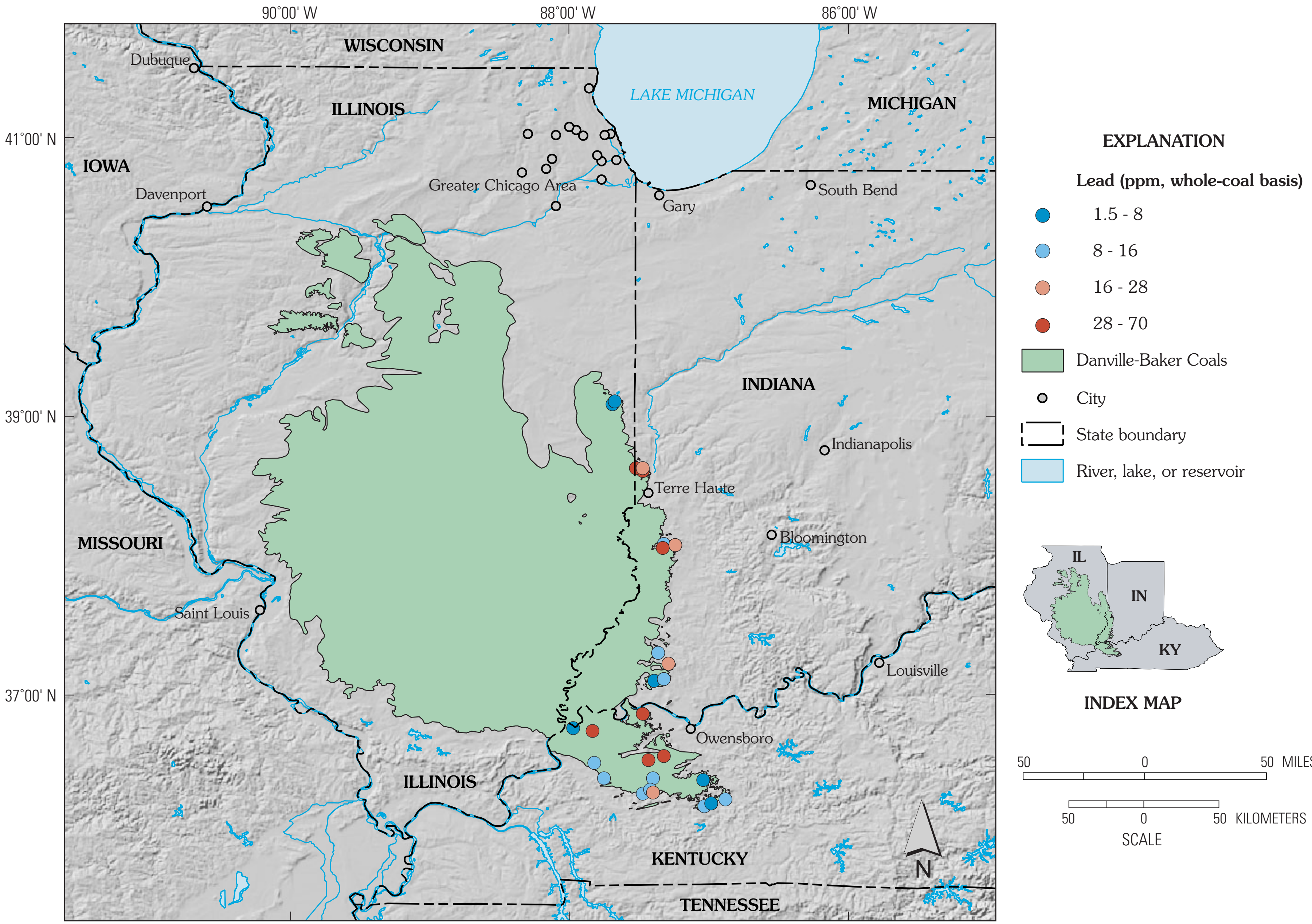

Figure 10. Graduated-symbol map for lead content (parts per million, as-received, whole-coal basis) of the Danville-Baker Coals in the Illinois Basin.

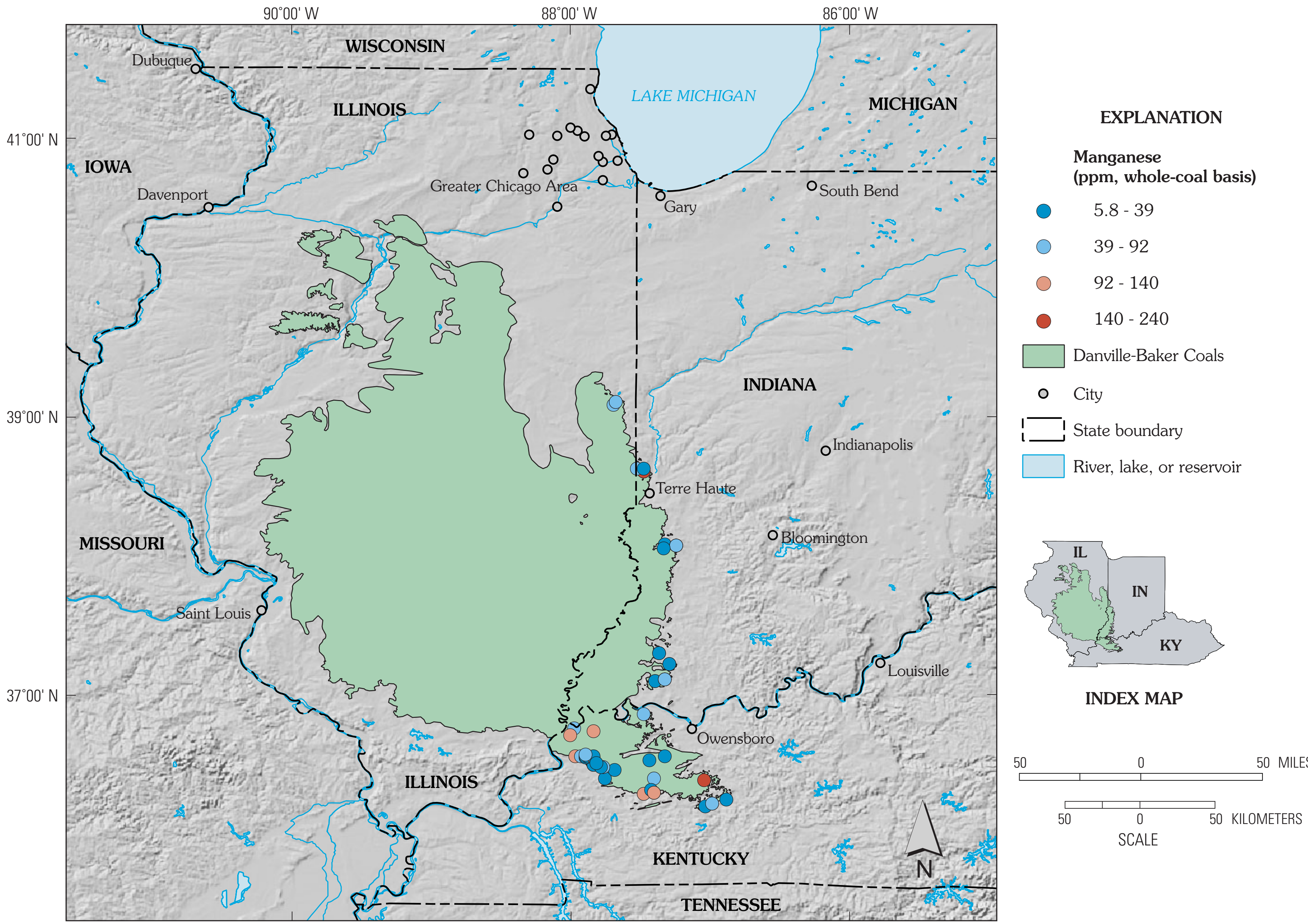

Figure 11. Graduated-symbol map for manganese content (parts per million, as-received, whole-coal basis) of the Danville-Baker Coals in the Illinois Basin.

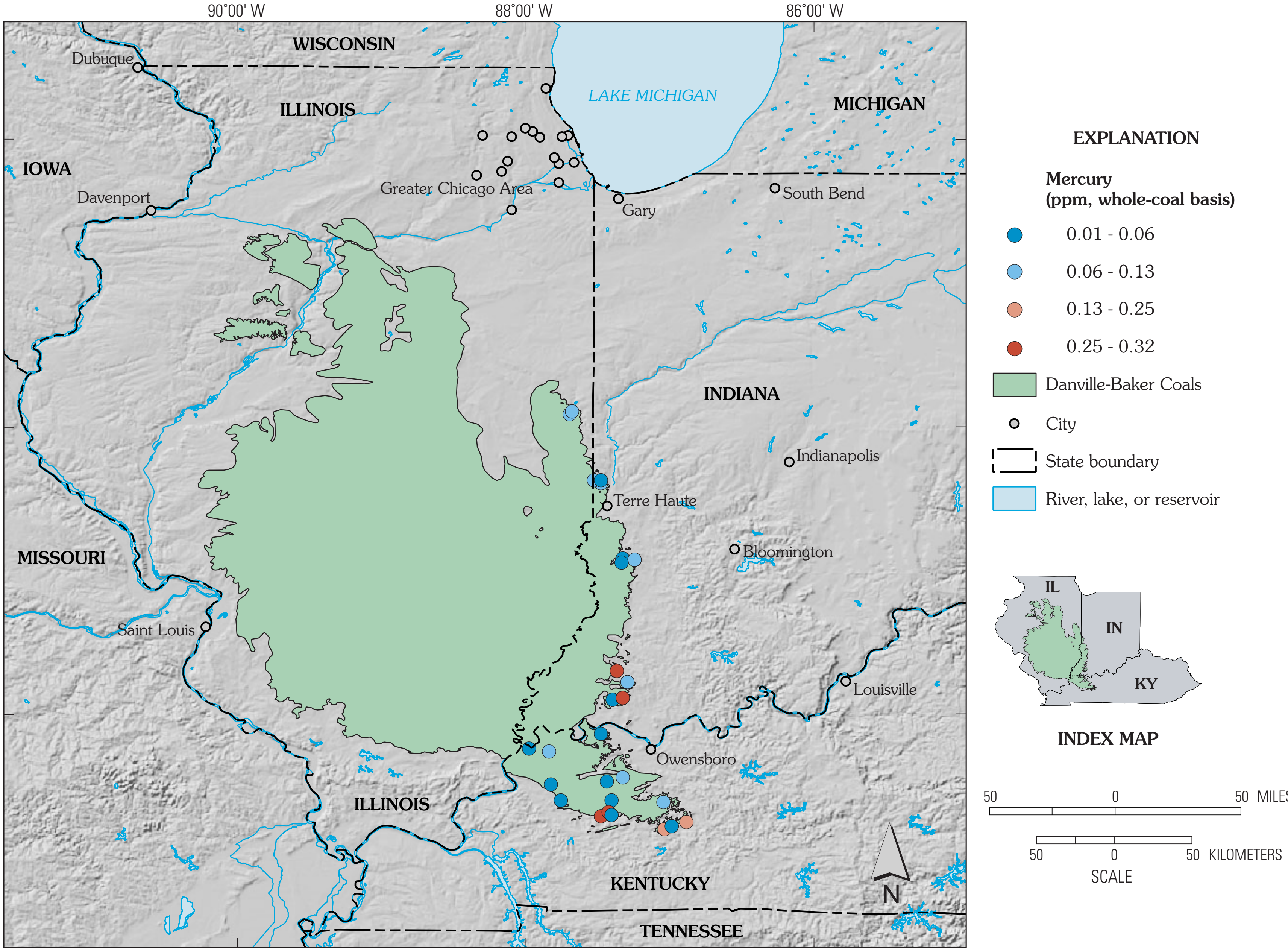

Figure 12. Graduated-symbol map for mercury content (parts per million, as-received, whole-coal basis) of the Danville-Baker Coals in the Illinois Basin.

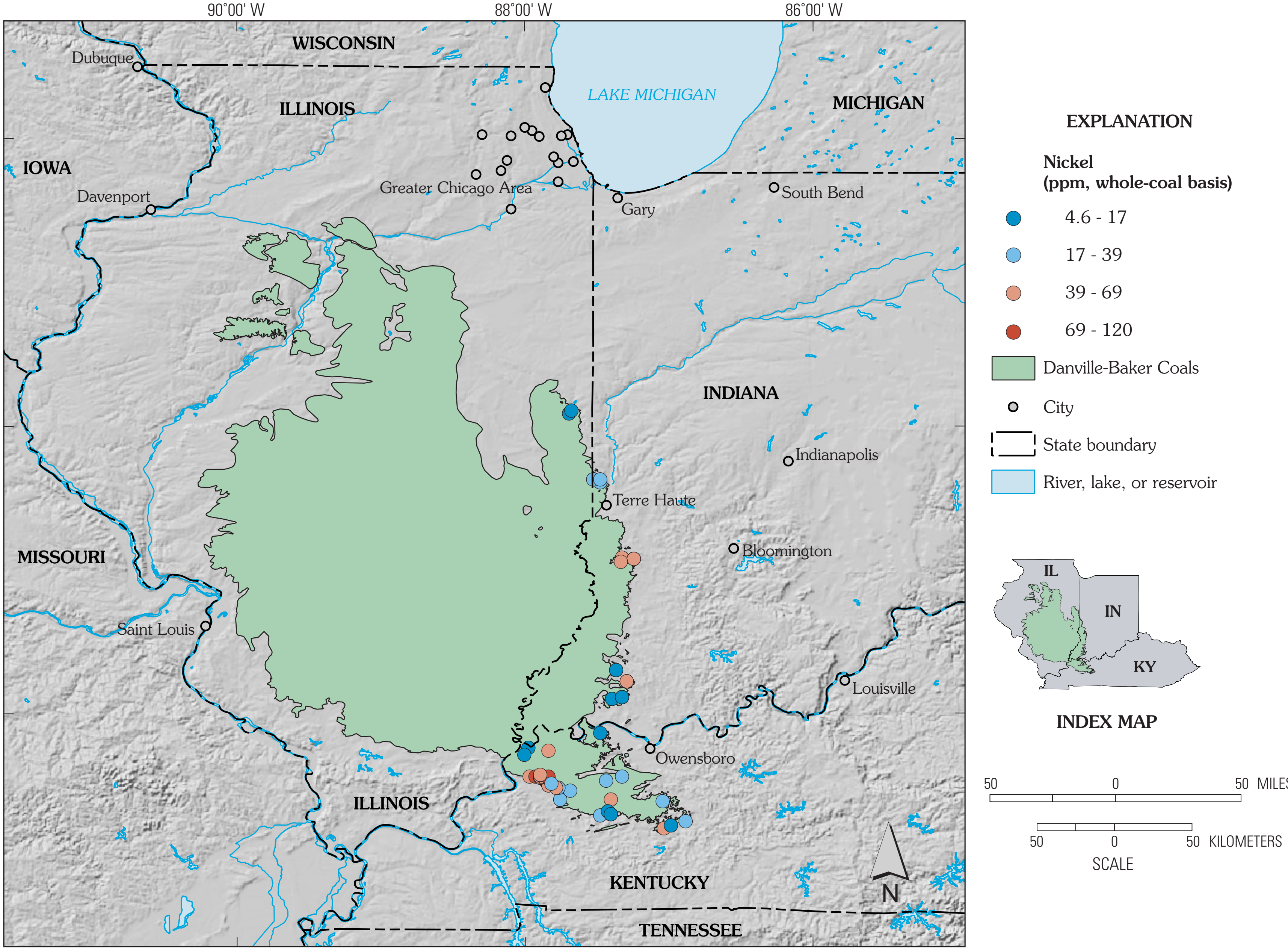

Figure 13. Graduated-symbol map for nickel content (parts per million, as-received, whole-coal basis) of the Danville-Baker Coals in the Illinois Basin.

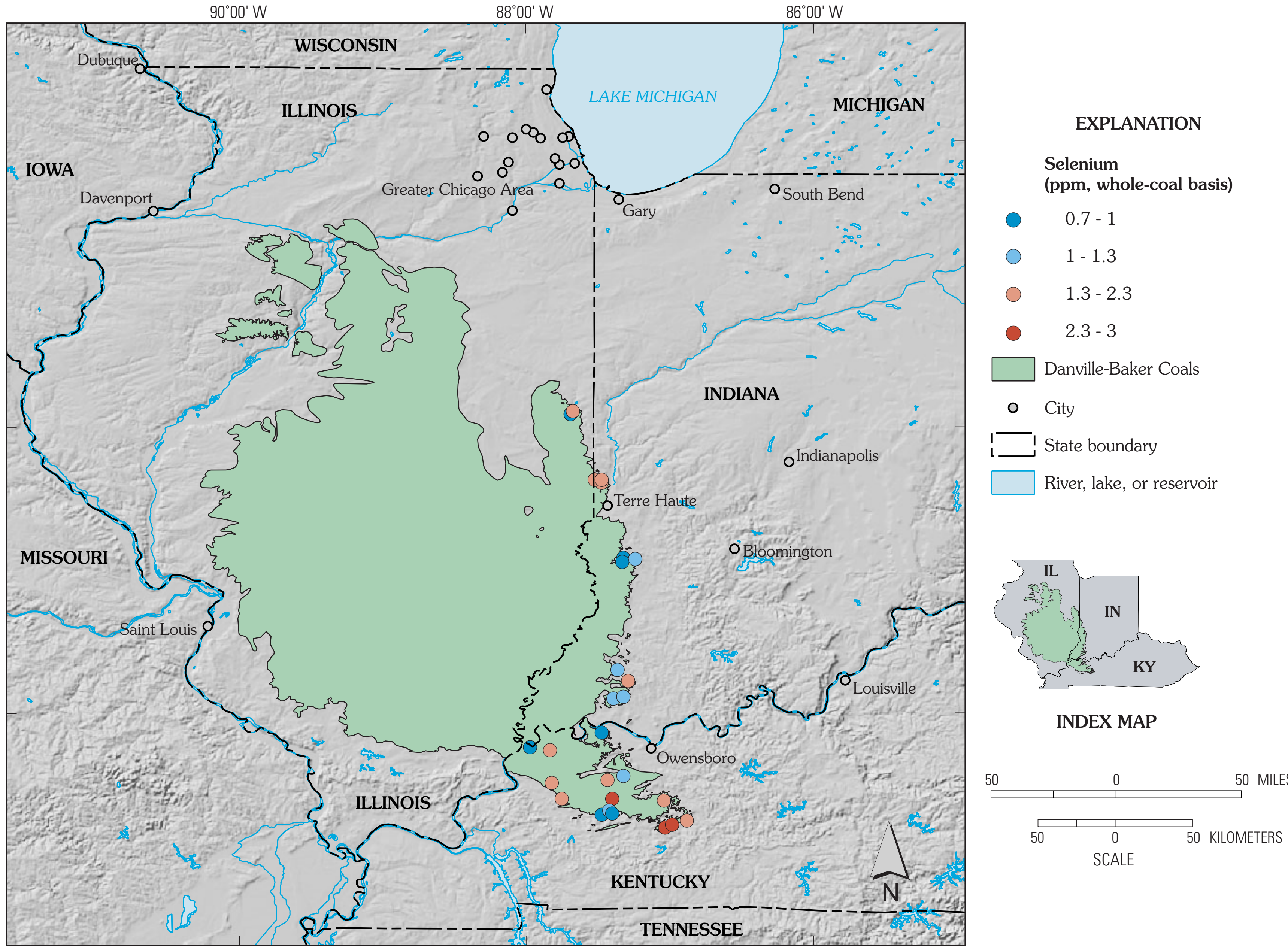

Figure 14. Graduated-symbol map for selenium content (parts per million, as-received, whole-coal basis) of the Danville-Baker Coals in the Illinois Basin.

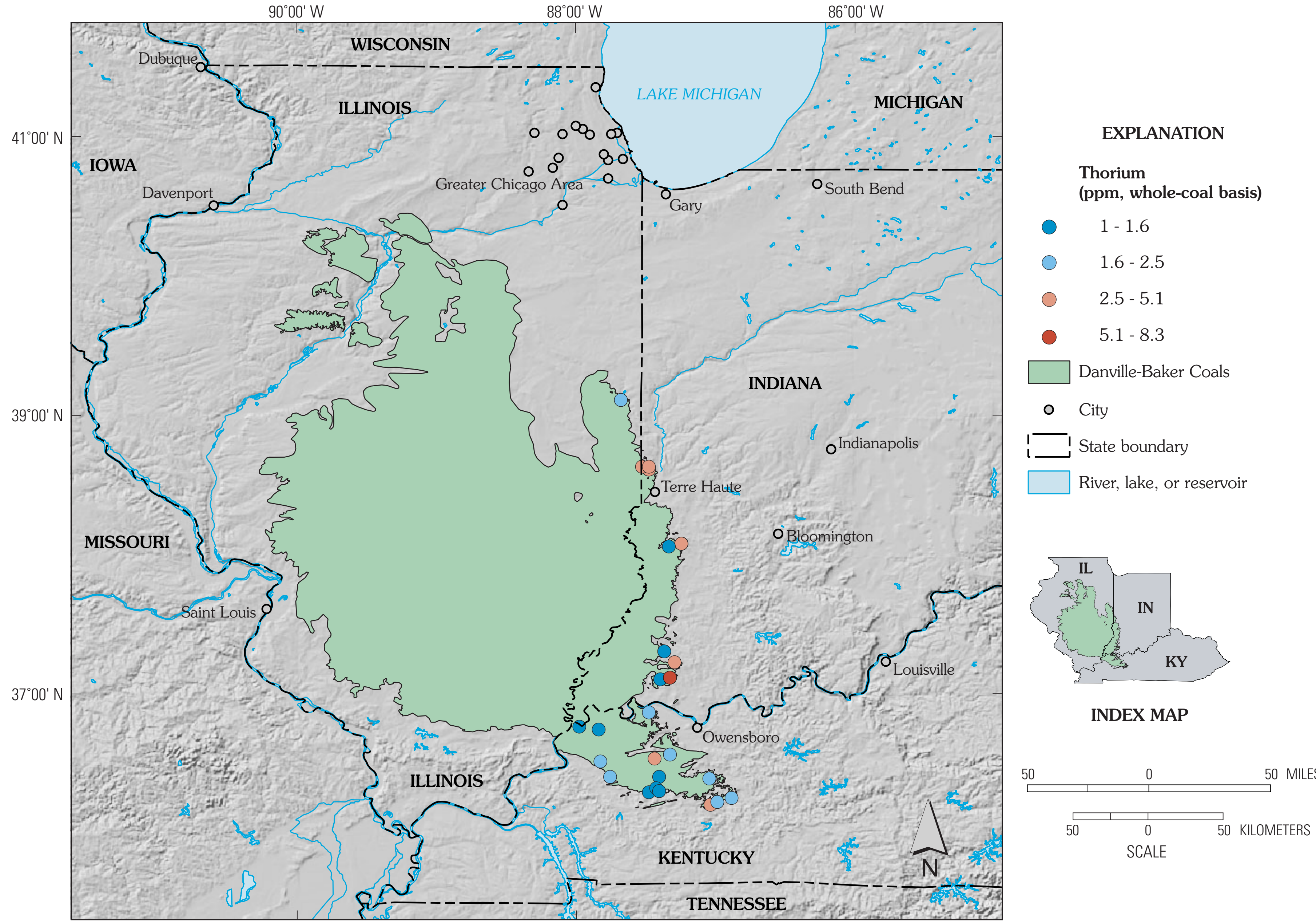

Figure 15. Graduated-symbol map for thorium content (parts per million, as-received, whole-coal basis) of the Danville-Baker Coals in the Illinois Basin.

