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ESTIMATE OF KNOWN RECOVERABLE RESERVES
OF COKING COAL IN CLARION COUNTY, PA.

BY D. W. BLAYLOCK, J. J. DOWD,
R. F. ABERNETHY, AND D. A. REYNOLDS

United States Department of the Interior — May 1956

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UNITED STATES DEPARTMENT OF THE INTERIOR
BUREAU OF MINES
Thos. H. Miller, Acting Director

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May 1956

FOREWORD

Since its creation by Congress in 1910, the Bureau of Mines has borne a heavy responsibility for technical progress in the mining, preparation, and utilization of our national fuel reserves. Similarly, it has pioneered in scientific studies leading to better health and safety in mining and more efficient conservation of fuel resources.

Conservation means a full but prudent use of the national resources with avoidance of waste. Conservation requires an inventory to determine the extent, availability, and condition of our resources, for without these facts it is impossible for either industry or Government to plan for sustained production and maintenance of the industrial capacity so essential to our peacetime prosperity and wartime survival. This is true particularly of fuels needed for special purposes, such as metallurgical coking coals that must possess certain favorable properties. Heavy use of our limited reserves of good coking coal has resulted in severe depletion and, in some areas, exhaustion of the thickest and best beds.

At the request of the Munitions Board, Department of Defense, the Bureau of Mines made preliminary arrangements early in 1948 for an investigation of known minable reserves of coal that were or could be made suitable for the manufacture of metallurgical coke. In August of that year, actual field work began in the low- and medium-volatile coking coal fields of the Appalachian region, specifically central Pennsylvania and southern West Virginia. As both the economic and technologic factors that determine whether a particular coal can be used for producing metallurgical coke will vary with changing conditions, the investigation was planned to cover three phases:

1. Determination, from available data, of coal reserves with coking properties that occur in beds thick enough and within depths considered economically minable by present methods, together with such additional reserves as may become economically minable under future conditions of improved technology and greater need.

2. Study of the preparation characteristics of the reserves thereby developed to determine (a) which coals are suitable under present standards for producing metallurgical coke either as mined or after beneficiation by conventional preparation methods, and (b) which coals would require special and more intensive treatment in mining, preparation, or both.

3. Study of the carbonizing properties of the reserves thus developed to determine the yield and quality of coke, gas, and chemical products that can be obtained from coals carbonized singly and in blends.

This report is one in a series, by counties, covering in detail the estimated known minable coking-coal reserves determined under the first phase of the investigation. It also includes the study, as determined under the second and third phases of the investigation, of the preparation and carbonizing properties of the most important beds and a table of analyses of typical coals from the county.

The estimates of coking-coal reserves in these reports were derived from data made available to the Bureau of Mines by coal companies, landowners, Federal, State, and municipal engineers, geologists, land-record officials, and others having authentic records of the occurrence and characteristics of the coal in the respective counties. All of the data were assembled from mine maps, records of core drilling, test pitting and trenching, and related sources of information, for no new core-drilling or geologic exploration was undertaken. Consequently, there are areas covered by these reports wherein the known data now available are inadequate to estimate reserves of measured and indicated coal, as these are defined in the reports. Geologic data also may indicate the presence of large reserves of inferred coal in these areas, but no estimates of inferred reserves are presented in these reports. As their titles indicate, they include only known, minable reserves of measured and indicated coal and not total estimated reserves of coal. Therefore, any comparison of these and other coal-reserve estimates should be made with this distinction clearly understood.

The percentage recovery shown in these reports is a weighted average, based on the thickness of clean coal, less all partings three-eighths inch or more thick, recovered from the mined-out areas in each bed. Thus, it is an overall net areal percentage recovery that, in many cases, will be lower than the recovery estimated by operators who eliminate from their calculations coal pillars left at property boundaries, under roads, and elsewhere. It is based on all coal removed since the beginning of mining operations and therefore may vary from that of recent operations in which recovery either has been improved substantially by technologic advances or has declined, owing to flooding or other conditions that make it expedient to leave more coal in the ground. As the estimates are dated and represent a factual record of all past operations in the particular area, the percentage recovery and estimate of minable coal may be adjusted by operators to suit their particular conditions at any given time.

This investigation was made possible only through the complete cooperation of the coal operators, landowners, and others who have made available to the Bureau their confidential records and data relating to mining operations, drillcore and test-pit operations, etc. This cooperation and assistance is appreciated and is gratefully acknowledged. To protect the confidence of data from private records, the Bureau of Mines is assembling and publishing the estimates on a county-wide basis only and will not release any supplementary or more detailed information.

This investigation will serve a triple purpose:

1. By providing an inventory of known, minable reserves of coking coal that are or can be made suitable for the manufacture of metallurgical coke.
2. By providing an inventory of known minable reserves of coal with coking properties but unsuited for metallurgical coking-coal use by present standards and techniques because of high sulfur, high ash, or weakly coking properties. When warranted by economic and technologic developments, these reserves later may be adapted to metallurgical use by suitable preparation, blending, carbonizing, or metallurgical techniques.

3. By ascertaining the approximate location and magnitude of areas in which geologic data indicate the presence of inferred reserves but where exploratory work has been too limited to determine measured and indicated reserves. It is in these areas that more intensive exploratory work is needed in the future to complete the coking-coal inventory.

