

GEOLOGICAL SURVEY CIRCULAR 266



COAL RESOURCES
OF INDIANA

Prepared in cooperation with the
Indiana Department of Conservation
Geological Survey
1953

UNITED STATES DEPARTMENT OF THE INTERIOR
Douglas McKay, Secretary

GEOLOGICAL SURVEY
W. E. Wrather, Director

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PREFACE

This report on the coal resources of Indiana is the tenth of a series of State summary reports prepared by the Geological Survey as part of a program to estimate the coal reserves of the United States. Studies of the reserves in other States are contained in the following publications: Geology of the Deep River coal field, Chatham, Lee, and Moore Counties, North Carolina, Preliminary map, 1949; Coal resources of Montana, Circular 53, 1949; Coal resources of Michigan, Circular 77, 1950; Coal resources of Wyoming, Circular 81, 1950; Coal resources of New Mexico, Circular 89, 1950; Lignite resources of South Dakota, Circular 159, 1952; Coal resources of Virginia, Circular 171, 1952; Lignite resources of North Dakota, Circular 226, 1953; and Coal resources of Colorado, Circular 258, 1953.

W. E. Wrather
Director

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COAL RESOURCES OF INDIANA

By Frank D. Spencer

INTRODUCTION

This report on the Coal Resources of Indiana has been prepared in cooperation with the Indiana Department of Conservation, Geological Survey, as a part of the U. S. Geological Survey's program to reappraise the coal reserves of the United States.

The first comprehensive estimate of the coal reserves of the United States was made by M. R. Campbell of the U. S. Geological Survey in the period between 1907 and 1928. Even as late as 1928, however, there had been no significant exploration or development of many coal-bearing areas, and information about the thickness and extent of coal was restricted to observations along outcrops.

In the years since 1928 approximately 11 billion tons of coal has been mined in the United States. This amount is more than one third of the total tonnage produced from the beginning of mining through 1950 (Bituminous Coal Institute, 1950, p. 12, 43). As a result of this mining and development, much new information about the thickness and continuity of coal at depth has been obtained.

The growth of the strip-mining industry in Indiana, which has taken place largely in the years since 1928, has been accompanied by an extensive program of exploratory drilling by private companies and by a related program of topographic mapping by the U. S. Geological Survey. With this increased amount of reliable data, it has been possible to prepare a new and detailed summary appraisal of the coal reserves in Indiana, classified according to the thickness of the coal, thickness of overburden, and relative abundance of information.

Sources of information

In preparing this report on the coal resources of Indiana many sources were examined. Chief among these were the Annual Reports of the Indiana Department of Conservation; mined-out area maps of the Indiana Bureau of Mines and Mining; Annual Reports, Bulletins, and Folios of the U. S. Geological Survey; Technical Papers and Mine Inspection Reports of the U. S. Bureau of Mines; and maps of strip-mined areas of the U. S. Department of Agriculture. Information was procured also from published and unpublished reports and maps of the Indiana Department of Conservation, Geological Survey. A large number of maps and drill records from many coal-mining companies were used, and in all more than 5,000 coal, oil, and water drill records and logs were examined.

The data for the coal reserve estimates for all counties south of Sullivan and Greene were gathered and plotted, and the coal reserve estimates calculated

by the U. S. Geological Survey. The coal reserve data for Clay, Greene, Owen, Parke, Sullivan, Vigo, and Vermillion Counties were provided by the Indiana Department of Conservation, Geological Survey, as part of a program of detailed geologic mapping in the coal field area. Many of these data were plotted and the coal reserve estimates prepared by that agency.

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The following companies have permitted the inspection and use of information, which contributed greatly to the accuracy and completeness of the study: Ayrshire Collieries Corporation; Big Bend Collieries; Black Hawk Coal Corporation; Blackfoot Mining Corporation; Walter Bledsoe & Company; August Brocksmyth Drilling Company; Cedar Valley Coal Company; Central Indiana Coal Company; Coal Trades Association of Indiana; Enoco Collieries, Inc.; Gulf Oil Company; Indiana Coal Producers Association; Indiana Truck Mine Operators Association; Indianapolis Power & Light Company; Ingle Coal Corporation; Knox Consolidated Coal Corporation; Little Betty Mining Corporation; Maumee Collieries Company; The Monon Railroad Company; the New York Central System; the Paul Weir Company; Pond River Coal Company; Princeton Mining Company; Pyramid Coal Corporation; Shasta Coal Corporation; Sherwood-Templeton Coal Company; Sinclair Coal Company; Sohio Petroleum Company; Snow Hill Coal Corporation; Standard Coal Company; Sunlight Coal Corporation; Tecumseh Coal Corporation; and Templeton Coal Company.

ABSTRACT

The Indiana coal field forms the eastern edge of the eastern interior coal basin, which is near some of the most densely populated and highly productive manufacturing areas of the United States. (See fig. 1.) For this reason Indiana coal reserves are an important State and National asset.

In dollar value the coal mining industry is the largest of Indiana's natural-resource-producing

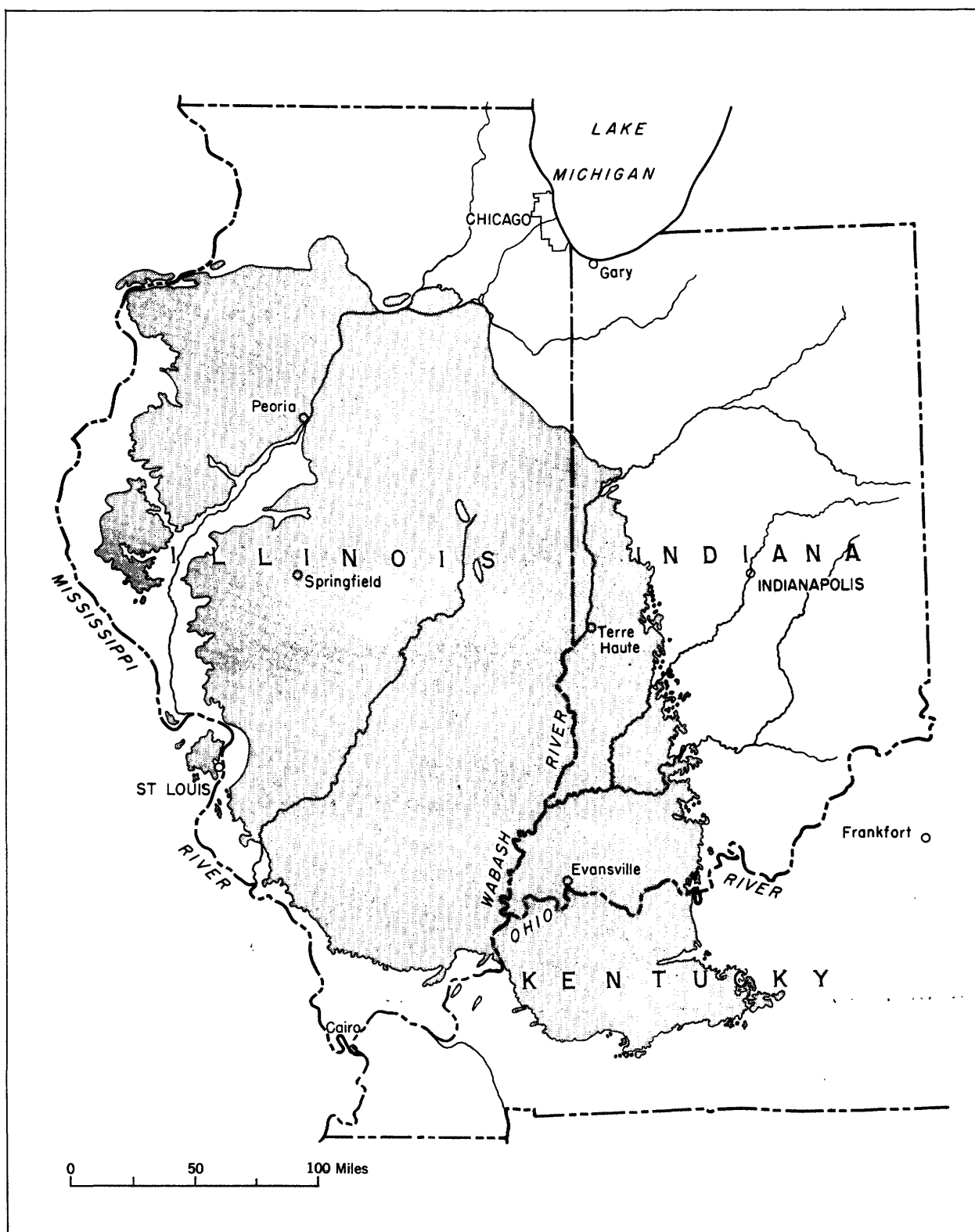


Figure 1.—Map of the eastern interior coal basin.

industries. The total value of coal production for the year 1950 was more than 100 million dollars, or more than that of all other natural-resource industries in the State combined.

As estimated herein, the original coal reserves of Indiana total 37,293 million tons, of which 27,320 million tons is contained in beds more than 42 inches thick; 7,632 million tons in beds 28 to 42 inches thick; and 2,341 million tons in beds 14 to 28 inches thick. The remaining reserves as of January 1, 1951, total 35,806 million tons, of which 18,779 million tons is believed to be recoverable. The distribution of the reserves in these several categories is summarized by counties in table 1.

Of the total original reserves of 37,293 million tons, 6,355 million tons can be classified as measured; 8,657 million tons as indicated; and 22,281 million tons as inferred. Strippable reserves constitute 3,524 million tons, or 9.5 percent of the total original reserves. The distribution of the strippable and nonstrippable original reserves is summarized in tables 2 and 3 by counties and by several categories, according to the thickness of the beds and the relative abundance and reliability of the information available for preparing the estimates.

The distribution of the estimated 18,779 million tons of recoverable strippable and nonstrippable reserves in Indiana is further summarized by counties in table 4, and the information is presented graphically in figures 2 and 3.

The tables 1 to 4 and figures 2 and 3 include beds in the 14- to 28-inch category, because thin beds have been mined in many places. However, many operators prefer to eliminate the thin beds from consideration as reserves, particularly for deep mining. It is notable, therefore, that only a small part of the estimated reserves in Indiana is contained in the thinner beds. Of the total estimated recoverable reserves of 18,779 million tons shown in table 4, only 1,233 million tons, or about 6 percent, is contained in beds less than 28 inches thick, whereas 17,546 million tons, or about 94 percent, is contained in beds more than 28 inches thick.

METHODS OF PREPARING RESERVE ESTIMATES

Because the coal beds in Indiana are largely concealed by non-coal-bearing rocks and as most of the available information about these beds is confined to observations at the outcrops and in widely spaced mines and exploratory drill holes, it was necessary in preparing the accompanying estimate of the coal reserves of Indiana to establish certain standardized definitions and procedures to insure uniform interpretation and classification of the data.

The distinctions thus established are based on characteristics of the coal, relative abundance of reliable data, and the point of view followed in preparing estimates.

Classification according to characteristics of coal

The characteristics of coal considered in preparing the reserve estimates are the rank, weight, thickness of bed, and thickness of overburden.

Rank of coal

The rank of coal is determined by its physical and chemical properties and is important, therefore, in determining utilization. The rank assigned to Indiana coal is based on the standard specifications of the American Society for Testing Materials. (See table 5.)

All of the coal in Indiana is of bituminous rank. The greater part is of high volatile C bituminous rank, the smaller part is of high volatile B bituminous rank. Block coal and cannel coal, which occur in small quantities in Indiana, are two varieties of bituminous coal that have distinctive characteristics.

Block coal is divided into blocks by vertical joints spaced 2 to 4 feet apart and by horizontal splits along laminations of fusain (mineral charcoal) and vitrain (bright coal). These regular systems of jointing

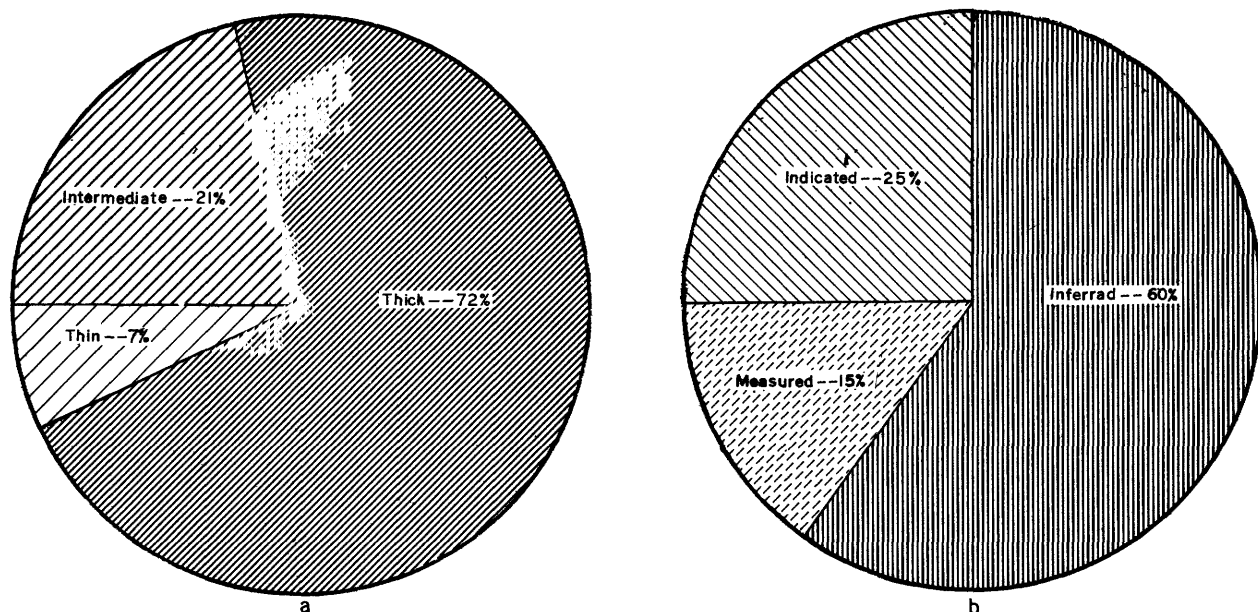


Figure 2.—Diagram showing comparison of recoverable coal reserves in Indiana according to: (a) Thickness (b) abundance of reliable data.

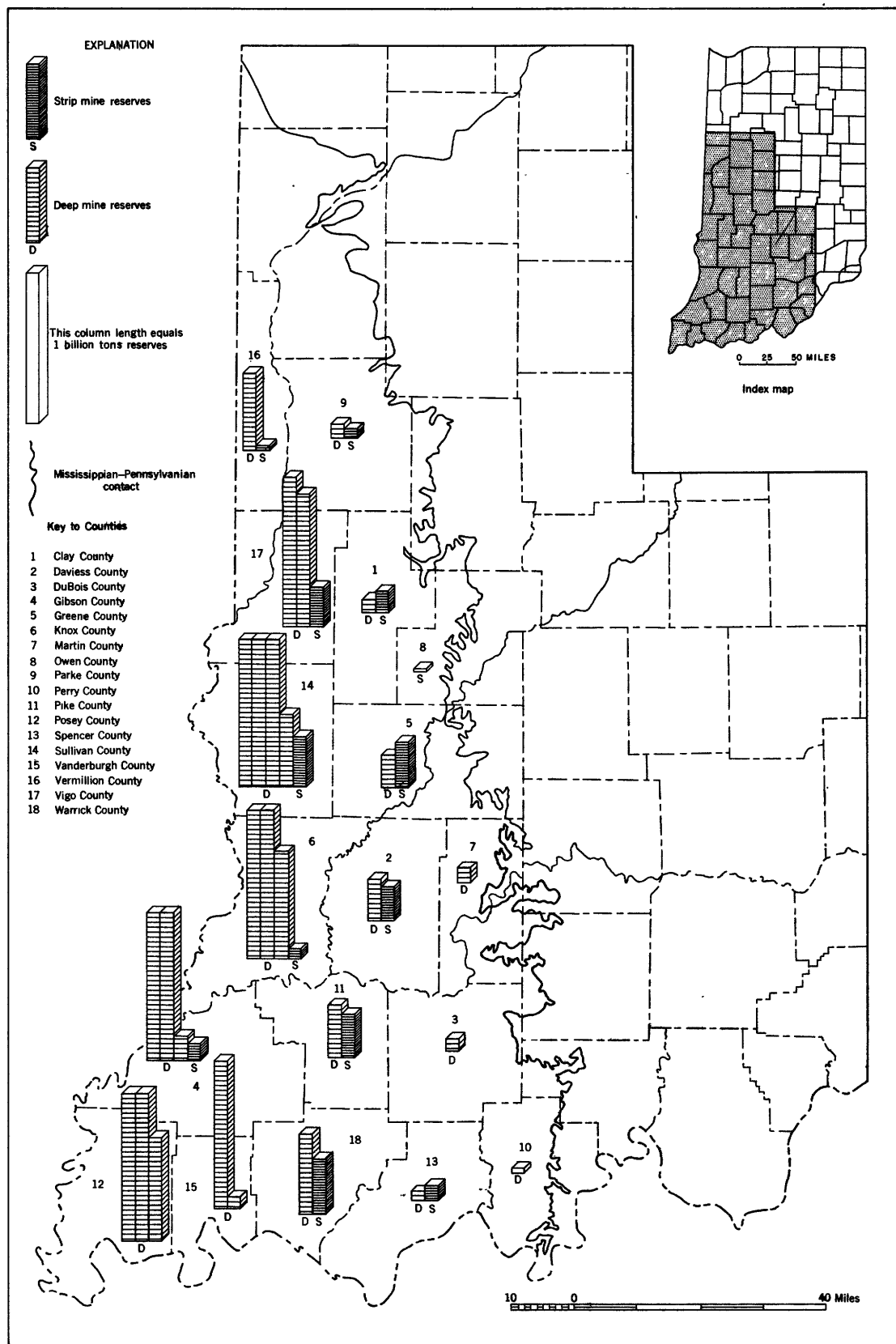


Figure 3.—Map of coal fields of Indiana showing comparison of recoverable strippable and nonstrippable reserves by counties.

Table 2.—Summary of original coal reserves in Indiana by counties, according to abundance and reliability of data
(in thousands of short tons)

County	Measured reserves			Indicated reserves			Inferred reserves			Total in all reserve categories		
	Coal 14-28 in. thick	Coal 28-42 in. thick	Coal more than 42 in. thick	Coal 14-28 in. thick	Coal 28-42 in. thick	Coal more than 42 in. thick	Coal 14-28 in. thick	Coal 28-42 in. thick	Coal more than 42 in. thick	Coal 14-28 in. thick	Coal 28-42 in. thick	Coal more than 42 in. thick
Stripplable reserves—overburden range less than 40, 60, and 90 feet												
Clay	1,238	2,789	130,566	2,206	4,154	33,403	39,763	4,376	12,917	7,820	19,860	203,067
Davies	17,424	39,171	30,334	38,681	75,198	58,298	172,377	8,164	1,405	64,469	115,774	113,813
Gibson	3,343	7,144	12,928	8,156	25,802	33,133	67,091	3,792	20,133	15,291	53,079	78,049
Greene	2,941	5,129	195,709	5,536	8,005	126,681	140,212	19,946	13,885	28,413	27,019	429,311
Knox	7,299	7,470	23,432	9,144	6,271	22,031	37,446	1,351	3,077	17,794	16,818	49,924
Owen	1,793	7,902	12,598	2,517	5,862	68,689	9,068	2,197	7,922	6,512	21,686	3,587
Parke	---	---	17,898	---	---	64,165	64,165	---	---	---	---	82,061
Pike	3,460	20,525	312,534	1,435	4,776	64,595	70,856	---	474	4,945	25,775	410,413
Spencer	5,476	8,082	17,434	37,553	50,273	20,464	108,290	---	---	43,029	58,355	125,724
Sullivan	2,922	102,336	302,016	368	68,018	79,627	147,973	---	29,205	3,250	199,559	308,542
Vermillion	35	880	40,953	---	---	10,791	10,791	---	---	35	880	61,244
Vigo	---	57,971	236,601	2,696	33,960	82,950	119,606	---	19,402	2,696	111,333	347,945
Warrick	25,536	48,735	367,188	3,323	23,371	75,899	102,555	1,207	3,228	30,066	75,334	462,997
Total	71,472	308,134	1,571,675	111,815	305,690	672,664	1,090,169	41,033	111,648	224,320	725,472	2,574,378
Nonstrippable reserves—overburden range more than 40, 60, and 90 feet												
Clay	20	110	34,184	---	---	46,998	46,998	---	---	20	110	190,657
Davies	25,256	40,027	103,122	107,742	153,786	90,313	351,841	5,939	7,131	138,937	200,944	234,451
Dubois	7,797	15,690	28,555	43,544	80,115	22,064	145,723	---	---	51,341	95,805	27,132
Gibson	9,374	27,920	425,570	46,806	150,595	721,332	918,723	173,226	550,134	229,406	728,639	3,470,894
Greene	---	---	109,514	---	---	141,742	141,742	---	---	246,130	---	497,386
Knox	138,948	184,951	694,539	292,745	434,220	893,464	1,620,429	139,391	768,629	571,084	1,387,800	3,606,098
Martin	14,388	17,451	36,893	59,478	81,308	18,935	159,721	---	---	73,866	98,759	23,989
Parke	---	167	54,178	---	---	51,513	51,513	---	---	---	167	218,256
Perry	4,715	2,991	9,140	20,733	24,383	4,950	50,066	---	---	25,448	27,374	6,384
Pike	5,572	12,989	92,454	11,799	24,321	158,046	194,166	39,224	80,056	56,595	117,366	563,825
Posey	3,525	10,711	66,999	18,238	87,982	505,145	611,365	96,596	613,935	118,359	712,628	4,562,454
Spencer	3,553	3,450	7,003	33,084	57,664	26,897	117,645	---	---	36,637	61,114	26,897
Sullivan	25,043	48,208	792,222	72,959	238,290	1,020,052	1,331,301	331,360	2,022,801	429,362	2,309,299	4,275,785
Vanderburgh	1,806	74,445	76,444	27,779	75,366	338,732	441,877	180,029	421,129	209,614	496,688	1,479,627
Vermillion	6,345	5,585	275,514	1,018	4,410	203,372	208,800	2,585	5,045	9,948	15,040	1,136,409
Vigo	7,528	23,825	819,133	18,146	107,532	702,043	827,721	90,258	358,364	115,932	489,721	3,423,890
Warrick	10,133	35,681	221,661	13,298	79,586	254,790	347,668	26,252	50,202	49,685	165,463	901,855
Total	264,003	429,949	3,709,641	767,369	1,599,542	5,200,388	7,567,299	1,084,860	4,877,426	2,116,232	6,906,917	24,745,760
State total	335,475	738,083	5,281,316	879,184	1,905,232	5,873,052	8,657,468	1,125,893	4,989,074	2,340,552	7,632,389	27,320,138
												37,293,079