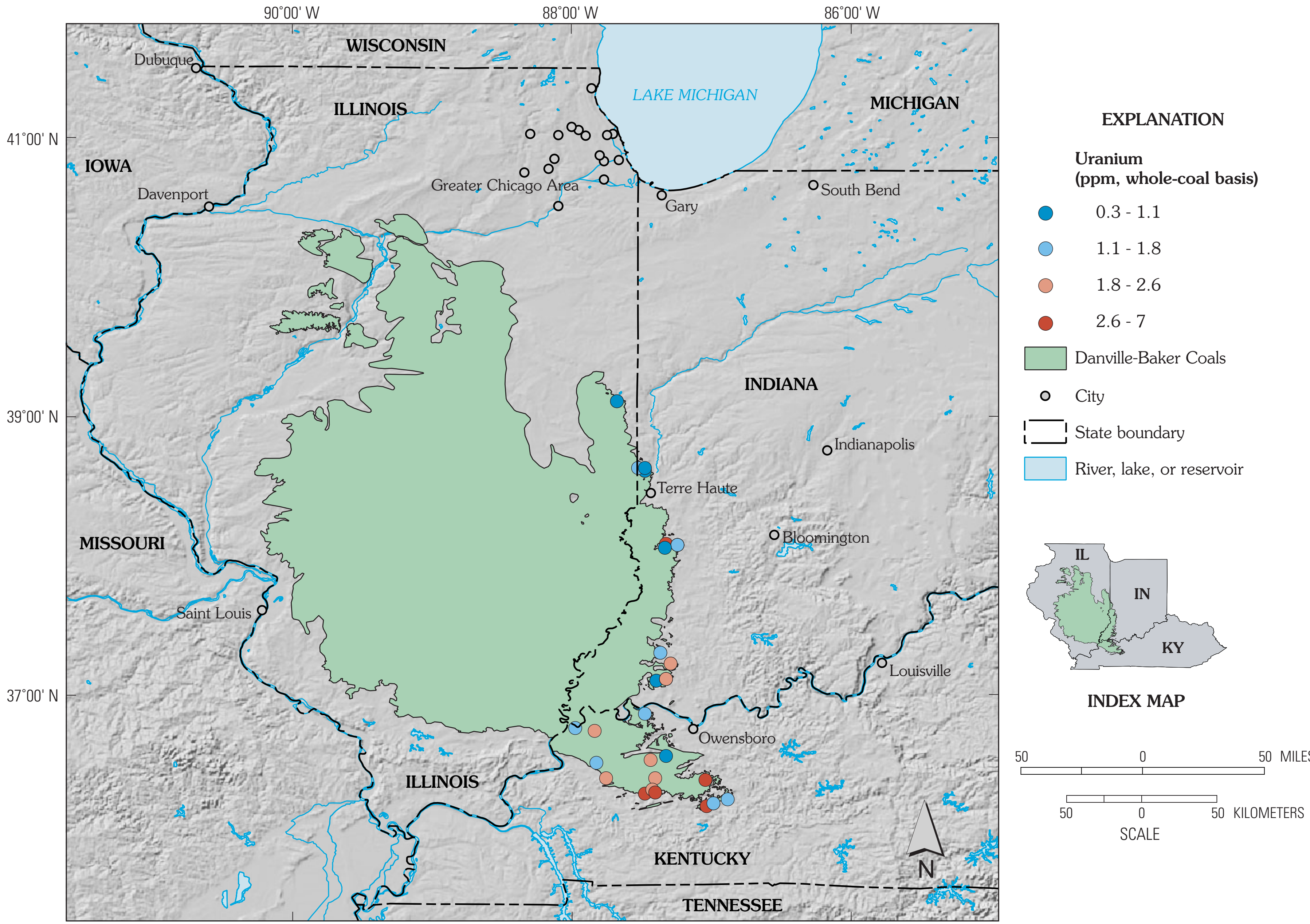

Figure 16. Graduated-symbol map for uranium content (parts per million, as-received, whole-coal basis) of the Danville-Baker Coals in the Illinois Basin.

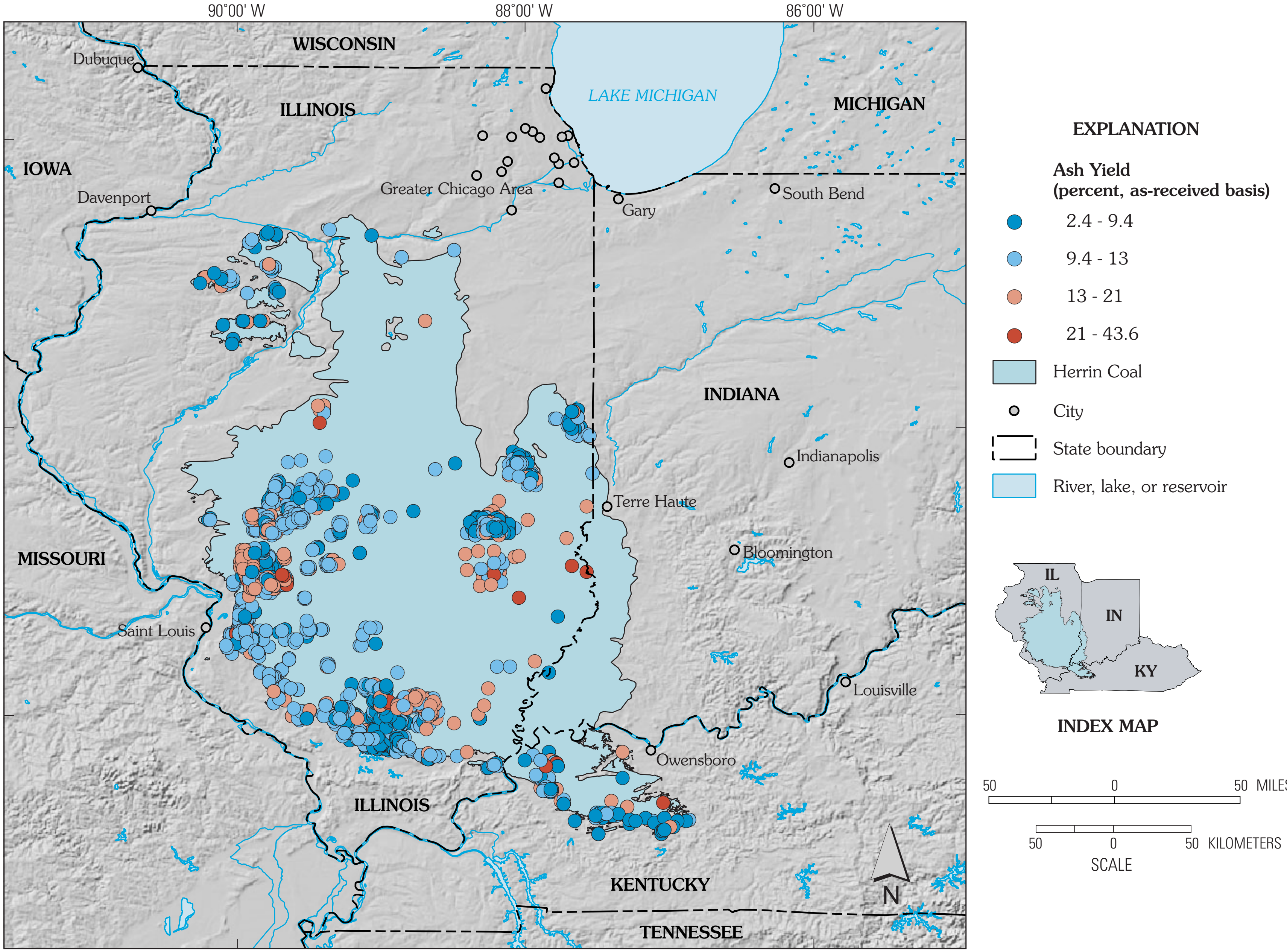

Figure 17. Graduated-symbol map for ash yield (percent, as-received basis) of the Herrin Coal in the Illinois Basin.

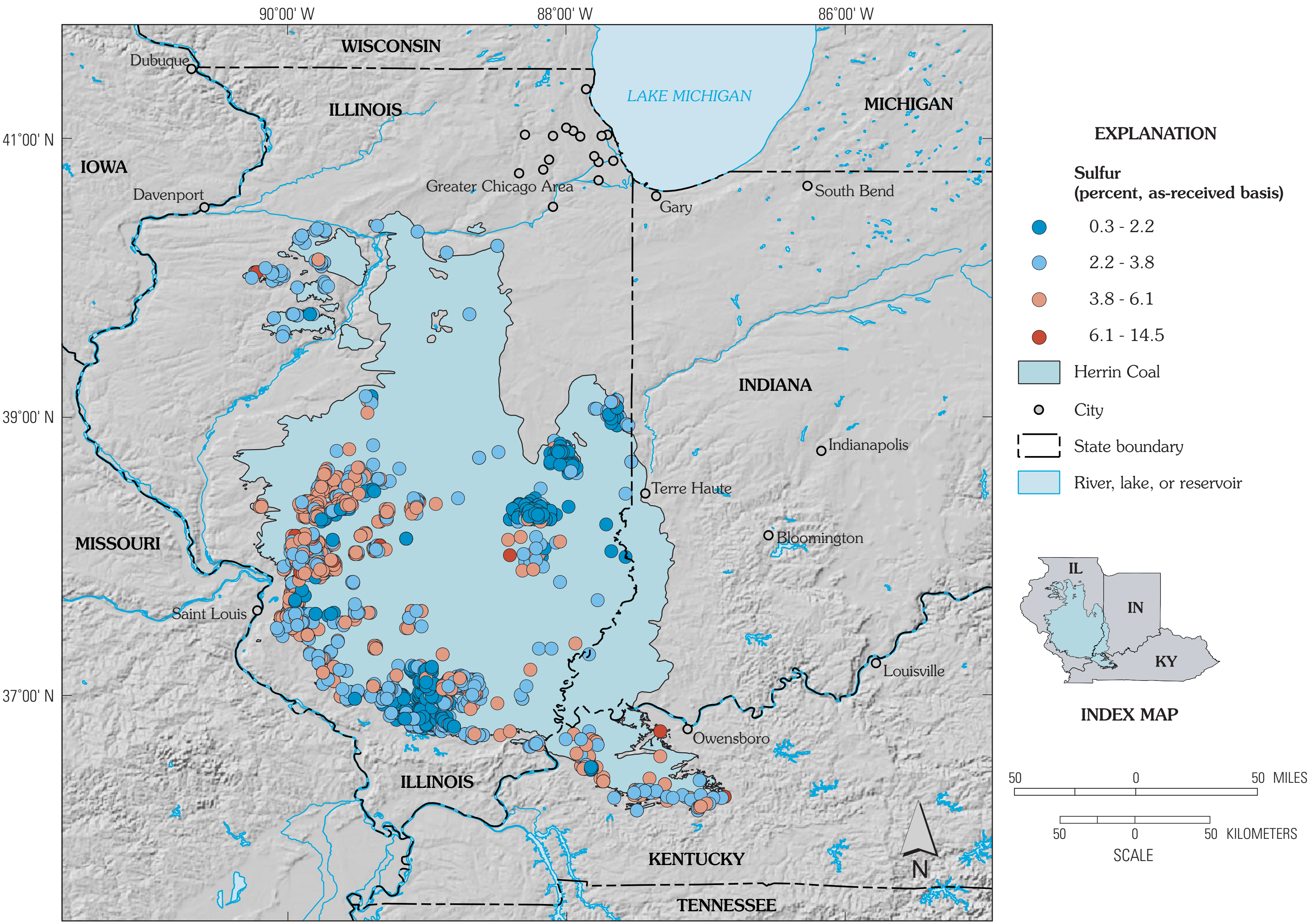

Figure 18. Graduated-symbol map for sulfur content (percent, as-received basis) of the Herrin Coal in the Illinois Basin.

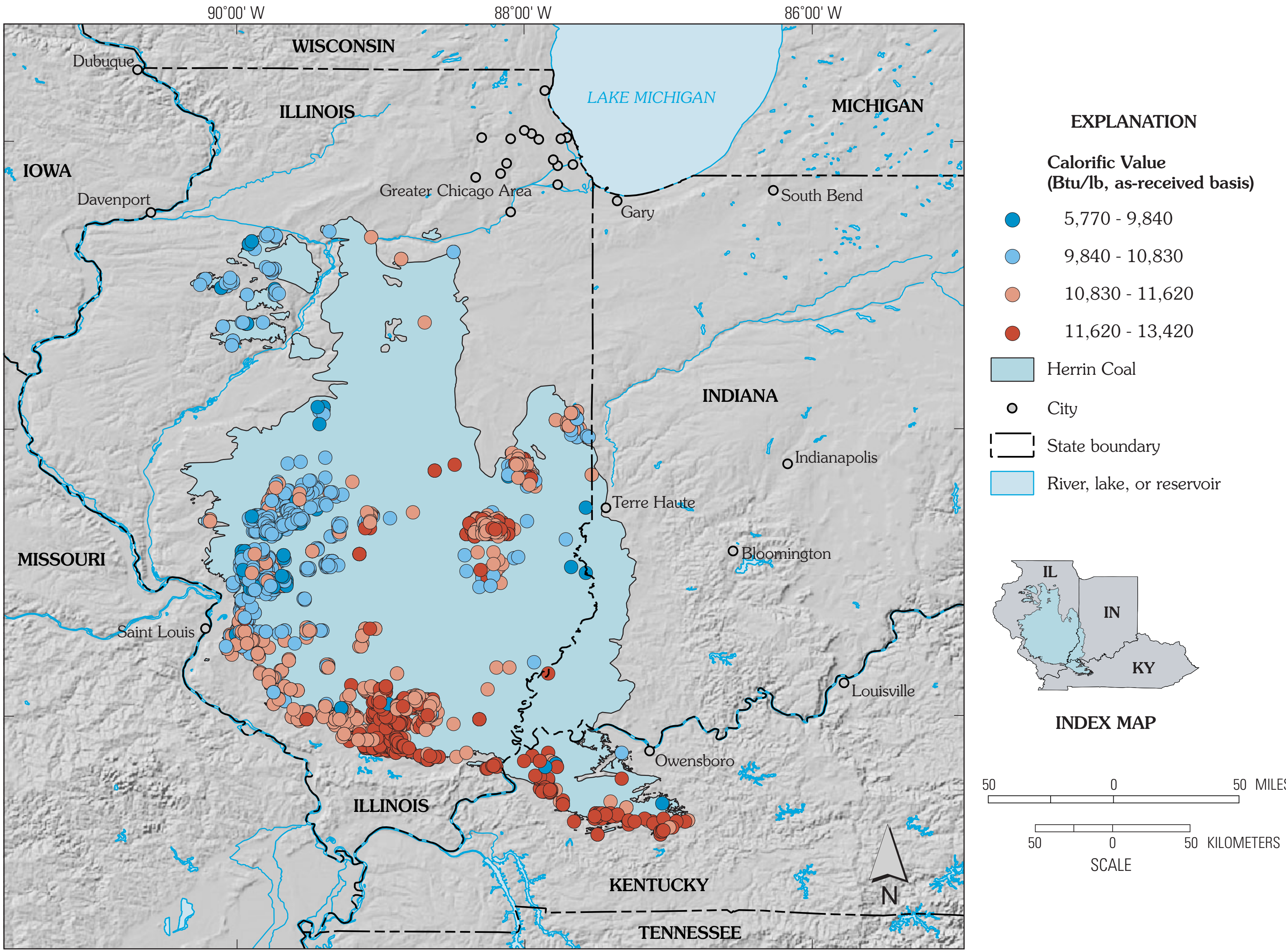

Figure 19. Graduated-symbol map for calorific values (Btu/lb, as-received basis) of the Herrin Coal in the Illinois Basin.

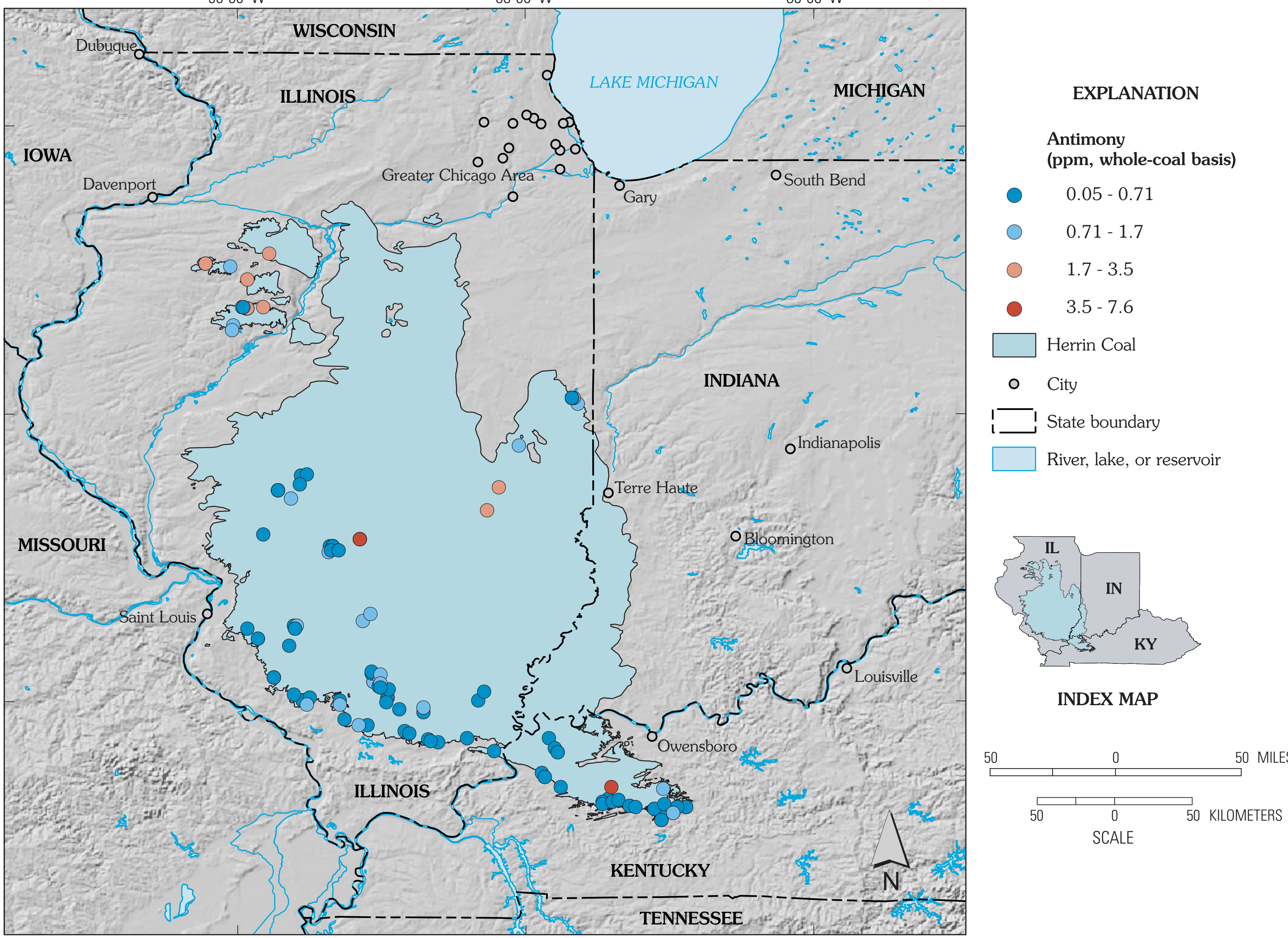

Figure 20. Graduated-symbol map for antimony content (parts per million, as-received, whole-coal basis) of the Herrin Coal in the Illinois Basin.

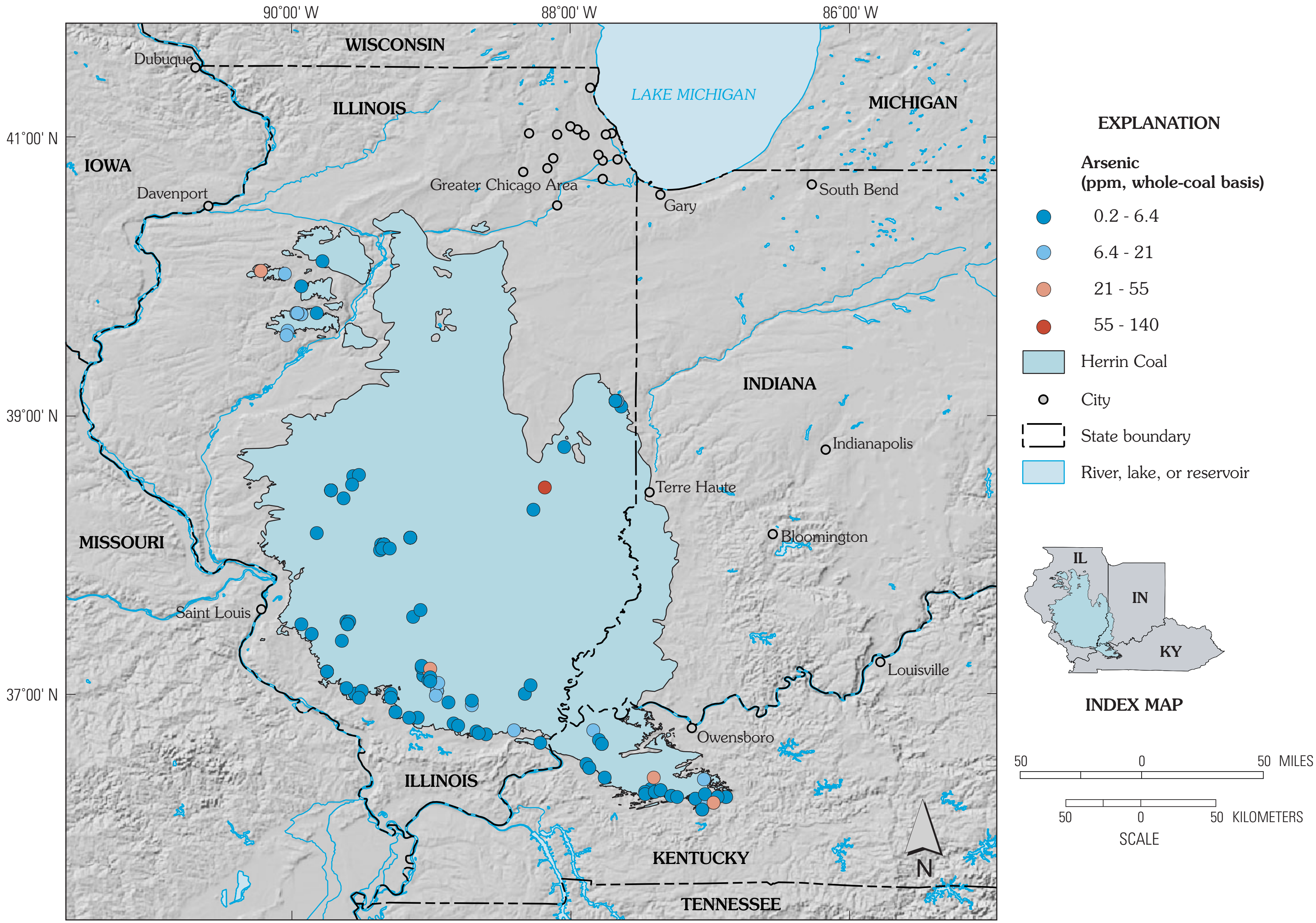

Figure 21. Graduated-symbol map for arsenic content (parts per million, as-received, whole-coal basis) of the Herrin Coal in the Illinois Basin.

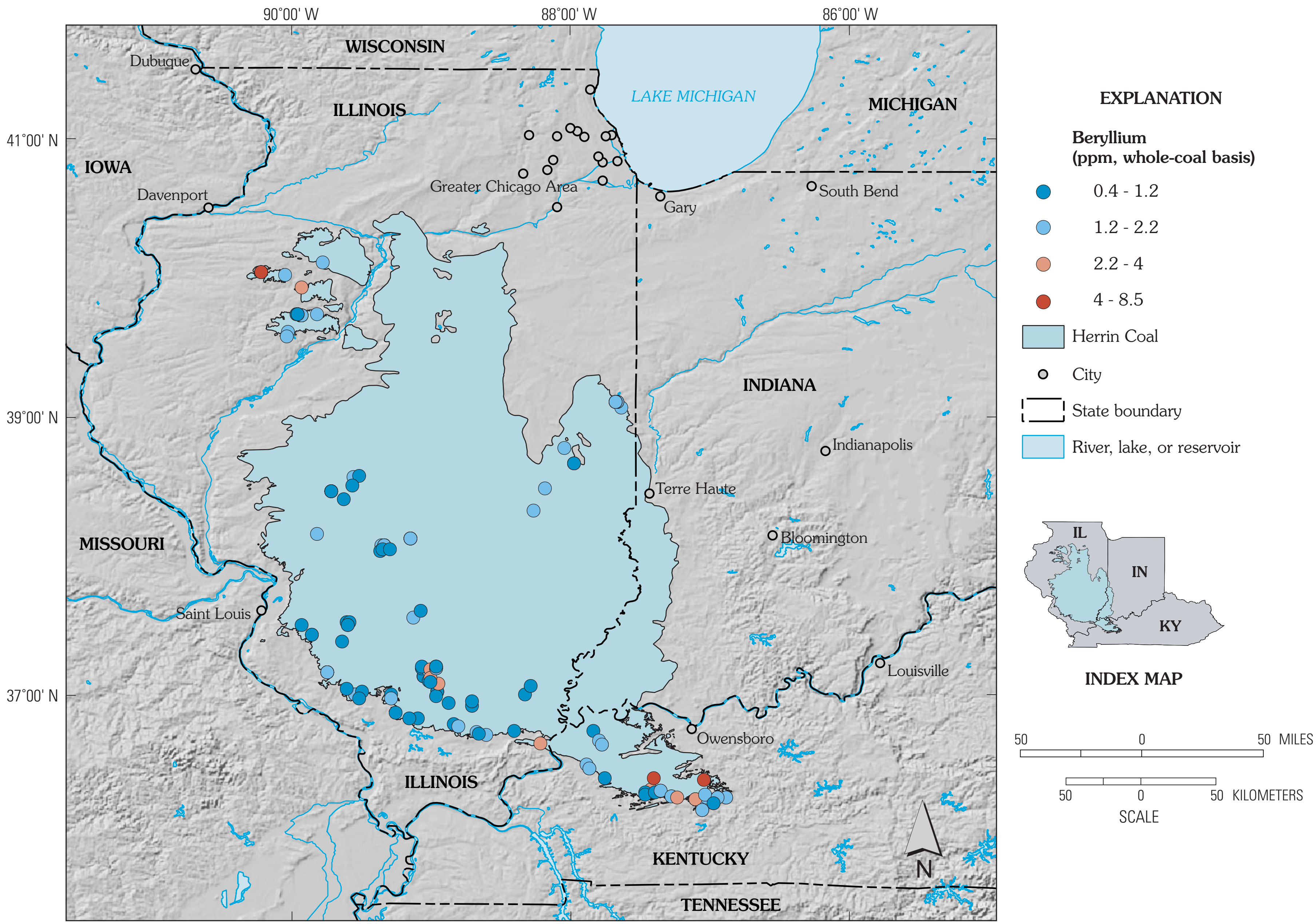

Figure 22. Graduated-symbol map for beryllium content (parts per million, as-received, whole-coal basis) of the Herrin Coal in the Illinois Basin.