The first of these objectives is of prime importance for the present and immediate future, and the second for the more distant future. Accomplishment of the third objective will be of major aid to both industry and State and Federal agencies in more effectively planning and executing coal exploratory and testing investigations.

RALPH L. BROWN
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ESTIMATE OF KNOWN RECOVERABLE RESERVES OF COKING COAL IN CLARION COUNTY, PA.

by

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CONCLUSIONS

1. The Lower Kittanning bed is the most important bed in Clarion County from the standpoint of present production, but the Clarion bed has the largest recoverable reserve.

2. Known measured and indicated reserves in all beds, based on a minimum thickness of 14 inches and 1,800 short tons per acre-foot of coal in place, are estimated at 1,210 million short tons as of January 1, 1952. Of this total, 790 million short tons is in beds 28 inches and more thick. Areas in some beds were omitted from the estimate because available data relative to the bed characteristics are too meager for making an estimate that conforms with the definitions of measured and indicated coal adopted for this study. Should future drilling or development prove reserves in these areas, they should be added to the total estimated reserves.

3. Recoverable reserves of coal have been estimated in beds 28 inches and more thick. This thickness is about the minimum now being mined by hand loading onto conveyors in the Appalachian region. The weighted average recovery for all beds in Clarion County, as determined by this investigation, is 54.2 percent. This percentage is based on the total thickness of coal (less parting three-eighths inch and more thick) in the bed rather than on the thickness of the coal mined. Based on the weighted average percentage of recovery for all beds in Clarion County, the recoverable reserves are estimated at 428 million short tons as of January 1, 1952.

4. Clarion County coals are of high-volatile A bituminous rank.

5. The Lower Kittanning coal in this county contracts during carbonization but yields well-fused coke. To produce metallurgical coke from this coal, it should be blended with low- or medium-volatile coal.

INTRODUCTION

The investigation to evaluate the reserves of coking coal was planned to cover three phases: (1) Estimation of known measured and indicated recoverable reserves of all coking coal; (2) study of upgrading marginal coals through effective preparation; and (3) study of carbonizing properties of coals and coal blends not now widely used for metallurgical coke making.

This is the 34th of a series of reports giving results of studies by counties under part (1) of the investigation. (See Appendix.) This report covers Clarion County, Pa., which comprises parts of the Oil City, Tionesta, Marienville, Foxburg, Clarion, Brookville, Kittanning and Rural Valley quadrangles. (See fig. 1.)