Table 3.—Summary of strippable and nonstrippable coal reserves in Indiana by counties
(in thousands of short tons)

County	Original reserves			Mined and lost in mining to January 1, 1951			Remaining reserves as of January 1, 1951			Recoverable reserves ¹ as of January 1, 1951						
	Coal 14-28 in. thick	Coal 28-42 in. thick	Coal more than 42 in. thick	Total	Coal 14-28 in. thick	Coal 28-42 in. thick	Coal more than 42 in. thick	Total	Coal 14-28 in. thick	Coal 28-42 in. thick	Coal more than 42 in. thick	Total				
Strippable reserves—overburden range less than 40, 60, and 90 feet																
Clay-----	7,820	19,860	203,067	230,747	403	480	45,740	46,623	7,417	19,380	157,327	184,124	5,934	15,504	125,861	147,299
Daviess-----	64,469	115,774	113,813	294,056	94	1,756	1,117	2,967	64,375	114,018	112,696	291,089	51,499	91,215	90,156	232,870
Gibson-----	15,291	53,079	78,049	146,419	---	72	992	1,064	15,291	53,007	77,057	145,355	12,231	42,406	40,147	116,284
Greene-----	28,413	27,019	429,311	484,743	253	1,301	100,645	102,199	28,160	25,718	328,666	382,544	22,526	20,575	262,932	306,033
Knox-----	17,794	16,818	49,924	84,536	---	---	4,242	4,242	17,794	16,818	45,682	80,294	14,235	13,456	36,544	64,235
Owen-----	6,512	21,686	3,587	31,785	101	657	606	1,364	6,411	21,029	2,981	30,421	5,127	16,824	2,395	24,336
Parke-----	---	---	82,061	82,061	---	---	3,129	3,129	---	---	78,932	78,932	---	---	63,145	63,145
Pike-----	4,945	25,775	410,413	441,133	71	749	133,613	134,433	4,874	25,026	276,800	306,700	3,899	20,021	22,441	245,361
Spencer-----	43,029	58,355	24,340	125,724	796	1,757	383	2,936	42,233	56,598	23,127	122,788	33,786	45,278	19,166	98,230
Sullivan-----	3,250	199,559	308,542	511,351	107	17,764	67,422	85,293	3,143	181,795	241,120	426,058	2,514	145,475	192,897	340,846
Vermillion-----	35	880	60,329	61,244	---	---	7,069	7,069	35	880	53,260	54,175	28	704	42,608	43,240
Warrick-----	2,696	111,333	247,945	461,974	---	7,730	111,034	118,764	2,696	103,603	236,911	343,210	2,157	82,881	189,529	274,567
Warrick-----	30,066	75,354	462,997	568,397	3,494	638	90,908	95,040	26,572	74,696	372,089	473,357	21,256	59,756	297,673	378,685
Total-----	224,320	725,472	2,574,378	3,524,170	5,319	32,904	566,900	605,123	219,001	692,568	2,007,478	2,919,047	175,192	554,055	1,605,984	2,335,231
Nonstrippable reserves—overburden range more than 40, 60, and 90 feet																
Clay-----	20	110	190,657	190,787	---	---	7,913	7,913	138,471	198,925	182,744	182,874	10	55	91,371	91,436
Daviess-----	138,937	200,944	234,451	574,332	466	2,021	4,949	7,436	51,241	95,805	27,132	174,278	69,235	99,460	114,753	285,448
Dubois-----	51,241	95,805	27,132	174,278	---	---	86,896	86,896	229,406	728,639	3,383,998	4,342,043	25,671	47,902	13,566	87,139
Gibson-----	229,406	728,659	3,470,894	4,428,939	---	---	56,759	56,759	---	---	440,627	440,627	---	364,320	1,691,998	2,171,022
Greene-----	---	---	497,386	497,386	---	---	153,494	153,855	571,084	1,387,439	3,452,544	5,411,067	285,541	693,718	1,726,274	220,314
Knox-----	571,084	1,387,800	3,606,038	5,564,922	---	361	153,494	153,855	73,866	98,759	23,989	196,614	36,932	49,381	11,994	2,705,533
Martin-----	73,866	98,759	23,989	196,614	---	---	21,606	21,606	---	167	196,483	196,650	---	84	98,245	98,307
Parke-----	---	167	218,089	218,256	---	---	---	---	---	27,374	6,384	59,206	12,725	13,687	3,191	29,603
Perry-----	25,448	27,374	6,384	59,206	---	---	11,514	11,514	56,595	117,366	552,311	726,272	28,296	58,684	276,155	363,135
Pike-----	56,595	117,366	563,825	737,786	---	---	---	---	118,359	712,628	4,562,454	5,393,441	59,178	356,315	2,281,227	2,696,723
Posey-----	118,359	712,638	4,562,454	5,393,441	---	---	---	---	36,340	60,878	26,897	124,115	18,171	30,438	13,448	62,057
Spencer-----	36,537	61,114	26,897	124,648	297	236	129,047	131,051	429,362	2,307,295	4,246,736	6,953,593	214,681	153,648	2,123,368	2,491,997
Sullivan-----	429,362	2,309,299	4,375,783	7,114,444	---	2,004	19,006	19,006	209,614	496,688	1,460,621	2,166,923	104,808	248,243	730,210	1,085,461
Vanderburgh-----	209,614	496,688	1,479,627	2,185,929	---	---	111,338	112,145	9,948	14,233	1,025,071	1,049,252	4,974	7,116	512,535	524,625
Vermillion-----	9,948	15,040	1,136,409	1,161,397	---	807	245,568	246,299	115,932	488,990	3,178,322	3,783,244	57,066	244,495	1,589,162	1,891,823
Vigo-----	115,932	489,721	3,423,890	4,029,543	---	731	27,167	27,167	49,683	165,463	874,688	1,089,834	24,841	82,732	437,344	544,917
Warrick-----	49,683	165,463	901,855	1,117,001	---	---	---	---	---	---	---	---	---	---	---	---
Total-----	2,116,232	6,906,917	24,745,750	33,768,909	763	6,160	875,257	882,180	2,115,469	6,900,757	23,870,503	32,886,729	1,057,733	3,450,378	11,935,251	16,443,362
State total-----	2,340,552	7,632,389	27,320,138	37,293,079	6,082	39,064	1,442,157	1,487,303	2,334,470	7,593,325	25,877,981	35,805,776	1,232,925	4,004,433	13,541,235	18,778,593

¹ Assuming 80 percent recoverability for strippable coal and 50 percent recoverability for nonstrippable coal.

Table 4. --Summary of recoverable coal reserves in Indiana by counties, according to abundance and reliability of data
(In thousands of short tons)

County	Measured reserves			Indicated reserves			Inferred reserves			Total in all reserve categories		
	Coal 14-28 in. thick	Coal more than 42 in. thick	Total	Coal 14-28 in. thick	Coal 28-42 in. thick	Coal more than 42 in. thick	Total	Coal 14-28 in. thick	Coal 28-42 in. thick	Coal more than 42 in. thick	Total	
Strippable reserves—overburden range less than 40, 60, and 90 feet, assuming 80 percent recoverability												
Clay-----	668	1,847	67,861	70,376	1,765	3,323	31,811	3,501	10,334	31,277	45,112	125,861
Davless-----	13,863	29,933	67,170	109,966	31,105	60,158	137,900	6,531	1,124	20,145	27,800	90,156
Gibson-----	2,674	5,658	17,880	26,112	6,524	20,641	53,674	3,033	16,107	25,590	44,730	61,647
Greene-----	2,150	3,062	81,263	86,475	7,421	6,404	112,169	15,955	11,109	85,537	112,601	262,932
Knox-----	5,839	5,977	27,167	39,083	7,315	5,017	29,957	1,081	2,462	3,568	7,111	36,544
Owen-----	1,357	5,796	8,987	15,940	2,013	4,690	7,354	1,757	6,338	---	8,095	2,395
Parke-----	---	---	11,815	11,815	---	---	51,330	---	---	---	---	63,145
Pike-----	2,711	15,821	143,137	161,669	1,188	3,821	56,685	---	379	26,628	27,007	20,021
Spencer-----	3,744	5,060	11,598	20,402	30,042	40,218	16,372	---	---	---	---	21,441
Sullivan-----	2,252	67,657	103,470	173,379	262	54,414	118,378	---	23,364	25,725	49,089	45,278
Vermillion-----	28	704	27,107	27,839	---	---	8,633	---	---	6,868	8,688	145,435
Vigo-----	---	40,192	100,454	140,646	2,157	27,168	95,685	---	15,521	22,715	38,236	704
Warrick-----	17,632	38,477	221,026	277,135	2,658	18,696	82,025	966	2,583	15,976	19,525	82,881
Total-----	52,918	220,184	803,822	1,076,924	89,450	244,550	872,133	32,824	89,321	264,029	386,174	59,756
												554,055
												1,605,984
												2,335,231
Nonstrippable reserves—overburden range more than 40, 60, and 90 feet, assuming 50 percent recoverability												
Clay-----	10	55	13,200	13,265	---	---	23,499	---	---	54,737	54,737	91,436
Davless-----	12,395	19,003	47,843	79,241	53,870	76,892	175,920	2,970	3,565	53,150	59,685	283,448
Dubois-----	3,899	7,844	14,277	25,920	21,772	40,058	72,862	86,614	275,065	1,161,996	1,523,675	13,566
Gibson-----	4,687	13,960	187,984	206,631	23,403	75,295	459,365	69,695	---	123,065	123,065	1,691,998
Greene-----	---	---	26,378	26,378	---	---	70,871	---	---	1,009,017	1,463,026	220,314
Knox-----	69,475	92,293	432,292	524,060	146,371	217,111	810,215	---	384,314	---	1,463,026	693,718
Martin-----	7,194	8,727	18,447	26,368	29,738	40,654	79,860	---	---	---	---	49,381
Parke-----	---	84	16,202	16,286	16,202	25,756	25,756	---	---	56,283	84	11,994
Perry-----	2,358	1,496	4,570	6,416	10,367	12,191	23,033	---	---	---	---	98,241
Pike-----	2,786	6,495	49,750	57,031	5,899	12,160	97,082	19,611	40,029	156,663	216,303	13,687
Posey-----	1,763	5,356	40,618	47,732	9,118	43,990	305,682	48,297	306,969	1,995,154	2,350,420	58,684
Spencer-----	1,628	1,606	3,224	4,830	16,543	28,832	58,823	---	---	---	---	30,438
Sullivan-----	12,521	23,102	367,211	392,834	36,480	119,145	665,651	165,680	1,011,401	1,281,754	2,498,835	1,153,648
Vanderburgh-----	903	27,719	87,719	116,831	13,890	37,681	220,938	90,015	210,565	533,224	833,804	248,343
Vermillion-----	3,173	82,088	87,650	172,911	509	2,205	104,400	1,292	2,522	328,761	332,575	7,116
Vigo-----	3,765	11,547	302,094	315,406	9,072	53,767	145,860	45,129	179,181	951,359	1,175,669	244,495
Warrick-----	5,067	17,840	120,153	143,050	6,648	39,790	173,835	13,126	25,102	212,701	250,929	82,732
Total-----	131,624	211,894	1,760,706	2,083,220	383,680	799,771	3,783,650	542,429	2,438,713	7,917,864	10,899,006	3,450,378
												11,935,251
												16,443,362
State total-----	184,542	432,078	2,837,630	3,454,232	473,130	1,044,321	4,655,783	575,253	2,528,034	8,181,893	11,285,180	4,004,433
												13,541,235
												18,778,593

Table 5. Classification of coals by rank^a

Legend: F.C. = Fixed Carbon.

V.M. = Volatile Matter.

Btu. = British thermal units.

Class	Group	Limits of Fixed Carbon or Btu. Mineral-Matter-Free Basis	Requisite Physical Properties
I. Anthracitic	1. Meta-anthracite.....	Dry F.C., 98 per cent or more (Dry V.M., 2 per cent or less)	Nonagglomerating ^b
	2. Anthracite.....	Dry F.C., 92 per cent or more and less than 98 per cent (Dry V.M., 8 per cent or less and more than 2 per cent)	
	3. Semianthracite.....	Dry F.C., 86 per cent or more and less than 92 per cent (Dry V.M., 14 per cent or less and more than 8 per cent)	
II. Bituminous ^d	1. Low volatile bituminous coal....	Dry F.C., 78 per cent or more and less than 86 per cent (Dry V.M., 22 per cent or less and more than 14 per cent)	Either agglomerating or nonweathering ^f
	2. Medium volatile bituminous coal.	Dry F.C., 69 per cent or more and less than 78 per cent (Dry V.M., 31 per cent or less and more than 22 per cent)	
	3. High volatile A bituminous coal.	Dry F.C., less than 69 per cent (Dry V.M., more than 31 per cent); and moist ^c Btu., 14,000 ^e or more	
	4. High volatile B bituminous coal.	Moist ^c Btu., 13,000 or more and less than 14,000 ^e	
	5. High volatile C bituminous coal.	Moist Btu., 11,000 or more and less than 13,000 ^e	
III. Subbituminous	1. Subbituminous A coal.....	Moist Btu., 11,000 or more and less than 13,000 ^e	Both weathering and nonagglomerating
	2. Subbituminous B coal.....	Moist Btu., 9500 or more and less than 11,000 ^e	
	3. Subbituminous C coal.....	Moist Btu., 8300 or more and less than 9500 ^e	
IV. Lignitic	1. Lignite.....	Moist Btu., less than 8300	Consolidated Unconsolidated
	2. Brown coal.....	Moist Btu., less than 8300	

^a This classification does not include a few coals which have unusual physical and chemical properties and which come within the limits of fixed carbon or Btu. of the high-volatile bituminous and subbituminous ranks. All of these coals either contain less than 48 per cent dry, mineral-matter-free fixed carbon or have more than 15,500 moist, mineral-matter-free Btu.

^b If agglomerating, classify in low-volatile group of the bituminous class.

^c Moist Btu. refers to coal containing its natural bed moisture but not including visible water on the surface of the coal.

^d It is recognized that there may be noncaking varieties in each group of the bituminous class.

^e Coals having 69 per cent or more fixed carbon on the dry, mineral-matter-free basis shall be classified according to fixed carbon, regardless of Btu.

^f There are three varieties of coal in the high-volatile C bituminous coal group, namely, Variety 1, agglomerating and nonweathering; Variety 2, agglomerating and weathering; Variety 3, nonagglomerating and nonweathering.

are developed in a high degree. Block coals generally are noncaking and noncoking. Most of this coal has been mined out in Indiana.

Cannel coal is a lusterless, even-textured coal with large conchoidal fracture. It is much cleaner than ordinary bituminous coal. Cannel coal burns with a yellow flame, taking fire readily, probably because of a large percentage of gas content. Cannel coal is composed of very finely divided plant fragments and conspicuous spore coats, which rarely exceed 10 percent of the total volume. No known commercial beds of cannel coal are being worked at present in Indiana.

Weight of coal

In the preparation of tonnage estimates, it is necessary to determine the weight of the coal in the ground. Because all of the coal in Indiana is of bituminous rank, the weight of the coal is fairly uniform and varies significantly only with variations in ash content. A consideration of the specific gravity of coal from a number of localities in Indiana shows that the specific gravity of a typical bed is 1.32 or a weight of 1,800 tons per acre-foot, and this factor has been used to compute all reserve estimates presented in this report.

Engineers and geologists employed by producing companies often employ lower figures, which are based on an anticipated loss in mining. Such a practice is not suitable for use in a general report, however, for recoverability may vary greatly in different areas, in different beds, and with different methods of mining. The factor of 1,800 tons per acre-foot is, therefore, intended to yield reserves of coal in the ground without regard to the recoverability.

Thickness of beds

As the thickness of beds is often one of the determining factors that govern the economic feasibility of coal mining operations, the coal reserves of Indiana are calculated and tabulated in three thickness categories of 14 to 28 inches, 28 to 42 inches, and more than 42 inches.

Partings of more than three-eighths of an inch in thickness are excluded from the bed thickness. Layers of thin coal above or below thicker partings that normally would be left underground in mining are also excluded from the total bed thickness.

Thickness of overburden

All of the coal of commercial value in Indiana lies less than 1,000 feet below the surface and is accessible by strip or shaft mining.

Because a large portion of Indiana's coal is obtained by strip mining and as recoverability in strip mining is higher than recoverability by underground mining, it is important that reserves under thin overburden be calculated and reported separately. A ratio of overburden to coal of 20 to 1 is considered the maximum practicable stripping ratio. Maximum thickness of overburden considered strippable is about

90 feet. In preparing the present appraisal of coal reserves in Indiana, three arbitrary categories of overburden, 0-40 feet, 0-60 feet, and 0-90 feet were established, depending upon the average thickness of each bed. When sufficient information was available, lines showing 40, 60, or 90 feet of overburden were drawn. In general, reserves under less than 40 feet of overburden are calculated for beds in the 14-28 inches range of thickness; reserves under less than 60 feet of overburden are calculated for beds in the 28-42 inches range of thickness; and reserves under less than 90 feet of overburden are calculated for beds more than 42 inches thick.

Classification according to abundance of reliable data

The estimates of reserves are further divided into three categories according to the relative abundance and reliability of the information available. These categories, termed "measured," "indicated," and "inferred," were established jointly by members of the U. S. Geological Survey and the U. S. Bureau of Mines.

Measured reserves

To determine measured reserves, tonnages are computed from positive information as to thickness and extent, based on measured coal outcrop sections, mine and pit workings, and drill holes. The points of measurement are so close that the computed tonnage can be considered to be within 20 percent of the true tonnage. In general, the points of measurement are not more than half a mile apart. If drill data is used for calculations, the outer limit of a block of measured coal is considered to be only a quarter of a mile beyond the outermost drill hole. This distance is occasionally reduced to one-eighth of a mile for calculating reserves of coal in beds considered to be sporadic. Along an outcrop or extent line where the continuity of the outcrop is measured in miles and suggests the presence of coal at great distances in from the outcrop, a belt of coal half a mile wide along the outcrop is classed as measured.

Indicated reserves

Indicated coal reserve tonnages are generally computed from more widely spaced drill hole and mine data. Reserves calculated in this category are assumed to extend half a mile beyond the areas of measured coal. Occasionally, reserves in some of the nonpersistent coal beds below Coal II were classed as indicated reserves for a distance of only one-eighth of a mile beyond the limits of measured coal. Electric logs and oil well drill logs were used to establish the presence of coal classed as indicated if the information derived from these sources could be checked and correlated with nearby mine and coal-drill data.

Inferred reserves

Inferred reserves are based essentially on the known geological characteristics of the individual beds. Inferred reserves usually lie beyond the areas of measured and indicated coals and are based on projections of the data used to compute measured and

indicated reserves. Occurrences of coal in isolated wells, shown on electric logs and oil well logs, also were used in estimating inferred reserves. Reserves in beds of doubtful continuity were classed as inferred for a distance of no more than two miles beyond the last point of observation. Reserves in beds that are not persistent, if inferred, were classed as inferred for a distance of only half a mile beyond the limits of indicated reserves.

Distinction between original, remaining, and recoverable reserves

Because several different points of view are used in discussing coal reserves, it is necessary to define the terms original, remaining, and recoverable reserves as they are used in this report.

Original reserves

In this report all coal reserves in the ground before the beginning of mining operations and having a thickness of more than 14 inches are considered original reserves. This includes coal in the narrow weathered strip at the outcrop; and coal underlying roads, railroads, cities, and coal formerly present in mined-out areas. The establishment of a figure for original reserves as a base is necessary for the successful determination of remaining and recoverable reserves, because the figures for remaining and recoverable reserves change annually with production and mining losses, and because recoverability in mining varies in different beds according to nature of the roof, thickness of overburden, and method of mining. An estimate of original reserves is therefore the stable base from which other estimates can be derived.

Remaining reserves

Reserves remaining in the ground on January 1, 1951, are considered remaining reserves regardless of the feasibility of extraction. Remaining reserves are obtained by subtracting from original reserves the tonnage of coal produced and lost in mining to the date of the appraisal or by subtracting the acreage in mined-out areas from the original acreage and calculating the tonnage in the remaining acreage.

Recoverable reserves

Recoverable reserves may be defined as the part of remaining reserves that can be taken out of the ground in mining. The percentage of remaining reserves deemed to be recoverable varies in individual beds and areas according to the quality and thickness of the coal, the nature of the roof and floor, the amount of overburden, the presence of faults and cutouts, the amount of ground water, the mining methods employed, and many other factors which vary with the individual mining properties.

A detailed study of past production as compared to known mined-out areas in several counties shows clearly, however, that overall recoverability in mining coal in Indiana is about 50 percent of the coal in the ground if mining is carried on by underground methods, and about 80 percent if the mining is by stripping.