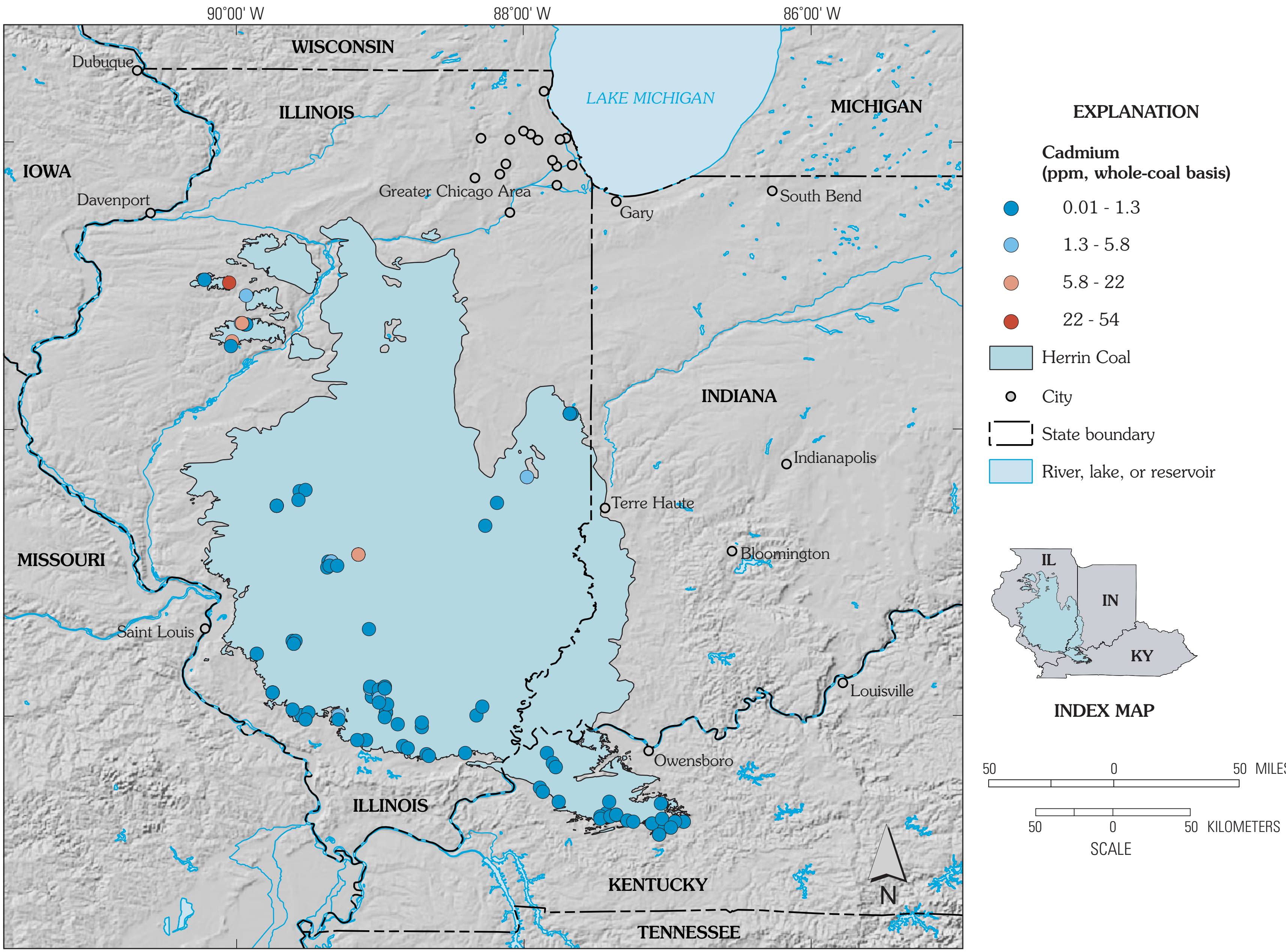

Figure 23. Graduated-symbol map for cadmium content (parts per million, as-received, whole-coal basis) of the Herrin Coal in the Illinois Basin.

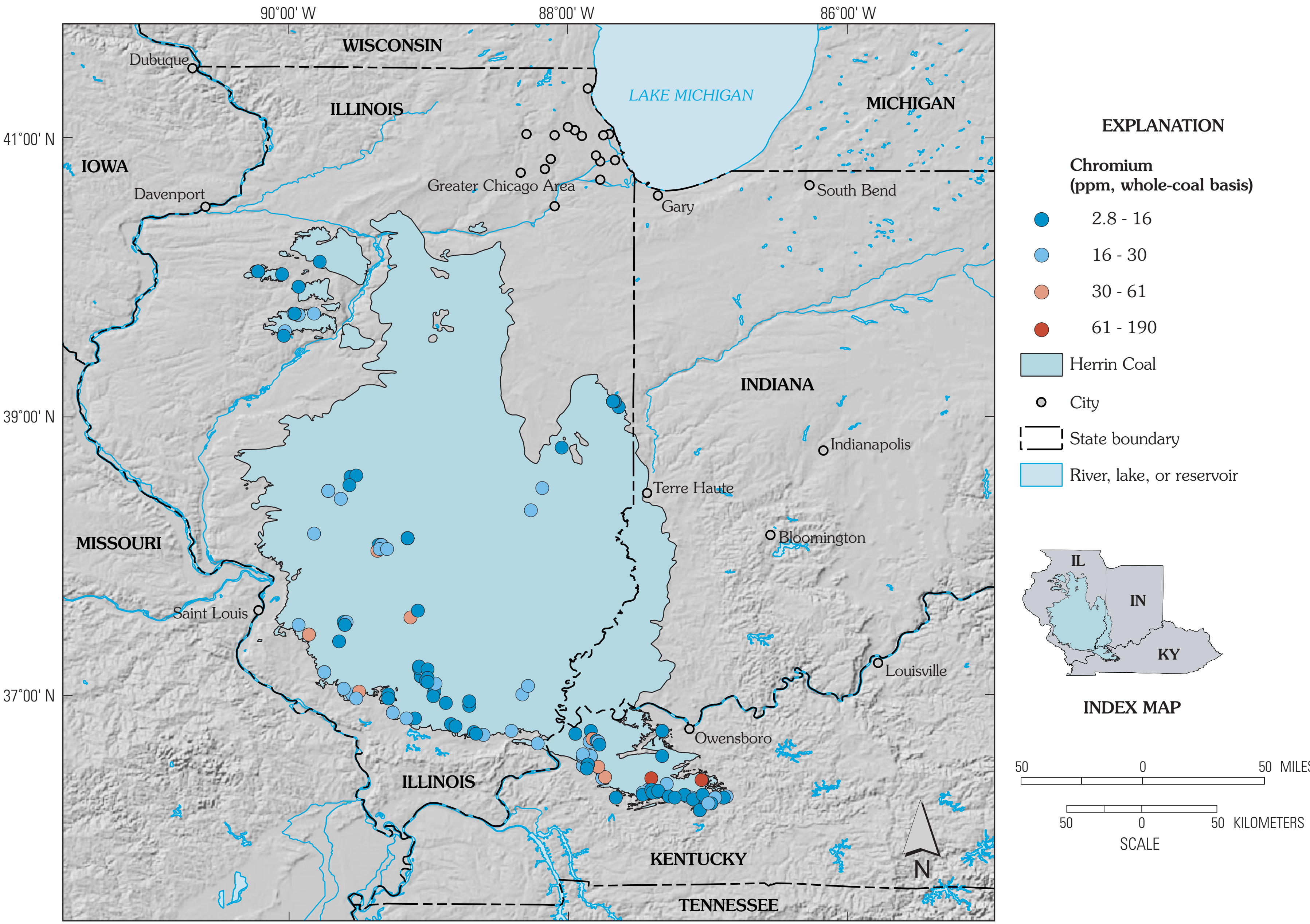

Figure 24. Graduated-symbol map for chromium content (parts per million, as-received, whole-coal basis) of the Herrin Coal in the Illinois Basin.

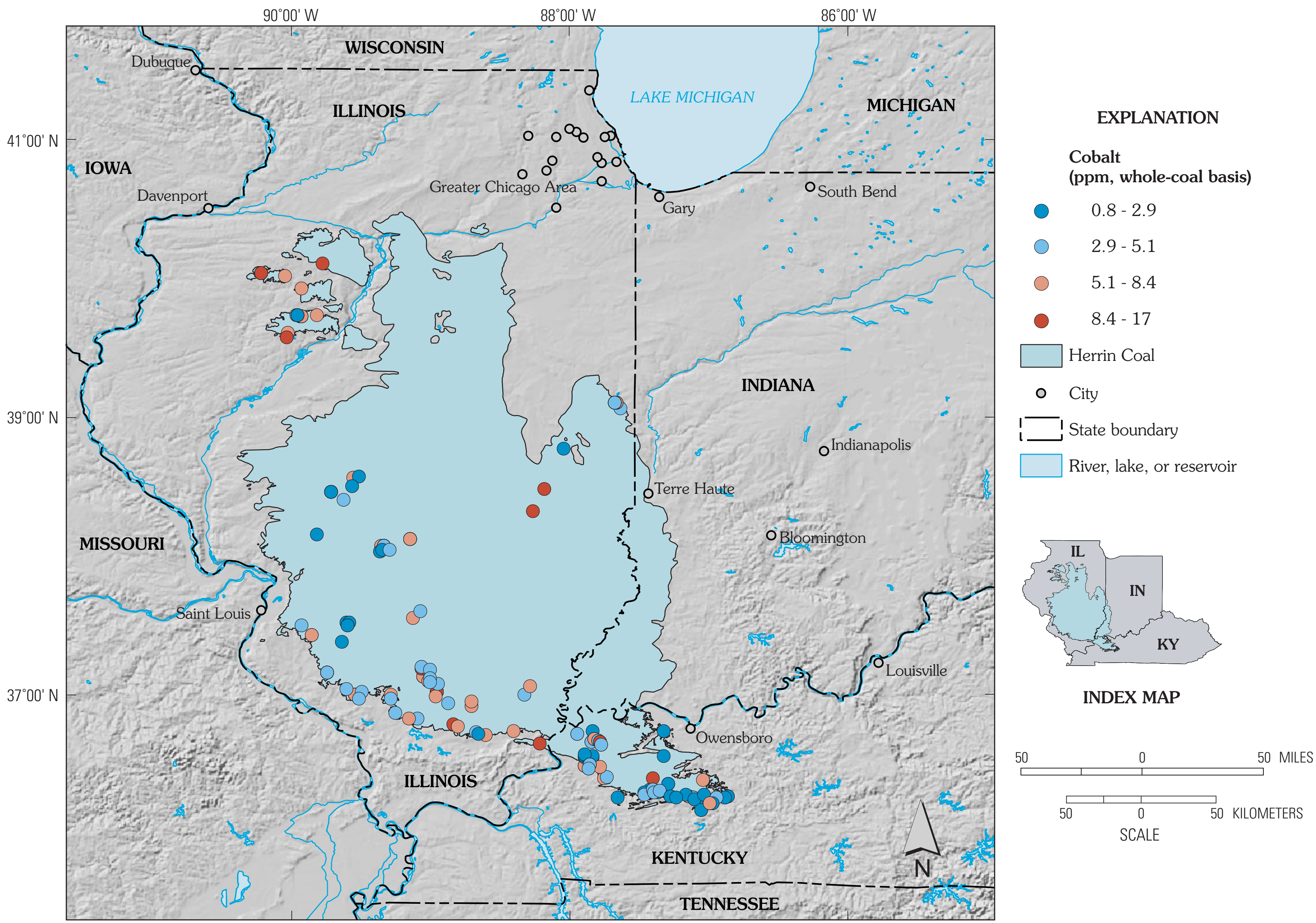

Figure 25. Graduated-symbol map for cobalt content (parts per million, as-received, whole-coal basis) of the Herrin Coal in the Illinois Basin.

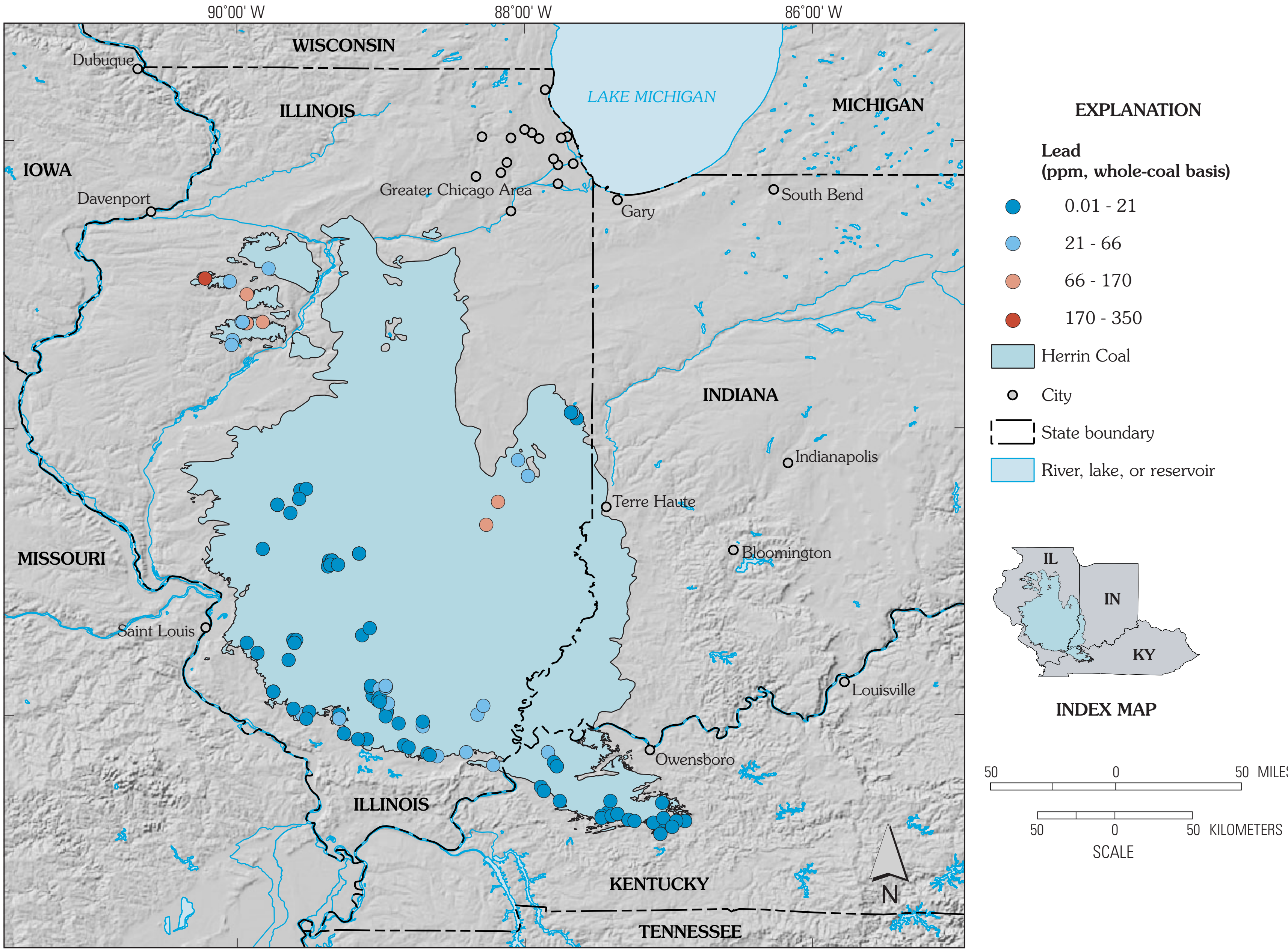

Figure 26. Graduated-symbol map for lead content (parts per million, as-received, whole-coal basis) of the Herrin Coal in the Illinois Basin.

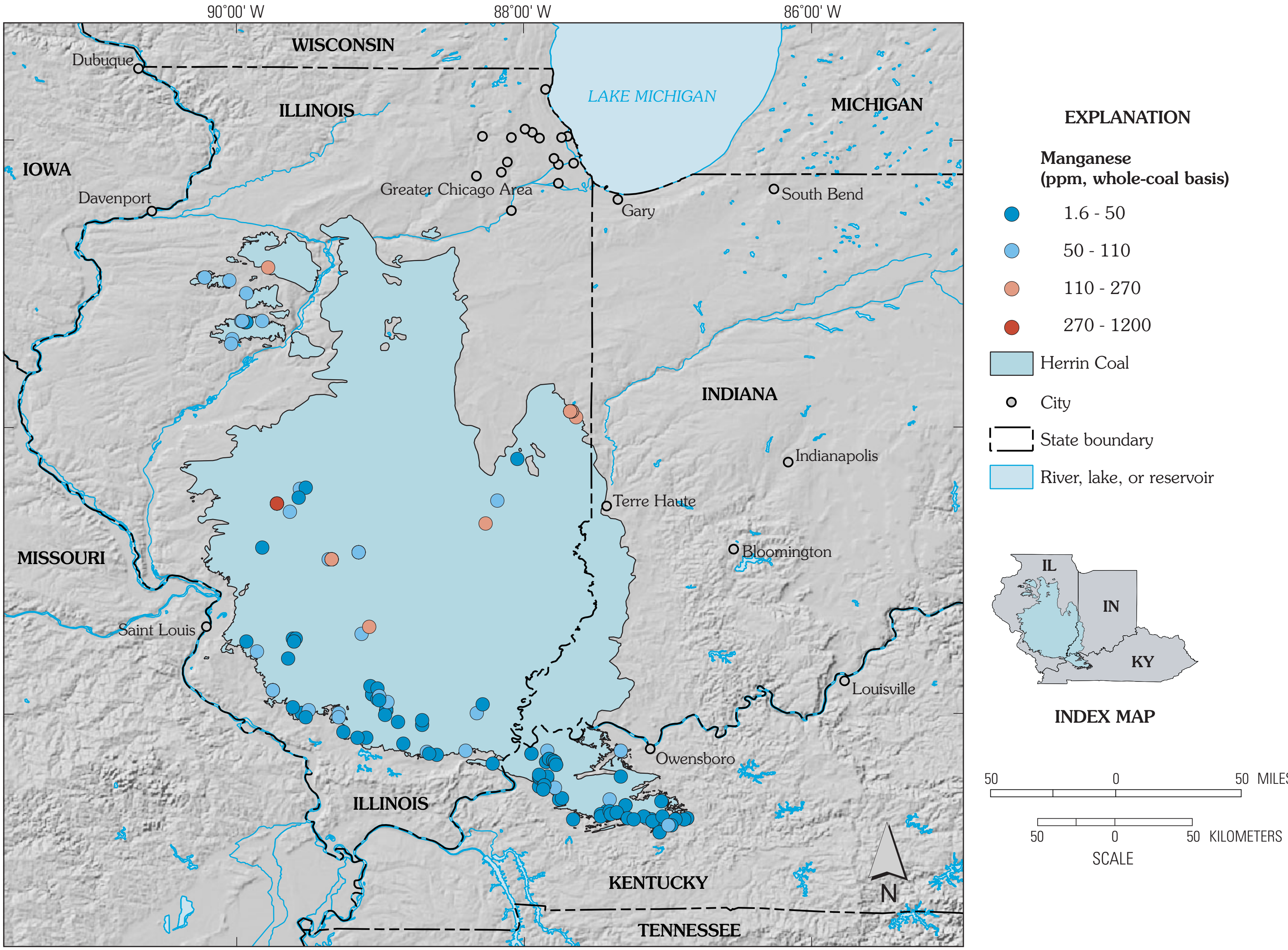

Figure 27. Graduated-symbol map for manganese content (parts per million, as-received, whole-coal basis) of the Herrin Coal in the Illinois Basin.

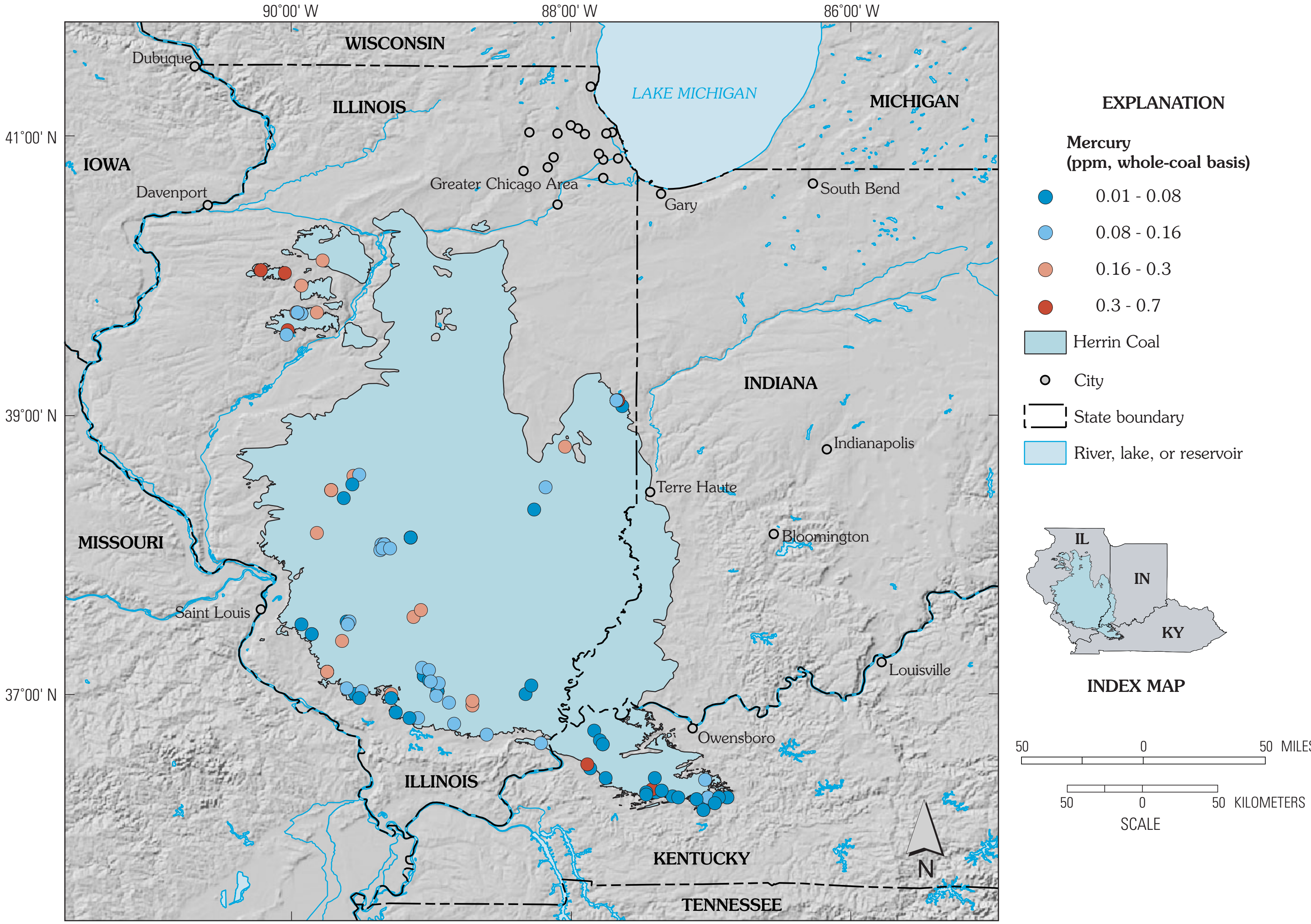

Figure 28. Graduated-symbol map for mercury content (parts per million, as-received, whole-coal basis) of the Herrin Coal in the Illinois Basin.