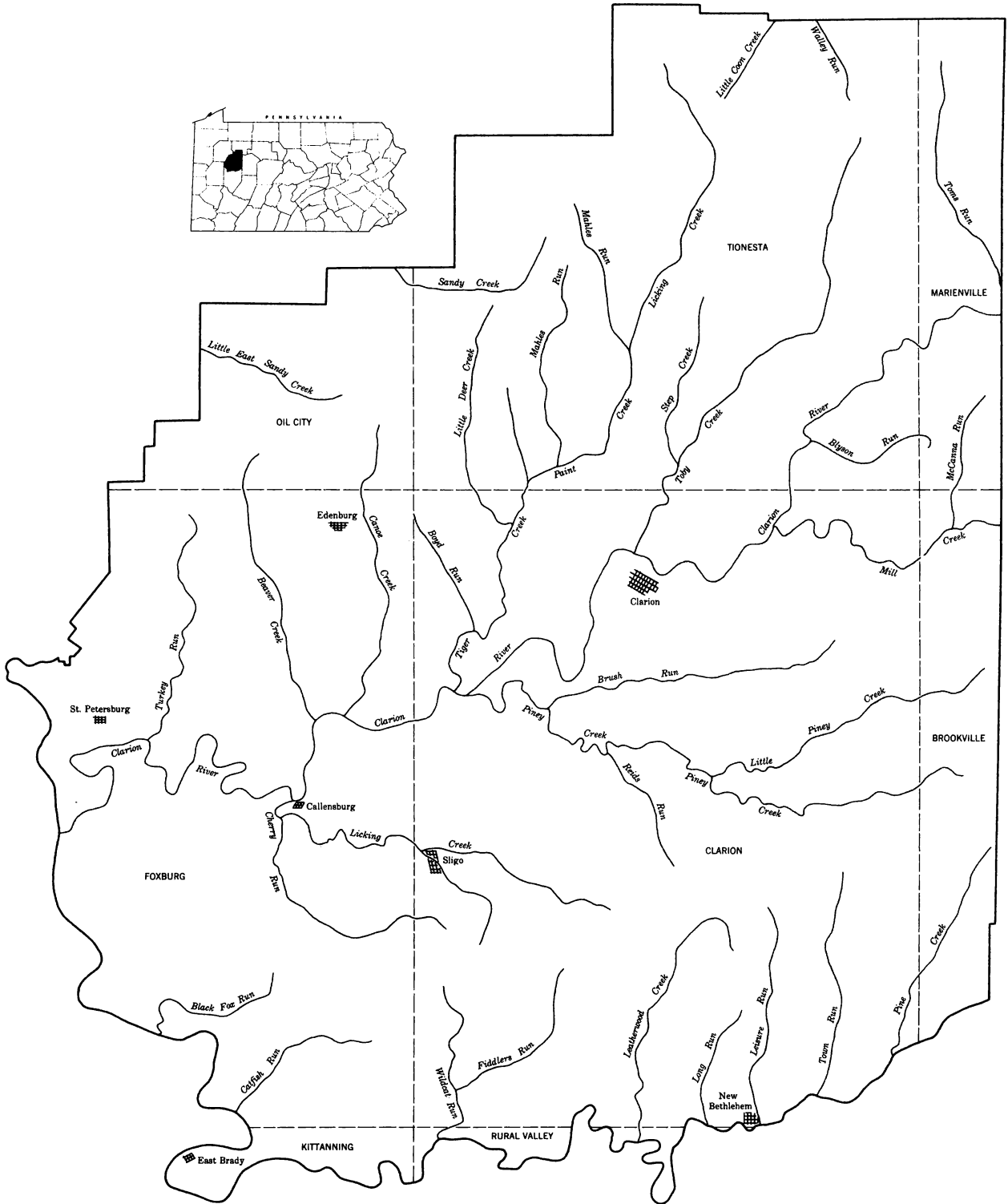


Figure 1. - Key map of Clarion County, Pa.

A base map for each bed in each quadrangle was made to the scale 1 inch equals 1,200 feet. The extent of mine workings, the location of drill holes, the bed and total coal thickness, and the outcrop of the bed were plotted on the base maps. With all available data plotted, isopach lines were drawn to limit areas of known unmined reserves in beds up to 14 inches thick, 14 to 28 inches thick, 28 to 42 inches thick, and over 42 inches thick. These areas of coal reserves also were divided into measured and indicated categories. All areas in each thickness range and in each category, mined-out areas, areas excluded from the estimate but that may contain reserves based only on geologic inference, and areas outside the outcrop were measured by planimeter on the base maps. Estimates of total reserves 14 inches and more thick for individual beds were prepared from these data.

ACKNOWLEDGMENTS

The information in this report could not have been obtained without the wholehearted cooperation of the officials of the companies and individual landowners whose property records were studied, and their cooperation and the courtesies extended are gratefully acknowledged. The advice and assistance of the Coal Resources Committees of both the National Bituminous Coal Advisory Council and American Institute of Mining and Metallurgical Engineers, members of the staffs of the Federal Geological Survey, Pennsylvania Topographic and Geologic Survey, and Pennsylvania Department of Mines, coal-operator associations, and consulting mining engineers are appreciated. The investigation was under the general supervision of the chief, Mining and Preparation Section, Branch of Bituminous Coal, Division of Solid Fuels Technology, Region V, Bureau of Mines, and the cooperation of the staff assigned to this study is acknowledged.

PREMISES AND DEFINITIONS OF TERMS USED

An estimate of coal reserves is the opinion of an individual or group of individuals based on certain premises and limitations adopted for that estimate. Therefore, to make a comparison between estimates, it is necessary to compare not only the final results but also the premises on which the estimates are based. The definitions "measured" coal and "indicated" coal used in this report have been agreed upon by the Bureau of Mines and the Federal Geological Survey. The premises and definitions of terms follow:

Coking coal. - All bituminous coals in the Appalachian region are potentially coking; therefore, until the carbonization tests in part (3) of the study have been completed to determine the coking quality of the coals, all known reserves of coal in the county are included as coking coal. This should not be construed to mean that all coals included in this report are suitable for the manufacture of metallurgical coke according to present-day standards. However, the general trend is toward the use of lower quality coals for metallurgical purposes.

Unit area. - The unit area used in estimating reserves is the 5-minute rectangle of the topographic quadrangle. The estimates for the nine 5-minute rectangles of a quadrangle are combined on a county basis.

Bed-thickness range. - Reserves in each coal bed are tabulated in bed-thickness ranges, as follows:

14 to 28 inches.

28 to 42 inches.

42 inches and more.

These measurements represent total bed thickness, including all coal and partings in the bed. If the top or bottom bench of a coal bed is separated from the remainder of the bed by a parting of equal or greater thickness and usually is not mined, such bench and partings are omitted in determining the bed thickness.

Measured coal. - Measured coal is coal for which tonnage is computed from dimensions revealed in outcrops, mine workings, and drill holes. The points of observation and measurement are so closely spaced and the thickness and extent of the coal are so well defined that the computed tonnage is judged to be within 20 percent or less of the true tonnage. Although the spacing of the points of observation necessary to demonstrate continuity of coal will vary in different regions according to the habit of the coal beds, the points of observation are, in general, about one-half mile apart. The outer limit of a block of measured coal, therefore, shall be about one-fourth mile from the last point of positive information (that is, half the distance between points of observation).

Where no data are available other than measurements along the outcrop but where the continuity of the outcrop is measured in miles and suggests the presence of coal at great distances in from the outcrop, a smooth line drawn roughly one-half mile in from the outcrop shall be used to mark the limit under cover of a block of coal that can also be classed as measured.

Indicated coal. - Indicated coal is coal for which tonnage is computed partly from specific measurements and partly from projection of visible data for a reasonable distance on geologic evidence. In general, the points of observation are about 1 mile apart but may be as much as 1-1/2 miles for beds of known geologic continuity. For example, if drilling on 1/2-mile centers has proved a block of measured coal of fairly uniform thickness and extent, the area of measured coal, according to the judgment of the estimator, is larger than the actual area of drilling by as much as one-fourth mile on all sides. If, from geologic evidence, the bed is believed to have greater continuity, the area of measured coal is surrounded by a belt of indicated coal, which, according to the judgment of the appraiser, may be as much as 1-1/2 miles wide.