The recoverable coal reserves in Indiana are therefore considered to be 50 percent of the remaining reserves to be mined by underground methods and 80 percent of the remaining reserves to be mined by stripping methods. The percentage of recovery from individual beds and areas may, of course, vary considerably from this assumed average.

Methods of recording data and making calculations

All of the reserve estimates in this report were calculated for individual coal beds and each political township. The first step in the preparation of reserve estimates was the drafting of a map for each individual coal bed in each county for which estimates are made. Available U. S. Geological Survey topographic quadrangle maps, scales 1:24,000 and 1:62,500, were used to make the base maps for counties. Indiana General Highway and Transportation maps and county base maps prepared by the Indiana Department of Conservation, Division of Geology, scale 1:63,360, were used for areas where no topographic maps have been made. Coal outcrops, coal extent lines, drill holes, mines, mined-out areas, and other pertinent data for each coal bed were plotted on the individual coal bed maps. The extent line marks the outer limits of a coal bed below the surface covering of glacial material. For estimating purposes this line is given equal weight with the outcrop line.

Using the topographic maps, interpretive lines were then drawn showing the respective overburden zones, with particular emphasis on stripping coal overburden ratios. Plotted thicknesses of coal were used to draw lines of assumed equal coal thickness. The possible area of the coal bed occurrence was then divided into the measured, indicated, and inferred categories according to the relative abundance and reliability of the available data.

The subareas of coal occurrence on the work maps representing categories as to thickness, reliability, and overburden, were then measured with a planimeter, and the acreage calculated. Next, the weighted average coal thickness within each measured area was determined, and the reserve tonnage computed, using the factor of 1,800 tons per acre-foot for the weight of the coal in the ground.

Areas excluded

Known areas showing faulting, erosional cutouts, or lensing-out of coal were excluded from the estimates. Also excluded were areas of coal having thicknesses less than 14 inches, and known areas of dirty or unusable coal.

Limitation of estimates

This summary report is intended to show the general order of magnitude of coal reserves in Indiana in various categories, to delimit areas favorable for further exploration, and to provide a reference to the available sources of detailed published information.

Like all appraisals of mineral reserves, this report is based largely on inferred data and on the

experience of the past. It will be noted by examination of table 4 that only 15 percent of the total estimated recoverable reserves in Indiana is actually measured by drilling or mine development, and only 25 percent is indicated. The remaining 60 percent is inferred from geologic evidence and by projecting information from known into unknown areas. It is certain that the present estimate will be modified as additional detailed mapping and exploration is completed. The amounts of measured and indicated reserves should be increased with additional detailed mapping and exploration, and the amount of inferred reserves should be decreased accordingly. It is believed, however, that the total estimate is conservative and is more likely to be increased than decreased with additional exploration, mapping, and development.

The recoverability of coal in mining is perhaps the largest single factor influencing the magnitude of reserves. In this report it has been assumed that only 50 percent of the coal in the ground will be recovered by underground mining methods. This factor is believed to represent the approximate average recovery obtained in large areas using present mining practices. The recoverability on some properties is much higher, however; and it is certain that the average recoverability could be improved by the more widespread adoption of more efficient mining methods. Experiments in new methods of mining and using coal are continually in progress and give hope of additional improvement in recoverability beyond that now known.

COMPARISON OF PAST AND PRESENT ESTIMATES

The coal reserves of Indiana were estimated in 1899 by G. H. Ashley, who subsequently revised the estimate in 1909 to allow for additional mine and exploratory data that had become available. In 1913 M. R. Campbell revised the Ashley figure by extrapolation, assuming a larger tonnage per acre-foot of coal. Table 6 shows a comparison of the present estimate with earlier estimates.

Although much new mine and exploratory data were available on which to base the present estimate, it is smaller than the older estimates, in part because more conservative methods were used to limit the assumed extent of beds below the surface, because beds less than 14 inches thick were omitted, and because reserves were not calculated for Crawford, Fountain, Orange, Putnam, and Warren Counties to which Ashley allotted about 1 billion tons of reserves. Taking these

and other differences into account it is apparent that the estimates are in fairly close accord. In particular, it is interesting to compare Ashley's 1909 estimate of 13.6 billion tons of recoverable reserves in beds 30 inches or more thick with the present estimate of 17.5 billion tons of recoverable reserves in beds 28 inches or more thick.

The present estimate is an improvement over the previous estimates in that the reserves are classified according to thickness, overburden, and the relative abundance of reliable information and are calculated and tabulated by beds for individual counties.

INDIANA COAL FIELDS

General features

The coal fields of Indiana are on the east side of the eastern interior coal basin. This large structural basin underlies a large part of the State of Illinois, a part of northwestern Kentucky, and approximately the southwestern fifth of the State of Indiana. (See fig. 1.)

The Indiana coal fields occupy an area of approximately 6,500 square miles. The coal-bearing area is broad to the south, with a maximum east-west width of approximately 80 miles, and wedges out to the north in the southern part of Benton County. Its total north-south length is approximately 200 miles.

The surface in the northern one-fourth of the coal fields is a glacial till plain, which is relatively undissected. The remainder of the area is a lowland of aggraded valley areas.

The coal-bearing area of Indiana is part of the Ohio River drainage system. Most of the area is drained by the Wabash River and its tributaries, the larger of which are the White and Patoka Rivers.

The coal fields are crossed by numerous roads and railroads. Feeder lines from the railroads give adequate hauling facilities to all the large coal-producing districts. Good, paved, all-weather Federal and State highways cross the coal-producing areas from north to south and east to west. A supporting system of secondary, semi-surfaced, all-weather roads furnish adequate means for hauling coal by truck.

Table 6.—Comparison of estimates of coal reserves in Indiana
(in thousands of short tons)

Source	Basis of estimate			Reserves
	Class	Minimum average thickness	Weight per acre-foot (tons)	
Ashley, 1909-----	Recoverable in part; original in part.	Generally less than 14 inches.	780 to 1,560	¹ 46,864,000
Campbell, 1913-----	Original-----	14 inches-----	1,770	² 53,051,000
Present report, 1953-----	Original-----	14 inches-----	1,800	37,293,079

¹Part of this tonnage is recoverable reserves only.

²Derived by extrapolation from 1909 estimate by Ashley.

Stratigraphy

The coal of commercial value in the Indiana coal fields is in strata of Pennsylvanian age. In places these strata unconformably overlie rocks that are of Devonian age, but generally unconformably overlie rocks of Mississippian age. The coal-bearing strata are overlain in numerous places by unconsolidated deposits of Pleistocene and Recent age. Glacial deposits of Pleistocene age (Wisconsin stage) conceal most of the bedrock in the northern part of the area as far south as northwestern Vigo County and central Parke County. South of this area older Pleistocene deposits locally conceal the bedrock, but in many places they have been removed by erosion. Where present, they are generally thin, except in preglacial valleys.

The Pennsylvanian rocks include a basal sandstone unit overlain by a variable sequence of shale, sandstone, limestone, coal, and clay that has a total thickness of 1,000 to 1,400 feet. Figure 4 summarizes various classifications of Pennsylvanian stratigraphy in the State from 1899 to 1951. This report follows the classification of formations used by Wier, 1949-1951. The Brazil, Staunton, Linton, Petersburg, and Dugger formations have been the source of most coal production. Small amounts of coal have been mined from beds of the lower Shelburn formation, and a few beds in the Mansfield sandstone have contributed meager tonnages. The coal-bearing formations from the Mansfield sandstone upward as far as the Shelburn formation are discussed briefly in the following paragraphs. Other formations of Pennsylvanian age in Indiana are listed in figure 4.

Mansfield sandstone

The Mansfield sandstone, which unconformably overlies strata of Devonian and Mississippian age, ranges in thickness from a few feet to 400 feet. It consists of massive sandstone that locally contains conglomerate, shale, limestone, and coal. The base is characterized generally by a coarse-grained conglomerate. The sandstone is light gray, buff, dark brown, or red. The Mansfield includes three thin and discontinuous coal beds that are named as follows: Coal I (Zone), Upper Cannelton, and Fulda.

Three units in addition to the coal beds in the Mansfield sandstone are named. (See fig. 4.) The Hindostan beds, which are in the lower 50 feet, are a series of thin fine-grained laminated beds. The Fulda and Ferdinand limestone beds, which are separated by an interval of about 15 feet, are thin, key beds that occur near the top of the Mansfield in southern Dubois County and northern Spencer County. The top of the Mansfield sandstone is at the base of the Lower Block coal bed or locally at the base of a thin underclay.

Brazil formation

The Brazil formation, which conformably overlies the Mansfield sandstone, ranges in thickness from 60 to 120 feet. It includes sandstone, shale, limestone, and four named coal beds of minable thickness. In ascending order the formation comprises: the Lower Block coal, averaging 3 feet in thickness; 15 to 30 feet of sandy shale or sandstone; the Upper Block coal, averaging 3 feet in thickness; 20 to 50 feet of sandstone or sandy shale; the Minshall coal, ranging

in thickness from 2 to 4 feet; 2 to 3 feet of shale; the so-called Minshall limestone, ranging in thickness from 2 to 8 feet; 8 to 12 feet of shale or fire clay; and Coal II, ranging from 2 to 3 feet in thickness. The top of the formation is at the unconformity above Coal II.

Staunton formation

The Staunton formation, which unconformably overlies the Brazil formation, is 30 to 90 feet thick. It consists of sandstone, shale, thin sporadic noncommercial coal beds and Coal III. The upper limit of the formation is the unconformity at the top of Coal III.

Linton formation

The Linton formation, which unconformably overlies the Staunton formation, is generally 60 to 75 feet thick. At the type locality, north of the town of Linton in Greene County, the formation in ascending order comprises: sandstone and shale, 10 to 20 feet thick; Coal IIIa, 8 inches thick; black shale, 2 to 5 feet thick; limestone, 1½ feet thick; sandstone and shale, 25 to 30 feet thick; and Coal IV, about 4 feet thick. The unconformity above Coal IV is the upper limit of the formation.

Petersburg formation

The Petersburg formation unconformably overlies the Linton formation and ranges in thickness from 75 to 140 feet. In ascending order it consists of the following units: sandstone and shale, 20 to 40 feet; Coal IVa, 1 to 1½ feet; shale, 1 to 3 feet; dark-gray to black, impure limestone, 1 to 2 feet; sandstone and shale, 40 to 75 feet; Coal V, 3 to 5 feet; black shale, 4 to 6 feet; and the Alum Cave limestone member, 4 to 6 feet. The member is split into two zones, the lower of which usually contains abundant fossils; it is the highest unit in the Petersburg formation.

Dugger formation

The Dugger formation, which overlies the Alum Cave limestone member of the Petersburg formation, is 80 to 150 feet thick. At the type locality, northeast of Dugger in Sullivan County, the formation contains, in ascending order: sandstone and shale, 55 feet thick, locally including two thin coal beds, which are Coals Va and Vb, and a massive partly brecciated limestone; Coal VI, in places absent, a maximum of 6 feet thick; sandstone and shale, 40 to 50 feet thick, locally containing a thin limestone bed called the Universal limestone member; Coal VII, generally 2½ to 4 feet thick; and varying amounts of shale. The top of the formation is the unconformity at the base of the Busseron sandstone member of the Shelburn formation.

Shelburn formation

The Shelburn formation unconformably overlies the Dugger formation and is 180 to 250 feet thick. It consists of sandstone, shale, a few thin limestone beds, and at least two thin sporadic, discontinuous coal beds. The formation includes several named members, of

Missouri series			Des Moines series			Atoka series			Morrow series			Wier, C. E., 1944 - 1951			Cumings, E. R., 1922			Fuller, M. L., 1902 & 1904			Ashley, G. H., 1899			
Conemaugh formation	Missouri series	Bufkin formation	Conemaugh formation	Shelburn formation	Conemaugh formation	Wabash formation	Division IX	Merom sandstone	Merom sandstone	Merom sandstone	Merom sandstone	Merom sandstone	Merom sandstone	Merom sandstone	Merom sandstone	Merom sandstone	Merom sandstone	Merom sandstone	Merom sandstone	Merom sandstone	Merom sandstone	Merom sandstone	Merom sandstone	Merom sandstone
		New Haven formation																						
		St. Wendells sandstone																						
		Parkers formation																						
		Dicksburg Hills sandstone																						
		Hazleton Bridge formation																						
		Merom sandstone																						
		Ditney formation																						
		West Franklin limestone																						
		Hayden Branch shale																						
Murphy's Bluff sandstone																								
Vigo limestone																								
Maria Creek limestone																								
Busseron sandstone																								
Coal VII (Millersburg)																								
Universal limestone																								
Coal VI (Dugger)																								
Coal Vb																								
Coal Va																								
Alum Cave limestone																								
Coal V (Petersburg)																								
Coal IVa (Houchin Creek)																								
Coal IV (Linton)																								
Coal IIIa (Velpen)																								
Coal III (Seelyville)																								
Coal II (Silverwood)																								
Minshall limestone																								
Minshall coal																								
Upper Block coal																								
Lower Block coal																								
Ferdinand limestone																								
Fulda limestone																								
Fulda coal																								
Upper Cannelton coal																								
Coal I (Zone) (Cannelton or Shoals)																								
Hindostan beds																								
Mississippian - Chester																								

Figure 4. —Classification of Pennsylvanian stratigraphy of Indiana, 1899 to 1951.

which the Busseron sandstone is the basal member. The top of the formation is at the contact with the West Franklin limestone. (See fig. 4.)

Structure

The coal-bearing rocks in Indiana lie on the east side of the eastern interior basin and on the western limb of the Cincinnati arch. The beds are monoclinial, striking generally N. 10° - 13° W. and usually dipping gently in a southwesterly direction but locally may dip in any direction. In general, the dips range from 20 to 50 feet to the mile, averaging between 20 to 24 feet. Maximum dips of 100 feet to the mile are occasionally seen, and the minimum dip is 10 feet to the mile. Dips in the western part of the field appear to be greater than those to the east.

Coal beds

At least 25 coal beds in Indiana locally attain a thickness of 2 feet or more. Seven of these beds are fairly persistent and have been mined at a number of places in the State. Three additional beds are less persistent but are minable locally. Coal V is apparently of minable thickness almost everywhere in the area of its occurrence. The three coal beds estimated to contain the largest reserves are, in order: Coal V, Coal III, and Coal IV. Future investigations may establish the correlation of the Millersburg coal with Coal VI or Coal VII; one of them would then be among the three coal beds of Indiana containing the largest estimated reserves. Many of the coal beds are described in the paragraphs below.

Coal I (Zone) Cannelton or Shoals coal

Coal I, which crops out in the eastern part of the coal fields, is the lowest coal that attains a minable thickness in the Mansfield sandstone. It is believed to be the Cannelton coal in Perry County, the Shoals coal in Martin County, and the Kirksville coal in Greene County. Coal I is referred to as the Coal I (Zone) because the coal occurs as lenses, generally in local pockets, and the correlation is uncertain. The range in average thickness of estimated reserves is 1.4 to 4.0 feet. The distribution of the estimated reserves is shown in figure 5, and the reserves in the zone are summarized in tables 7 through 10. The area included in the estimate extends as far north as Martin County. From this area northward as far as Parke County, the coal beds are in places 1.5 to 3 feet thick, locally attaining a maximum thickness of 4 feet. In Fountain, Warren, and Benton Counties the coal is very thin and unworkable.

Original measured and indicated reserves were calculated for these coals of the Mansfield sandstone in Dubois, Martin, Perry, and Spencer Counties. These reserves are herein termed reserves of Coal I (Zone) because of uncertain correlations between beds in different localities. No attempt was made to calculate inferred reserves in these counties. Because of the small size of the mining operations in these counties, the operators are exempt by law from filing worked-out-area coal mining maps with the Indiana State Bureau of Mines and Mining. On the other hand,

the larger but older mines in or near Cannelton and in a few other areas were worked out and abandoned prior to the enactment of State laws requiring filing worked-out-area maps. The amount of coal estimated to be mined out and lost in mining in the Coal I (Zone), therefore, is somewhat incomplete.

The following proximate analysis on an as-received basis of a sample from Coal I (Kirksville) was taken from Logan (1922, p. 624):

	Percent
Fixed carbon-----	32.96
Volatile matter-----	42.74
Moisture-----	17.42
Ash-----	4.30
Sulphur-----	2.76

Btu: 14,599

Lower Block coal

Several coal beds appear in the stratigraphic section between the Zone I coals and Coal II (Silverwood or Upper Minshall). These beds, because of their characteristics or locations, have been identified by names rather than by roman numerals. The lowest of these beds of noteworthy commercial value is the Lower Block coal, which occurs at the base of the Brazil formation.

The Lower Block coal has been recognized along the outcrop from southern Parke County to Greene County but because of a tendency to occur in narrow basins has rarely been recognized more than 4 miles from the outcrop. However, Wier (1950) reports 4.2 feet of Lower Block coal at a depth of 212 feet in sec. 2, T. 8 N., R. 7 W., Greene County, approximately 6 miles from the outcrop. Correlations of both Upper and Lower Block coals with coals of nearby basins are often made on the basis of position in the stratigraphic section, because these coals thin or pinch out between basins and do not always show the distinctive physical characteristics attributed to them. Coals in Dubois, Martin, Perry, and Spencer Counties apparently occupy the same stratigraphic horizon and exhibit enough common characteristics so that they may be correlated with the Lower Block coals of Clay County.

The Lower Block coal has an average thickness of 3 feet but has attained a maximum thickness of 5 feet in the Brazil district. Here, the upper 6 to 10 inches consists of normal banded bituminous coal, not jointed with any degree of regularity; the middle portion, 2 to 3 feet thick, has the pronounced joint crevices that produce the typical blocky appearance of the bed and a few inches to 1 foot of bone or soft coal. The blocky portion of the bed is often separated from the overlying and underlying coal by a thin layer of clay. The fire clay that underlies this bed is inferior in places. The roof rock of the Lower Block coal is usually sandy shale or sandstone. The greater portion of the known minable area of the bed has been mined out although in 1951 a few truck mines were producing coal which was said to be either the Upper or Lower Block coal. Known distribution of reserves of the Lower Block coal in Indiana is shown on figure 6. The estimated reserves in

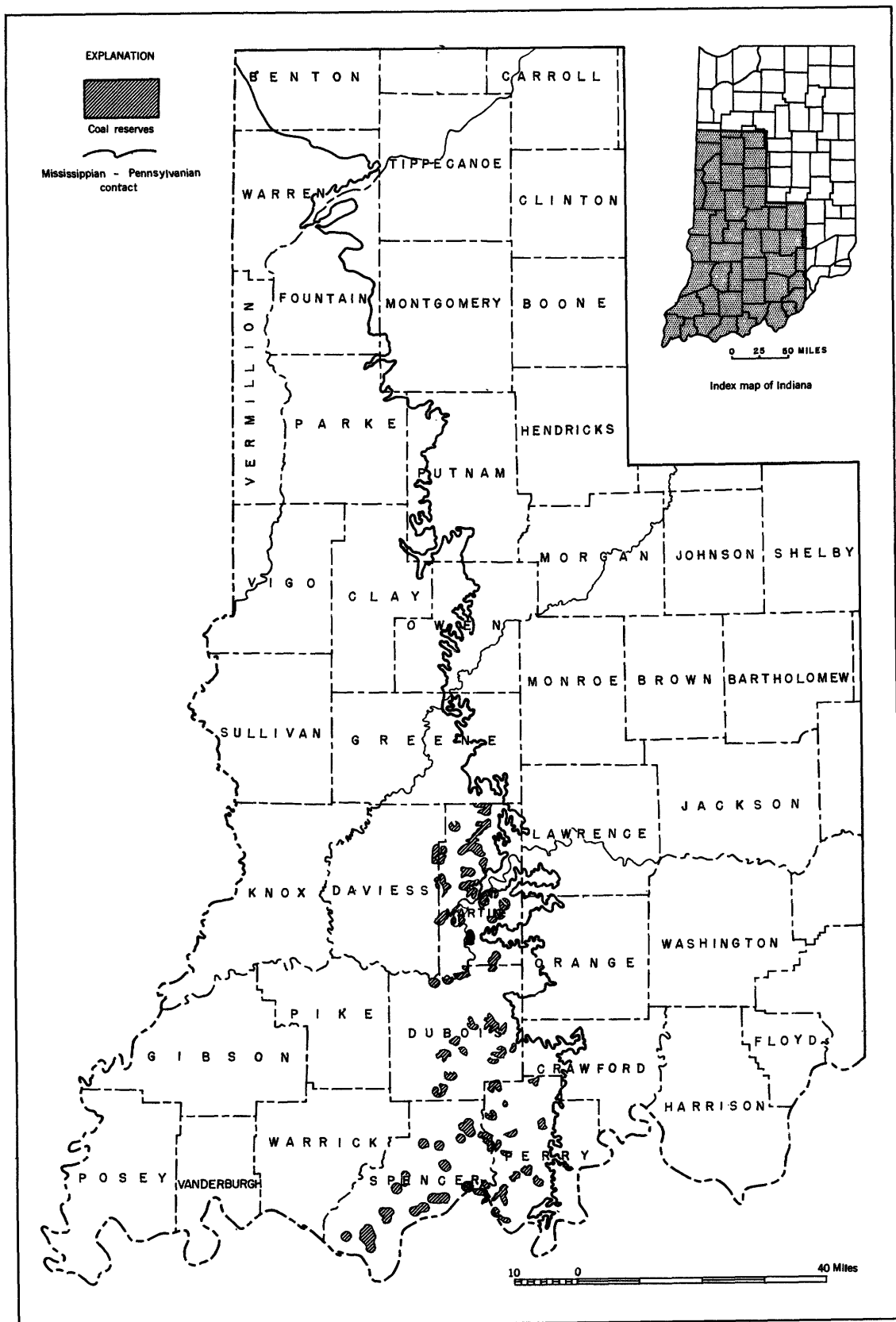


Figure 5. —Map showing reserves of Coal I (Zone) in Indiana.