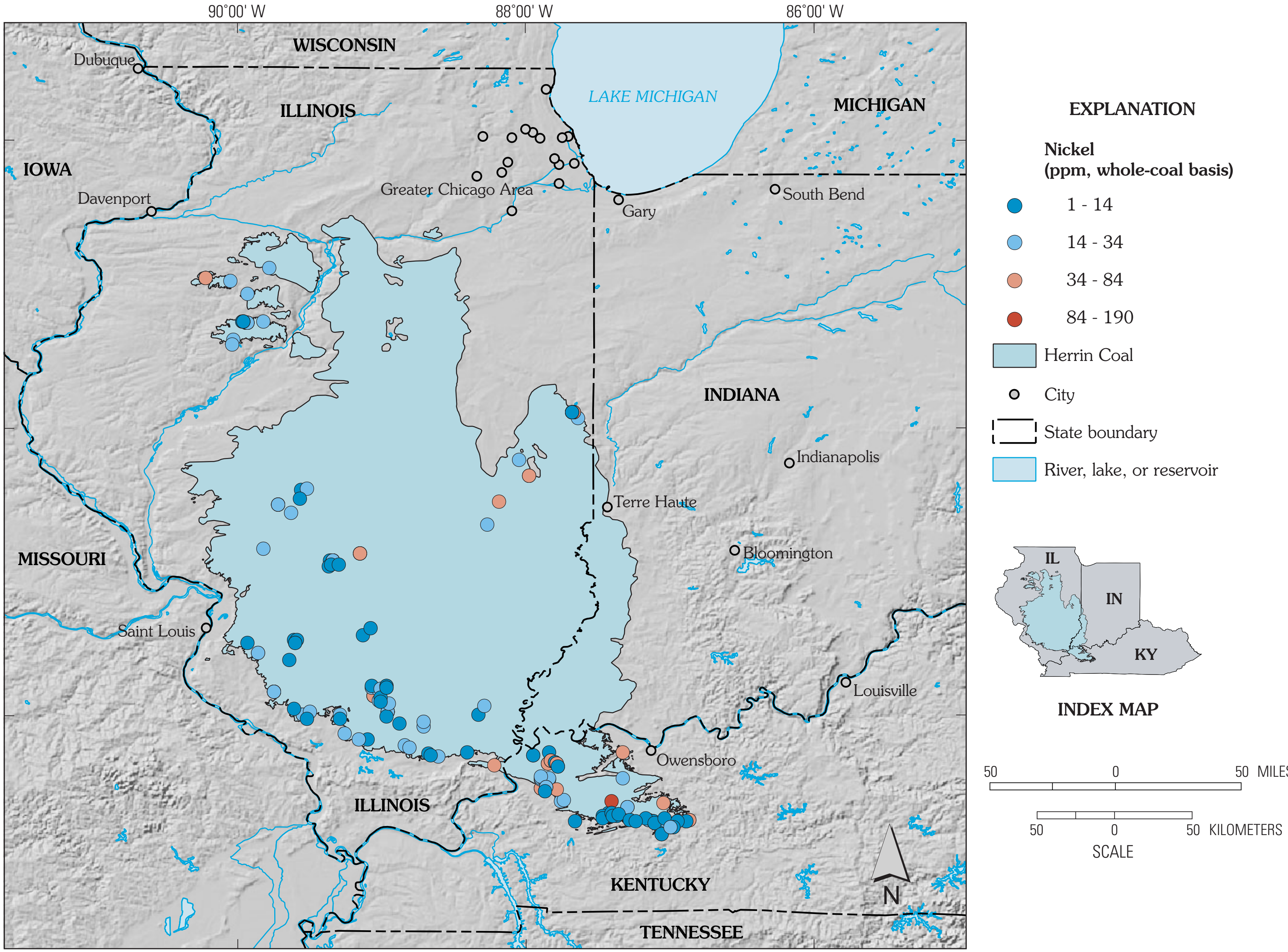

Figure 29. Graduated-symbol map for nickel content (parts per million, as-received, whole-coal basis) of the Herrin Coal in the Illinois Basin.

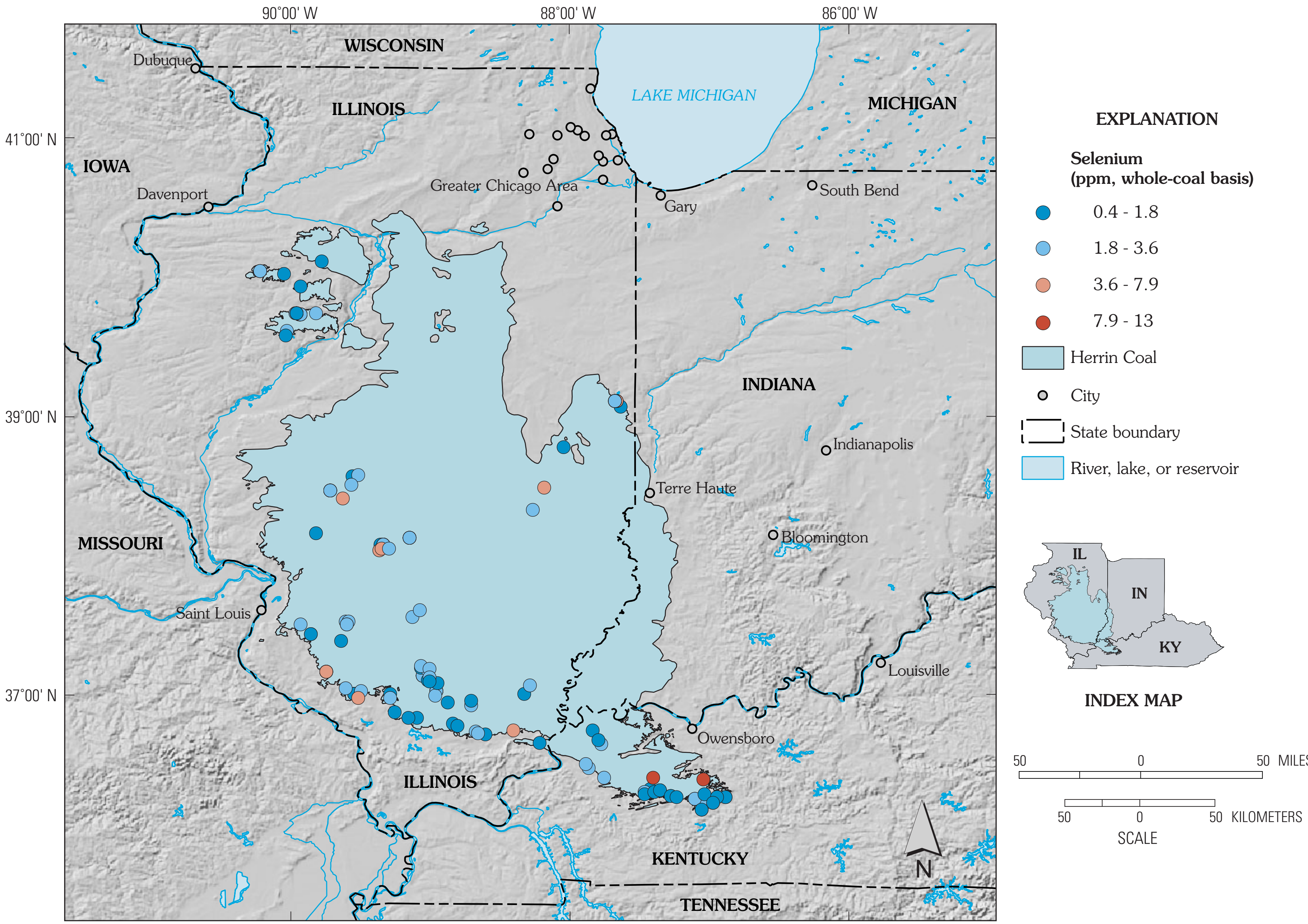

Figure 30. Graduated-symbol map for selenium content (parts per million, as-received, whole-coal basis) of the Herrin Coal in the Illinois Basin.

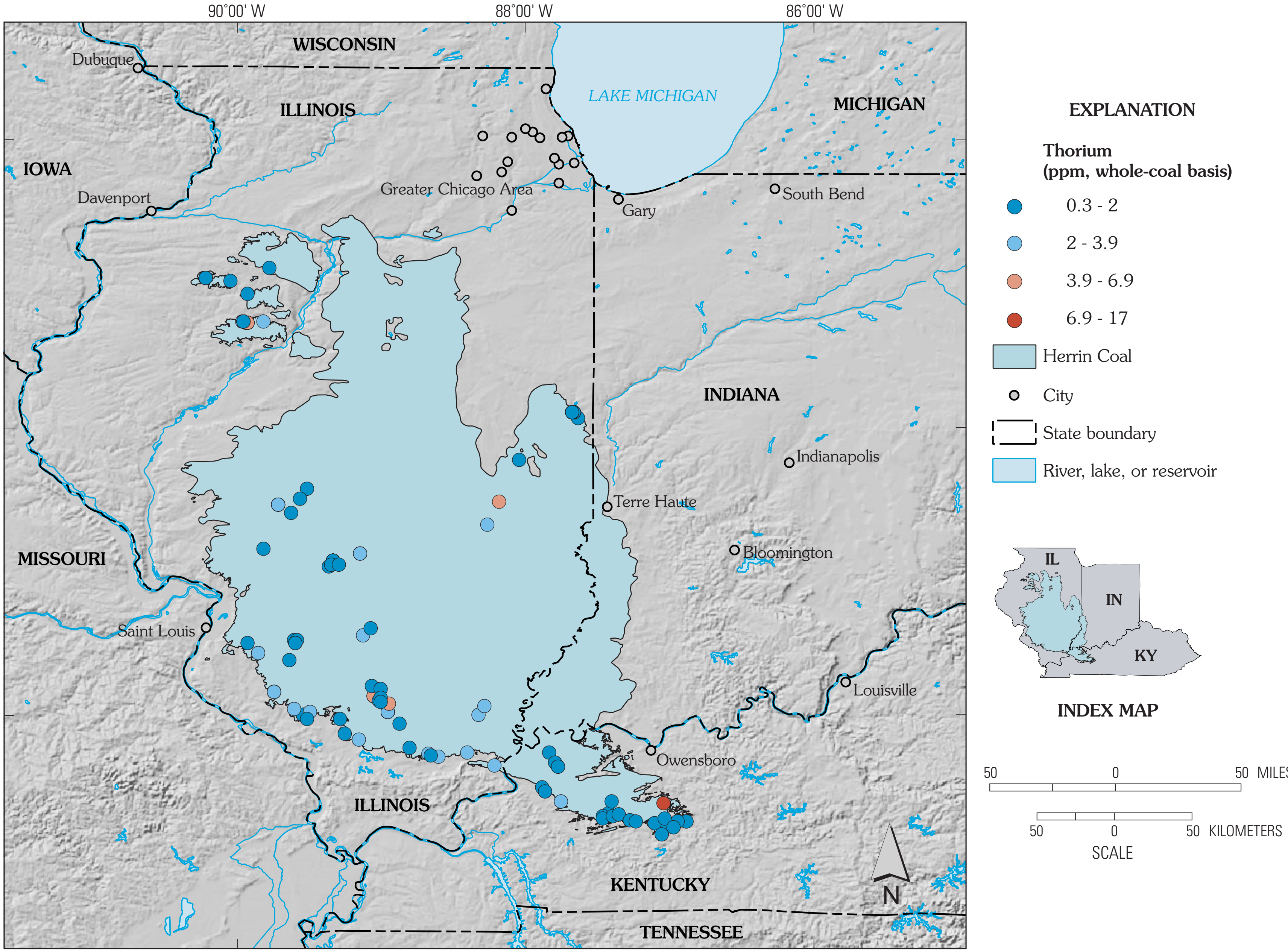

Figure 31. Graduated-symbol map for thorium content (parts per million, as-received, whole-coal basis) of the Herrin Coal in the Illinois Basin.

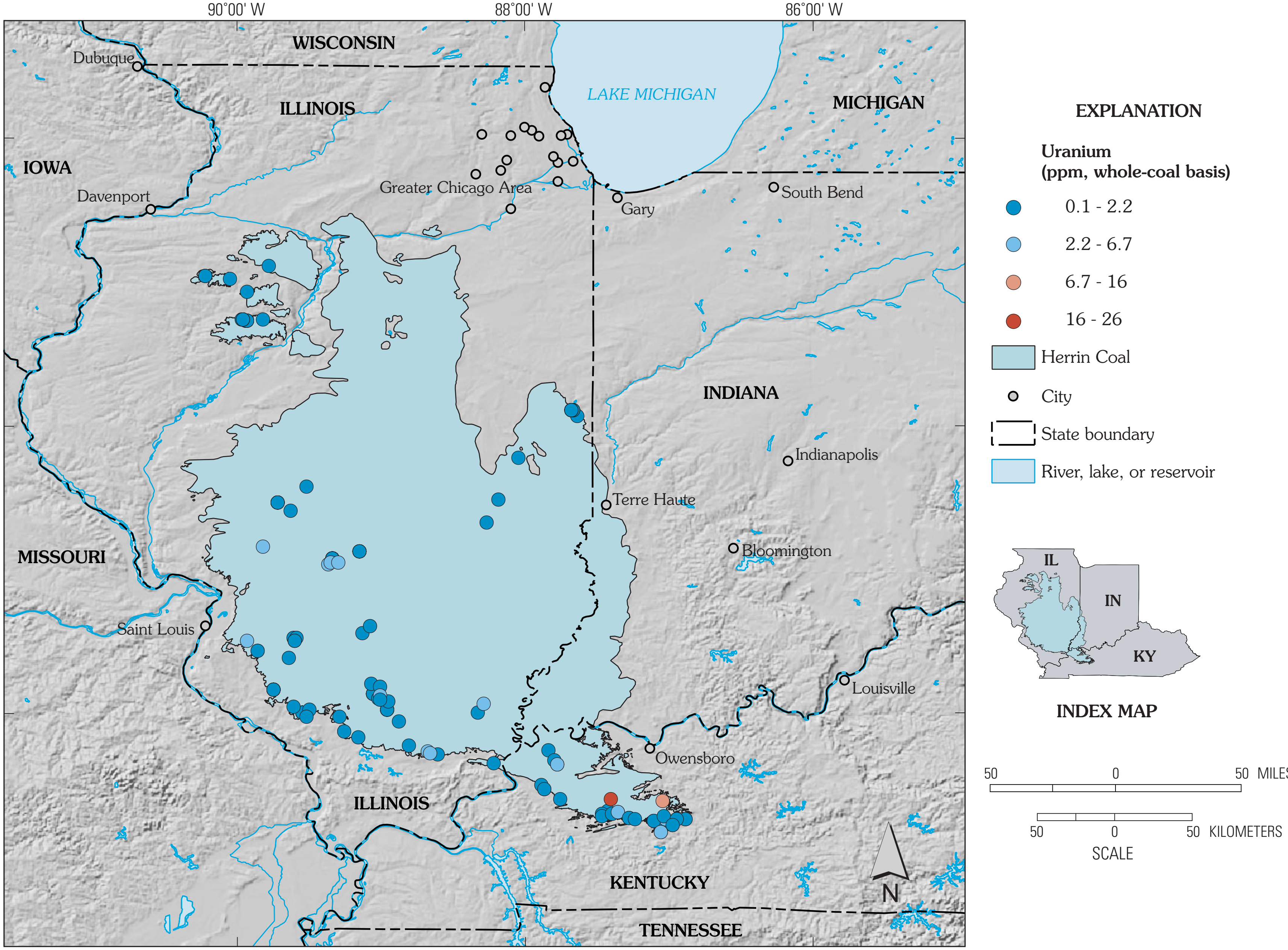

Figure 32. Graduated-symbol map for uranium content (parts per million, as-received, whole-coal basis) of the Herrin Coal in the Illinois Basin.

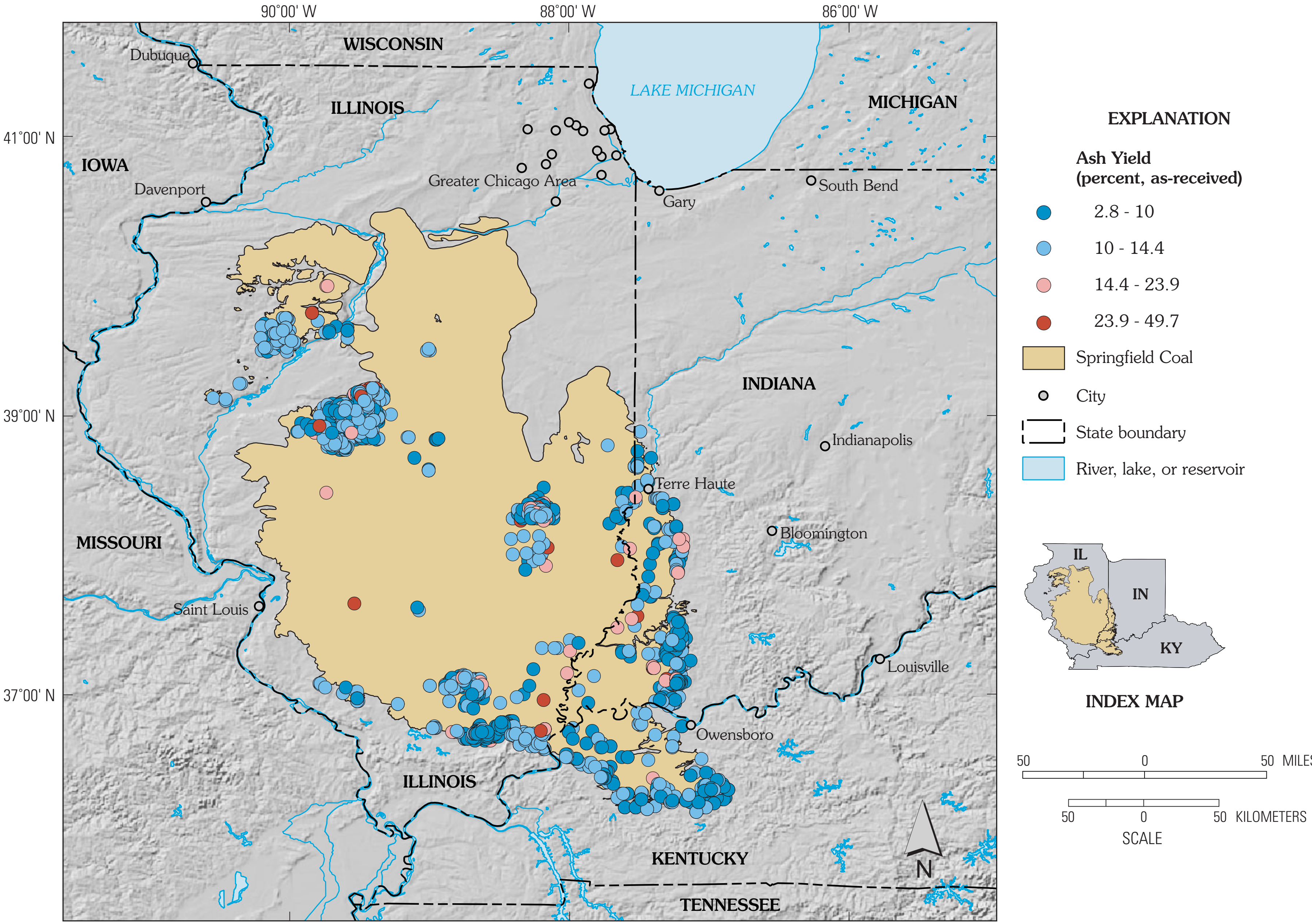

Figure 33. Graduated-symbol map for ash yield (percent, as-received basis) of the Springfield Coal in the Illinois Basin.

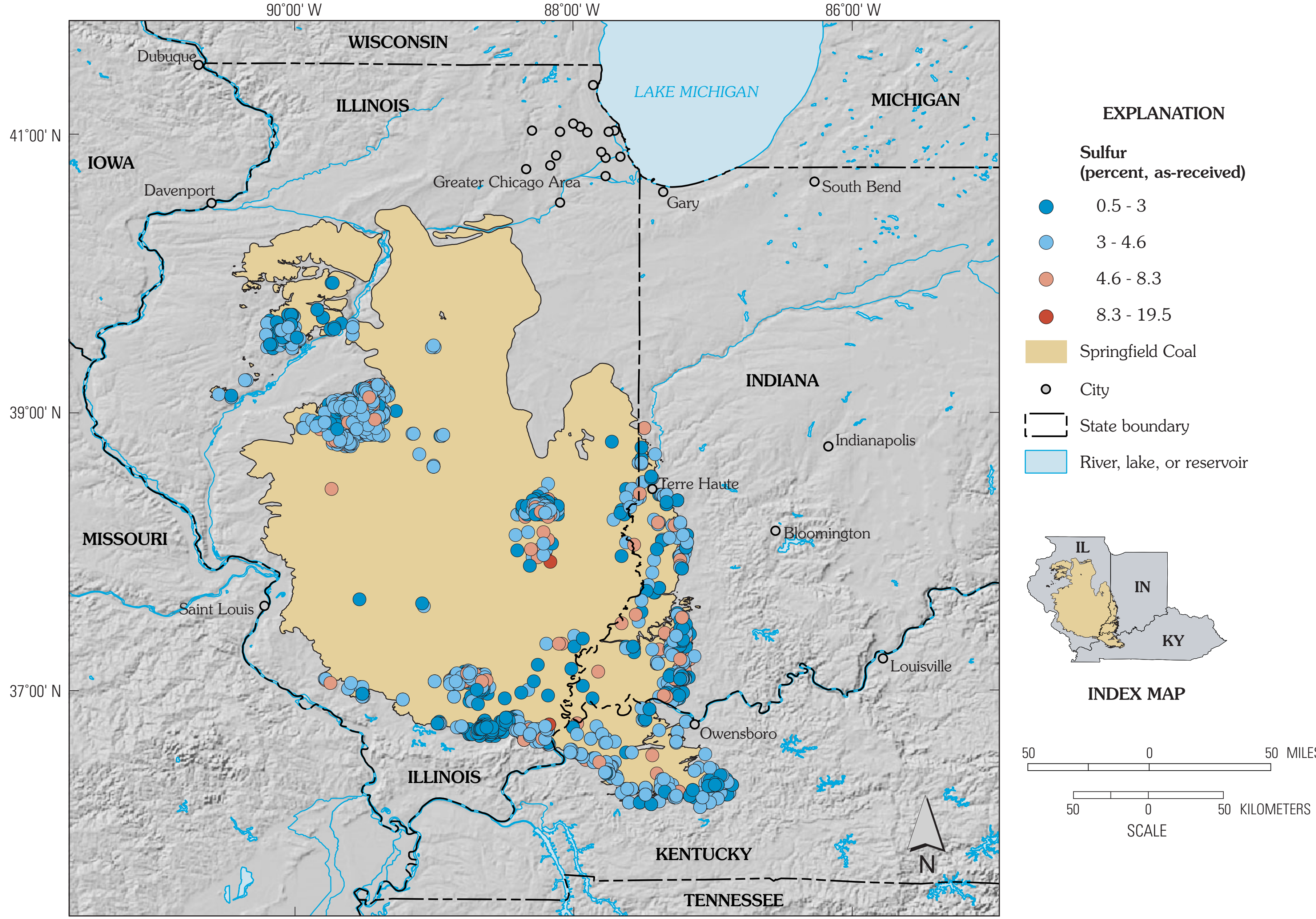

Figure 34. Graduated-symbol map for sulfur content (percent, as-received basis) of the Springfield Coal in the Illinois Basin.