Where no data are available other than measurements along the outcrops but where the continuity of the outcrop is measured in miles and suggests the presence of coal at great distances in from the outcrop, two lines drawn roughly parallel to the outcrop, one one-half mile in from the outcrop and one 2 miles in from the outcrop, define a block of coal that may be classed as indicated.

Inferred coal. - As no estimate of reserves has been made from geologic inference alone, inferred coal is not included in this report. This category often contains large reserves.

Areas excluded from estimate. - In each bed are areas in which coal may be present but for which reserves have not been estimated. There are too few or no bed sections from drill holes, mine workings, or coal outcrops in the area on which to base estimates that would qualify under the definitions of "measured" or "indicated" reserves. These areas may contain additional geologically inferred reserves, and, thus, correspond approximately to areas of inferred reserves.

Overburden. - All known reserves in Clarion County are under less than 2,000 feet of overburden.

Thickness of coal. - In computing the volume of reserves in each thickness category for each bed, the total thickness of clean coal in the bed section is used.

If the top or bottom bench of coal described under definition of "bed-thickness range" usually is not mined, the thickness of the bench is not used to compute the volume of reserves. A weighted average thickness in each thickness category for each 5-minute rectangle of each bed is computed.

Weight of coal. - Estimated coal in place is based on 1,800 short tons per acre-foot.

Percentage of recovery. - The weighted average percentage of recovery is computed for each bed in each quadrangle. The total number of tons of coal produced from each mine is obtained from either the mine operator or the published reports of the Pennsylvania Department of Mines. An estimate is made of the tons of coal originally in place in the mined-out area of each mine. The percentage of recovery for each mine is the ratio of the total number of tons produced from a mine (to January 1, 1952, the date of this estimate) to the total tons originally in place in the mined-out area. The weighted average percentage of recovery for all mines in the same bed in a quadrangle is the percentage of recovery used in calculating recoverable reserves for that bed in the quadrangle.

All coal remaining for any reason within the mined-out area of a mine is considered a loss. No distinction is made between avoidable or unavoidable losses. Included in these losses is some coal considered too thin to mine, also coal that legally is required to be left unmined, such as coal under some highways, railroads, and rivers; coal left to protect gas and oil wells; and coal left in barrier pillars between mines and adjacent to property boundaries.

Recoverable reserves. - The recoverable reserves are estimated tons of unmined coal in beds 28 inches and more thick, as of the date of the estimate, multiplied by the percentage of recovery. Twenty-eight inches is about the minimum thickness of coal being mined mechanically (hand-loaded conveyors). Some areas in some of the beds in this county may not be considered economically minable at present because of conditions considered adverse today.

COAL RESERVES

Detailed estimates of known measured and indicated reserves of coal in Clarion County, Pa., as of January 1, 1952, are given in tables 1 to 7, inclusive.

Table 8 is a recapitulation of reserves by beds in Clarion County. Reserves in all beds 14 inches and more thick are estimated at 1,209,583,000 short tons as of January 1, 1952. Of this total, 790,455,000 short tons is in beds 28 inches and more thick.

The weighted average percentage of recovery for each bed by quadrangles, or the estimated percentage recovery when no production records are available, is shown in column 19 of tables 1 to 7, inclusive. The highest recovery is that estimated at 64 percent for the Upper Freeport in the Clarion and Brookville quadrangle and the Lower Kittanning bed in the Foxburg quadrangle. It is believed that in these areas much coal will be recovered by strip mining. The lowest recovery is 38 percent, which has been estimated for the Brookville bed in the Clarion quadrangle. The recovery is estimated lower than usual because of poor mining conditions, especially poor roof.

The weighted average recovery for all beds is 54.2 percent. Based on this recovery, the known recoverable reserves 28 inches and more thick in Clarion County are estimated at 428,276,000 short tons as of January 1, 1952.

CLARION COUNTY

TABLE 1. - RESERVES IN UPPER FREEPORT BED, January 1, 1952

Quadrangle	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
	Area of quadrangle in county, acres	Areas excluded from estimate, <u>1/</u> acres	Area outside outcrop, acres	Underlain by coal 0" to 14" thick, acres	Coal over 14" thick, in place originally, acres	Mined out, acres	Coal over 14" thick remaining, acres	Measured Indicated	Estimated coal reserves, in tons of 2,000 lb.						Total reserves, in tons of 2,000 lb.				Percentage recoverable, including all mining losses	Estimated recoverable reserves 28" and more thick, thousands of tons
									14" to 28" thick		28" to 42" thick		Over 42" thick		14" and more thick		28" and more thick			
									Acres	Thousands of tons	Acres	Thousands of tons	Acres	Thousands of tons	Acres	Thousands of tons	Acres	Thousands of tons		
Clarion	140,719	199	138,839	-	1,681	1,192	489	Measured Indicated	-	-	85	395	404	3,018	489	3,413	489	3,413		2,184
								Total	-	-	85	395	404	3,018	489	3,413	489	3,413	<u>2/</u> 64.0	2,184
Foxburg	90,820	1,587	85,943	-	3,290	1,173	2,117	Measured Indicated	440	1,198	1,260	6,863	417	3,398	2,117	11,459	1,677	10,261		5,141
								Total	440	1,198	1,260	6,863	417	3,398	2,117	11,459	1,677	10,261	50.1	5,141
Brookville	18,147	-	17,325	-	822	376	446	Measured Indicated	18	54	-	-	321	2,311	339	2,365	321	2,311		1,479
								Total	18	54	-	-	428	3,081	446	3,135	428	3,081	<u>2/</u> 64.0	1,972
Kittanning	5,104	-	4,476	-	628	312	316	Measured Indicated	211	570	43	232	26	168	280	970	69	400		200
								Total	247	667	43	232	26	168	316	1,067	69	400	50.1	200
								Measured Indicated	669	1,822	1,388	7,490	1,168	8,895	3,225	18,207	2,556	16,385		9,004
								Total	705	1,919	1,388	7,490	1,275	9,665	3,368	19,074	2,663	17,155	55.4	9,497
Total	254,790	1,786	246,583	-	6,421	3,053	3,368	Total	705	1,919	1,388	7,490	1,275	9,665	3,368	19,074	2,663	17,155	55.4	9,497