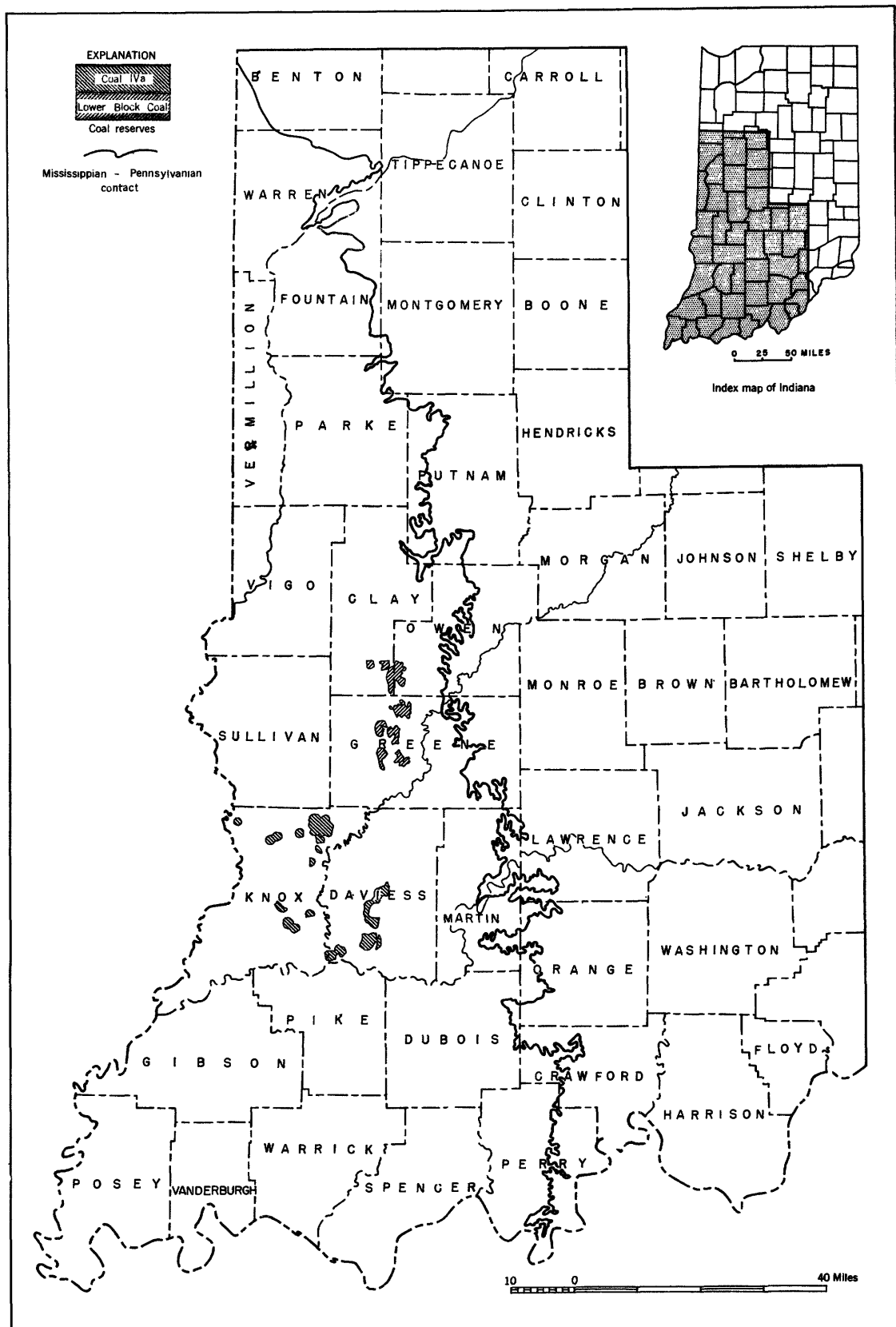


Figure 6. —Map showing reserves of Coal IVa and the Lower Block coal in Indiana.

Table 8. --Summary of original coal reserves in Indiana by beds, according to abundance and reliability of data
(in thousands of short tons)

Bed	Measured reserves			Indicated reserves			Inferred reserves			Total in all reserve categories		
	Coal 14-28 in. thick	Coal 28-42 in. thick	Coal more than 42 in. thick	Coal 14-28 in. thick	Coal 28-42 in. thick	Coal more than 42 in. thick	Coal 14-28 in. thick	Coal 28-42 in. thick	Coal more than 42 in. thick	Coal 14-28 in. thick	Coal 28-42 in. thick	Coal more than 42 in. thick
Stripplable reserves—overburden range less than 40, 60, and 90 feet												
Coal VII-----	8,112	110,864	222,309	222,309	86,268	77,780	173,194	13,645	74,216	22,225	252,736	194,758
Upper Millersburg.	9,623	29,217	52,391	52,391	17,308	1,477	22,955	---	2,472	13,793	48,997	15,028
Lower & Upper Millersburg. ¹	---	946	48,830	48,830	---	11,865	12,001	---	---	---	1,082	59,749
Coal VI-----	11,545	12,669	45,500	45,500	9,220	14,581	25,251	323	2,286	14,202	22,645	36,190
Upper Millersburg.	4,224	6,322	213,338	213,338	14,715	71,479	89,152	12,757	20,699	7,347	28,814	287,624
Underlier of Coal VI.	329	---	329	329	---	---	1,440	---	---	1,769	---	---
Coal V-----	161	115	276	276	574	---	1,013	---	---	600	689	---
Upper Millersburg.	6,876	39,934	867,908	867,908	35,442	262,539	304,877	9,056	244,056	21,947	84,432	1,310,502
Coal IV-----	---	---	---	---	---	---	---	---	---	---	---	---
Coal III-----	8,179	72,674	188,754	188,754	17,615	47,657	137,741	15,850	18,399	26,672	121,992	196,220
Coal II-----	8,489	15,954	252,673	252,673	55,011	73,128	172,620	51,213	51,213	52,970	70,965	352,571
Coal I-----	141	1,080	1,221	1,221	1,684	---	1,684	---	---	141	2,764	2,905
Minshall.	2,375	2,046	5,226	5,226	6,388	7,143	21,575	---	---	8,765	10,090	7,948
Upper Block--	4,868	1,823	24,634	24,634	3,379	64,163	69,034	2,837	9,274	14,664	6,152	82,106
Lower Block--	5,352	3,583	8,935	8,935	7,377	4,364	11,761	8,055	24,182	21,819	16,022	44,878
Coal I (zone).	860	9,506	13,760	13,760	10,537	1,185	13,219	23,430	35,893	12,471	43,473	62,872
Coal I (zone).	338	1,031	1,369	1,369	4,579	10,416	26,075	---	---	4,917	12,111	10,416
Total-----	71,472	308,134	1,951,281	1,951,281	111,815	672,664	1,090,169	41,033	482,720	224,320	725,472	2,574,378
Nonstripplable reserves—overburden range more than 40, 60, and 90 feet												
Coal VII-----	29,614	142,508	322,589	322,589	62,025	303,674	796,650	542,300	2,184,969	202,926	2,104,841	996,441
Upper Millersburg.	7,022	26,455	41,275	41,275	23,734	21,251	103,748	649,880	1,285,384	250,801	500,677	678,929
Lower & Upper Millersburg.	---	140	59,072	59,072	---	14,631	16,026	---	---	---	1,535	73,563
Coal VI-----	5,475	19,096	69,216	69,216	8,048	231,678	298,457	1,297,138	1,529,343	24,258	299,297	1,573,461
Upper Millersburg.	13,987	45,754	587,649	587,649	45,475	683,978	876,817	1,496,153	2,034,703	163,257	627,873	2,708,039
Underlier of Coal VI.	34,758	4,891	40,390	40,390	76,489	4,925	83,899	---	---	111,247	9,816	3,226
Coal V-----	52,613	22,461	79,648	79,648	88,667	52,761	148,378	---	---	158,739	75,222	11,524
Coal IV-----	9,023	51,638	1,912,906	1,912,906	33,021	204,417	2,322,511	7,712,112	8,632,651	68,266	1,150,372	11,947,329
Coal III-----	15,819	1,799	20,666	20,666	47,202	11,868	18,325	---	---	63,021	13,667	21,373
Coal II-----	45,566	58,202	495,698	495,698	137,279	259,483	748,707	917,476	2,484,703	692,432	1,375,325	1,765,119
Coal I-----	12,194	25,410	518,880	518,880	78,676	171,942	1,406,013	3,220,672	3,628,805	176,560	519,795	4,857,343
Coal I (zone).	297	1,363	1,660	1,660	1,472	78	1,550	---	---	1,769	1,441	3,210
Minshall.	5,214	13,753	22,936	22,936	15,343	57,470	91,207	---	---	20,557	71,223	22,363
Upper Block--	7,674	285	21,846	21,846	15,196	26,252	41,601	---	---	22,870	438	40,139
Lower Block--	4,862	121	4,963	4,963	2,019	8,912	32,574	---	---	27,881	9,033	640
Coal I (zone).	---	---	---	---	6,477	5,594	12,071	---	---	6,477	5,594	---
Coal I (zone).	19,885	16,073	39,750	39,750	105,286	124,695	272,460	---	---	125,171	140,768	46,271
Total-----	264,003	429,949	4,403,593	4,403,593	767,369	1,599,542	7,567,299	15,875,731	21,798,017	2,116,232	6,906,917	24,745,760
State total	335,475	738,083	6,354,874	6,354,874	879,184	1,905,232	8,657,468	16,165,770	22,280,731	2,340,552	7,632,399	27,320,138
												37,293,079

¹ Estimated as one bed, only in part of Warrick County.

Table 9.—Summary of strippable and nonstrippable coal reserves in Indiana by beds
(in thousands of short tons)

Bed	Original reserves			Mined and lost in mining to January 1, 1951			Remaining reserves as of January 1, 1951			Recoverable reserves ¹ as of January 1, 1951		
	Coal 14-28 in. thick	Coal 28-42 in. thick	Coal more than 42 in. thick	Coal 14-28 in. thick	Coal 28-42 in. thick	Coal more than 42 in. thick	Coal 14-28 in. thick	Coal 28-42 in. thick	Coal more than 42 in. thick	Coal 14-28 in. thick	Coal 28-42 in. thick	Coal more than 42 in. thick
Strippable reserves—overburden range less than 40, 60, and 90 feet												
Coal VII-----	22,225	252,736	194,758	---	10,766	15,618	26,384	241,970	179,140	443,335	17,779	143,313
Upper Millersburg.	13,793	48,997	15,028	---	149	1,220	1,369	48,848	13,808	76,449	11,034	11,047
Lower Millersburg.	---	1,082	59,749	---	---	15,559	15,559	1,082	44,190	45,272	---	35,353
Coal VI-----	14,202	22,645	36,190	3,494	489	81	4,064	22,156	36,109	68,973	8,565	28,888
Upper Block--	7,347	28,814	287,624	107	---	79,578	79,685	28,814	208,046	244,100	5,792	166,436
Underlayer of	1,769	---	---	---	---	---	---	---	---	1,769	1,415	---
Coal V-----	600	689	---	---	---	---	---	689	---	1,289	480	---
Coal Vb-----	21,947	84,432	1,416,881	71	7,819	294,374	302,264	76,613	1,016,128	1,114,617	17,500	812,902
Coal IV-----	---	2,508	7,301	---	---	---	---	2,508	7,301	9,809	---	5,841
Coal IVa-----	26,672	121,992	196,220	94	9,410	59,289	68,793	112,582	136,931	276,091	21,262	109,544
Coal III-----	52,970	70,965	352,571	796	1,833	97,446	100,075	69,132	255,125	376,431	41,740	204,099
Coal IIIa-----	141	2,764	2,905	---	---	---	---	2,764	---	2,905	113	---
Coal II-----	8,763	10,090	7,948	---	---	---	---	10,090	7,948	26,801	8,072	6,359
Minshall-----	14,684	6,152	82,106	160	878	3,129	4,167	5,274	78,977	98,775	11,618	63,181
Upper Block--	21,819	16,022	44,878	597	894	---	1,491	21,222	15,128	43,367	16,974	5,630
Lower Block--	12,471	6,473	6,928	---	666	606	1,272	42,807	6,322	61,600	9,977	5,058
Coal I (zone).	4,917	12,111	10,416	---	---	---	---	12,111	10,416	27,444	3,933	8,333
Total-----	224,320	725,472	3,524,170	5,319	32,904	566,900	605,123	692,568	2,007,478	2,919,047	175,192	1,605,984
Nonstrippable reserves—overburden range more than 40, 60, and 90 feet												
Coal VII-----	202,926	2,104,841	996,441	---	---	534	534	2,104,841	995,907	3,303,674	101,463	497,953
Upper Millersburg.	250,801	500,677	678,929	---	---	---	---	500,677	678,929	1,430,407	125,400	339,464
Lower & Upper Millersburg.	---	1,535	73,563	---	---	8,976	8,976	1,535	64,587	66,122	---	32,293
Coal VI-----	24,258	299,297	1,573,461	---	---	---	---	299,297	1,573,461	1,897,016	12,129	786,730
Upper Block--	163,257	627,873	2,708,039	---	361	60,068	60,429	627,512	2,647,971	3,438,740	81,630	1,323,986
Underlayer of	111,247	9,816	3,226	---	---	---	---	9,816	3,226	124,289	55,623	1,613
Coal V-----	158,739	75,222	11,524	---	---	---	---	75,222	11,524	245,485	79,369	5,762
Coal Vb-----	68,266	1,150,372	13,165,967	466	2,885	515,299	518,650	1,147,487	11,432,030	12,647,317	33,903	5,716,015
Coal IV-----	63,021	13,667	21,373	---	---	---	---	13,667	21,373	98,061	31,510	6,353
Coal IVa-----	692,432	1,375,325	3,832,876	---	2,511	220,575	223,086	1,372,814	1,544,544	3,609,730	346,212	772,275
Coal III-----	176,560	519,795	4,857,343	297	403	66,069	66,769	519,392	4,791,274	5,486,929	88,129	2,395,638
Coal IIIa-----	1,769	1,441	3,210	---	---	---	---	1,441	---	3,210	720	1,605
Coal II-----	20,557	71,223	22,363	---	---	---	---	71,223	22,363	114,143	10,278	35,613
Minshall-----	22,870	438	40,139	---	---	3,736	3,736	438	36,403	59,711	11,435	18,201
Upper Block--	27,881	9,033	640	---	---	---	---	27,881	9,033	37,554	13,941	28,856
Lower Block--	6,477	5,594	12,071	---	---	---	---	6,477	5,594	12,071	3,238	2,797
Coal I (zone).	125,171	140,768	46,271	---	---	---	---	140,768	46,271	312,210	62,588	70,384
Total-----	2,116,232	6,906,917	24,745,760	763	6,160	875,257	882,180	6,900,757	22,870,503	32,886,729	1,057,733	3,450,378
State total--	12,340,552	7,632,389	27,320,138	6,082	39,064	1,442,157	1,487,303	7,593,325	25,877,981	35,805,776	1,232,925	13,541,235

¹ Assuming 80 percent recoverability for strippable coal and 50 percent recoverability for nonstrippable coal.

² Estimated as one bed, only in part of Warrick County.

Table 10.—Summary of recoverable coal reserves in Indiana by beds, according to abundance and reliability of data.¹
(In thousands of short tons)

Bed	Measured reserves				Indicated reserves				Inferred reserves				Total in all reserve categories			
	Coal 14-28 in. thick	Coal 28-42 in. thick	Coal more than 42 in. thick	Total	Coal 14-28 in. thick	Coal 28-42 in. thick	Coal more than 42 in. thick	Total	Coal 14-28 in. thick	Coal 28-42 in. thick	Coal more than 42 in. thick	Total	Coal 14-28 in. thick	Coal 28-42 in. thick	Coal more than 42 in. thick	Total
Stripplable reserves—overburden range less than 40, 60, and 90 feet																
Coal VII—Upper Millersburg.	6,490	80,077	70,173	156,740	7,216	69,015	62,224	138,555	3,973	44,483	10,916	59,372	17,779	193,575	143,313	354,667
Coal VII—Lower & Upper Millersburg. ²	7,698	23,254	9,865	40,817	3,336	13,846	1,182	18,364	---	1,978	---	1,978	11,034	39,078	11,047	61,159
Coal VI—Upper Millersburg.	---	756	25,861	26,617	---	109	9,492	9,601	---	---	---	---	---	865	35,353	36,218
Coal VI—Lower Millersburg.	6,440	9,745	16,964	33,149	1,159	7,375	11,666	20,200	966	605	258	1,829	8,565	17,725	28,888	55,178
Coal VI—Underrider of Coal VI.	3,293	5,058	99,048	107,399	2,367	11,771	57,184	71,322	132	6,222	10,204	16,558	5,792	23,051	166,436	195,279
Coal V—Coal Vb.	---	---	---	263	1,152	---	---	1,152	---	---	---	---	1,415	---	---	1,415
Coal V—Coal Va.	129	92	---	221	351	459	---	810	---	---	---	---	480	551	---	1,031
Coal IV—Coal IVa.	5,443	25,632	421,380	452,515	5,517	28,355	210,030	243,902	6,540	7,245	181,492	195,277	17,500	61,292	812,902	891,694
Coal IV—Coal IVb.	2,200	2,200	---	4,400	---	---	---	---	---	---	---	---	---	---	---	---
Coal III—Coal IIIa.	6,467	50,612	38,889	95,968	14,093	38,125	5,975	58,193	702	1,329	12,680	14,711	21,262	90,066	109,544	220,872
Coal III—Coal IIIb.	6,155	11,237	104,626	122,078	35,585	58,503	58,503	138,996	---	---	40,970	40,970	41,740	55,305	204,099	301,144
Coal II—Coal IIa.	113	864	---	977	---	1,247	---	1,247	---	---	---	---	113	---	---	2,324
Coal II—Coal IIb.	1,900	1,637	644	4,181	5,110	6,435	5,715	17,260	---	---	---	---	7,010	8,072	6,359	21,441
Coal I—Minshall.	3,766	756	11,851	16,373	2,703	1,194	51,330	55,227	5,149	2,270	---	7,419	11,618	4,220	63,181	79,019
Coal I—Upper Block.	3,803	2,152	---	5,955	5,900	3,508	---	9,408	7,271	6,445	5,630	19,346	16,974	12,105	5,630	34,709
Coal I—Lower Block.	688	7,071	2,231	9,990	1,198	8,429	948	10,575	8,091	18,744	1,879	28,714	9,977	34,244	5,058	49,279
Coal I (zone)	270	825	---	1,095	3,663	8,864	8,333	20,860	---	---	---	---	3,933	9,689	8,333	21,955
Total	52,918	220,184	803,822	1,076,924	89,450	244,550	538,133	872,133	32,824	89,321	264,029	386,174	175,192	554,055	1,605,984	2,335,231
Nonstripplable reserves—overburden range more than 40, 60, and 90 feet																
Coal VII—Upper Millersburg.	14,807	71,254	74,967	161,028	31,013	215,475	151,856	398,324	55,643	765,692	271,150	1,092,485	101,463	1,052,421	497,953	1,651,837
Coal VII—Lower & Upper Millersburg. ²	3,512	13,227	3,898	20,637	11,866	29,381	10,627	51,874	110,022	207,731	324,939	642,692	125,400	250,339	339,464	715,203
Coal VI—Upper Millersburg.	---	70	24,978	25,048	---	698	7,315	8,013	---	---	---	---	---	768	32,293	33,061
Coal VI—Lower Millersburg.	2,738	9,548	22,322	34,608	4,024	29,366	115,859	149,229	5,367	110,735	648,569	764,671	12,129	149,649	786,730	948,508
Coal VI—Underrider of Coal VI.	6,993	22,696	233,922	263,611	22,718	73,702	341,988	438,408	51,919	217,357	748,076	1,017,352	81,630	313,755	1,323,986	1,719,371
Coal V—Coal Va.	17,379	2,445	371	20,195	38,244	2,463	1,242	41,949	---	---	---	---	55,623	4,908	1,613	62,144
Coal V—Coal Vb.	26,307	11,230	2,287	39,824	44,333	26,381	3,475	74,189	8,729	---	---	8,729	79,369	37,611	5,762	122,742
Coal IV—Coal IVa.	4,279	24,377	698,802	727,458	16,512	102,206	1,161,157	1,279,875	13,112	447,157	3,856,056	4,316,325	33,903	573,740	5,716,015	6,323,658
Coal IV—Coal IVb.	7,909	900	1,524	10,333	23,601	5,933	9,163	38,697	254,793	528,818	458,740	1,242,351	31,510	6,833	10,687	49,030
Coal III—Coal IIIa.	22,785	27,845	137,560	188,188	68,636	129,744	175,975	374,355	42,844	161,223	1,610,334	1,814,401	346,212	686,407	772,275	1,804,894
Coal III—Coal IIIb.	5,949	12,504	207,604	226,057	39,336	85,970	577,700	703,006	42,844	161,223	1,610,334	1,814,401	88,129	259,697	2,395,638	2,743,464
Coal II—Coal IIa.	149	681	---	830	736	39	---	775	---	---	---	---	885	720	---	1,605
Coal II—Coal IIb.	2,607	6,878	1,984	11,469	7,671	28,735	9,197	45,603	---	---	---	---	10,278	35,613	11,181	57,072
Coal I—Minshall.	3,837	143	5,075	9,055	7,598	4,456	13,126	20,801	---	---	---	---	11,435	220	18,201	29,856
Coal I—Upper Block.	2,431	60	---	2,491	11,510	4,556	320	16,286	---	---	---	---	13,941	4,516	18,777	34,234
Coal I—Lower Block.	---	---	---	---	3,238	2,797	---	6,035	---	---	---	---	3,238	2,797	---	6,035
Coal I (zone)	9,944	8,036	1,894	19,874	52,644	62,348	21,239	136,231	---	---	---	---	62,588	70,384	23,133	156,105
Total	131,624	211,894	1,417,188	1,760,706	383,680	799,771	2,600,199	3,783,650	542,429	2,438,713	7,917,864	10,899,006	1,057,733	3,450,378	11,935,251	16,443,362
State total—	184,542	432,078	2,221,010	2,837,630	473,130	1,044,321	3,138,332	4,655,783	575,253	2,528,034	8,181,893	11,285,180	1,232,925	4,004,433	13,541,235	18,778,593

¹Assuming 80 percent recoverability for stripplable coal and 50 percent for nonstripplable coal.