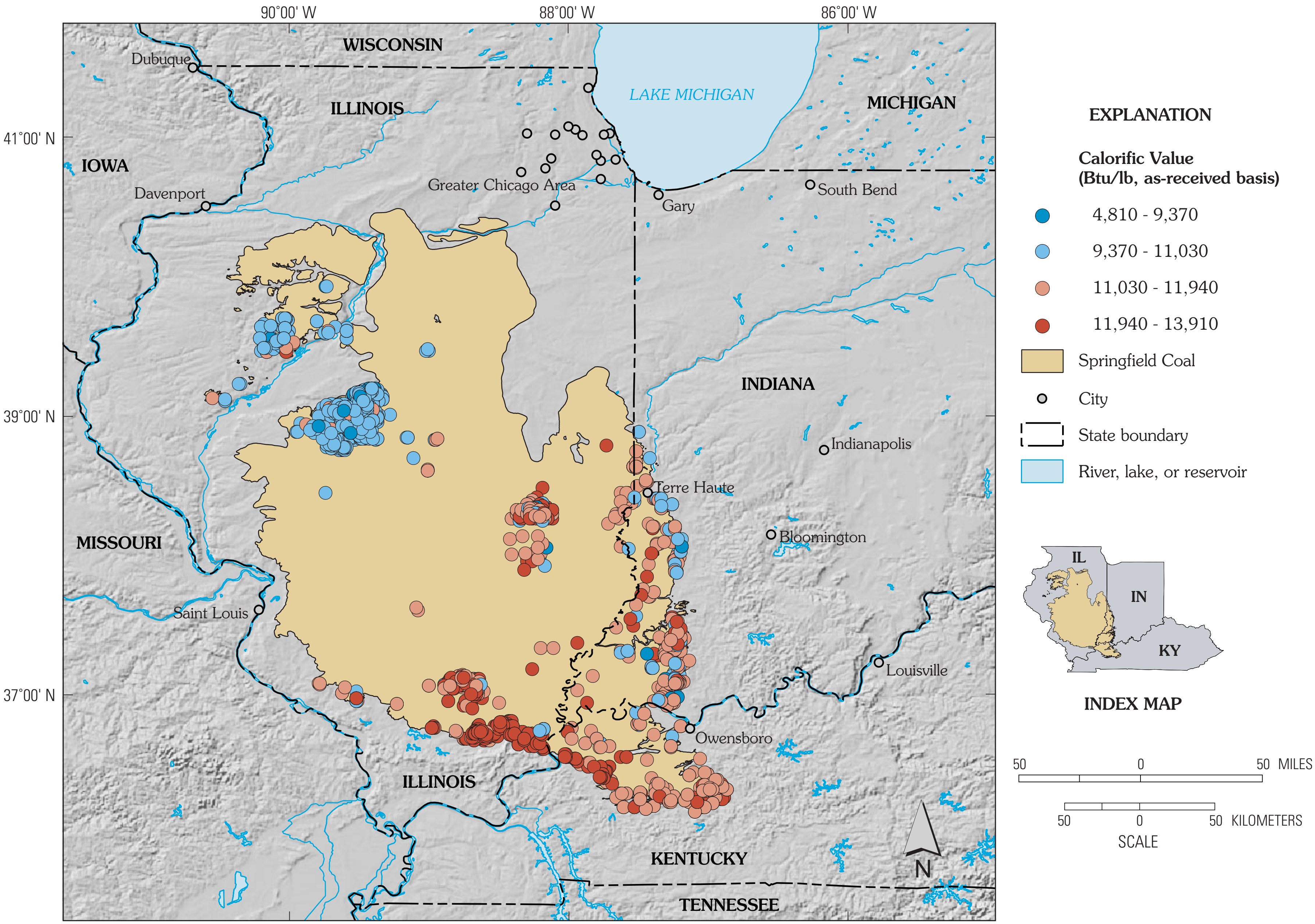

Figure 35. Graduated-symbol map for calorific values (Btu/lb, as-received basis) of the Springfield Coal in the Illinois Basin.

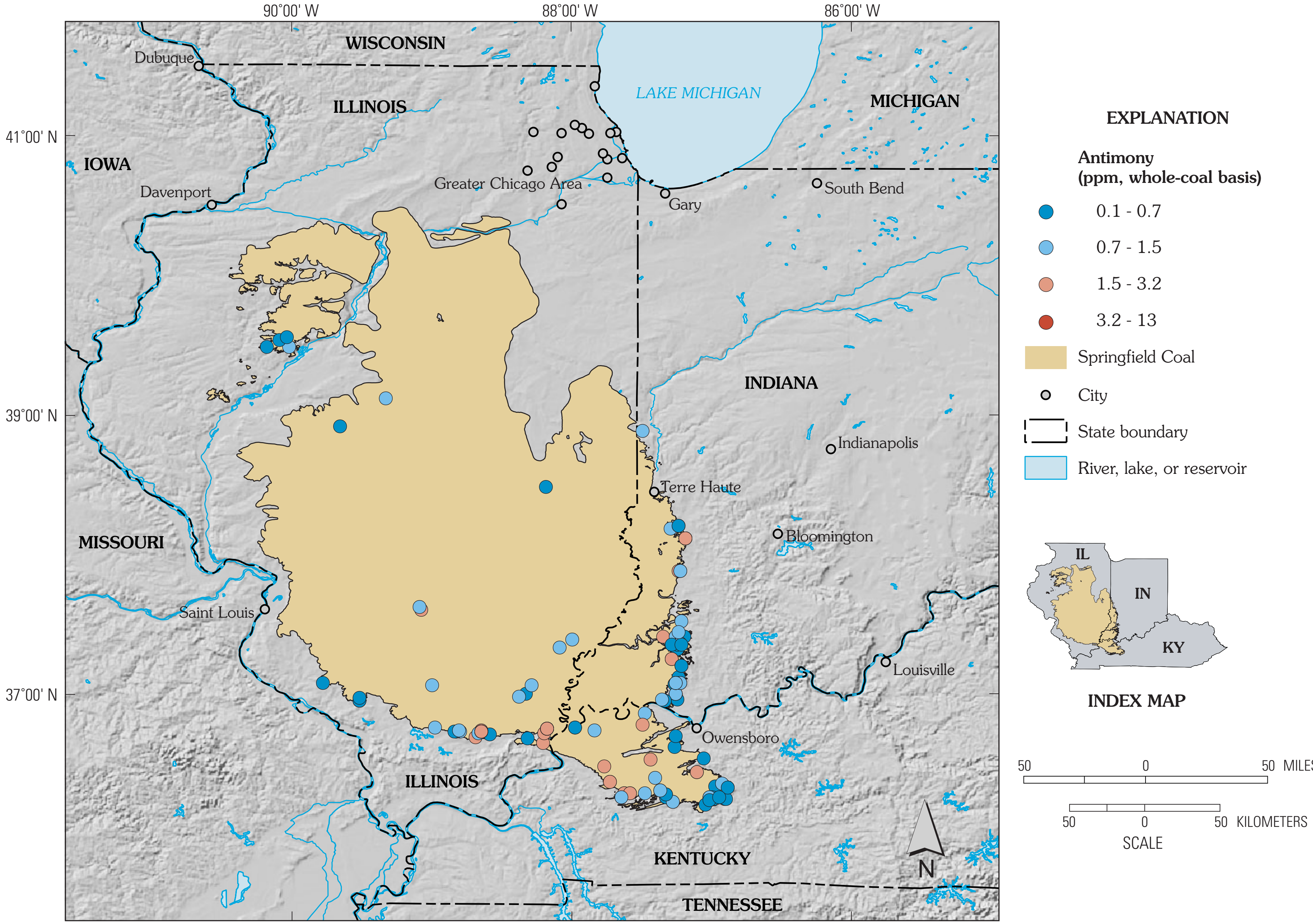

Figure 36. Graduated-symbol map for antimony content (parts per million, as-received, whole-coal basis) of the Springfield Coal in the Illinois Basin.

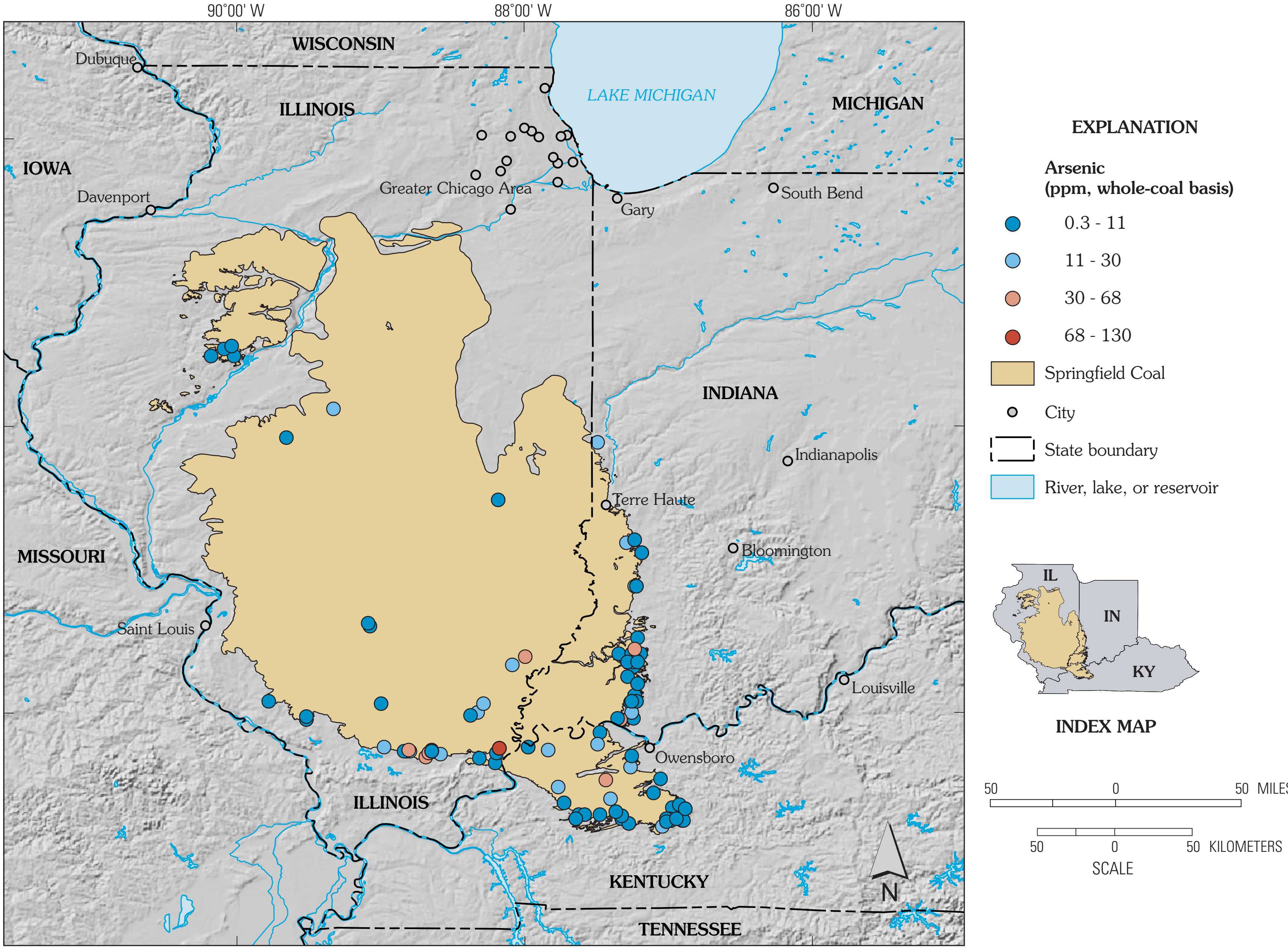

Figure 37. Graduated-symbol map for arsenic content (parts per million, as-received, whole-coal basis) of the Springfield Coal in the Illinois Basin.

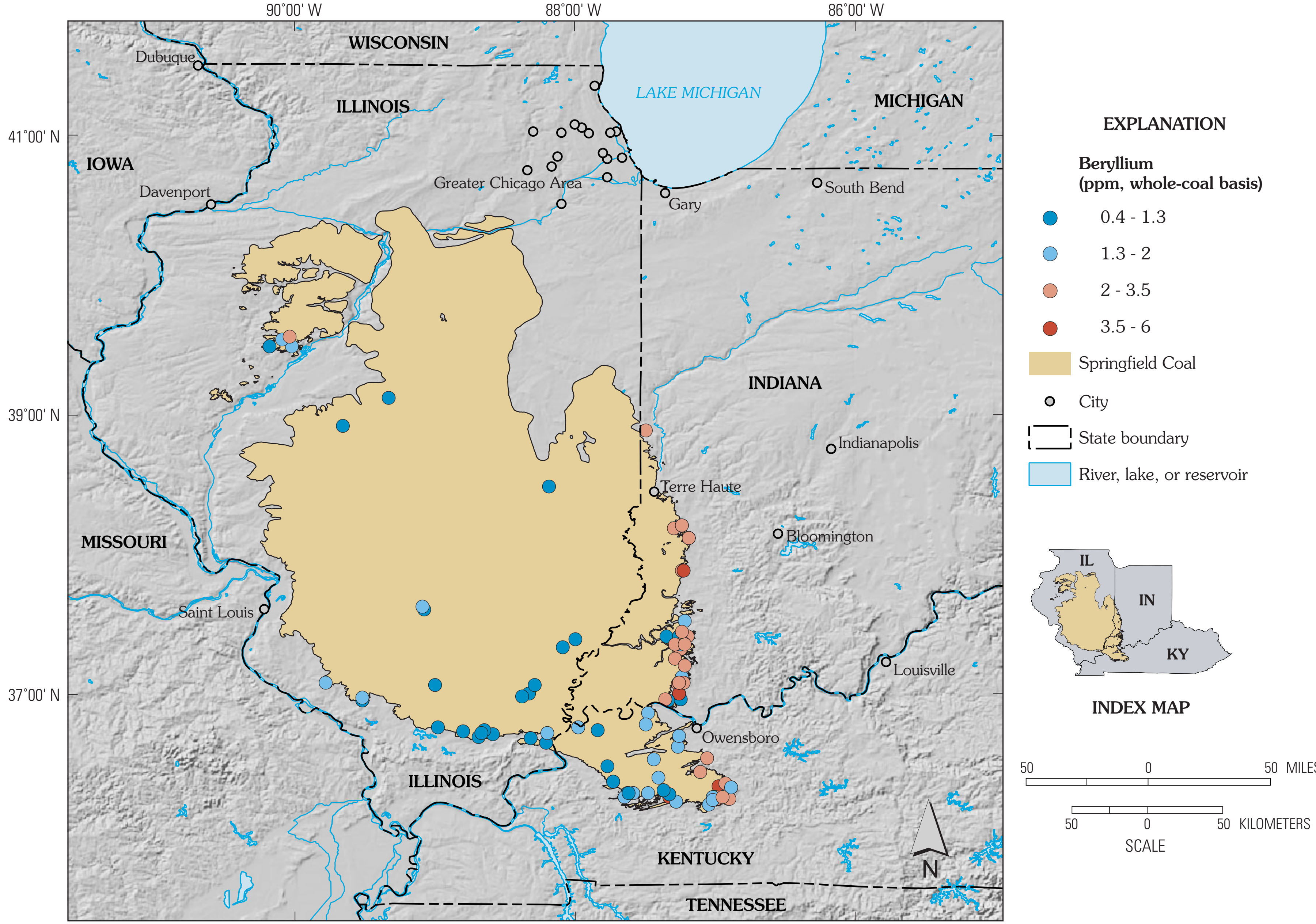

Figure 38. Graduated-symbol map for beryllium content (parts per million, as-received, whole-coal basis) of the Springfield Coal in the Illinois Basin.

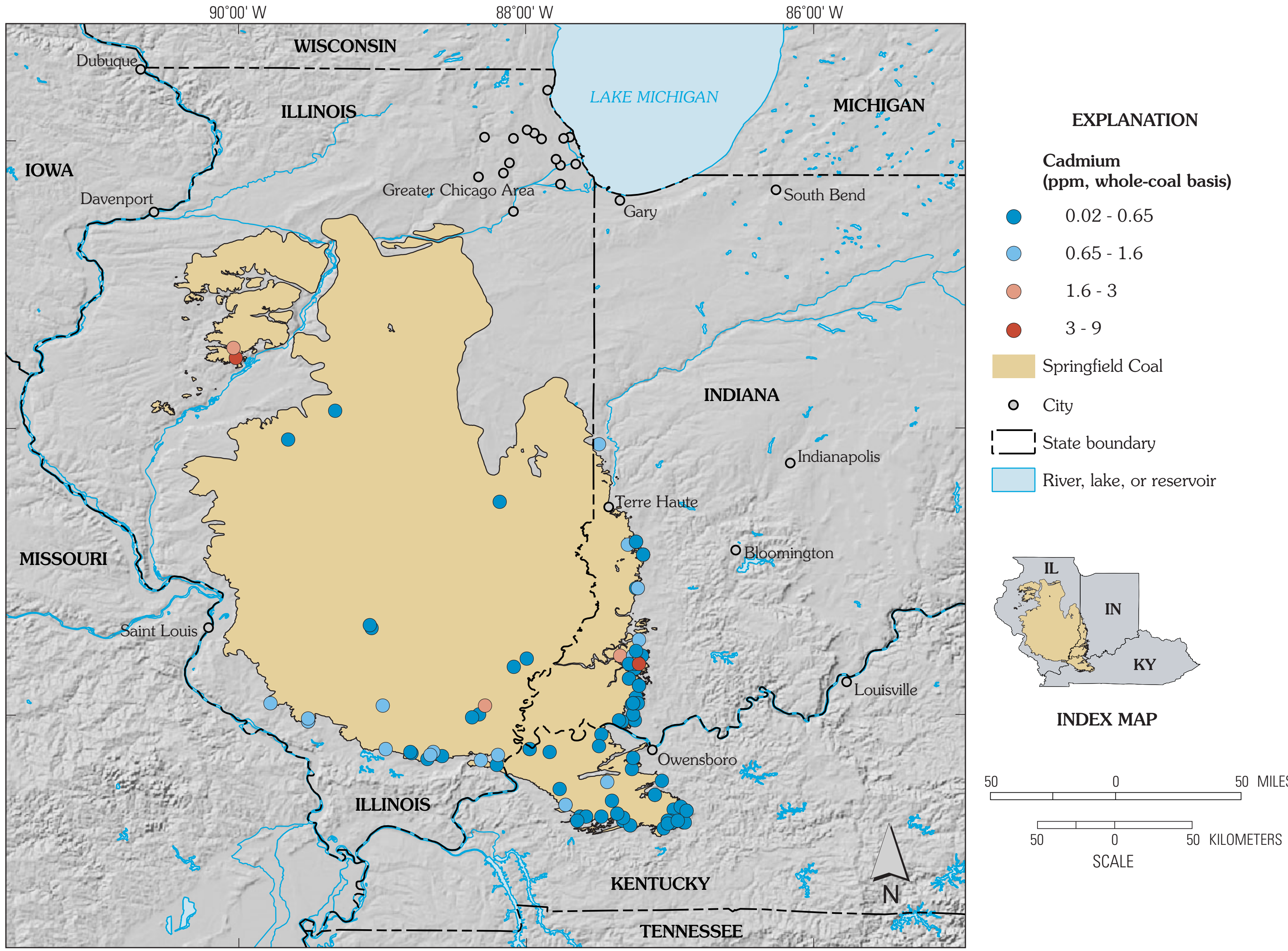

Figure 39. Graduated-symbol map for cadmium content (parts per million, as-received, whole-coal basis) of the Springfield Coal in the Illinois Basin.

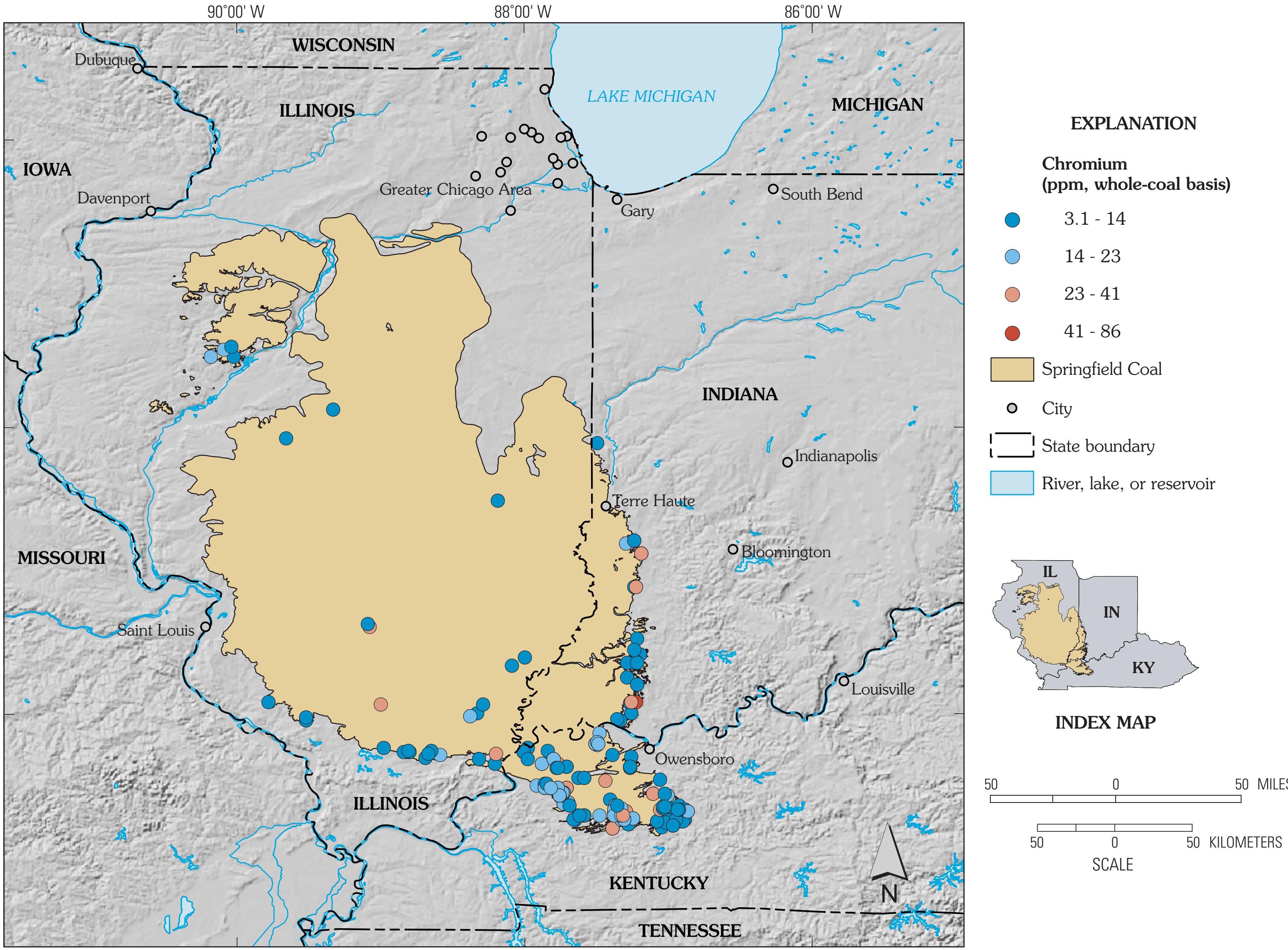

Figure 40. Graduated-symbol map for chromium content (parts per million, as-received, whole-coal basis) of the Springfield Coal in the Illinois Basin.

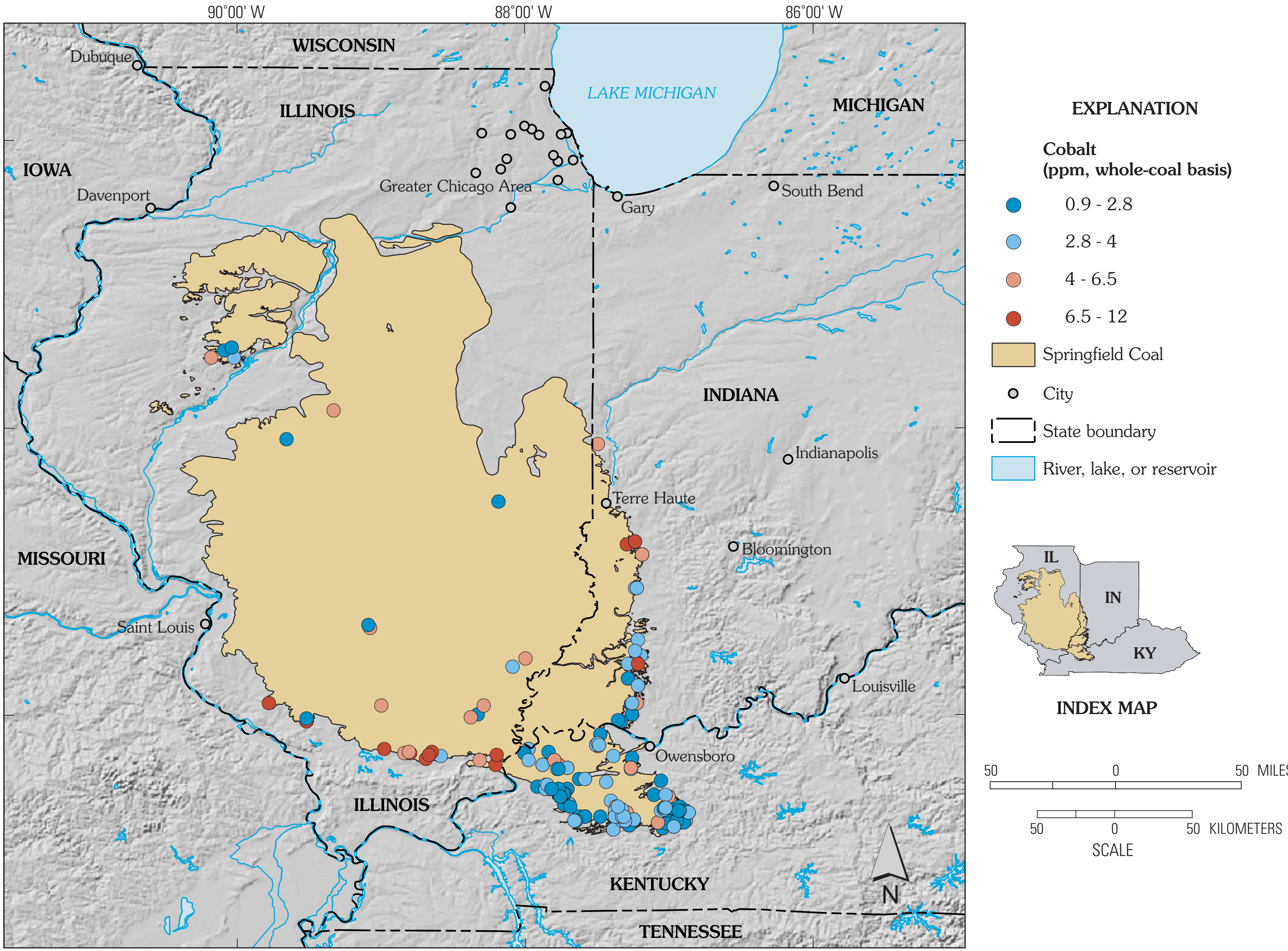

Figure 41. Graduated-symbol map for cobalt content (parts per million, as-received, whole-coal basis) of the Springfield Coal in the Illinois Basin.