TABLE 2. - RESERVES IN LOWER FREEPORT BED, January 1, 1952

Quadrangle	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
	Area of quadrangle in county, acres	Areas excluded from estimate, <u>1/</u> acres	Area outside outcrop, acres	Underlain by coal 0" to 14" thick, acres	Coal over 14" thick, in place originally, acres	Mined out, acres	Coal over 14" thick remaining, acres	Measured Indicated	Estimated coal reserves, in tons of 2,000 lb.						Total reserves, in tons of 2,000 lb.				Percentage recoverable, including all mining losses	Estimated recoverable reserves 28" and more thick, thousands of tons
									14" to 28" thick		28" to 42" thick		Over 42" thick		14" and more thick		28" and more thick			
									Acres	Thousands of tons	Acres	Thousands of tons	Acres	Thousands of tons	Acres	Thousands of tons	Acres	Thousands of tons		
Clarion	140,719	747	136,304	-	3,668	2,673	995	Measured Indicated	391	1,466	123	717	481	4,308	995	6,491	604	5,025		2,764
								Total	391	1,466	123	717	481	4,308	995	6,491	604	5,025	<u>2/</u> 55.0	2,764
Foxburg	90,820	8,767	81,759	-	294	-	294	Measured Indicated	-	-	294	1,366	-	-	294	1,366	294	1,366		683
								Total	-	-	294	1,366	-	-	294	1,366	294	1,366	<u>2/</u> 50.0	683
Brookville	18,147	540	17,038	-	569	161	408	Measured Indicated	219	788	162	875	-	-	381	1,663	162	875		525
								Total	246	885	162	875	-	-	408	1,760	162	875	<u>2/</u> 60.0	525
								Measured Indicated	610	2,254	579	2,958	481	4,308	1,670	9,520	1,060	7,266		3,972
								Total	637	2,351	579	2,958	481	4,308	1,697	9,617	1,060	7,266	<u>2/</u> 54.7	3,972
Total	249,686	10,054	235,101	-	4,531	2,834	1,697	Total	637	2,351	579	2,958	481	4,308	1,697	9,617	1,060	7,266	<u>2/</u> 54.7	3,972

1/ No information available from core drilling, mine workings, or coal outcrops on which to base estimates of measured and indicated reserves. These areas may contain additional geologically inferred reserves.

2/ Estimated

TABLE 3. - RESERVES IN MIDDLE KITTTANNING BED, January 1, 1952

Quadrangle	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
	Area of quadrangle in county, acres	Areas excluded from estimate, 1/ acres	Area outside outcrop, acres	Underlain by coal 0" to 14" thick, acres	Coal over 14" thick, in place originally, acres	Mined out, acres	Coal over 14" thick remaining, acres	Measured Indicated	Estimated coal reserves, in tons of 2,000 lb.						Total reserves, in tons of 2,000 lb.				Percentage recoverable, including all mining losses	Estimated recoverable reserves 28" and more thick, thousands of tons
									14" to 28" thick		28" to 42" thick		Over 42" thick		14" and more thick		28" and more thick			
									Acres	Thousands of tons	Acres	Thousands of tons	Acres	Thousands of tons	Acres	Thousands of tons	Acres	Thousands of tons		
Clarion	140,719	18,643	112,271	169	9,636	153	9,483	Measured Indicated	5,080 3,124	16,712 9,971	1,052 227	4,869 1,114	-	-	6,132 3,351	21,581 11,085	1,052 227	4,869 1,114		2,240 512
								Total	8,204	26,683	1,279	5,983	-	-	9,483	32,666	1,279	5,983	2/46.0	2,752
Foxburg	90,820	23,893	63,860	211	2,856	47	2,809	Measured Indicated	1,784 -	5,405 -	1,025 -	6,150 -	-	-	2,809 -	11,555 -	1,025 -	6,150 -		2,460 -
								Total	1,784	5,405	1,025	6,150	-	-	2,809	11,555	1,025	6,150	2/40.0	2,460
Kittanning	5,104	-	3,077	2,027	-	-	-	Measured Indicated	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -		- -
								Total	-	-	-	-	-	-	-	-	-	-	-	-
Total	236,643	42,536	179,208	2,407	12,492	200	12,292	Total	9,988	32,088	2,304	12,133	-	-	12,292	44,221	2,304	12,133	2/43.0	5,212