²Estimated as one bed, only in part of Warrick County.

the Lower Block bed are summarized in tables 7 through 10.

The composition on an as-received basis of several samples of Lower Block coal is shown in the proximate analyses tabulated at the bottom of the page (Logan, 1922, p. 624). The samples are: No. 1 from Cardonia near Cart No. 5, Brazil Block Coal Co.; No. 2, Brazil, Mine No. 1, Brazil Block Coal Co.; No. 3, Carbon, near Eureka, Brazil Block Coal Co., No. 1; No. 4, Asherville, near Crawford, Block Coal Co., No. 3; Nos. 5, 6, 7 southwest of Perth. Analyst of first four is W. A. Noyes; of the last three, F. M. Stanton.

Upper Block coal

The Upper Block coal, in the lower part of the Brazil formation, contains estimated reserves in Clay, Daviess, Greene, and Owen Counties. Coal beds probably of equivalent age are found in Parke, Dubois, Martin, and Spencer Counties.

The Upper Block coal shows commercial thickness in comparatively small basins, ranging in area from a few acres to several square miles. Thin, unminable coal connects these basins. The average thickness of the bed in the areas where the reserves were estimated ranges from 1.3 to 3.6 feet. A 2-inch layer of brittle coal is usually present near the middle of the bed. Immediately underlying this coal is a very fine fire clay, which is usually mined with the coal and is considered a good marker for correlation purposes. The stratigraphic interval between the Lower and Upper Block beds ranges in thickness between 15 and 30 feet. Much of the Upper Block coal has been strip mined, doubtless because of its valuable, underlying clay bed. The distribution of the estimated reserves in the Upper Block bed is shown in figure 7. Tables 7 through 10 give a summary of the estimated reserves in the bed.

The proximate analysis on the as-received basis of a sample of Upper Block coal from Woodside, Owen County, is shown by Logan (1922, p. 625) as follows:

	Percent
Fixed carbon-----	47.40
Volatile matter-----	36.45
Moisture-----	12.73
Ash-----	3.42
Sulphur-----	.55

Calories: 6,636

Minshall coal

The Minshall coal is 20 to 30 feet above the Upper Block bed. It has an average thickness of about 4 feet and locally attains a maximum of about 6 feet.

This coal usually has fire clay underlying it and shale overlying it. Overlying the shale, and occasionally overlying the coal, is a dark-gray, fossiliferous, thin-bedded limestone unit locally called the Minshall limestone. A coal believed to be the Minshall is mined near the surface at Switz City in Greene County. Similarly, in southeastern Daviess County on Sugar Creek, a coal bed 2 to 3 feet thick is overlain by a limestone, which has been correlated as the Minshall limestone (Kugler, 1951, p. 17). Numerous drill holes in this area show a coal bed having an average thickness of 2.0 feet in the approximate stratigraphic position of the Minshall coal. South from Jasper in Dubois County, a coal with a limestone roof has been called the Holland coal at Buffaloville, Newtonville, and Lincoln City. This coal is also believed to be stratigraphically equivalent to the Minshall coal; however, it is too thin in most places to be worked. The distribution of the Minshall coal in Indiana is shown on figure 8. A summary of estimated reserves in the Minshall bed is shown in tables 7 through 10.

The proximate analysis on an as-received basis of a sample of the Minshall coal is reported (Logan, 1922, p. 625) from the Gifford No. 1 mine, Williamstown, as follows:

	Percent
Fixed carbon-----	39.48
Volatile matter-----	37.67
Moisture-----	13.12
Ash-----	9.75
Sulphur-----	2.95

Calories: 6,107

Coal II (Silverwood or Upper Minshall coal)

Coal II generally occurs 10 to 20 feet above the Minshall coal. Locally, however, the limestone overlying the Minshall coal may be absent, thus allowing the fire clay under Coal II to rest directly upon the Minshall coal. The bed was being mined on a small scale in 1951. Near Burns City in Martin County is a bed that is believed to be correlative with Coal II. Similarly, in southeastern Daviess County on Sugar Creek is a bed lying 20 to 25 feet above the Minshall coal. This bed has an average thickness of 2.4 feet and locally is of considerable extent. Because of its stratigraphic position, this coal is also assumed to be equivalent to Coal II. The distribution of estimated reserves of Coal II is shown on figure 9, and the estimated reserves are summarized in tables 7 through 10.

Analyses of Lower Block coal, as-received basis
(percent)

	No. 1	No. 2	No. 3	No. 4	No. 5	No. 6	No. 7
Fixed carbon-----	49.16	49.96	50.42	48.23	46.08	46.05	38.87
Volatile matter-----	37.11	35.16	36.32	36.34	32.56	33.19	26.85
Moisture-----	11.20	13.82	9.80	11.26	15.39	15.91	16.91
Ash-----	3.53	1.06	3.46	4.16	5.88	4.85	7.37
Sulphur-----	.62	1.47	.34	.56	1.95	1.22	1.80
Calories-----	6,774	6,888	7,050	6,858	6,489	---	5,291
Btu-----	---	---	---	---	11,680	---	5,244

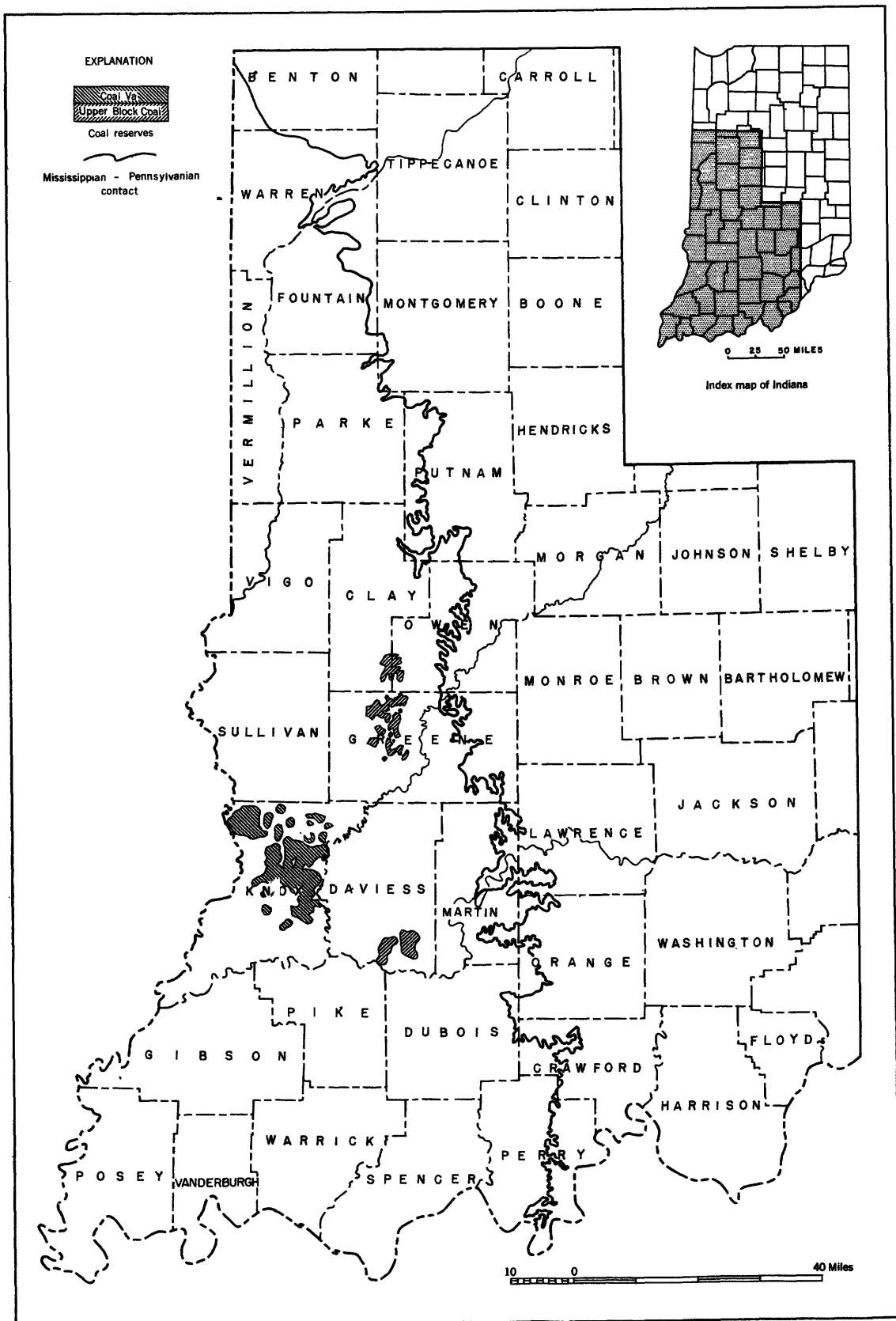


Figure 7. —Map showing reserves of Coal Vb and the Upper Block coal in Indiana.

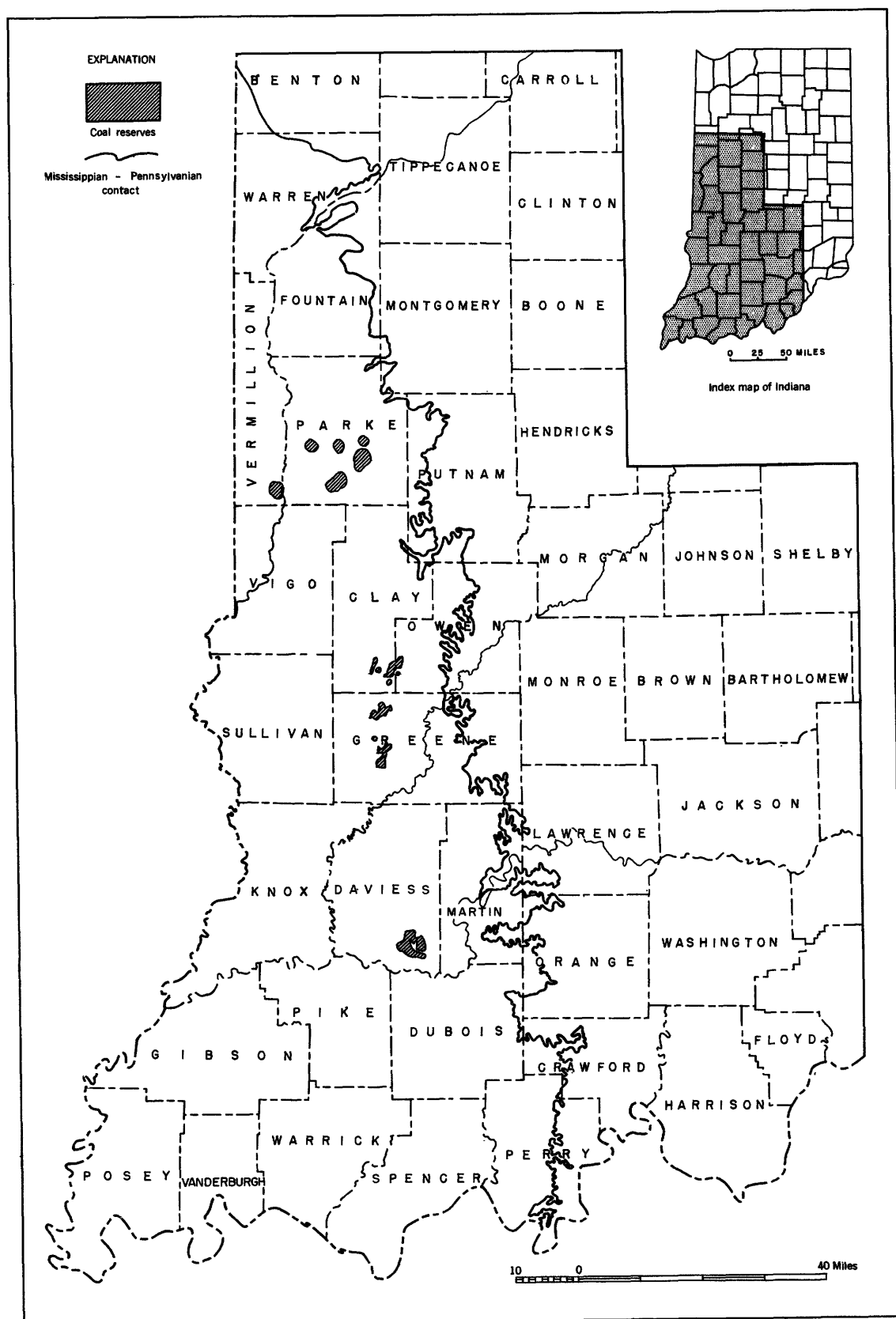


Figure 8.—Map showing reserves of the Minshall coal in Indiana.

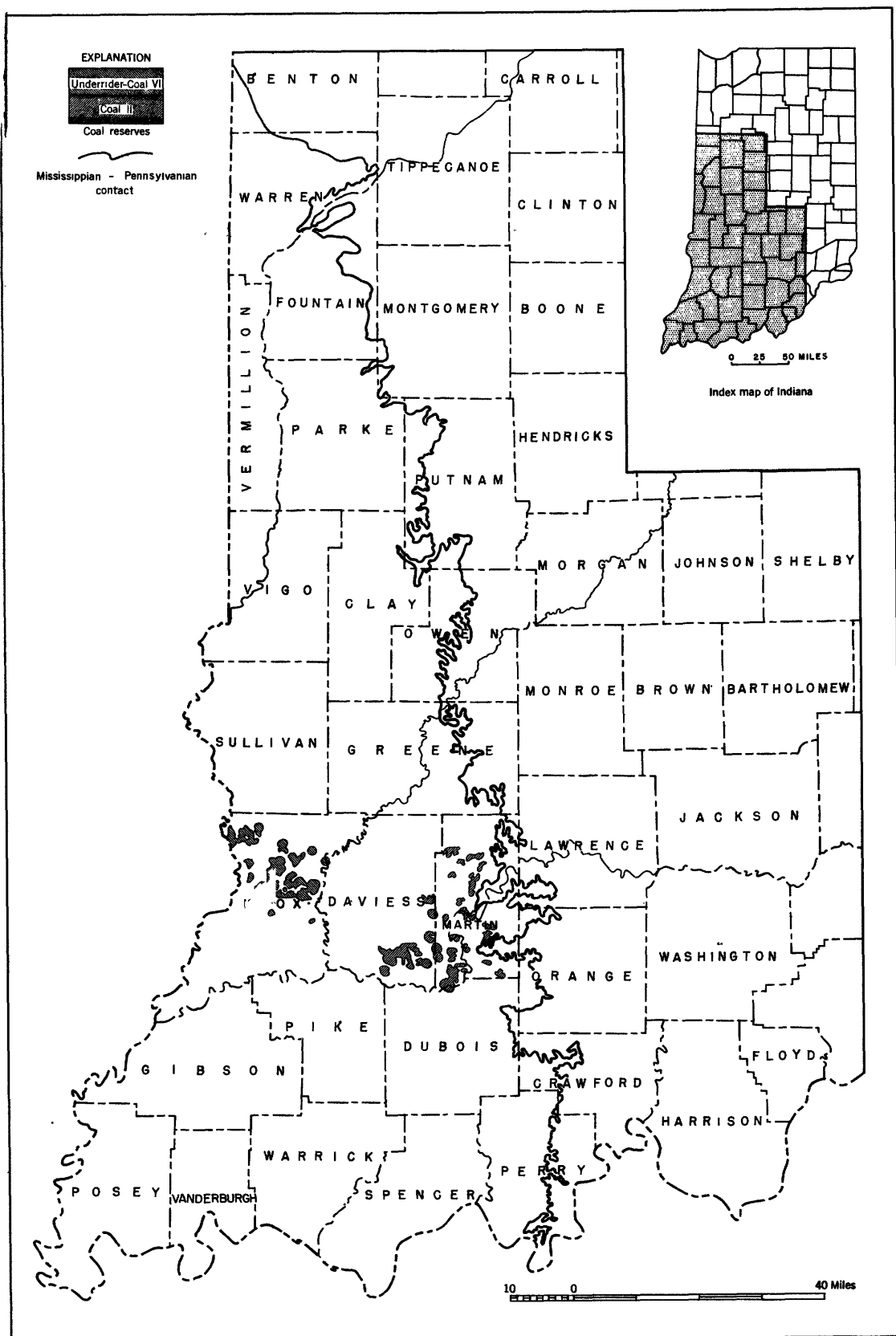


Figure 9. —Map showing reserves of Coal II and the underrider of Coal VI in Indiana.

Coal IIa

Coal IIa, which lies above Coal II, is a local bed that is of minable thickness in Daviess County. The range in average thickness in the area of estimated reserves is 1.5 to 2.7 feet. The reserves are summarized in tables 7 through 10.

Coal III (Seelyville or Staunton coal)

Coal III contains next to the largest estimated coal reserves in Indiana. It has been mined extensively at Coxville in Parke County and at Clinton in Vermillion County. This bed, which is the top unit of the Staunton formation, is 30 to 90 feet above Coal II and 15 to 30 feet below Coal IIIa.

Coal III is typically developed in northeastern Vigo County. It can be traced north into Vermillion County, and borings show it to be continuous into the Danville, Ill., area. In Vermillion County, where it has been called the Hanging Rock coal, the average thickness of the estimated reserves is 6 feet.

Southward from Clay County, Coal III may be traced into Greene County, where it thins rapidly on the outcrop. Identification of this coal is therefore uncertain at numerous localities in southern Indiana. However, a coal assumed to be Coal III was being mined in 1951 south of Cannelburg in Daviess County. Here, the coal has a sandstone roof and ranges from 1.5 to 4.2 feet in thickness. Locally this bed contains cannel coal (Ashley, 1899, p. 659). In several places in Dubois County, a coal bed ranging between 2 to 4 feet in thickness and assumed to be Coal III, has been opened. In Spencer County a coal bed ranging in thickness between 1.5 to 4 feet appears at apparently the same horizon as Coal III. Drillings in southern Gibson, eastern Vanderburgh, and western Warrick Counties show the presence of a coal bed, called Coal III, having an average thickness of 5.5 to 6 feet. The distribution of Coal III in Indiana is shown on figure 10. The estimated reserves of Coal III are summarized in tables 7 through 10.

Clay and pyrite partings are common in Coal III and range from 5 or 6 inches to more than 2 feet in thickness. Several $\frac{1}{4}$ - to 1-inch bands of pyrite or shale are usually present.

Sandstone rolls impregnated with pyrite frequently occur in this bed. Coal III usually has a red ash due to the presence of the pyrite in the coal. At the Dyna mine in eastern Vanderburgh and western Warrick Counties, large amounts of salt water, encountered when the coal was opened, were so detrimental to the operation that the mine was abandoned.

The composition of Coal III on an as-received basis is given in the proximate analyses nos. 1 through 6 tabulated at the bottom of the page (Logan, 1922, p. 626). Analyses 7 and 8 are of samples of cannel coal from this bed (Ashley, 1918, p. 20). The samples are as follows: No. 1, Coxville, Cox No. 3, Brazil Block Coal Co.; Nos. 2 and 3, Rosedale, Parke County Coal Co.; Nos. 4, 5, and 6, Hymera No. 4, Consolidated Indiana Coal Co. (see 33d Ann. Rept. Ind. Geol. Surv.); Nos. 7 and 8, cannel coal from Coal III, Daviess County, Indiana (Ashley, 1918, p. 20).

Coal IIIa (Velpen coal)

Coal IIIa, which is 15 to 30 feet above Coal III, is too thin for mining in many areas. No reserves have been estimated for this bed although it is exposed in several places in Spencer, Pike, Daviess, Clay, Parke, and Vermillion Counties. It is usually overlain by shale or sandstone. Locally, where the sandstone between Coal IIIa and the next coal bed above is comparatively thick and massive, it resembles the Mansfield sandstone, and this fact has, doubtless, caused erroneous correlations in the past.