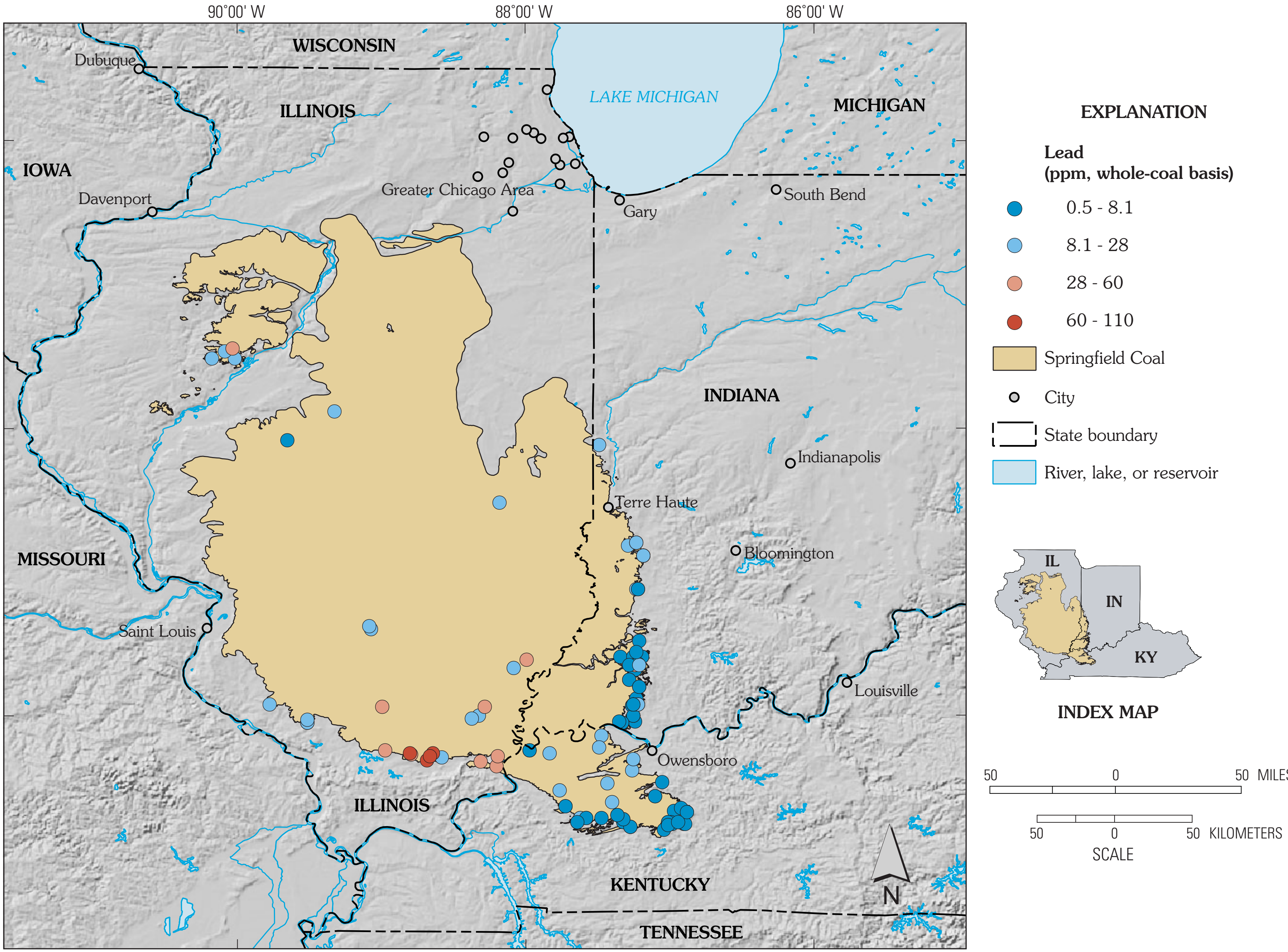

Figure 42. Graduated-symbol map for lead content (parts per million, as-received, whole-coal basis) of the Springfield Coal in the Illinois Basin.

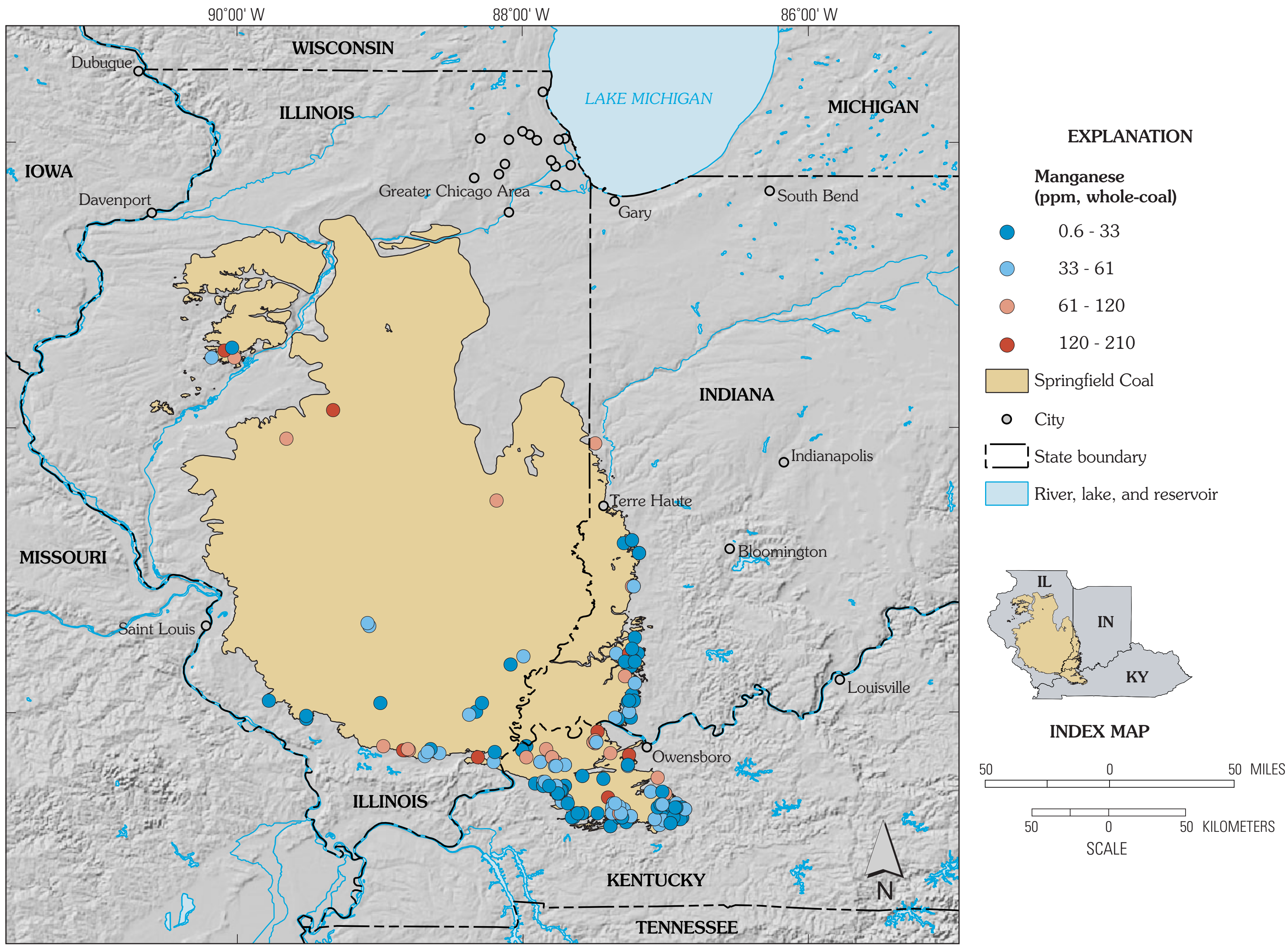

Figure 43. Graduated-symbol map for manganese content (parts per million, as-received, whole-coal basis) of the Springfield Coal in the Illinois Basin.

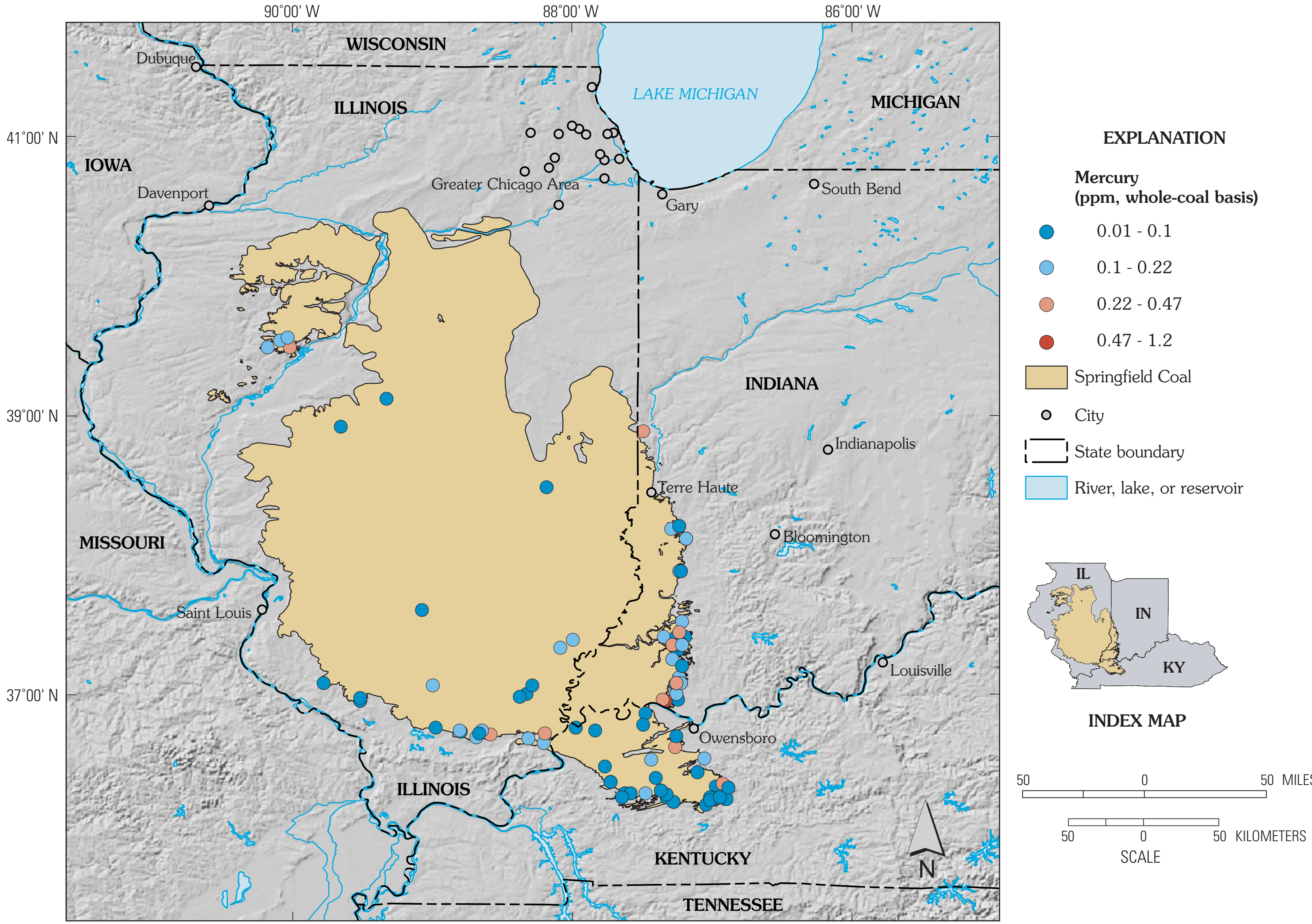

Figure 44. Graduated-symbol map for mercury content (parts per million, as-received, whole-coal basis) of the Springfield Coal in the Illinois Basin.

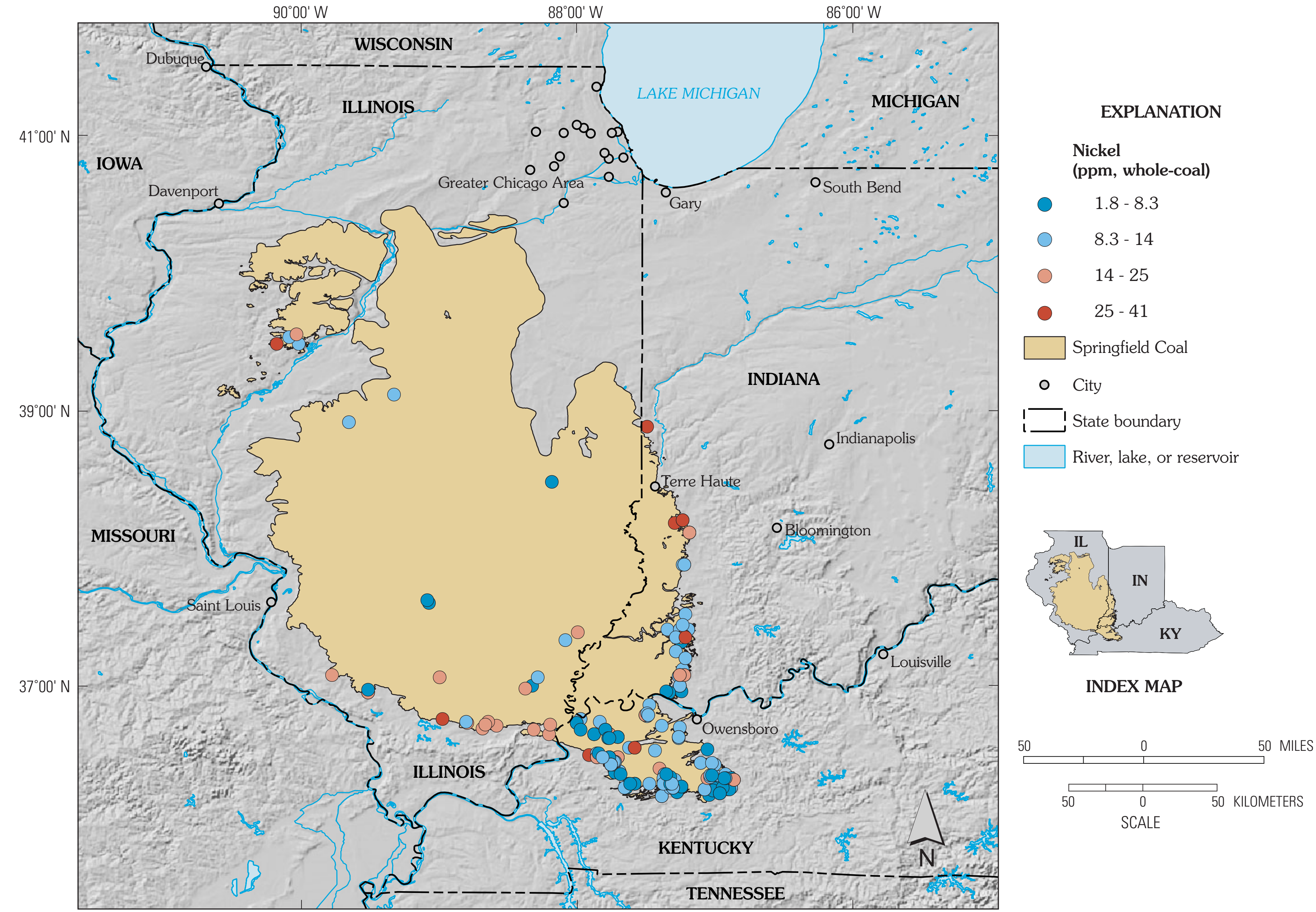

Figure 45. Graduated-symbol map for nickel content (parts per million, as-received, whole-coal basis) of the Springfield Coal in the Illinois Basin.

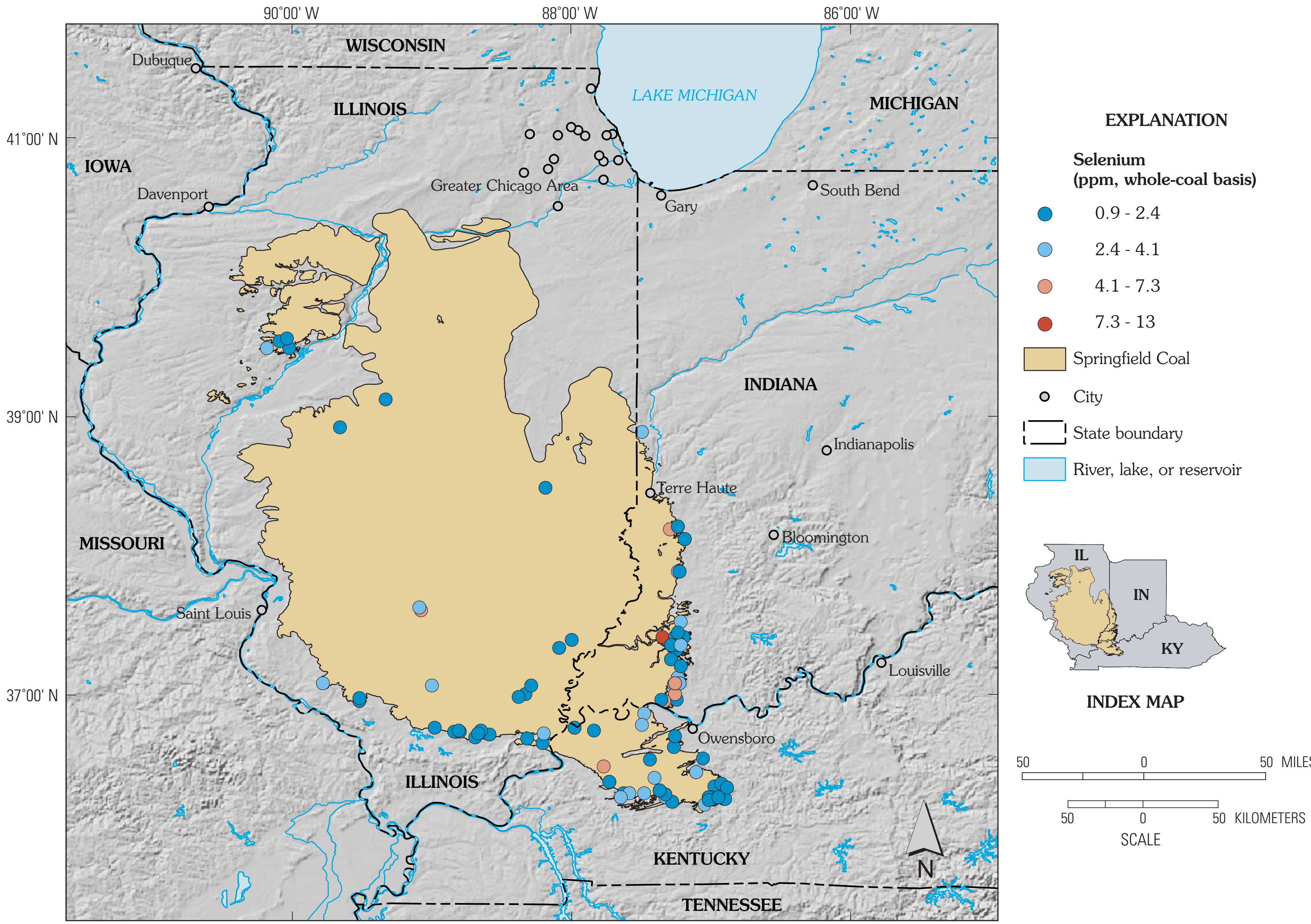

Figure 46. Graduated-symbol map for selenium content (parts per million, as-received, whole-coal basis) of the Springfield Coal in the Illinois Basin.

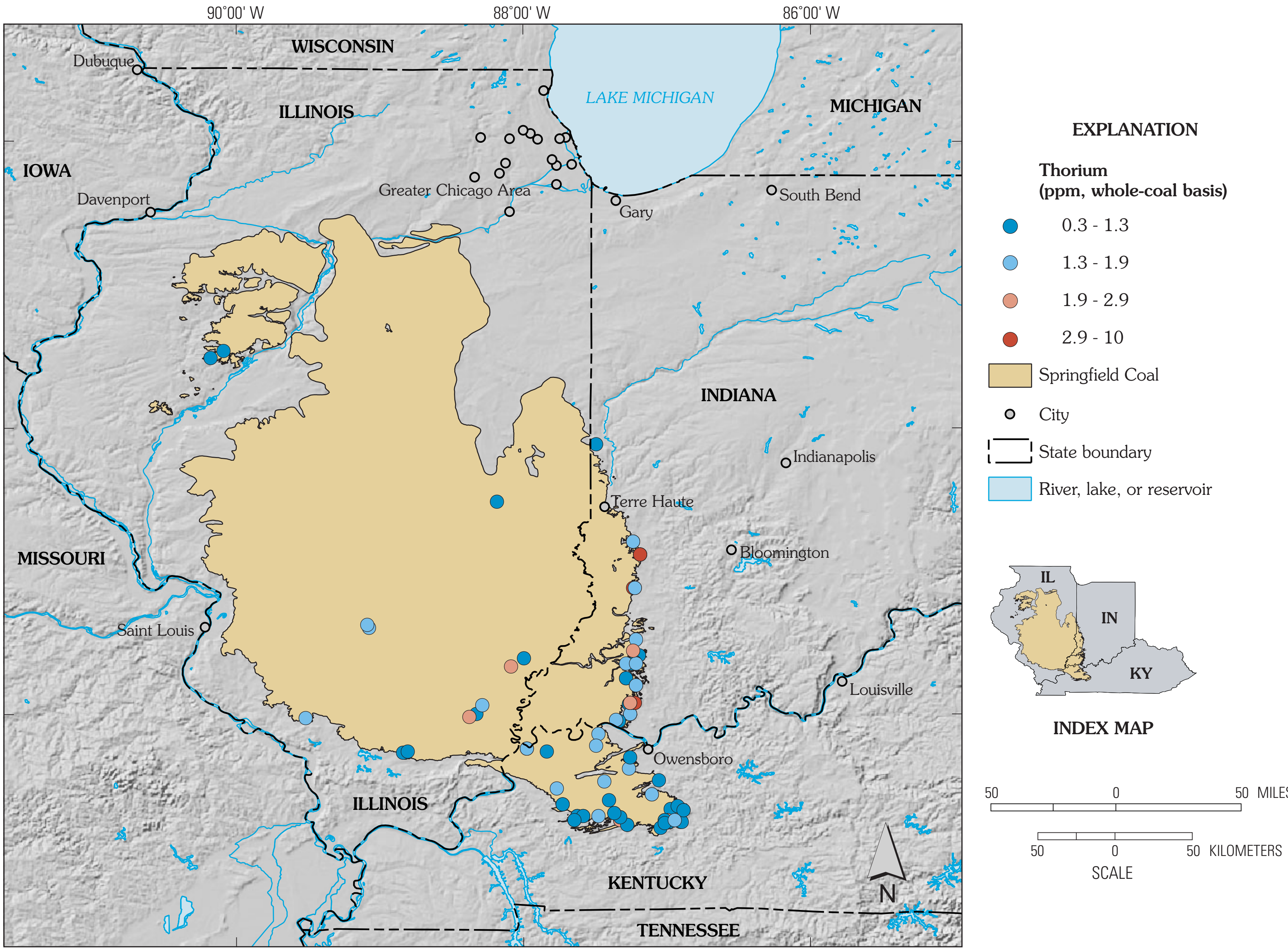

Figure 47. Graduated-symbol map for thorium content (parts per million, as-received, whole-coal basis) of the Springfield Coal in the Illinois Basin.