TABLE 4. - RESERVES IN LOWER KITTTANNING BED, January 1, 1952

Quadrangle	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
	Area of quadrangle in county, acres	Areas excluded from estimate, 1/ acres	Area outside outcrop, acres	Underlain by coal 0" to 14" thick, acres	Coal over 14" thick, in place originally, acres	Mined out, acres	Coal over 14" thick remaining, acres	Measured Indicated	Estimated coal reserves, in tons of 2,000 lb.						Total reserves, in tons of 2,000 lb.				Percentage recoverable, including all mining losses	Estimated recoverable reserves 28" and more thick, thousands of tons
									14" to 28" thick		28" to 42" thick		Over 42" thick		14" and more thick		28" and more thick			
									Acres	Thousands of tons	Acres	Thousands of tons	Acres	Thousands of tons	Acres	Thousands of tons	Acres	Thousands of tons		
Clarion	140,719	311	90,269	775	49,364	11,452	37,912	Measured Indicated	3,745 7,854	13,011 27,510	20,665 5,356	105,571 27,971	292	2,328	24,702 13,210	120,910 55,481	20,957 5,356	107,899 27,971		54,597 14,153
								Total	11,599	40,521	26,021	133,542	292	2,328	37,912	176,391	26,313	135,870	50.6	68,750
Foxburg	90,820	4,599	55,138	250	30,833	9,428	21,405	Measured Indicated	2,209 217	7,346 842	17,129 -	91,266 -	1,850	13,043	21,188 217	111,655 842	18,979 -	104,309 -		66,758 -
								Total	2,426	8,188	17,129	91,266	1,850	13,043	21,405	112,497	18,979	104,309	2/64.0	66,758
Oil City	20,544	26	20,208	45	265	41	224	Measured Indicated	184 -	580 -	40 -	225 -	-	-	224 -	805 -	40 -	225 -		113 -
								Total	184	580	40	225	-	-	224	805	40	225	2/50.0	113
Tionesta	92,153	-	91,455	-	698	79	619	Measured Indicated	38 -	138 -	421 115	2,301 604	45	331	504 115	2,770 604	466 115	2,632 604		1,527 350
								Total	38	138	536	2,905	45	331	619	3,374	581	3,236	2/58.0	1,877
Marienville	16,762	1,111	14,713	-	938	3	935	Measured Indicated	41 -	111 -	574 320	3,014 1,632	-	-	615 320	3,125 1,632	574 320	3,014 1,632		1,808 979
								Total	41	111	894	4,646	-	-	935	4,757	894	4,646	2/60.0	2,787
Brookville	18,147	219	11,934	-	5,994	1,350	4,644	Measured Indicated	360 -	1,156 -	2,625 1,659	12,396 7,466	-	-	2,985 1,659	13,552 7,466	2,625 1,659	12,396 7,466		6,942 4,181
								Total	360	1,156	4,284	19,862	-	-	4,644	21,018	4,284	19,862	2/56.0	11,123
Rural Valley	3,009	-	2,568	-	441	98	343	Measured Indicated	- -	- -	296 47	1,421 226	-	-	296 47	1,421 226	296 47	1,421 226		769 122
								Total	-	-	343	1,647	-	-	343	1,647	343	1,647	54.1	891
Kittanning	5,104	-	2,486	-	2,618	2,168	450	Measured Indicated	- -	- -	45 -	203 -	405	2,612	450 -	2,815 -	450 -	2,815 -		1,523 -
								Total	-	-	45	203	405	2,612	450	2,815	450	2,815	54.1	1,523
Total	387,258	6,266	288,771	1,070	91,151	24,619	66,532	Total	14,648	50,694	49,292	254,296	2,592	18,314	66,532	323,304	51,884	272,610	56.4	153,822

1/ No information available from core drilling, mine workings, or coal outcrops on which to base estimates of measured and indicated reserves. These areas may contain additional geologically inferred reserves.