Coal IV (Linton or Survant coal)

Coal IV is estimated to contain the third largest reserves in Indiana. Because of its exceptionally desirable qualities, it has been extensively worked and prospected near Linton, Green County. The average thickness near Linton is more than 4 feet, the maximum thickness is 7 feet. Although it is too thin to be mined in some places, it is of workable thickness in Daviess, Greene, Knox, Parke, Pike, Vermillion, Vigo, and Warrick Counties. A bed 8 feet thick believed by Ashley (1899, p. 1301) to be at the stratigraphic position of Coal IV formerly was worked at the Coal Knobs, north of Rockport, Spencer County. Coal IV has been mined in Knox County north of

Analyses of Coal III, as-received basis
(percent)

	No. 1	No. 2	No. 3	No. 4	No. 5	No. 6	No. 7	No. 8
Fixed carbon-----	46.45	39.35	40.80	41.35	41.85	40.49	26.30	42.00
Volatile matter-----	41.88	39.49	38.62	38.62	37.76	36.09	49.00	48.50
Moisture-----	6.49	11.54	12.26	10.45	9.22	10.45	---	---
Ash-----	5.18	9.62	8.32	9.58	11.17	12.62	23.10	6.00
Sulphur-----	2.93	4.41	4.71	4.04	3.94	4.39	1.40	1.00
Calories-----	6,897	6,475	---	6,525	---	6,214	---	---
Btu-----	---	11,655	---	11,745	---	11,185	---	---

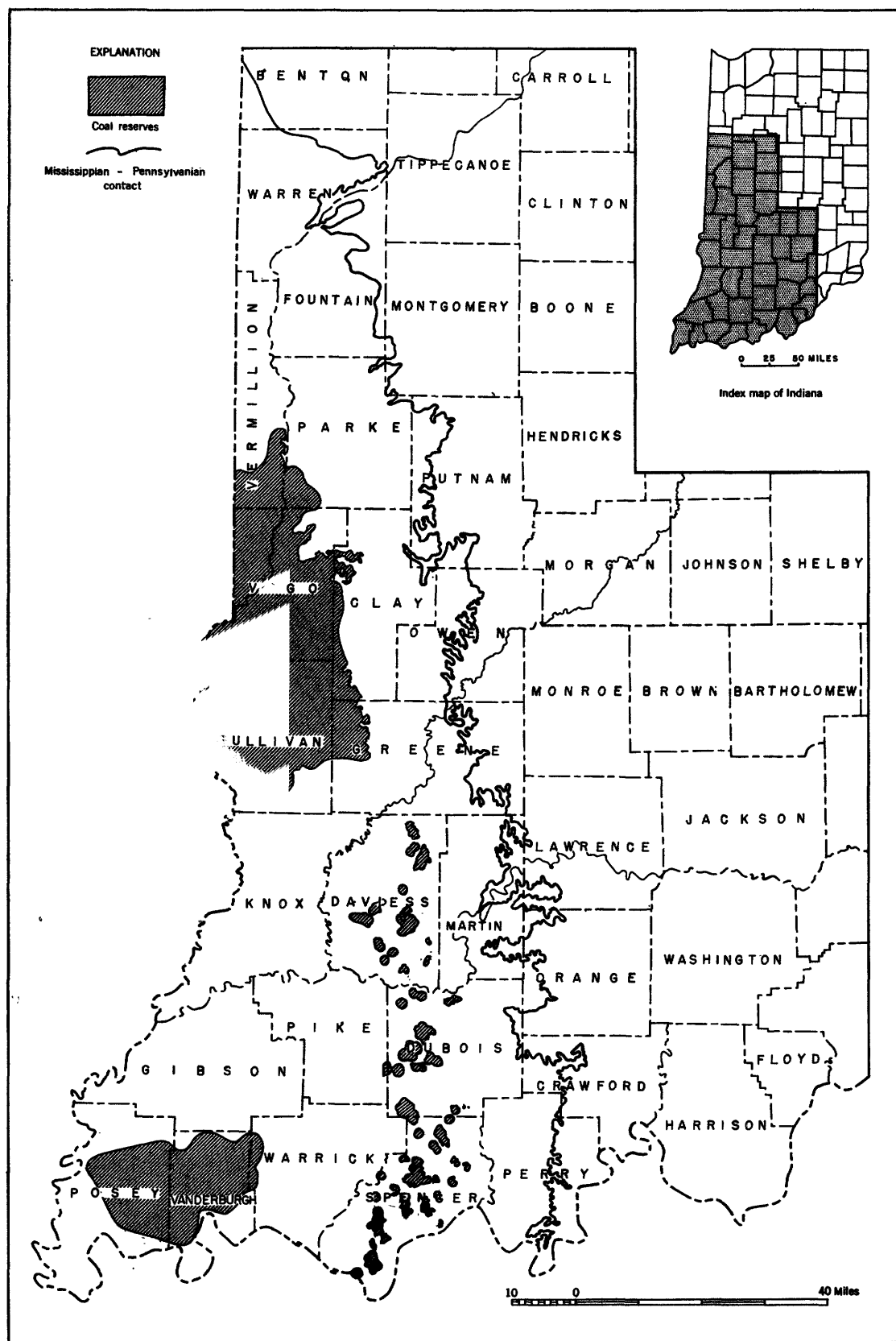


Figure 10. —Map showing reserves of Coal III in Indiana.

Edwardsport. It is presently being worked in Sullivan, Greene, Daviess, and Pike Counties. The distribution of Coal IV in Indiana is shown on figure 11 and the estimated reserves are summarized in tables 7 through 10.

Northward from Linton, Coal IV maintains its normal thickness in places but generally is thinner. Southwest of Linton, a medial parting becomes prominent, attaining a thickness of 10 to 20 feet and separating the upper 2 to 3 feet of coal from the lower 1 to 2 feet. Southward, Coal IV maintains its normal thickness in eastern Knox County but thins to the west. Coal IV is about 3 feet thick in Daviess and Pike Counties but thins in Warrick County and either

disappears or is unworkable in Vanderburgh County. The Survant coal of Fuller and Ashley (1902a, b) in Pike County is Coal IV.

The roof of Coal IV, the top unit of the Linton formation, is usually gray shale but occasionally is sandstone, and the floor is usually sandstone or clay. The stratigraphic interval between Coal IV and Coal III is normally 60 to 65 feet but occasionally thins to as little as 20 feet.

The composition of Coal IV on an as-received basis is given by Logan (1922, p. 626) in the following proximate analyses of samples from six localities:

Analyses of Coal IV, as-received basis
(percent)

	No. 1	No. 2	No. 3	No. 4	No. 5	No. 6
Fixed carbon-----	45.38	46.35	46.20	44.45	47.01	46.23
Volatile matter-----	35.54	32.57	32.07	35.94	33.04	33.48
Moisture-----	13.53	13.98	13.58	13.70	14.23	12.15
Ash-----	7.55	7.10	8.15	5.90	5.72	8.14
Sulphur-----	.95	.96	.91	2.66	.89	1.41
Calories-----	6,521	---	6,344	6,628	6,512	6,534
Btu-----	11,738	---	11,419	11,930	11,722	11,761

The samples are as follows: Nos. 1, 2, and 3 from northwest of Linton, Greene County; No. 4, Diamond, northwest of Mine No. 9, Brazil Block Coal Co., Parke County; Nos. 5 and 6, Dugger No. 4 mine, Island Coal Co., Sullivan County.

to Vermillion County. In 1951 Coal V was being mined in Gibson, Daviess, Knox, Greene, Pike, Sullivan, Vigo, Vermillion, and Warrick Counties. The distribution of Coal V in Indiana is shown on figure 12, and a summary of the estimated reserves is given in tables 7 through 10.

Coal IVa (Houchin Creek coal)

Coal IVa in the Petersburg formation occurs typically about 20 feet above Coal IV. A coal bed appearing to be IVa has been called Houchin Creek coal (Fuller and Ashley, 1902a, b) in southern Pike and northern Warrick Counties. The coal bed is thin, ranging generally from 12 to 18 inches in thickness; however, it is mined locally in small areas. The coal bed is overlain at Houchin Creek by black shale and limestone. The distribution of the estimated reserves in this bed is shown in figure 6, and the estimated reserves are summarized in tables 7 through 10.

Coal V (Petersburg coal bed or Alum Cave coal)

Coal V in the Petersburg formation contains the largest estimated reserves in Indiana and is the most widespread minable coal in the eastern interior basin, cropping out almost continually from the Ohio River

Coal V has an average thickness of 5 feet; locally, however, it has attained a maximum thickness of 11 feet. Although the bed is persistent, it may be cut out locally for some distance. The areas of coal cutouts appear to have restricted, channellike forms. The top of Coal V has an undulating surface giving rise to many small so-called "plains type structures." The quality of the coal varies, but it is usually a good steam coal and is generally sold for household use. Locally, the bed becomes very shaly and has a high ash content. Although in places the roof is composed of sandstone, it is usually composed of 3 to 10 feet of black shale containing large pyrite concretions, many of which project downward into the coal. The black shale or sandstone is overlain in turn by 4 to 6 feet of limestone called the Alum Cave limestone member, which is the top member of the Petersburg formation. The interval between Coal V and Coal IV is generally 100 to 125 feet.

The composition of Coal V on an as-received basis is shown in the following proximate analyses:

Analyses of Coal V, as-received basis
(percent)

	No. 1	No. 2	No. 3	No. 4	No. 5	No. 6
Fixed carbon-----	49.16	41.64	44.42	47.27	42.17	43.53
Volatile matter-----	37.99	36.31	32.48	34.71	42.60	40.64
Moisture-----	6.50	10.30	12.08	12.88	6.49	7.06
Ash-----	6.35	11.75	11.02	6.14	8.74	8.77
Sulphur-----	1.85	4.23	3.65	1.70	3.18	3.64
Calories-----	6,981	6,232	6,117	6,556	7,002	6,811
Btu-----	---	11,218	11,011	11,801	---	12,260

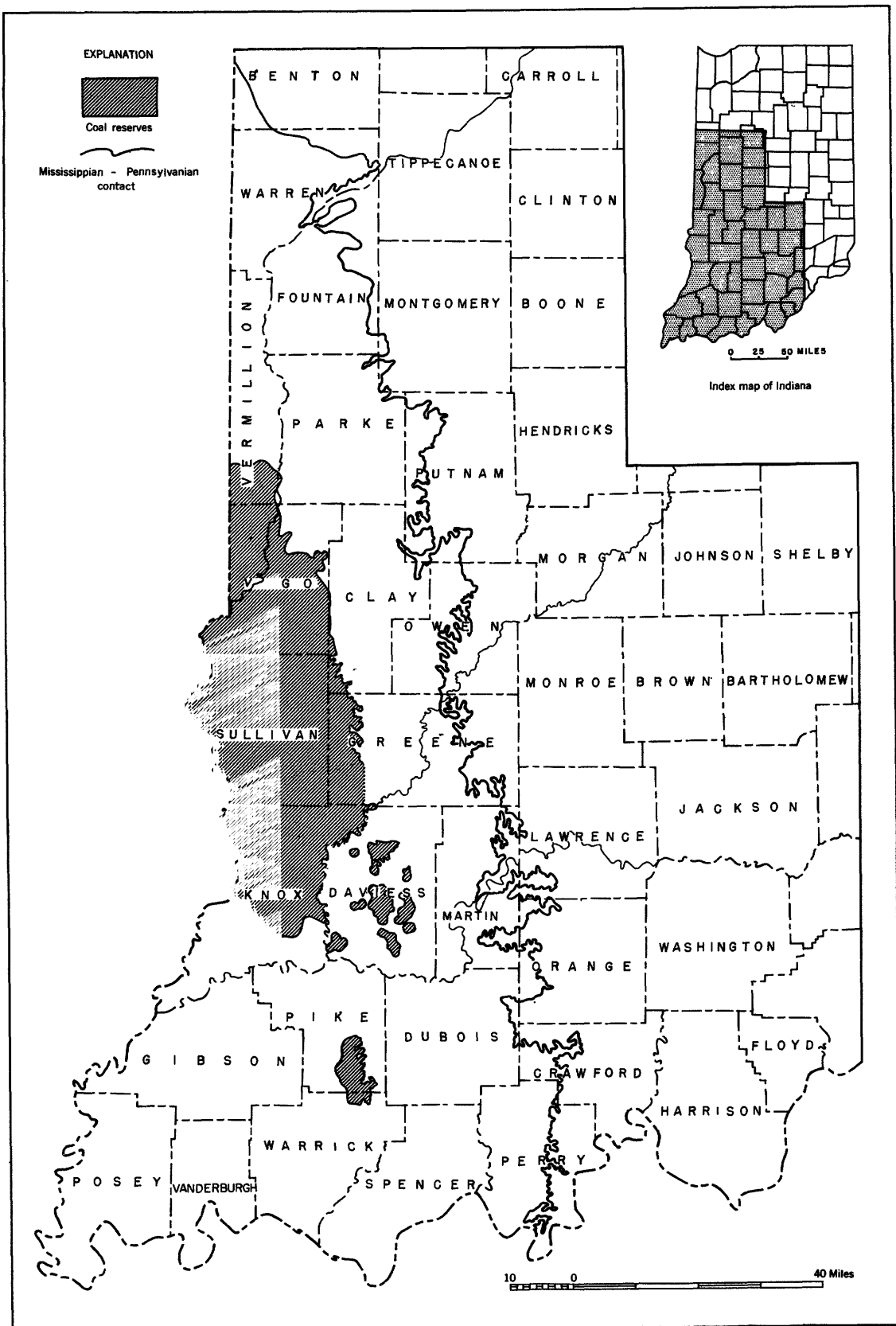


Figure 11. —Map showing reserves of Coal IV in Indiana.

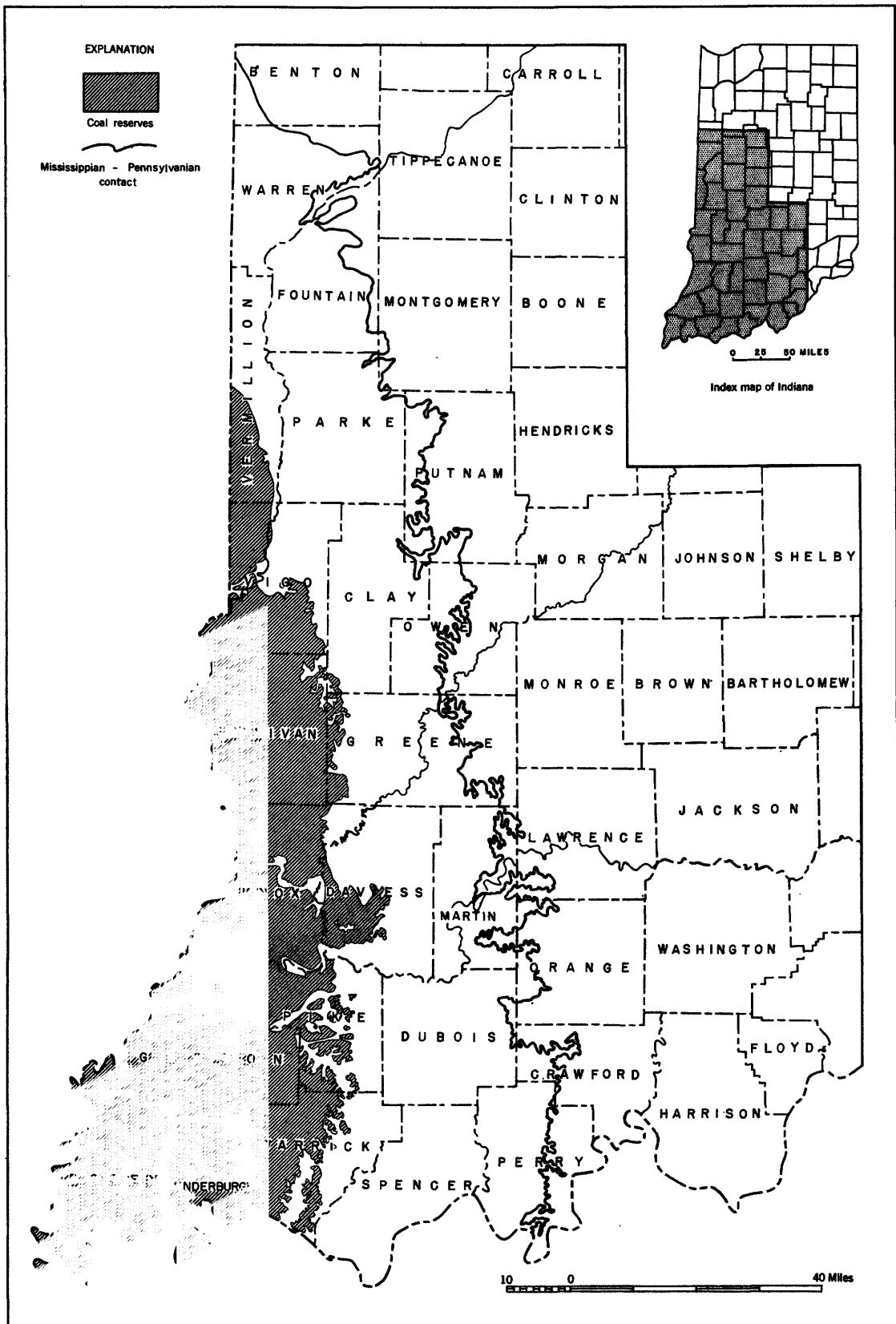


Figure 12. —Map showing reserves of Coal V in Indiana.

The samples are as follows: No. 1, Cabel and Kauffman, Mine No. 9, three miles southwest of Washington, Daviess County; No. 2, West of Linton, Greene County; No. 3, Bicknell, Knox County; No. 4, Ayrshire, Pike County; No. 5, Alum Cave, Phoenix No. 1 mine, New Pittsburg Coal and Coke Co., Sullivan County; No. 6, Booneville, Big Four mine, Warrick County.

Coals Va and Vb

Coals Va and Vb are two thin beds of the Dugger formation lying between Coals V and VI. Bed Va is the lower of the pair and is 10 to 15 feet above Coal V; bed Vb is 30 to 35 feet above Coal V. The estimated reserves in Coal Vb, which is of workable thickness locally, are limited to Knox County. (See fig. 7.) The reserves of Coal Vb are summarized in tables 7 through 10; no reserves have been estimated for Coal Va.

Coal VI (Dugger coal)

Coal VI of the Dugger formation is typically developed in Sullivan County, where it is locally 6 to 8 feet thick. The coal is characterized by a shale roof and floor and two thin shale partings in the middle of the bed. The interval between Coal V and Coal VI is normally about 75 feet but has a range in thickness of 60 to 100 feet. North of Sullivan County Coal VI splits or pinches out. Sullivan and Knox Counties contain the largest estimated reserves. In Gibson County the bed included as Coal VI (see fig. 13) is possibly the lower unit of the Millersburg bed. A coal in Posey County called Coal VI by the petroleum companies is included with the estimated reserves of the lower unit of the Millersburg coal bed. The estimated reserves of Coal VI are summarized in tables 7 through 10.

Tabulated at the bottom of the page are proximate analyses on an as-received basis of samples from Coal VI. Analysis No. 1 was made by the U. S. Bureau of Mines. Analyses Nos. 2 through 6 were taken from Logan (1922, p. 628). The samples are as follows: No. 1, Vandalia Coal Co., Mine No. 17, Sullivan, Sullivan County; No. 2, Bicknell Coal Co., Knox County; Nos. 3 and 4, Star City mine 29, Consolidated Indiana Coal Co.; Nos. 5 and 6, West Terre Haute, Fauvre Coal Co., Vigo County.

An overriding coal 3 to 8 feet below Coal VI occurs in Knox County and is possibly a split of Coal VI. The distribution of the estimated reserves in the under- rider is shown in figure 9, and the estimated reserves are summarized in tables 7 through 10.

Analyses of Coal VI, as-received basis
(percent)

	No. 1	No. 2	No. 3	No. 4	No. 5	No. 6
Fixed carbon-----	42.71	48.54	46.14	42.29	42.08	40.91
Volatile matter-----	33.91	35.22	31.65	29.40	34.80	34.80
Moisture-----	11.15	7.61	13.99	12.17	12.82	13.53
Ash-----	12.23	8.63	14.32	9.16	10.30	10.76
Sulphur-----	2.01	1.67	2.31	4.66	3.27	3.15
Calories-----	6,137	6,489	6,291	5,732	6,117	6,082
Btu-----	11,046	---	11,324	10,318	11,119	10,948

Millersburg coal

The Millersburg coal, which consists of two widely separated benches, is at the approximate stratigraphic position of both Coal VI and Coal VII. Because the correlation of the Millersburg coal is uncertain, the bed was considered to be a separate bed in estimating the reserves.

The Millersburg coal is best developed at Little Ditney Hill about three miles south of Elberfeld in Warrick County, where it is 70 to 100 feet above Coal V. At this locality it averages 7 feet in thickness and is a maximum of 10 feet thick. The thickness of a medial parting in the coal becomes so great in places that in effect the Millersburg is two coal beds, separated by a stratigraphic interval ranging from 1½ to 22 feet in Warrick County, 12 to 40 feet in Gibson County, and 30 to 40 feet in Posey County. The distribution of the reserves is shown in figures 14 and 15, and tables 7 through 10 summarize the estimated tonnages.

Following is a proximate analysis on an as-received basis of a combined sample of both benches of the Millersburg coal (No. B-52964, U. S. Bureau of Mines):

	Percent
Fixed carbon-----	46.80
Volatile matter-----	28.40
Moisture-----	15.90
Ash-----	8.90
Sulphur-----	.90

Calories: ---

Btu: 10,610

This sample was taken from Ingle Coal Co. mine, at Ditney Hill, 2 miles south of Elberfeld, Warrick County.