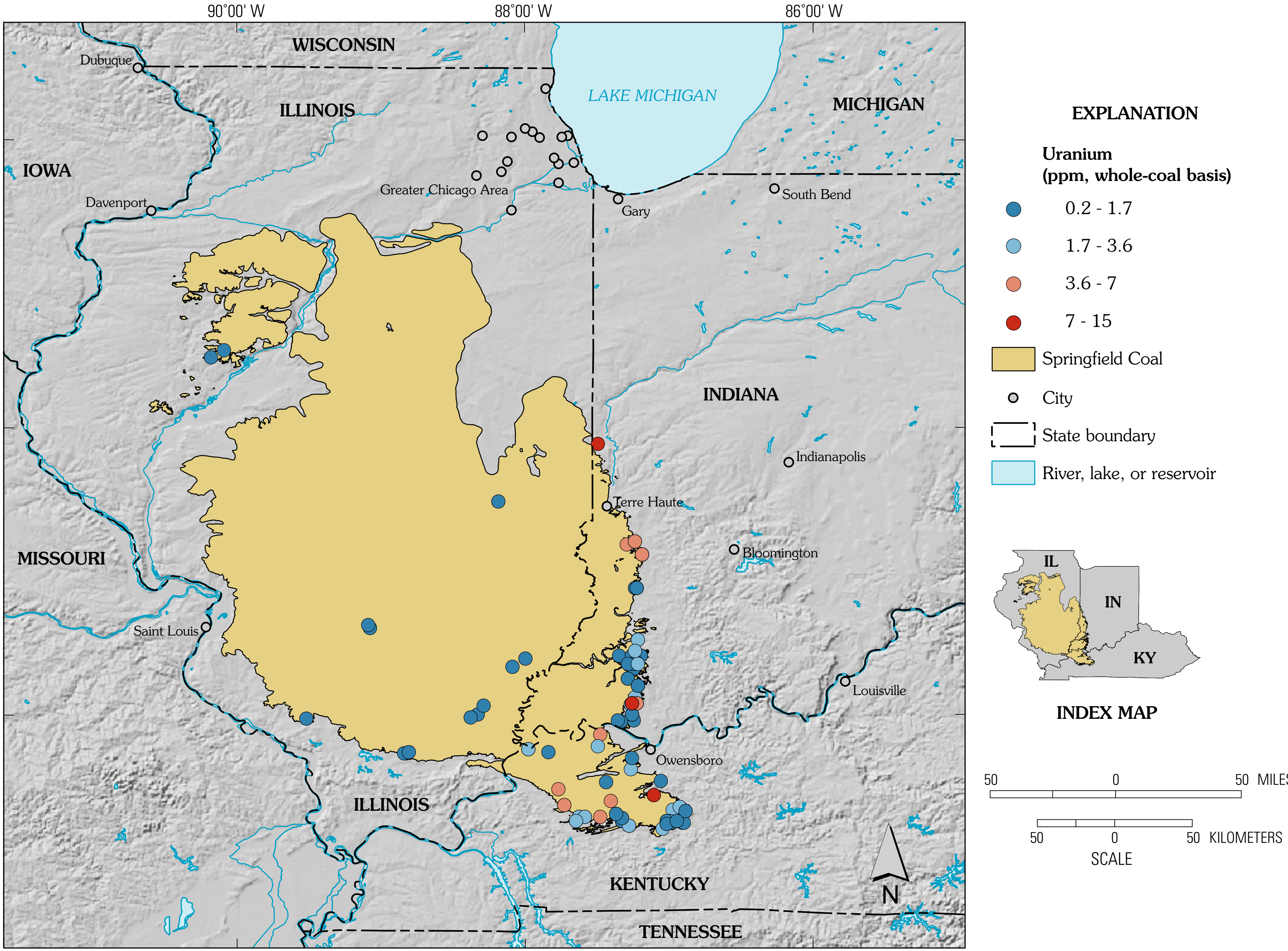

Figure 48. Graduated-symbol map for uranium content (parts per million, as-received, whole-coal basis) of the Springfield Coal in the Illinois Basin.

Appendix 8. Explanation of chemical data columns in the U.S. Geological Survey, Indiana Geological Survey, Kentucky Geological Survey, and Illinois State Geological Survey coal database files created for the resource assessment of the Springfield, Herrin, Danville, and Baker Coals in the Illinois Basin.

Table 1. Explanation of chemical data columns in the U.S. Geological Survey's chemical files created for the resource assessment of the Springfield, Herrin, Danville, and Baker Coals in the Illinois Basin.

[This is a simplified data dictionary showing Field Name, Type, and Description for all the columns in the ASCII files ilhechmu.txt, indachmu.txt, inspchmu.txt, incgchmu.txt, inrgchmu.txt, kyspchmu.txt, kydachmu.txt, kyhechmu.txt, kyrgchmu.txt, kycgchmu.txt, and uschmu.txt. These text files and this file were created by R.H. Affolter (affolter@usgs.gov) of the U.S. Geological Survey from the USGS USCHEM database and were used to create the ArcView chemical data shapefiles for the assessed Springfield, Herrin, Danville, and Baker Coals, and the nonassessed Carbondale Group or Formation, Raccoon Creek Group, and McLeansboro Group coals in the Illinois Basin. Column definitions were modified from Bragg and others, 1998. All columns_Q in these files are used for the qualified data values and are indicated by L (less than), B (not determined), N (not detected), or G (greater than). For detailed descriptions of U.S. Geological Survey analytical methods, see Swanson and Huffman (1976), Baedecker (1987), and Golightly and Simon (1989), or see the related metadata files for USGS chemical data. For limitations of the coal quality, data see Finkelman and others (1994). All columns except DLAT and DLONG are in text to preserve significant figures.]

Field Name	Type	Description
SAMPID	TEXT	Analysis Identification Number.
STATE	TEXT	Name of State where sample was collected.
COUNTY	TEXT	Name of county in State where sample was collected.
DLAT	REAL	Decimal Latitude coordinate for point source location of coal sample.
DLONG	REAL	Decimal Longitude coordinate for point source location of coal sample.
CFORMATN	TEXT	Formation Name—Stratigraphic formation name specified by the collector of the sample.
CGROUP	TEXT	Group Name—Stratigraphic group name specified by the collector of the sample.
CBED	TEXT	Bed Name—Stratigraphic bed name specified by the collector of the sample.
DEPTH	TEXT	Depth from the surface of the earth to the top of the sample if the sample is part of a drill core. If samples are not drill cores, but samples are benched, then depth is a measure from the top of the uppermost bench to the top of the next sample in the benched series. (Depth is measured in inches).
SAMPTHK	TEXT	Thickness of the sample, measured in inches.
COMMENTS	TEXT	Used as a comment field to describe the mine name, the drill hole identified, or other miscellaneous information about the sample.
SYSTEM	TEXT	System designates a fundamental unit of the sample's geologic age.
POINTID	TEXT	The field number assigned by the collector or submitter of the sample.
MOISTR	TEXT	(as-received basis) Moisture content in percent as determined by ASTM method D-3173.

Table 1. Explanation of chemical data columns in the U.S. Geological Survey's chemical files created for the resource assessment of the Springfield, Herrin, Danville, and Baker Coals in the Illinois Basin—Continued.

Field Name	Type	Description
VOLMAT	TEXT	(as-received basis) Volatile matter content in percent as determined by ASTM method D-3175.
FIXEDC	TEXT	(as-received basis) Fixed Carbon content in percent as determined by ASTM method D-3172.
STDASH	TEXT	(as-received basis) Ash yield in percent as determined by ASTM method D-3174 (ash obtained at 750 degrees Centigrade).
HYDRGN	TEXT	(as-received basis) Hydrogen content in percent as determined by ASTM method D-3178.
CARBON	TEXT	(as-received basis) Carbon content in percent as determined by ASTM method D-3178.
NITRGN	TEXT	(as-received basis) Nitrogen content in percent as determined by ASTM method D-3179.
OXYGEN	TEXT	(as-received basis) Oxygen content in percent as determined by ASTM method D-3176.
SULFUR	TEXT	(as-received basis) Sulfur content in percent as determined by ASTM method D-3177.
BTU	TEXT	(as-received basis) Gross calorific value of the coal sample expressed in British Thermal Units (BTU/lb) as determined by ASTM method D-2015.
SLFATE	TEXT	(as-received basis) Sulfate content in percent as determined by ASTM method D-2492.
SLFPYR	TEXT	(as-received basis) Pyritic Sulfur content in percent as determined by ASTM method D-2492.
SLFORG	TEXT	(as-received basis) Organic Sulfur content in percent as determined by ASTM method D-2492.
ASHDEF	TEXT	(as-received basis) Ash Deformation temperature in degrees Fahrenheit as determined by ASTM method D1857 in reducing atmosphere.
ASHSOF	TEXT	(as-received basis) Ash Softening temperature in degrees Fahrenheit as determined by ASTM method D1857 in reducing atmosphere.
ASHFLD	TEXT	(as-received basis) Ash Fluid temperature in degrees Fahrenheit as determined by ASTM method D1857 in reducing atmosphere.
FRESWL	TEXT	(as-received basis) Free-Swelling index as determined by ASTM method D-720.
ADLOSS	TEXT	(as-received basis) Air-Dried loss content in percent as determined by ASTM method D-2013.
GSASH	TEXT	Ash yield in percent as determined by USGS laboratories (ash obtained at 525 degrees Centigrade).

Table 1. Explanation of chemical data columns in the U.S. Geological Survey's chemical files created for the resource assessment of the Springfield, Herrin, Danville, and Baker Coals in the Illinois Basin—Continued.

Field Name	Type	Description
SI_E	TEXT	(as-received, whole-coal basis) Silicon (Si) content in percent converted from content as determined on coal ash by USGS laboratories using X-ray fluorescence analysis (ash obtained at 525 degrees Centigrade)—May be converted from SiO_2 content in percent which was determined by the same method.
AL_E	TEXT	(as-received, whole-coal basis) Aluminum (Al) content in percent converted from content as determined on coal ash by USGS laboratories using X-ray fluorescence analysis (ash obtained at 525 degrees Centigrade)—May be converted from Al_2O_3 content in percent which was determined by the same method.
CA_E	TEXT	(as-received, whole-coal basis) Calcium (Ca) content in percent converted from content as determined on coal ash by USGS laboratories using X-ray fluorescence analysis (ash obtained at 525 degrees Centigrade)—May be converted from CaO content in percent which was determined by the same method.
MG_E	TEXT	(as-received, whole-coal basis) Magnesium (Mg) content in percent converted from content as determined on coal ash by USGS laboratories using wet chemistry analysis (atomic absorption: ash obtained at 525 degrees Centigrade)—May be converted from MgO content in percent which was determined by the same method.
NA_E	TEXT	(as-received, whole-coal basis) Sodium (Na) content in percent converted from content as determined on coal ash by USGS laboratories using wet chemistry analysis (atomic absorption: ash obtained at 525 degrees Centigrade)—May be converted from Na_2O content in percent which was determined by the same method.
K_E	TEXT	(as-received, whole-coal basis) Potassium (K) content in percent converted from content as determined on coal ash by USGS laboratories using X-ray fluorescence analysis (ash obtained at 525 degrees Centigrade)—May be converted from K_2O content in percent which was determined by the same method.
FE_E	TEXT	(as-received, whole-coal basis) Iron (Fe) content in percent converted from content as determined on coal ash by USGS laboratories using X-ray fluorescence analysis (ash obtained at 525 degrees Centigrade)—May be converted from Fe_2O_3 content in percent which was determined by the same method.
TI_E	TEXT	(as-received, whole-coal basis) Titanium (Ti) content in percent converted from content as determined on coal ash by USGS laboratories using X-ray fluorescence analysis (ash obtained at 525 degrees Centigrade)—May be converted from TiO_2 content in percent which was determined by the same method.
AS_E	TEXT	(as-received, whole-coal basis) Arsenic (As) content in parts per million as determined on whole-coal by USGS laboratories using either wet chemistry analysis or Instrumental Neutron Activation Analysis (INAA).
B_E	TEXT	(as-received, whole-coal basis) Boron (B) content in parts per million converted from content determined on coal ash by USGS laboratories using either 6-Step emission spectrographic analysis for older samples or automatic plate reading computer-assisted emission spectrographic analysis (ash obtained at 525 degrees Centigrade).

Table 1. Explanation of chemical data columns in the U.S. Geological Survey's chemical files created for the resource assessment of the Springfield, Herrin, Danville, and Baker Coals in the Illinois Basin—Continued.

Field Name	Type	Description
BA_E	TEXT	(as-received, whole-coal basis) Barium (Ba) content in parts per million converted from content determined on coal ash by USGS laboratories using either 6-Step emission spectrographic analysis for older samples or automatic plate reading computer-assisted emission spectrographic analysis (ash obtained at 525 degrees Centigrade).
BE_E	TEXT	(as-received, whole-coal basis) Beryllium (Be) content in parts per million converted from content determined on coal ash by USGS laboratories using either 6-Step emission spectrographic analysis for older samples or automatic plate reading computer-assisted emission spectrographic analysis (ash obtained at 525 degrees Centigrade).
CD_E	TEXT	(as-received, whole-coal basis) Cadmium (Cd) content in parts per million converted from content determined on coal ash by USGS laboratories using wet chemistry analysis (atomic absorption—ash obtained at 525 degrees Centigrade).
CO_E	TEXT	(as-received, whole-coal basis) Cobalt (Co) content in parts per million converted from content determined on coal ash by USGS laboratories using either semi-quantitative 6-Step emission spectrographic analysis or automatic plate reading computer-assisted emission spectrographic analysis (ash obtained at 525 degrees Centigrade) or on a whole-coal basis using Instrumental Neutron Activation Analysis (INAA).
CR_E	TEXT	(as-received, whole-coal basis) Chromium (Cr) content in parts per million converted from content determined on coal ash by USGS laboratories using either semi-quantitative 6-Step emission spectrographic analysis for older samples or automatic plate reading computer-assisted emission spectrographic analysis (ash obtained at 525 degrees Centigrade) or on a whole-coal basis using Instrumental Neutron Activation Analysis.
CU_E	TEXT	(as-received, whole-coal basis) Copper (Cu) content in parts per million converted from content determined on coal ash by USGS laboratories using wet chemistry analysis (atomic absorption—ash obtained at 525 degrees Centigrade).
F_E	TEXT	(as-received, whole-coal basis) Fluorine (F) content in parts per million as determined on whole-coal by USGS laboratories using wet chemistry analysis (ion-selective electrode).
GA_E	TEXT	(as-received, whole-coal basis) Gallium (Ga) content in parts per million converted from content determined on coal ash by USGS laboratories using either 6-Step emission spectrographic analysis for older samples or automatic plate reading computer-assisted emission spectrographic analysis (ash obtained at 525 degrees Centigrade).
GE_E	TEXT	(as-received, whole-coal basis) Germanium (Ge) content in parts per million converted from content determined on coal ash by USGS laboratories using either 6-Step emission spectrographic analysis for older samples or automatic plate reading computer-assisted emission spectrographic analysis (ash obtained at 525 degrees Centigrade).

Table 1. Explanation of chemical data columns in the U.S. Geological Survey's chemical files created for the resource assessment of the Springfield, Herrin, Danville, and Baker Coals in the Illinois Basin—Continued.

Field Name	Type	Description
HG_E	TEXT	(as-received, whole-coal basis) Mercury (Hg) content in parts per million as determined on whole-coal by USGS laboratories using wet chemistry analysis (cold-vapor atomic absorption).
LA_E	TEXT	(as-received, whole-coal basis) Lanthanum (La) content in parts per million converted from content determined on coal ash by USGS laboratories using either 6-Step emission spectrographic analysis for older samples or automatic plate reading computer-assisted emission spectrographic analysis (ash obtained at 525 degrees Centigrade) or on a whole-coal basis using Instrumental Neutron Activation Analysis (INAA).
LI_E	TEXT	(as-received, whole-coal basis) Lithium (Li) content in parts per million converted from content determined on coal ash by USGS laboratories using wet chemistry analysis (atomic absorption—ash obtained at 525 degrees Centigrade).
MN_E	TEXT	(as-received, whole-coal basis) Manganese (Mn) content in parts per million converted from content determined on coal ash by USGS laboratories using either 6-Step emission spectrographic analysis for older samples or automatic plate reading computer-assisted emission spectrographic analysis (ash obtained at 525 degrees Centigrade) and later using wet chemistry analysis (atomic absorption on the ash).
MO_E	TEXT	(as-received, whole-coal basis) Molybdenum (Mo) content in parts per million converted from content determined on coal ash by USGS laboratories using either 6-Step emission spectrographic analysis for older samples or automatic plate reading computer-assisted emission spectrographic analysis (ash obtained at 525 degrees Centrigrade).
NB_E	TEXT	(as-received, whole-coal basis) Niobium (Nb) content in parts per million converted from content determined on coal ash by USGS laboratories using either 6-Step emission spectrographic analysis for older samples or automatic plate reading computer-assisted emission spectrographic analysis (ash obtained at 525 degrees Centrigrade).
NI_E	TEXT	(as-received, whole-coal basis) Nickel (Ni) content in parts per million converted from content determined on coal ash by USGS laboratories using either 6-Step emission spectrographic analysis for older samples or automatic plate reading computer-assisted emission spectrographic analysis (ash obtained at 525 degrees Centrigrade).
P_E	TEXT	(as-received, whole-coal basis) Phosphorus (P) content in parts per million as determined on the coal ash or whole-coal by USGS laboratories using X-ray fluorescence analysis (ash obtained at 525 degrees Centigrade)—May be converted from P_2O_5 content in percent which was determined by the same method.
PB_E	TEXT	(as-received, whole-coal basis) Lead (Pb) content in parts per million converted from content determined on coal ash by USGS laboratories using wet chemistry analysis (atomic absorption—ash obtained at 525 degrees Centigrade).
SB_E	TEXT	(as-received, whole-coal basis) Antimony (Sb) content in parts per million as determined on whole-coal by USGS laboratories using wet chemistry analysis (Rhodamine B) or on Instrumental Neutron Activation Analysis (INAA).

Table 1. Explanation of chemical data columns in the U.S. Geological Survey's chemical files created for the resource assessment of the Springfield, Herrin, Danville, and Baker Coals in the Illinois Basin—Continued.

Field Name	Type	Description
SC_E	TEXT	(as-received, whole-coal basis) Scandium (Sc) content in parts per million converted from content determined on coal ash by USGS laboratories using either 6-Step emission spectrographic analysis for older samples or automatic plate reading computer-assisted emission spectrographic analysis (ash obtained at 525 degrees Centigrade) or on a whole-coal basis using Instrumental Neutron Activation Analysis (INAA).
SE_E	TEXT	(as-received, whole-coal basis) Selenium (Se) content in parts per million as determined on whole-coal basis by USGS laboratories using Xray-fluorescence or on a whole-coal basis using Instrumental Neutron Activation Analysis (INAA).
SR_E	TEXT	(as-received, whole-coal basis) Strontium (Sr) content in parts per million converted from content determined on coal ash by USGS laboratories using either 6-Step emission spectrographic analysis for older samples or automatic plate reading computer-assisted emission spectrographic analysis (ash obtained at 525 degrees Centigrade).
TH_E	TEXT	(as-received, whole-coal basis) Thorium (Th) content in parts per million as determined on whole-coal basis by USGS laboratories using Delayed Neutron Analysis (DNA) for older samples and Instrumental Neutron Activation analysis (INAA).
U_E	TEXT	(as-received, whole-coal basis) Uranium (U) content in parts per million as determined on whole-coal basis by USGS laboratories using Delayed Neutron Analysis (DNA).
V_E	TEXT	(as-received, whole-coal basis) Vanadium (V) content in parts per million converted from content determined on coal ash by USGS laboratories using either 6-Step emission spectrographic analysis for older samples or automatic plate reading computer-assisted emission spectrographic analysis (ash obtained at 525 degrees Centigrade).
Y_E	TEXT	(as-received, whole-coal basis) Yttrium (Y) content in parts per million converted from content determined on coal ash by USGS laboratories using either 6-Step emission spectrographic analysis for older samples or automatic plate reading computer-assisted emission spectrographic analysis (ash obtained at 525 degrees Centigrade).
YB_E	TEXT	(as-received, whole-coal basis) Ytterbium (Yb) content in parts per million converted from content determined on coal ash by USGS laboratories using either 6-Step emission spectrographic analysis for older samples or automatic plate reading computer-assisted emission spectrographic analysis (ash obtained at 525 degrees Centigrade) or on a whole-coal basis using Instrumental Neutron Activation Analysis (INAA).
ZN_E	TEXT	(as-received, whole-coal basis) Zinc (Zn) content in parts per million converted from content determined on coal ash by USGS laboratories using wet chemistry analysis (atomic absorption ash obtained at 525 degrees Centigrade).
ZR_E	TEXT	(as-received, whole-coal basis) Zirconium (Zr) content in parts per million converted from content determined on coal ash by USGS laboratories using either 6-Step emission spectrographic analysis for older samples or automatic plate reading omputer-assisted emission spectrographic analysis (ash obtained at 525 degrees Centigrade).

Table 2. Explanation of chemical data columns in the Indiana coal analysis database files created for the resource assessment of the Springfield, Herrin, Danville, and Baker Coals in the Illinois Basin.

[This is a simplified data dictionary showing Field Name, Value, and Description for all the columns in the ASCII files indachms.txt, inspchms.txt, incgchms.txt, inrgchms.txt, and inchms.txt. These text files and this file were created by R.H. Affolter (affolter@usgs.gov) of the U.S. Geological Survey from "The Indiana coal analysis database; Computer database I," 1992, by Walter A. Hasenmueller and Louis V. Miller, and were used to create the ArcView chemical data shape files of the Springfield, Danville, Carbondale Group, and Raccoon Creek Group coals for the Illinois Basin resource assessment. The purpose of this file is to briefly explain the abbreviations used in the Indiana coal analysis database published by the Indiana Geological Survey (IGS). Each record in this file represents a coal sample and comprises the variables defined below in the order they appear in the database. For detailed information on field names, values, and descriptions see Hasenmueller (whasenmu@indiana.edu) and Miller (1992). For additional information see the related metadata files for the Indiana chemical data. All columns except Lat-dd and Long-dd are in text to preserve the original numbers.]

Field Name	Type	Description
Smpnme	**Text**	Coal sample number
Cnty	**Text**	County name
Cvltwp	**Text**	Civil township name
Clctr	**Text**	Collector(s) of coal and associated samples and the recorder(s) of sample-site description including the sample-site stratigraphic section.
Smpsrc	**Text**	Source of the sample.
Smptyp	**Text**	Sample type
Moist	**Text**	Visual estimate of the moisture condition of the sample made when the sample was collected.
Cond	**Text**	Weathering condition of the sampled coal. Sample can be assumed to be freshly exposed coal when this field is blank. "Weathered" indicates that the coal had a weathered appearance.
Strnme	**Text**	Stratigraphic name for the sampled coal bed.
Altnme	**Text**	Alternate names for the sampled coal bed, or commonly used unofficial names for a coal bed.
Date	**Text**	Date sample was collected and recorded in the form MM/DD/YY where MM = month, DD = day, and YY last two digits of year.
Wdth	**Text**	Width of channel cut or diameter of drill core in decimal feet.
Dpth	**Text**	Depth of channel cut in decimal feet.
Twp	**Text**	Township number followed by "N" for north and "S" for south of Buckingham's Base Line.

Table 2. Explanation of chemical data columns in the Indiana coal analysis database files created for the resource assessment of the Springfield, Herrin, Danville, and Baker Coals in the Illinois Basin—Continued.