2/ Estimated

CLARION COUNTY

TABLE 5. - RESERVES IN UPPER CLARION BED, January 1, 1952

Quadrangle	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
	Area of quadrangle in county, acres	Areas excluded from estimate, <u>1</u> / acres	Area outside outcrop, acres	Underlain by coal 0" to 14" thick, acres	Coal over 14" thick, in place originally, acres	Mined out, acres	Coal over 14" thick remaining, acres	Measured Indicated	Estimated coal reserves, in tons of 2,000 lb.						Total reserves, in tons of 2,000 lb.				Percentage recoverable, including all mining losses	Estimated recoverable reserves 28" and more thick, thousands of tons
									14" to 28" thick		28" to 42" thick		Over 42" thick		14" and more thick		28" and more thick			
									Acres	Thousands of tons	Acres	Thousands of tons	Acres	Thousands of tons	Acres	Thousands of tons	Acres	Thousands of tons		
Clarion	140,719	781	55,320	67,099	17,519	498	17,021	Measured Indicated	6,854 3,275	23,381 9,962	2,879 2,347	14,234 11,878	1,666 -	11,995 -	11,399 5,622	49,610 21,840	4,545 2,347	26,229 11,878		13,901 6,295
								Total	10,129	33,343	5,226	26,112	1,666	11,995	17,021	71,450	6,892	38,107	2/53.0	20,196
Foxburg	90,820	33,345	36,967	4,950	15,558	149	15,409	Measured Indicated	5,819 1,455	19,620 4,844	7,961 -	38,109 -	174 -	1,201 -	13,954 1,455	58,930 4,844	8,135 -	39,310 -		21,227 -
								Total	7,274	24,464	7,961	38,109	174	1,201	15,409	63,774	8,135	39,310	2/54.0	21,227
Oil City	20,544	1,396	13,216	416	5,516	230	5,286	Measured Indicated	1,030 1,956	3,884 6,011	1,773 486	8,948 2,479	41 -	295 -	2,844 2,442	13,127 8,490	1,814 486	9,243 2,479		5,361 1,438
								Total	2,986	9,895	2,259	11,427	41	295	5,286	21,617	2,300	11,722	2/58.0	6,799
Tionesta	92,153	1,641	83,268	154	7,090	910	6,180	Measured Indicated	1,732 871	5,212 3,068	2,464 471	13,055 2,386	642 -	4,308 -	4,838 1,342	22,575 5,454	3,106 471	17,363 2,386		9,376 1,288
								Total	2,603	8,280	2,935	15,441	642	4,308	6,180	28,029	3,577	19,749	2/54.0	10,664
Brookville	18,147	633	8,262	6,502	2,750	137	2,613	Measured Indicated	2,333 139	7,916 354	141 -	635 -	- -	- -	2,474 139	8,551 354	141 -	635 -		318 -
								Total	2,472	8,270	141	635	-	-	2,613	8,905	141	635	2/50.0	318
Rural Valley	3,009	-	2,318	691	-	-	-	Measured Indicated	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -		- -
								Total	-	-	-	-	-	-	-	-	-	-	-	-
Kittanning	5,104	1,836	1,867	1,401	-	-	-	Measured Indicated	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -		- -
								Total	-	-	-	-	-	-	-	-	-	-	-	-
								Measured Indicated	17,768 7,696	60,013 24,239	15,218 3,304	74,981 16,743	2,523 -	17,799 -	35,509 11,000	152,793 40,982	17,741 3,304	92,780 16,743		50,183 9,021
Total	370,496	39,632	201,218	81,213	48,433	1,924	46,509	Total	25,464	84,252	18,522	91,724	2,523	17,799	46,509	193,775	21,045	109,523	2/54.1	59,204

1/ No information available from core drilling, mine workings, or coal outcrops on which to base estimates of measured and indicated reserves. These areas may contain additional geologically inferred reserves.

2/ Estimated

CLARION COUNTY

TABLE 6. - RESERVES IN LOWER CLARION BED, January 1, 1952

Quadrangle	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
	Area of quadrangle in county, acres	Areas excluded from estimate, ^{1/} acres	Area outside outcrop, acres	Underlain by coal 0" to 14" thick, acres	Coal over 14" thick, in place originally, acres	Mined out, acres	Coal over 14" thick remaining, acres	Measured Indicated	Estimated coal reserves, in tons of 2,000 lb.						Total reserves, in tons of 2,000 lb.				Percentage recoverable, including all mining losses	Estimated recoverable reserves 28" and more thick, thousands of tons
									14" to 28" thick		28" to 42" thick		Over 42" thick		14" and more thick		28" and more thick			
									Acres	Thousands of tons	Acres	Thousands of tons	Acres	Thousands of tons	Acres	Thousands of tons	Acres	Thousands of tons		
Clarion	140,719	7,818	46,659	19,920	66,322	816	65,506	Measured Indicated	4,970 39,250	14,738 89,292	13,163 5,642	66,328 26,959	2,481 -	17,975 -	20,614 44,892	99,041 116,251	15,644 5,642	84,303 26,959		43,837 14,019
								Total	44,220	104,030	18,805	93,287	2,481	17,975	65,506	215,292	21,286	111,262	2/52.0	57,856
Foxburg	90,820	10,471	34,077	517	45,755	1,529	44,226	Measured Indicated	5,257 12,943	17,148 30,773	8,284 16,432	42,741 75,298	1,310 -	9,031 -	14,851 29,375	68,920 106,071	9,594 16,432	51,772 75,298		27,439 39,908
								Total	18,200	47,921	24,716	118,039	1,310	9,031	44,226	174,991	26,026	127,070	2/53.0	67,347
Oil City	20,544	374	11,721	266	8,183	442	7,741	Measured Indicated	2,179 2,316	8,205 9,033	1,878 1,211	8,758 5,450	157 -	1,130 -	4,214 3,527	18,093 14,483	2,035 1,211	9,888 5,450		5,735 3,161
								Total	4,495	17,238	3,089	14,208	157	1,130	7,741	32,576	3,246	15,338	2/58.0	8,896
Tionesta	92,153	25	74,914	5,221	11,993	4,013	7,980	Measured Indicated	2,456 971	8,487 2,783	3,773 -	19,104 -	710 70	5,409 567	6,939 1,041	33,000 3,350	4,483 70	24,513 567		13,972 323
								Total	3,427	11,270	3,773	19,104	780	5,976	7,980	36,350	4,553	25,080	2/57.0	14,295
Marienville	16,762	4,348	11,307	236	871	10	861	Measured Indicated	516 -	1,627 -	345 -	1,857 -	- -	- -	861 -	3,484 -	345 -	1,857 -		1,114 -
								Total	516	1,627	345	1,857	-	-	861	3,484	345	1,857	2/60.0	1,114
Brookville	18,147	781	6,657	804	9,905	349	9,556	Measured Indicated	2,563 3,752	8,612 12,266	2,987 241	15,348 1,301	13 -	113 -	5,563 3,993	24,073 13,567	3,000 241	15,461 1,301		8,040 676
								Total	6,315	20,878	3,228	16,649	13	113	9,556	37,640	3,241	16,762	2/52.0	8,716
Rural Valley	3,009	-	2,169	-	840	2	838	Measured Indicated	41 790	105 1,659	- 7	- 29	- -	- -	41 797	105 1,688	- 7	- 29		- 15
								Total	831	1,764	7	29	-	-	838	1,793	7	29	2/50.0	15
Kittanning	5,104	1,876	1,550	-	1,678	1	1,677	Measured Indicated	128 1,549	326 3,950	- -	- -	- -	- -	128 1,549	326 3,950	- -	- -		- -
								Total	1,677	4,276	-	-	-	-	1,677	4,276	-	-	-	-
Total	387,258	25,693	189,054	26,964	145,547	7,162	138,385	Measured Indicated	18,110 61,571	59,248 149,756	30,430 23,533	154,136 109,037	4,671 70	33,658 567	53,211 85,174	247,042 259,360	35,101 23,603	187,794 109,604		100,137 58,102
								Total	79,681	209,004	53,963	263,173	4,741	34,225	138,385	506,402	58,704	297,398	2/53.2	158,239