Coal VII

Coal VII, which lies normally 35 to 50 feet above Coal VI, contains its largest reserves in Sullivan County. In Sullivan and Greene Counties, it lies 15 to 20 feet above the Universal limestone member of the Dugger formation and immediately below the massive Busseron sandstone member of the Shelburn formation. The average thickness of the bed is 3.4 feet where the reserves were estimated. The roof is usually shale, but locally it may be sandstone, which is rolling and

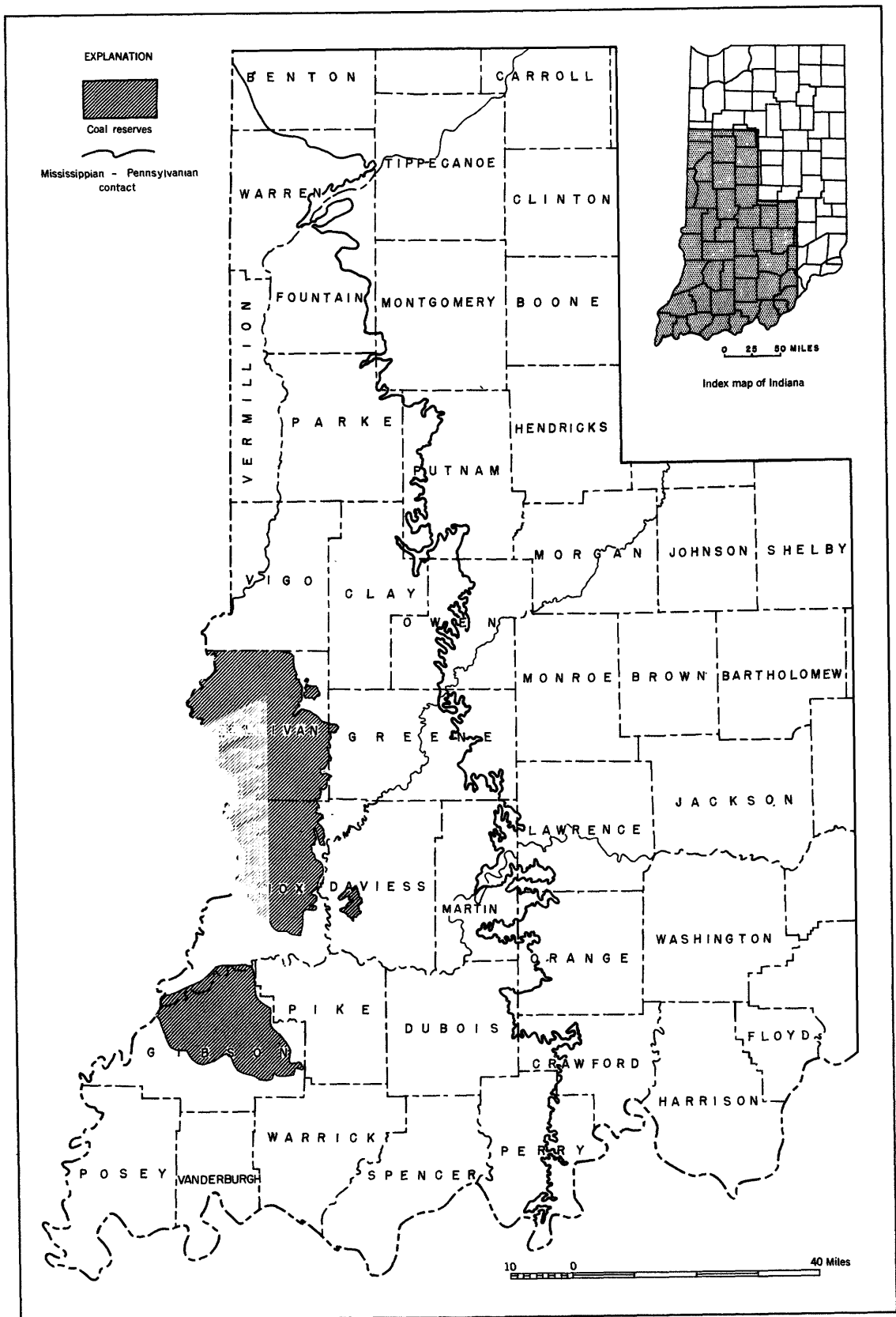


Figure 13.—Map showing reserves of Coal VI in Indiana.

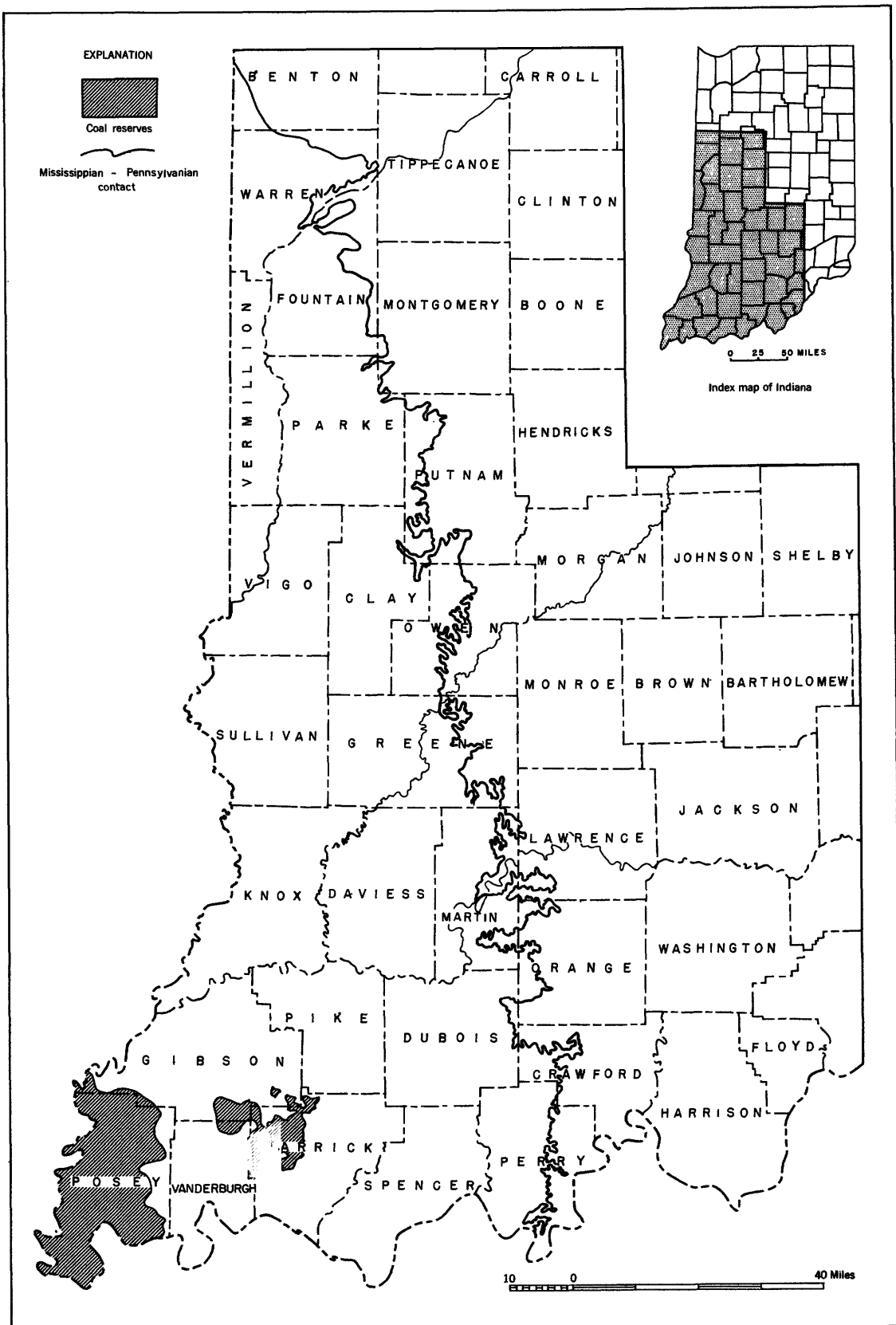


Figure 14. —Map showing reserves of the lower Millersburg coal in Indiana.

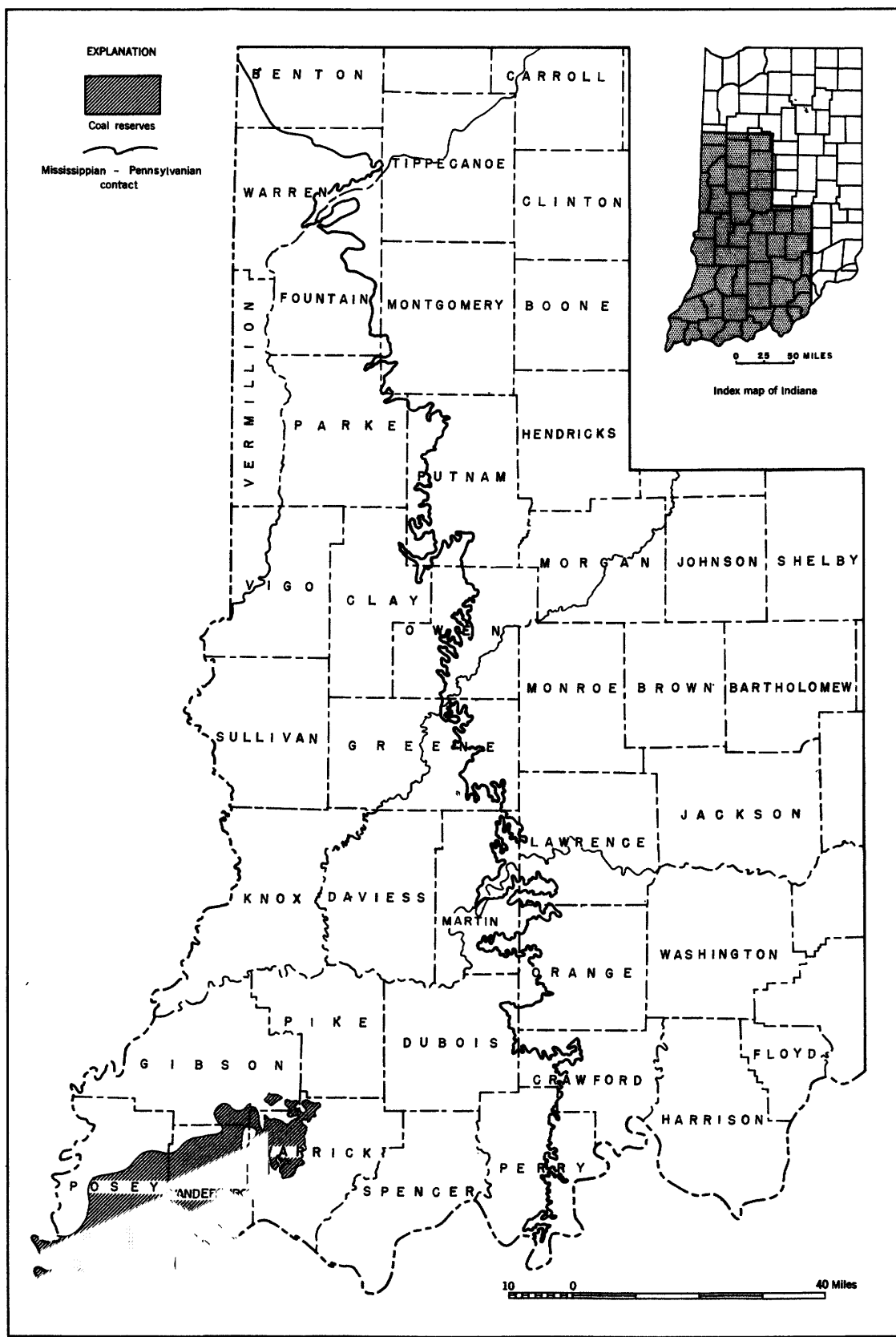


Figure 15.—Map showing reserves of the upper Millersburg coal in Indiana.

irregular. Coal VII is mined extensively west of Terre Haute in Vigo County and a small amount is mined south of Oakland City in Gibson County. A coal in Vanderburgh and Posey Counties called Coal VII by the petroleum companies may just as logically be called Millersburg (upper bench) and has been treated as such in this report. The distribution of estimated reserves of Coal VII in Indiana is shown on figure 16 and the estimated reserves of Coal VII are summarized in tables 7 through 10.

The proximate analysis on an as-received basis of a sample of Coal VII is given below:

	Percent
Fixed carbon-----	42.10
Volatile matter-----	35.50
Moisture-----	13.70
Ash-----	8.70
Sulphur-----	3.00

Calories: 6,311

Btu: 11,360

The sample was taken from Macksville, Red Bird mine (U. S. Bureau of Mines, 1920, p. 29).

At least four thin coal beds occur above Coal VII in the southwestern part of the State. Although all of them probably have been worked locally, these beds are of small economic importance, and no reserves were calculated for these beds.

PRODUCTION OF COAL IN INDIANA

During the 112 years of commercial coal production in Indiana, more than one billion tons of coal has been mined. The maximum production for one year was 30 million tons in 1918. In 1944 almost 28 million tons was produced, and the production of 20 million tons in 1950 placed Indiana sixth in the ranks of coal producing states. (See table 11.)

History of production

The presence of coal in Indiana was noted as early as 1763 (Ashley, 1899, p. 5). A small amount of coal was dug by Robert Fulton for his steamboat "Orleans" in 1812. Twenty years later, in 1832, coal was being mined at numerous points in Indiana, and as early as 1840 was being transported on the White, Wabash, and Ohio Rivers. During the year 1870, nearly 500,000 short tons of coal was mined in the State. Since 1876, Indiana has been among the first eight bituminous coal-producing states. The Office of State Mine Inspector was created in 1879, and the U. S. Bureau of Mines office for the State of Indiana was established at Vincennes in the fall of 1918. An interesting account of early mining in the State is contained in a report by Eavenson (1942).

Coal mining had become a large industry by 1892; in that year over 4,494,811 tons of coal were mined with more than 7,600 people employed in the mines. In 1897 Indiana was eighth (Nicolls, 1897, p. 115) in

bituminous coal production. Production tonnages rose to peaks during the war years of 1916-1919 and 1942-1946 with the maximum annual production of 30,678,634 tons in 1918. Coal production for 1950 was 19,957,029 tons. The total known production of coal in Indiana from 1840 through 1950 is 988,000,000 tons. Table 11 shows the production of Indiana by counties from 1900 through 1950. Clay, Greene, Knox, Pike, Sullivan, Vigo, and Warrick Counties produce more than 90 percent of the State's present coal production. In 1950, a total of 170 mines were known to be operating in 17 counties, and 9,500 men were employed in the industry. Doubtless several more small mines were operated of which there has been no mention in inspectors' reports.

From 1917 through 1950, Coal V has furnished more than 50 percent of the coal production of Indiana; in some years the percentage has closely approached 70 percent. The second largest production came from Coal IV for the period 1917-41; percentages of the State production from Coal IV ranged from 12 to 32 percent. During the years 1942-43 and 1945-50, Coal VI supplanted Coal IV as second largest producing coal bed with a total of 11 to 18 percent of the State's total production. Coal III held second place in production for the year 1944 but dropped to third place from 1945-50 with an average of 11 to 13 percent of Indiana's annual production (Coal Trades Association of Indiana, 1951, p. 21-22).

Underground mining

The first methods used in mining were of necessity quite simple. Coal was opened along the outcrop and drifts driven down the dip. Cross entries were driven, and then rooms were worked from these. These early coal mines were called "coal banks," undoubtedly because they often were developed near the bank of a stream where the coal cropped out above the water level.

Later, methods used to reach coal buried too deep or impossible to drift upon involved the sinking of a slope. As the demand for coal increased and better machinery became available, shafts were sunk, and hoists and loading equipment were installed. Most of the mines are now mechanized. Of the 19,957,029 tons mined in 1950 in Indiana, 9,217,462 tons or 46 percent were mined by approximately 6,400 men using underground methods.

Strip mining

Production by strip mining was first recorded in 1917, and as early as 1924-25 Indiana led the Nation in tonnage of strip-mined bituminous coal. Approximately 43 percent of the State's production was strip mined in 1935 as compared to the national average that year of 6.4 percent. Of the 19,957,029 tons of coal produced, 10,739,567 tons or 54 percent of the State's production in 1950 came from the strip pits.

More than 3,000 people were employed during 1950 in the strip-mining industry. Heavy equipment is in use in the State; of 25 stripping shovels employed in the industry, four have a capacity of 40 cubic yards or more and several handle 15 to 25 cubic yards.

Table 11.—Recorded coal production in

Year	Clay	Daviess	Dubois	Fountain	Gibson	Greene	Knox	Owen	Parke
1900-----	1,165,302	^b 276,625	---	44,232	66,889	723,255	60,749	---	649,665
1901-----	1,080,164	^b 238,699	---	34,826	116,526	944,621	94,579	---	631,032
1902-----	1,315,046	217,326	10,094	17,099	105,468	1,663,785	119,225	---	1,155,457
1903-----	1,242,958	183,692	^b 8,546	18,660	81,946	2,303,512	117,046	---	989,983
1904-----	960,094	143,877	^b 13,833	41,452	98,257	2,440,420	173,406	---	924,001
1905-----	781,574	101,429	^b 7,200	^d 72,655	99,322	2,458,665	293,480	---	750,314
1906-----	1,101,228	135,985	^b 14,700	^d 84,469	142,444	2,307,486	333,833	---	707,027
1907-----	1,266,507	120,996	^b 8,460	^d 41,270	207,472	2,773,944	374,099	---	655,312
1908-----	863,649	77,034	^b 12,320	^d 4,800	188,500	2,361,404	428,821	---	644,062
1909-----	958,732	73,877	^b 35,404	^d 12,650	232,599	2,612,686	642,727	15,904	730,082
1910-----	980,016	87,374	^b 8,290	^d 8,422	296,753	3,439,002	1,003,909	10,690	764,115
1911-----	779,372	79,466	^b 4,119	^d 5,625	247,128	2,563,366	879,323	22,693	521,567
1912-----	700,323	105,079	^b 16,500	^d 5,066	228,557	2,636,509	1,212,596	30,707	523,150
1913-----	564,957	84,030	^b 7,948	^d 64,902	227,100	2,780,708	1,760,748	127,283	507,508
1914-----	454,009	91,608	^b 5,400	^d 40,764	280,636	2,230,085	1,619,083	111,355	331,845
1915-----	295,451	79,061	^b 3,000	^d 23,800	271,177	2,324,634	2,212,315	91,318	166,648
1916-----	629,522	78,537	(e)	^d 13,911	333,980	2,440,311	2,752,213	(e)	281,697
1917-----	1,141,029	147,224	---	^d 20,910	471,575	3,498,038	3,119,922	^g 87,378	387,055
1918-----	1,572,582	215,808	---	^d 15,280	609,693	3,426,168	3,822,853	^g 266,520	313,996
1919-----	1,006,780	320,249	^g 25,500	^d 13,317	476,613	2,021,868	2,965,658	97,115	92,912
1920-----	1,370,402	343,572	^b 7,675	^d 2,571	823,057	2,878,868	3,705,711	121,928	105,254
1921-----	547,480	271,104	^b 9,144	^d 2,527	658,127	1,885,479	2,736,111	77,345	28,249
1922-----	452,901	123,794	^b 1,200	^d 2,640	513,702	1,946,445	2,507,063	40,827	116,546
1923-----	645,393	171,931	^g 7,455	^d 2,514	542,200	2,393,322	3,510,842	93,986	110,263
1924-----	730,617	96,422	^g 10,241	^d 2,083	846,362	1,873,695	2,364,015	107,671	84,534
1925-----	974,415	38,247	(e)	^k 73,452	1,003,766	1,274,544	2,821,785	83,148	(e)
1926-----	1,176,169	29,732	---	^k 4,695	1,315,129	1,275,647	3,101,144	77,794	(e)
1927-----	783,412	56,803	---	^k 4,086	1,031,913	1,122,967	1,289,762	22,830	(e)
1928-----	883,957	75,906	---	^k 2,230	1,104,149	1,439,618	418,940	23,455	(e)
1929-----	1,073,364	50,658	---	---	1,091,975	1,447,495	1,473,171	88,936	---
1930-----	942,954	23,161	^b 8,300	---	857,189	1,722,181	1,434,581	92,178	18,091
1931-----	637,100	17,863	^b 7,578	^k 21,846	862,131	1,622,929	1,459,138	110,571	(e)
1932-----	594,925	22,947	^b 5,800	(e)	1,138,834	1,729,638	1,561,318	142,380	(e)
1933-----	641,533	17,151	^b 7,650	(e)	1,097,863	1,694,687	1,368,634	48,178	(e)
1934-----	916,287	23,740	^g 18,263	(e)	1,067,526	1,614,489	1,413,493	(e)	33,435
1935-----	1,058,949	25,807	---	(e)	1,205,334	1,604,419	1,596,196	141,680	34,150
1936-----	1,077,917	33,233	(e)	43,117	1,207,177	1,852,959	1,977,198	211,969	115,203
1937-----	1,256,247	46,001	25,424	39,637	1,289,822	2,099,896	1,933,215	159,835	113,929
1938-----	1,137,434	66,033	19,265	44,746	1,050,714	1,908,372	1,599,582	92,561	118,230
1939-----	1,318,283	60,369	14,172	32,591	(e)	2,147,834	2,122,107	(e)	132,949
1940-----	1,358,941	69,342	8,751	58,489	973,715	2,247,473	2,466,614	30,992	143,899
1941-----	2,013,710	83,139	13,906	85,844	1,157,862	2,591,754	2,868,350	(e)	118,957
1942-----	2,129,947	123,730	14,947	86,931	1,212,387	2,925,890	3,142,857	43,319	122,544
1943-----	1,916,129	126,712	9,088	81,686	1,035,661	2,663,606	3,525,675	222,162	65,182
1944-----	1,901,383	69,394	17,458	(e)	(e)	2,443,267	3,957,887	199,130	21,995
1945-----	1,857,074	84,577	(e)	88,245	1,019,007	1,159,099	3,969,151	1,962	41,164
1946-----	1,874,585	46,485	22,340	87,338	745,581	1,090,684	3,496,951	14,731	30,644
1947-----	2,077,412	61,122	24,789	78,215	951,142	1,357,598	3,699,743	8,741	95,830
1948-----	1,902,673	507,934	31,997	^k 169,091	774,806	930,402	3,205,688	15,401	(e)
1949-----	1,156,039	353,258	7,410	69,188	456,471	671,211	2,237,527	126,084	70,605
1950-----	1,199,396	411,178	7,900	69,858	669,408	464,855	3,128,026	189,307	19,200
Total 1900-50--	56,466,323	6,389,321	482,067	1,737,730	32,485,645	102,031,790	100,079,060	3,450,064	13,468,281 ¹

^a Figures, 1900-23, from U. S. Geol. Survey, Mineral Resources of the United States; 1924-31, from U. S. Bureau of Mines, Mineral Resources of the United States; 1932-50, from U. S. Bureau of Mines, Minerals Yearbook. ^b Includes Martin Co. ^c Includes Martin and Warren Co. ^d Includes Warren Co. ^e Small production combined with another county or included in column headed "Other counties." ^f Includes Owen, Perry, and Dubois Co. ^g Includes Perry Co. ^h Includes Crawford Co. ⁱ Exclusive of wagon mine production. ^j Wagon mines served by rail. ^k Includes Parke Co. ^l Includes Spencer, Vanderburgh, and Dubois Co.