Field Name	Type	Description
Rng	**Text**	Range number followed by "W" or "E" to designate west or east of the Second Principal Meridian.
Sec	**Text**	Section number or equivalent. Three alpha characters followed by a "." indicate the type of land subdivision, which is followed by the two- or three-digit integer number of that subdivision.
Qtr	**Text**	Subdivisions of sections. Abbreviations for quarter, half, and center are separated by commas and listed in the normal order, i.e., smallest to the largest quarter.
Lat-dd	**Real**	Latitude in decimal degrees.
Long-dd	**Real**	Longitude in decimal degrees.
Spe	**Text**	State plane easting coordinate.
Spn	**Text**	State plane northing coordinate.
Utme	**Text**	Universal transverse Mercator easting coordinate.
Utmn	**Text**	Universal transverse Mercator northing coordinate.
Quad	**Text**	U.S. Geological Survey 71/2-minute quadrangle map name.
Comp	**Text**	Name of the company operating the mine from which a sample was collected or the name of the company operating the drill rig that cut the core from which the sample was collected.
Mine	**Text**	Name of the mine or drill hole from which a sample was collected.
Cmnt	**Text**	Comment field.
Analdate	**Text**	Date analysis was completed and recorded in the form MM/DD/YY, where MM = month, DD = date, and YY = last two digits of year.
Analyst	**Text**	Chemist who analyzed the coal sample.
Adl	**Text**	Air dried loss.
Moar	**Text**	Moisture on the as-received basis.
Ashar	**Text**	Ash on the as-received basis.
Volar	**Text**	Volatile matter on the as-received basis.
Fixar	**Text**	Fixed carbon on the as-received basis.
Car	**Text**	Ultimate carbon on the as-received basis.

Table 2. Explanation of chemical data columns in the Indiana coal analysis database files created for the resource assessment of the Springfield, Herrin, Danville, and Baker Coals in the Illinois Basin—Continued.

Field Name	Type	Description
Har	**Text**	Ultimate hydrogen on the as-received basis.
Nar	**Text**	Ultimate nitrogen on the as-received basis.
Oar	**Text**	Ultimate oxygen on the as-received basis.
Sar	**Text**	Ultimate sulfur on the as-received basis.
Btuar	**Text**	Heating value on the as-received basis (Btu/Ib).
S04ar	**Text**	Sulfate sulfur on the as-received basis.
Pyrar	**Text**	Pyritic sulfur on the as-received basis.
Orgar	**Text**	Organic sulfur on the as-received basis.
Ashmf	**Text**	Ash on the moisture-free basis.
Volmf	**Text**	Volatile matter on the moisture-free basis.
Fixmf	**Text**	Fixed carbon on the moisture-free basis.
Cmf	**Text**	Ultimate carbon on the moisture-free basis.
Hmf	**Text**	Ultimate hydrogen on the moisture-free basis.
Nmf	**Text**	Ultimate nitrogen on the moisture-free basis.
Omf	**Text**	Ultimate oxygen on the moisture-free basis.
Smf	**Text**	Ultimate sulfur on the moisture-free basis.
Btumf	**Text**	Heating value on the moisture-free basis (Btu/Ib).
S04mf	**Text**	Sulfate sulfur on the moisture-free basis.
Pyrmf	**Text**	Pyritic sulfur on the moisture-free basis.
Orgmf	**Text**	Organic sulfur on the moisture-free basis.
Volmaf	**Text**	Volatile matter on the moisture and ash-free basis.
Fixmaf	**Text**	Fixed carbon on the moisture and ash-free basis.
Cmaf	**Text**	Ultimate carbon on the moisture and ash-free basis.
Hmaf	**Text**	Ultimate hydrogen on the moisture and ash-free basis.
Nmaf	**Text**	Ultimate nitrogen on the moisture and ash-free basis.
Omaf	**Text**	Ultimate oxygen on the moisture and ash-free basis.
Smaf	**Text**	Ultimate sulfur on the moisture and ash-free basis.

Table 2. Explanation of chemical data columns in the Indiana coal analysis database files created for the resource assessment of the Springfield, Herrin, Danville, and Baker Coals in the Illinois Basin—Continued.

Field Name	Type	Description
Btumaf	**Text**	Heating value on the moisture and ash-free basis (Btu/Ib).
S04maf	**Text**	Sulfate sulfur on the moisture and ash-free basis.
Pyrmaf	**Text**	Pyritic sulfur on the moisture and ash-free basis.
Orgmaf	**Text**	Organic sulfur on the moisture and ash-free basis.
Agi	**Text**	Agglomerating index.
Id	**Text**	Initial deformation temperature in the fusibility of coal ash test. The temperature in degrees Fahrenheit at which the first rounding of the apex of the ash cone occurs in a reducing atmosphere.
Id +	**Text**	A plus sign in this field indicates that the sample had not yet undergone initial deformation at the temperature recorded in the Id field. This field is blank when the Id temperature represents a precise measurement.
Heqw	**Text**	Height-equals-width temperature in the fusibility of coal-ash test. The temperature in degrees Fahrenheit at which the height of the ash cone equals its width in a reducing atmosphere.
Heqw +	**Text**	A plus sign in this field indicates that the sample had not yet reached the height-equals-width condition at the temperature recorded in the Heqw field. This field is blank when the Heqw temperature represents a precise measurement.
Heqhw	**Text**	Height equals one-half width temperature in the fusibility of coal-ash test. Temperature in degrees Fahrenheit at which height of ash cone equals one-half the width in a reducing atmosphere.
Heqhw+	**Text**	A plus sign in the field indicates that the sample had not yet reached the height-equals-half width condition at the temperature recorded in the Heqhw field**.** This field is blank when the Heqhw temperature represents a precise measurement.
Fluid	**Text**	Fluid temperature in the fusibility of coal-ash test. Temperature in degrees Fahrenheit at which ash becomes fluid in a reducing atmosphere.
Fluid+	**Text**	A plus sign in this field indicates that the sample had not yet reached a fluid condition at the temperature recorded in the Fluid field. This field is blank when the Fluid temperature represents a precise measurement.

Table 3. Explanation of chemical data columns in the Kentucky coal chemistry database files created for the resource assessment of the Springfield, Herrin, Danville, and Baker Coals in the Illinois Basin.

[This is a simplified data dictionary showing Field Name, Type, and Description for all the columns in the ASCII files kyspchms.txt, kyhechms.txt, kydachms.txt, kycgchms.txt, kyrgchms.txt, kymgchms.txt, and kychms.txt. These text files and this file were created by R.H. Affolter (affolter@usgs.gov) of the U.S. Geological Survey from selected parts of several files that were received from Cortland Eble (eble@kgs.mm.uky.edu) of the Kentucky Geological Survey and were used to create the ArcView chemical data shapefiles of the Springfield, Baker, Herrin, Carbondale Formation, Raccoon Creek Group, and the McLeansboro Group coals for the Illinois Basin resource assessment. For additional information, see the related metadata files for the Kentucky chemical data. Currently, there is no information on published reports detailing the analytical method used for this Kentucky data. For additional information about analytical methodology, contact Cortland Eble (KGS) or see the related metadata files for Kentucky chemical data. All columns except NORTH_LATITUDE and WEST_LONGITUDE are in text to preserve the original numbers.]

Field Name	Type	Description
FOREIGN_LAB_ID	TEXT	Laboratory ID
ANALYZING_LAB	TEXT	Name of laboratory
ANALYSIS_NAME	TEXT	Type of analysis
ANALYSIS_TYPE	TEXT	Portion of bed analyzed
ANALYSIS_NUMBER	TEXT	Analysis number
COAL_NUMBER	TEXT	Coal number—Kentucky coals are arranged by group with the first 3 numbers representing the group and the last 3 digits reflecting the named coal that was collected. Any code with an XXX199 or XXX999 means the coal zone was identified, but not the individual coal name.
COAL_NAME	TEXT	Coal name
NORTH_LATITUDE	TEXT	Decimal degrees north latitude
WEST_LONGITUDE	TEXT	Decimal degrees west longitude
RESERVE_DISTRICT	TEXT	Reserve district
COUNTY_NAME	TEXT	County name
QUADRANGLE_NAME	TEXT	7.5 minute quadrangle name
TOTAL_COAL	TEXT	Total coal thickness in inches
TOTAL_PARTING	TEXT	Total parting thickness in inches
COAL_ELEVATION	TEXT	Elevation of coal in feet
Si_wc	TEXT	(dry, whole-coal basis) silicon content in percent converted from SiO_2 content in percent.
Al_wc	TEXT	(dry, whole-coal basis) aluminum content in percent converted from Al_2O_3 content in percent.

Table 3. Explanation of chemical data columns in the Kentucky coal chemistry database files created for the resource assessment of the Springfield, Herrin, Danville, and Baker Coals in the Illinois Basin—Continued.

Field Name	Type	Description
Ca_wc	TEXT	(dry, whole-coal basis) calcium content in percent converted from CaO content in percent.
Na_wc	TEXT	(dry, whole-coal basis) sodium content in percent converted from Na_2O content in percent.
Mg_wc	TEXT	(dry, whole-coal basis) magnesium content in percent converted from MgO content in percent.
Fe_wc	TEXT	(dry, whole-coal basis) iron content in percent converted from Fe_2O_3 content in percent.
K_wc	TEXT	(dry, whole-coal basis) potassium content in percent converted from K_2O content in percent.
Ti_wc	TEXT	(dry, whole-coal basis) titanium content in percent converted from TiO_2 content in percent.
P_wc	TEXT	(dry, whole-coal basis) phosphorous content in parts per million converted from P_2O_5 content in percent.
As_wc	TEXT	(dry, whole-coal basis) arsenic content in parts per million
Be_wc	TEXT	(dry, whole-coal basis) beryllium content in parts per million
Cd_wc	TEXT	(dry, whole-coal basis) cadmium content in parts per million
Co_wc	TEXT	(dry, whole-coal basis) cobalt content in parts per million
Cr_wc	TEXT	(dry, whole-coal basis) chromium content in parts per million
Hg_wc	TEXT	(dry, whole-coal basis) mercury content in parts per million
Mn_wc	TEXT	(dry, whole-coal basis) manganese content in parts per million
Ni_wc	TEXT	(dry, whole-coal basis) nickel content in parts per million
Pb_wc	TEXT	(dry, whole-coal basis) lead content in parts per million
Sb_wc	TEXT	(dry, whole-coal basis) antimony content in parts per million

Table 3. Explanation of chemical data columns in the Kentucky coal chemistry database files created for the resource assessment of the Springfield, Herrin, Danville, and Baker Coals in the Illinois Basin—Continued.

Field Name	Type	Description
Se_wc	TEXT	(dry, whole-coal basis) selenium content in parts per million
Th_wc	TEXT	(dry, whole-coal basis) thorium content in parts per million
U_wc	TEXT	(dry, whole-coal basis) uranium content in parts per million
TOTAL_MOISTURE	TEXT	(as-received basis) total moisture in percent
DRY_ASH	TEXT	(dry basis) ash yield in percent
DRY_VOLATILE_MATTER	TEXT	(dry basis) volatile matter content in percent
DRY_FIXED_CARBON	TEXT	(dry basis) fixed carbon content in percent
DRY_TOTAL_SULFUR	TEXT	(dry basis) total sulfur content in percent
DRY_COMPLIANCE	TEXT	Compliance sulfur is calculated by the following formula: (% total S *19,500) / Calorific Value in BTU/lb. The resulting number is in lbs $S0_2$ / MM
DRY_BTU	TEXT	(dry basis) Gross calorific value of the coal sample expressed in British Thermal Units (BTU/lb)
DRY_CARBON	TEXT	(dry basis) carbon content in percent
DRY_HYDROGEN	TEXT	(dry basis) hydrogen content in percent
DRY_NITROGEN	TEXT	(dry basis) nitrogen content in percent
DRY_OXYGEN	TEXT	(dry basis) oxygen content in percent

Table 4. Explanation of chemical data columns in the Illinois State Geological Survey's coal database files created for the resource assessment of the Springfield, Herrin, Danville, and Baker Coals in the Illinois Basin.

[This is a simplified data dictionary showing Field Name, Value, and Description for all the columns in the ASCII files ildachms.txt, ilhechms.txt, ilspchms.txt, and ilchms.txt. These text files, as well as this file, were created by R.H. Affolter (affolter@usgs.gov) of the U.S. Geological Survey from several files received from Colin Treworgy (colin@isgs.uiuc.edu) of the Illinois State Geological Survey and were used to create the ArcView chemical data shapefiles of the Springfield, Danville, and Herrin coals for the Illinois Basin resource assessment. All columns that are labeled column_Q were generated by R.H. Affolter and indicate the qualified values (indicated by L = less than) for selected elements. All columns except DLONG and DLAT are in text to preserve original numbers. For additional information see the related metadata files for Illinois chemical data.]

Field Name	Type	Description
LABNO	TEXT	Laboratory sample number
STATE	TEXT	FIPS state code
COUNTY	TEXT	FIPS county code
STRATCODE	TEXT	ISGS stratigraphic code
DLONG	REAL	Decimal Longitude
DLAT	REAL	Decimal Latitude
THICK	TEXT	Thickness of sample
DEPTH	TEXT	Depth of sample
ELEV	TEXT	Elevation
SAMPLEDATE	TEXT	Sample date
ANALDATE	TEXT	Analysis date
SAMPLETYPE	TEXT	Sample type
ADL	TEXT	Air dried loss
MOISTURE	TEXT	(as received) Moisture content in percent.
VOLATILE	TEXT	(dry basis) Volatile matter content in percent.
FIXEDC	TEXT	(dry basis) Fixed carbon content in percent.
ASH	TEXT	(dry basis) Ash yield in percent.
TOTAL-SUL	TEXT	(dry basis) Total sulfur content in percent.
BTU	TEXT	(dry basis) Btu/lb

Table 4. Explanation of chemical data columns in the Illinois State Geological Survey's coal database files created for the resource assessment of the Springfield, Herrin, Danville, and Baker Coals in the Illinois Basin—Continued.

Field Name	Type	Description
CARBON	TEXT	(dry basis) Carbon content in percent.
HYDROGEN	TEXT	(dry basis) Hydrogen content in percent.
NITROGEN	TEXT	(dry basis) Nitrogen content in percent.
OXYGEN	TEXT	(dry basis) Oxygen content in percent.
ORGANIC-SUL	TEXT	(dry basis) Organic sulfur content in percent.
PYRITIC-SUL	TEXT	(dry basis) Pyritic sulfur content in percent.
SULFATE-SUL	TEXT	(dry basis) Sulfate sulfur content in percent.
FSI	TEXT	Free swelling index
TOT-CHLOR	TEXT	(dry basis) Total chlorine content in percent.
AFUSION-INIT	TEXT	(dry basis) Initial ash fusion temperature in degrees Fahrenheit.
AFUSION-SOFT	TEXT	(dry basis) softening temperature in degrees Fahrenheit.
AFUSION-HEMI	TEXT	(dry basis) Hemi ash fusion temperature in degrees Fahrenheit.
AFUSION-FLUID	TEXT	(dry basis) Fluid ash fusion temperature in degrees Fahrenheit.
EQM	TEXT	Equilibrium moisture
COMMENT	TEXT	Comments
TYPE	TEXT	Type of sample
MINE	TEXT	Mine name
SI	TEXT	(dry, whole-coal basis) Silicon content in percent converted from Silicon content in parts per million.
AL	TEXT	(dry, whole-coal basis) Aluminum content in percent. converted from Aluminum content in parts per million.
FE	TEXT	(dry, whole-coal basis) Iron content in percent converted from Iron content in parts per million.
MG	TEXT	(dry, whole-coal basis) Magnesium content in percent converted from Magnesium content in parts per million.
CA	TEXT	(dry, whole-coal basis) Calcium content in percent converted from Calcium content in parts per million.
NA	TEXT	(dry, whole-coal basis) Sodium content in percent converted from Sodium content in parts per million.

Table 4. Explanation of chemical data columns in the Illinois State Geological Survey's coal database files created for the resource assessment of the Springfield, Herrin, Danville, and Baker Coals in the Illinois Basin—Continued.

Field Name	Type	Description
K	TEXT	(dry, whole-coal basis) Potassium content in percent converted from Potassium content in parts per million.
TI	TEXT	(dry, whole-coal basis) Titanium content in percent converted from Titanium content in parts per million.
P	TEXT	(dry, whole-coal basis) Phosphorus content in parts per million.
AS	TEXT	(dry, whole-coal basis) Arsenic content in parts per million.
B	TEXT	(dry, whole-coal basis) Boron content in parts per million.
BA	TEXT	(dry, whole-coal basis) Barium content in parts per million.
BE	TEXT	(dry, whole-coal basis) Beryllium content in parts per million.
CD	TEXT	(dry, whole-coal basis) Cadmium content in parts per million.
CO	TEXT	(dry, whole-coal basis) Cobalt content in parts per million.
CR	TEXT	(dry, whole-coal basis) Chromium content in parts per million.
CU	TEXT	(dry, whole-coal basis) Copper content in parts per million.
F	TEXT	(dry, whole-coal basis) Fluorine content in parts per million.
GA	TEXT	(dry, whole-coal basis) Gallium content in parts per million.
GE	TEXT	(dry, whole-coal basis) Germanium content in parts per million.
HG	TEXT	(dry, whole-coal basis) Mercury content in parts per million.
LA	TEXT	(dry, whole-coal basis) Lanthanum content in parts per million.
LI	TEXT	(dry, whole-coal basis) Lithium content in parts per million.
MN	TEXT	(dry, whole-coal basis) Manganese content in parts per million.
MO	TEXT	(dry, whole-coal basis) Molybdenum content in parts per million.
NI	TEXT	(dry, whole-coal basis) Nickel content in parts per million.
PB	TEXT	(dry, whole-coal basis) Lead content in parts per million.
SB	TEXT	(dry, whole-coal basis) Antimony content in parts per million.
SC	TEXT	(dry, whole-coal basis) Scandium content in parts per million.
SE	TEXT	(dry, whole-coal basis) Selenium content in parts per million.

Table 4. Explanation of chemical data columns in the Illinois State Geological Survey's coal database files created for the resource assessment of the Springfield, Herrin, Danville, and Baker Coals in the Illinois Basin—Continued.

Field Name	Type	Description
SR	TEXT	(dry, whole-coal basis) Strontium content in parts per million.
TH	TEXT	(dry, whole-coal basis) Thorium content in parts per million.
U	TEXT	(dry, whole-coal basis) Uranium content in parts per million.
V	TEXT	(dry, whole-coal basis) Vanadium content in parts per million.
YB	TEXT	(dry, whole-coal basis) Ytterbium content in parts per million.
ZN	TEXT	(dry, whole-coal basis) Zinc content in parts per million.
ZR	TEXT	(dry, whole-coal basis) Zirconium content in parts per million.

GENERAL COMMENTS

The following information was received from Colin Treworgy (ISGS) and helps to clarify the Illinois State Geological Survey chemical data descriptions.

Each analysis in the Illinois coal quality database has a unique 12-character identifier called LABNO (laboratory number). The first character in the item LABNO is a letter assigned by the ISGS indicating the laboratory that analyzed the sample. The 11 characters following the letter are, in most cases, the identifier assigned by the original laboratory. If the laboratory number is unknown, the company drill hole number is used.

Letter	Laboratory
A	USBM analyses, prior to ISGS "C" lab numbers, old ASTM methods
B	ISGS analyses of oil field brines
C	ISGS analyses of coal or coal-related material
D	ISGS isotopic analyses (e.g. carbon-14)
E	AMAX MIDWEST AREA LAB analyses of coal or coal-related material
G	ISGS analyses of gas
L	COALFIELD RESEARCH, INC. analyses of coal or coal-related material
M	CDM-Acculabs analyses of coal or coal-related material
O	ISGS analyses of oil or oil-related samples
R	ISGS analyses of rocks, soil, and other non-coal sediments
S	ISGS analyses of Devonian black shales
T	COMMERCIAL TESTING & ENGINEERING analyses of coal or coal-related material
U	Unknown laboratory
V	SUNNYVALE MINERALS analyses of coal or coal-related material
W	ISGS analyses of water
X	BLOOMINGTON EXPLORATION analyses of coal or coal-related material

Selected Stratigraphic Codes

2490 Danville Coal
2660 Herrin Coal
2790 Springfield Coal

Table 4. Explanation of chemical data columns in the Illinois State Geological Survey's coal database files created for the resource assessment of the Springfield, Herrin, Danville, and Baker Coals in the Illinois Basin—Continued.

	Sampletype Codes
B	Bench sample undifferentiated
C	Column
W	Washed sample undifferentiated
B	Bench sample undifferentiated
C	Column
CB	Composite of bench or block samples; details in remarks
CC	Composite of column samples
FC	Channel of seam; impurities > 3/8" present, but excluded
IC	Channel of seam; impurities > 3/8" present in sample
PC	Channel of seam; impurities > 3/8" not present
W	Washed sample undifferentiated
B	Bench sample undifferentiated
B1	Bench sample of the first bench of the seam
B2	Bench sample of the second bench of the seam
B3	Bench sample of the third bench of the seam
B4	Bench sample of the fourth bench of the seam
B5	Bench sample of the fifth bench of the seam
B6	Bench sample of the sixth bench of the seam
B7	Bench sample of the seventh bench of the seam
B8	Bench sample of the eighth bench of the seam
BD1	Bench sample of core - first bench of seam
BD2	Bench sample of core- second bench of seam
BD3	Bench sample of core- third bench of seam
BD4	Bench sample of core- fourth bench of seam
BD5	Bench sample of core- fifth bench of seam
BF	Channel of bench; impurities > 3/8" present but excluded
BF1	Channel of bench 1; impurities > 3/8" present but excluded.
BF2	Channel of bench 2; impurities > 3/8" present but excluded.
BF3	Channel of bench 3; impurities > 3/8" present but excluded.
BF4	Channel of bench 4; impurities > 3/8" present but excluded.
BF5	Channel of bench 5; impurities > 3/8" present but excluded.
BF6	Channel of bench 6; impurities > 3/8" present but excluded
BF7	Channel of bench 7; impurities > 3/8" present but excluded
BI	Channel of bench; impurities > 3/8" present in sample
BI1	Channel of bench 1; impurities > 3/8" present in sample
BI2	Channel of bench 2; impurities > 3/8" present in sample
BI3	Channel of bench 3; impurities > 3/8" present in sample
BI4	Channel of bench 4; impurities > 3/8" present in sample
BI5	Channel of bench 5; impurities > 3/8" present in sample
BL	Blend of 2 or more different coals, details in remarks
BP	Channel of bench; impurities > 3/8" not present
BP1	Channel of bench 1; impurities > 3/8" not present
BP2	Channel of bench 2; impurities > 3/8" not present
BP3	Channel of bench 3; impurities > 3/8" not present
BP4	Channel of bench 4; impurities > 3/8" not present
BP5	Channel of bench 5; impurities > 3/8" not present
BP6	Channel of bench 6; impurities > 3/8" not present
BP7	Channel of bench 7; impurities > 3/8" not present
BP8	Channel of bench 8; impurities > 3/8" not present
BP9	Channel of bench 9; impurities > 3/8" not present

Table 4. Explanation of chemical data columns in the Illinois State Geological Survey's coal database files created for the resource assessment of the Springfield, Herrin, Danville, and Baker Coals in the Illinois Basin—Continued.

Sampletype Codes

C	Column
CB	Composite of bench or block samples
CC	Composite of column samples
CDC	Composite of drill core samples
CFC	Composite channel samples; impurities > 3/8" present but excluded
CGD	Composite of composited samples collected on grids
CIC	Composite of channel samples; impurities > 3/8" present in sample
CPC	Composite of channel samples; impurities > 3/8" not present
D C	Drill core
DC	Drill core
DF	Drill core of bench; impurities > 3/8" present, but excluded
DFC	Drill core of seam
DI	Drill core of bench; impurities > 3/8" present in sample
DIC	Drill core of seam
DP	Drill core of bench; impurities > 3/8" not present
DP1	Drill core of bench 1; impurities > 3/8" not present
DP2	Drill core of bench 2; impurities > 3/8" not present
DP3	Drill core of bench 3; impurities > 3/8" not present
DPC	Drill core of seam
FC	Channel of seam; impurities > 3/8" present, but excluded
GB	Grab sample, details in remarks
Bn	Grab sample of strata 1..n (1 = top)
GD	Grid sample, composite of individual samples collected on a grid
IC	Channel of seam; impurities > 3/8" present in sample
LAB	Laboratory generated sample, details in remarks
PC	Channel of seam; impurities > 3/8" not present
RM	Run of mine, details in remarks
RP	Run of preparation plant, details in remarks
SP	Special sample, details in remarks
SZ	A particle size fraction; feed sample noted elsewhere.
UNN	Unknown type of sample, details in remarks
W	Washed sample undifferentiated
W1	Washed sample- first bench of seam
W2	Washed sample- second bench of seam
W3	Washed sample- third bench of seam
CDS	Calculated composite of sized core samples

The following publications document the analytical procedures used for most Illinois State samples.

Rees, O. W., 1966, Chemistry, Uses and Limitations of Coal Analyses: Illinois State Geological Survey Report of Investigations 220, 55 p. (This publication documents the proximate, ultimate, etc. analysis methodology)

Gluskoter, H. J., Ruch, R. R., Miller, W. G., Cahill, R. A., Dreher, G. B., and Kuhn, J. K., 1977, Trace Elements in Coal: Occurrences and Distribution: Illinois State Geological Survey Circular 499, 154 p. (The appendix at the end of this publication details element analyses methodology).