Indiana, 1900-50^a (in short tons)

Perry	Pike	Spencer	Sullivan	Vanderburgh	Vermillion	Vigo	Warrick	Other counties and small mines	Total
24,077 16,822 21,577 24,941 26,218	245,433 269,268 510,017 505,564 408,391	9,106 18,885 16,274 19,948 17,511	939,989 910,725 1,268,945 1,788,358 2,061,212	192,532 193,716 218,112 241,088 258,254	649,525 684,253 718,102 915,171 1,068,427	1,151,643 1,362,041 1,652,798 1,826,393 1,756,250	249,064 286,068 416,062 435,797 416,311	36,000 36,000 21,037 31,089 34,275	6,484,086 6,918,225 9,446,424 10,734,692 10,842,189
17,018 13,261 17,965 10,601 15,603	452,396 497,957 516,418 460,180 447,122	16,935 19,256 25,916 13,206 11,118	2,571,818 2,415,847 2,897,840 2,602,543 3,227,515	300,112 302,919 317,371 263,171 271,644	1,302,667 1,342,478 1,442,103 1,142,802 1,443,099	2,189,603 2,197,459 2,724,743 2,735,399 3,562,534	447,576 447,995 568,522 482,613 488,194	^b 32,488 28,216 26,775 23,785 52,769	11,895,252 12,092,560 13,985,713 12,314,890 14,834,259
26,317 16,683 15,904 14,910 13,800	697,385 467,623 559,337 583,637 578,693	9,096 9,551 10,306 8,479 8,510	4,035,934 3,261,787 3,091,368 3,084,419 2,999,148	398,293 279,109 302,074 280,522 288,191	1,635,623 1,673,621 1,547,126 2,085,311 2,135,836	4,181,799 2,793,352 3,564,046 4,237,274 4,767,828	768,706 545,132 691,475 685,020 624,770	38,091 51,838 45,595 60,915 59,571	18,389,815 14,201,355 15,285,718 17,165,671 16,641,132
11,075 (^c) (^c) (^c) (^c)	646,166 815,304 983,974 1,139,412 1,024,973	6,695 6,746 5,081 8,456 25,720	2,587,108 2,763,433 3,528,902 4,346,857 3,096,059	227,331 330,135 384,199 347,440 264,760	2,734,546 3,420,088 4,212,638 4,205,808 2,844,845	4,688,838 5,285,542 7,303,343 8,935,376 5,802,244	577,473 774,116 1,169,386 1,399,746 781,317	^d 59,516 ^e 167,993 78,675 52,639 52,358	17,006,152 20,093,528 26,539,329 30,678,634 20,912,288
15,997 8,064 8,500 (^c) (^c)	1,422,013 1,035,469 1,359,328 1,818,324 2,000,247	32,713 7,472 12,740 6,877 9,933	4,523,306 3,418,435 3,184,684 5,510,510 4,919,197	370,993 224,665 208,678 308,584 287,403	3,551,187 2,185,886 2,146,848 3,247,298 2,208,293	8,232,106 6,364,245 5,519,218 6,781,735 5,079,692	1,583,232 859,707 805,310 986,661 859,808	260,000 --- ^f 182,465 ^g 91,204 ---	29,350,585 20,319,509 19,132,889 26,229,099 21,480,213
9,213 6,212 (^c) (^c) (^c) 9,515	2,136,333 2,597,749 2,719,593 1,949,578 2,484,370	(^c) ^m 287,224 (^c) (^c) (^c) (^c)	4,572,830 4,661,026 3,588,488 2,984,478 2,949,614	(^c) (^c) (^c) (^c) (^c)	2,326,337 2,371,258 1,922,491 2,060,776 2,190,892	4,781,606 5,262,588 1,290,740 3,364,612 3,955,684	891,474 1,019,639 1,290,740 1,767,073 1,226,712	^h 237,816 --- ⁿ 402,100 ⁿ 303,808 ^o 301,972	21,224,966 23,186,006 17,935,758 16,378,580 18,344,358
(^c) 7,508 (^c) (^c) (^c) (^c)	2,709,804 2,721,304 2,697,570 2,068,234 2,440,081	(^c) ^m 225,815 ⁿ 9,714 ⁿ 9,556 (^c)	2,778,758 2,257,984 1,532,541 2,104,447 2,288,226	(^c) (^c) 205,444 135,251 160,649	1,682,563 1,433,158 1,049,310 1,344,433 1,268,344	2,963,978 2,049,717 1,578,485 2,274,609 2,549,449	1,023,355 860,523 1,019,202 923,361 883,931	ⁿ 232,869 --- ^p 35,465 ^p 25,465 ^r 115,730	16,489,962 14,295,165 13,323,573 13,761,052 14,793,643
(^c) (^c) (^c) (^c) 24,110 26,844	2,728,767 3,121,493 3,208,339 2,649,045 3,396,684	^s 11,154 8,104 22,046 81,318 (^c)	2,261,687 2,248,518 1,916,977 1,393,515 1,498,804	(^c) 154,174 151,081 (^c) (^c)	1,091,780 884,044 637,538 524,393 487,621	2,892,804 3,561,278 3,465,691 2,889,998 3,279,406	965,516 1,304,529 1,358,516 1,031,027 1,251,760	^s 135,971 ^t 21,623 ^u 40,560 ^v 128,141 ^w 1,173,348	15,754,214 17,822,536 17,764,754 14,758,484 16,942,772
29,881 41,054 45,354 25,465 8,298	3,580,896 4,253,896 4,426,500 3,905,445 4,197,668	91,791 144,940 121,625 110,351 180,254	1,638,087 2,059,467 2,094,488 2,276,089 3,044,807	(^c) (^c) ^b 106,390 90,609 (^c)	562,593 519,039 501,138 472,883 509,235	3,903,394 3,751,630 4,329,483 4,655,755 5,643,213	1,597,437 2,611,389 3,960,521 3,877,079 4,375,701	^v 106,277 ^x 168,992 --- ^b 5,006 ^y 1,392,193	18,868,572 22,483,929 25,388,051 25,064,583 27,961,883
2,450 2,450 1,200 1,220 3,200 ---	4,093,828 3,458,816 4,050,615 3,665,386 2,603,867 3,127,263	205,888 248,350 221,614 204,730 168,408 84,283	3,087,887 2,844,162 3,802,850 3,399,350 2,360,902 2,496,945	(^c) --- --- --- --- ---	399,006 268,079 450,303 558,189 442,501 393,719	5,205,128 4,004,972 4,315,096 4,590,215 3,238,395 4,426,343	3,920,772 3,459,445 4,252,827 3,892,175 2,581,776 3,268,301	^z 47,373 ^b 1,334 --- --- ^b 2,914 ^b 1,047	25,182,611 21,696,947 25,449,097 23,849,257 16,549,756 19,957,029
563,307	100,437,755	2,773,695	143,178,866	8,064,894	76,895,204	201,329,603	71,964,842	6,403,298	928,201,745

^m Includes Vanderburgh Co. ⁿ Includes Spencer, Vanderburgh, and Perry Co. ^o Includes Spencer, Vanderburgh, and Martin Co. ^p Includes Fountain, Parke, and Warren Co. ^q Includes Perry and Spencer Co. ^r Includes Fountain, Owen, and Warren Co. ^s Includes Fountain, Vanderburgh, and Warren Co. ^t Includes Dubois, Martin, and Perry Co. ^u Includes Perry, Warren, and Martin Co. ^v Includes Vanderburgh, Warren, and Martin Co. ^w Includes Gibson, Owen, Spencer, Vanderburgh, Martin, and Warren Co. ^x Includes Martin, Owen, Vanderburgh, and Warren Co. ^y Includes Fountain, Gibson, and Vanderburgh Co. ^z Includes Dubois and Vanderburgh Co.

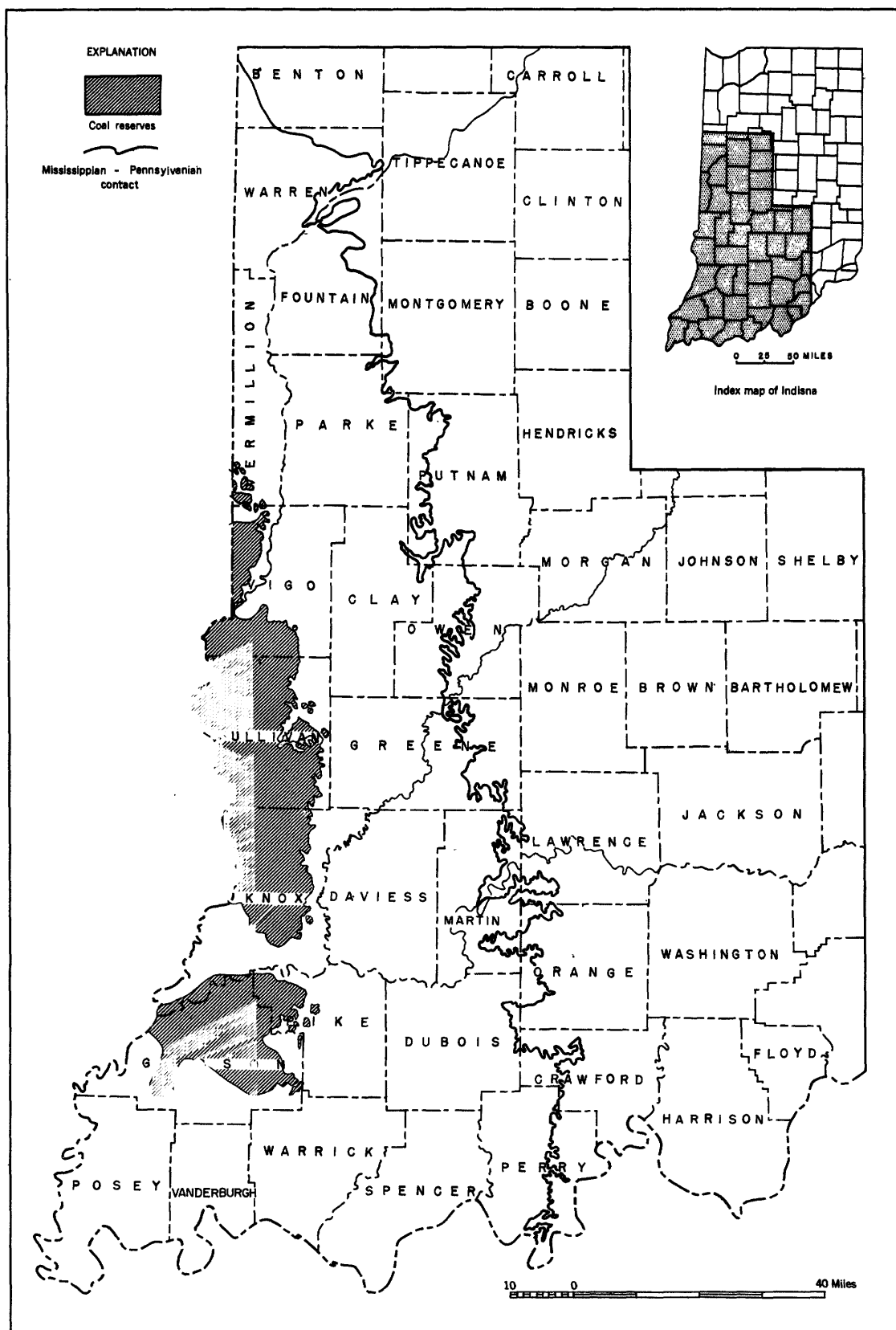


Figure 16. —Map showing reserves of Coal VII in Indiana.

There are more than 80 loading shovels used in the industry ranging in size from 1 to 5 cubic yards. Approximately 65 draglines, which vary in size from 2½ to 25 cubic yards, are in use. More than 50 bulldozers of varying sizes and 100 large capacity tractor trucks of 18- to 32-ton capacity are employed in the industry; numerous smaller trucks are also employed. Eleven steam locomotives and three electric locomotives pull a total of 110 railroad cars, exclusive of regular haulage from the mines by feeder line railways.

The average overburden moved is approximately 35 feet. The maximum overburden stripped in most mines is less than 90 feet, but occasionally overburden more than 100 feet thick has been moved from small areas.

RECOVERABILITY IN MINING

Underground mining operations in various parts of the United States usually have a recovery of not more than 50 percent of the original reserves. The recovery is dependent on methods and conditions existing in the mines. Careful estimations of tonnages mined and lost in mining were made during the progress of this study. Comparisons of calculated tonnages of coal in the ground with actual production tonnages in Knox, Vanderburgh, and Warrick Counties show an extraction of 55 to 60 percent and a corresponding loss of 40 to 45 percent. These calculations were made on mines having no wash plant.

Most of the larger mines in the State have wet cleaning plants. As impurities are extracted and discarded, there also exists another pair of efficiency factors. The first is the qualitative efficiency or the percentage loss of impurities removed from the coal. The second is the quantitative efficiency or "bank loss" which is the loss of coal in the refuse dump in terms of feed coal. Neither of these losses are actually mining losses, but they contribute to the total coal loss and therefore are included in the percentage of loss by mining.

Some other factors which contribute sizable loss in extraction efficiency are: coal left in the roof, coal lost because of faults, and loss of coal between adjacent mines and in hazardous mining areas. Certainly these and other factors are sufficient to produce final tipple production figures showing extraction of not more than 50 percent of the original reserves for coal mined by underground methods. This convenient figure is therefore the one used in computing recoverable reserves of coal to be mined by underground methods.

Roy Kattman (1950), Chief Engineer of Enoco Collieries, Inc., estimates mining loss at approximately

40 percent for his company; however, washing losses reduce the actual recovery to 50 percent.

H. P. Miller (1951), assistant to the Chief Engineer, Ayrshire Collieries Corporation, has conducted washability studies on samples collected from diamond-drill cores on deep reserves of Coals III, V, VI, and VII and estimated the amount of recoverable coal using, the washing yield percentages obtained in their laboratories and using extraction percentages given at the bottom of the page. The estimated total recoveries are as follows:

Seam	Washing plant yield percentage	Extraction percentage	Total recovery (percent)
III-----	71.8	50	36
V-----	84.9	55	47
VI-----	76.1	55	¹ 40
VII-----	84.5	55	47

¹ Includes a 2 percent total loss for clay seams.

The recovery of coal in strip mines is relatively high, depending upon mining conditions. Mr. Miller (1951) estimates a 10 to 25 percent loss of the attempted mined tonnage in strip mines in Indiana. The tabulation at the bottom of the page is the recovery cited by Miller (1951) for individual strip operations of the Ayrshire Collieries. Robert A. McClevey (1951), Engineer of Sunlight Coal Corporation, Warrick County, estimates a 15 percent loss of the attempted mined tonnage on the Millersburg coal bed. Charles R. Barnard (1950), Engineer of Enoco Collieries Company, Pike County, estimates that usually the loss is 20 percent of the attempted mined tonnage on Coal V. The foregoing data from the engineers of three of the largest strip-mining organizations in the State suggest that 80 percent is the average recovery of the coal in the ground in strip mining in Indiana; and this convenient figure has been used in this report to compute recoverable reserves of strippable coal.

USE OF COAL IN INDIANA

Although Indiana produces more than 20 million tons of coal annually, and exports about 25 percent of this amount, the coal is not suitable for making metallurgical coke. Indiana's thriving steel industry is thus dependent upon the Appalachian Basin states for coking coal, which is imported in amounts greatly exceeding the exports of noncoking coal. A study of the distribution and use of coal in the United States during 1946, prepared by the U. S. Bureau of Mines (1948), which takes into account about 90 percent of the total

Recovery in some Indiana strip mines

Sunspot mine, Vermillion County-----	No. VII	Seam	75 percent	(Raw)
Chinook mine, Clay County-----	No. III	Seam	75 percent	(Washed)
Ayrshire mine, Pike County-----	No. V	Seam	90 percent	(Raw)
Ayrshire mine, Pike County-----	No. IV	Seam	85 percent	(Raw)
Patoka mine, Pike County-----	No. V	Seam	90 percent	(Raw)
Patoka mine, Pike County-----	No. VI	Seam	80 percent	(Raw)
Undeveloped Boonville field, Warrick County-----	No. V	Seam	80 percent	(Assumed washed)
Undeveloped Newburgh field, Warrick County-----	No. V	Seam	80 percent	(Assumed washed)
Undeveloped Millersburg field, Warrick County.	Millers-	Seam	80 percent	(Assumed washed)
	burg.			

coal production, provides a reasonably accurate picture of the movements and use of coal in Indiana in that year. The results of this study, which are summarized in the tabulation at the bottom of the page, show that Indiana produced nearly 22 million and imported 16 million tons of coal in 1946 to make a total of 38 million tons produced and imported. Nearly 14 million tons of the imported coal was obtained from West Virginia, eastern Kentucky, and Virginia, and most of this amount was used in byproduct ovens to manufacture coke for the steel industry. Of the noncoking coal produced in Indiana, nearly 7 million tons was used by railroads in Indiana, and surrounding States and Canada; and 5 million tons was shipped to surrounding States, particularly Illinois, Wisconsin, Iowa, and Minnesota, for use other than by railroads. The remainder was used for heat, light, and power by industry, for the production of electricity by the utilities, and for domestic heating.

Although the use of coal as a source of energy in Indiana has decreased somewhat in recent years owing to the availability of natural gas and fuel oil, a relatively large proportion of the energy produced in Indiana is obtained from coal. A breakdown of the use of bituminous coal and competing fuels prepared by the Bituminous Coal Institute (1951, p. 96) shows that of the total energy used in Indiana in 1949, bituminous coal supplied 72.3 percent; fuel oil, 20.0 percent; natural gas, 7.1 percent; and hydroelectric power, 0.6 percent.

The coal of egg and nut sizes is used by the railroads. Nut and slack sizes are largely used by general industries and electric generating plants throughout Indiana and in the several surrounding States. Both coarse and small sizes are used by other phases of general industry. Large quantities of specially washed coal are consumed by household stokers and small industries. Locally, small mines produce mine-run and unprepared screened coal for household use.

Coal produced and used in Indiana in 1946

(Sources: U. S. Bur. Mines, 1948a, b)

Origin	Produced or imported (tons)
Produced in Indiana.....	21,696,947
Imported from:	
West Virginia, Virginia, and eastern Kentucky.....	13,738,744
Illinois.....	1,989,664
Western Kentucky.....	414,594
Pennsylvania.....	209,516
Ohio.....	<u>147,426</u>
Total imported.....	<u>16,499,944</u>
Total produced and imported.....	38,196,891
Destination	Used by railroads or exported (tons)
Used by railroads in Indiana, surrounding States, and Canada.....	6,877,142
Exported to:	
Illinois.....	3,330,446
Wisconsin.....	728,665
Iowa.....	620,881
Minnesota.....	118,399
Michigan.....	101,930
Lake ports.....	61,790
Ohio.....	30,832
Kentucky.....	5,907
Missouri.....	4,843
South Dakota.....	2,143
Nebraska.....	1,543
Kansas.....	<u>103</u>
Total exported.....	<u>5,007,482</u>
Total used by railroads and exported.....	11,884,624
Total used in Indiana by other than railroads.....	<u>26,312,267</u>
Total used in Indiana, and exported.....	38,196,891

CONCLUSIONS

On the basis of the conservative estimate of reserves presented herein, it is apparent that Indiana's coal supplies are more than adequate for the foreseeable future.

Because of the many variable factors that must be taken into account, however, it is impossible to estimate the life expectancy of the reserves with any satisfactory degree of accuracy. These factors include the observed increase in population and use of energy in this country, the ready interchangeability of fuels at most installations, the variations in efficiency in the recovery and use of fuels, the availability of petroleum from other continents, and the possibility of new fuels being developed or old fuels being exhausted.

Relation of maximum annual production to total estimated recoverable reserves in Indiana

Class of reserves	Years of production at rates assumed			
	Measured	Indicated	Inferred	Total
Strippable (Beds 14 inches or more thick under thin overburden)-----	78	63	28	169
Nonstrippable (Beds 28 inches or more thick under thick overburden)-----	56	118	362	536
Total-----	134	181	370	705

It is therefore apparent that Indiana has recoverable strippable coal reserves sufficient to supply the needs of several generations, and that the recoverable reserves of coal in more deeply buried beds are at least 3 times that of the strippable reserves. These reserves vary considerably in accessibility, and only the measured reserves in the thicker beds are regarded as being immediately available. The total reserves in all categories, however, give comfortable assurance that the needs of the State for noncoking coal can be met in any emergency for many years to come.

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If, for example, it should become desirable to manufacture synthetic liquid fuels from coal, the needs for coal will be enormous, for our use of liquid fuels is very great, and half of the energy in coal is consumed in the conversion. Nevertheless, it is possible to make interesting comparisons between present rates of production and the total estimated recoverable reserves.

Taking into account only beds 14 inches or more thick for strippable reserves and beds 28 inches or more thick for nonstrippable reserves, and using the 1947 peak production rate of 14 million tons for strip mined coal, and the 1918 peak production rate of 29 million tons for deep mined coal as the assumed average rates of production of these two classes of coal in the future, the following are obtained:

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