^{1/} No information available from core drilling, mine workings, or coal outcrops on which to base estimates of measured and indicated reserves. These areas may contain additional geologically inferred reserves.

^{2/} Estimated

CLARION COUNTY

TABLE 7. - RESERVES IN BROOKVILLE BED, January 1, 1952

Quadrangle	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	
	Area of quadrangle in county, acres	Areas excluded from estimate, ^{1/} acres	Area outside outcrop, acres	Underlain by coal 0" to 14" thick, acres	Coal over 14" thick, in place originally, acres	Mined out, acres	Coal over 14" thick remaining, acres	Measured Indicated	Estimated coal reserves, in tons of 2,000 lb.						Total reserves, in tons of 2,000 lb.				Percentage recoverable, including all mining losses	Estimated recoverable reserves 28" and more thick, thousands of tons	
									14" to 28" thick		28" to 42" thick		Over 42" thick		14" and more thick		28" and more thick				
									Acres	Thousands of tons	Acres	Thousands of tons	Acres	Thousands of tons	Acres	Thousands of tons	Acres	Thousands of tons			
Clarion	140,719	97,230	26,825	7,682	8,982	-	8,982	Measured	2,579	7,867	3,421	17,471	209	2,382	6,209	27,720	3,630	19,853		7,544	
								Indicated	1,850	5,550	325	1,414	598	3,947	2,773	10,911	923	5,361		2/38.0	2,037
								Total	4,429	13,417	3,746	18,885	807	6,329	8,982	38,631	4,553	25,214			9,581
Oil City	20,544	16,425	2,623	-	1,496	-	1,496	Measured	-	-	-	-	-	-	-	-	-	-	-		-
								Indicated	1,496	4,937	-	-	-	-	-	1,496	4,937	-	-		-
								Total	1,496	4,937	-	-	-	-	1,496	4,937	-	-		-	
Tionesta	92,153	73,468	16,341	405	1,939	-	1,939	Measured	812	2,206	60	360	-	-	872	2,566	60	360		180	
								Indicated	1,067	2,881	-	-	-	-	1,067	2,881	-	-		2/50.0	-
								Total	1,879	5,087	60	360	-	-	1,939	5,447	60	360			180
Marienville	16,762	11,530	4,499	-	733	-	733	Measured	324	972	409	2,454	-	-	733	3,426	409	2,454		1,227	
								Indicated	-	-	-	-	-	-	-	-	-	-		-	-
								Total	324	972	409	2,454	-	-	733	3,426	409	2,454	2/50.0	1,227	
Brookville	18,147	751	3,708	1,791	11,897	224	11,673	Measured	1,026	3,341	2,238	12,114	1,994	16,818	5,258	32,273	4,232	28,932		17,070	
								Indicated	3,575	11,066	2,092	10,766	748	6,644	6,415	28,476	2,840	17,410		2/59.0	10,272
								Total	4,601	14,407	4,330	22,880	2,742	23,462	11,673	60,749	7,072	46,342			27,342
Total	288,325	199,404	53,996	9,878	25,047	224	24,823	Measured	4,741	14,386	6,128	32,399	2,203	19,200	13,072	65,985	8,331	51,599		26,021	
								Indicated	7,988	24,434	2,417	12,180	1,349	10,591	11,251	47,205	3,763	22,771		2/51.5	12,309
								Total	12,729	38,820	8,545	44,579	3,549	29,791	24,823	113,190	12,094	74,370			38,330

^{1/} No information available from core drilling, mine workings, or coal outcrops on which to base estimates of measured and indicated reserves. These areas may contain additional geologically inferred reserves.

^{2/} Estimated

TABLE 8. - Recapitulation of reserves, Clarion County, Pa., January 1, 1952

Bed	Thousands of tons		Recoverable ^{1/}	
	In beds 14 inches and more thick	In beds 28 inches and more thick	Percentage	Thousands of tons
Upper Freeport	19,074	17,155	55.4	9,497
Lower Freeport	9,617	7,266	2/54.7	3,972
Middle Kittanning	44,221	12,133	2/43.0	5,212
Lower Kittanning	323,304	272,610	56.4	153,822
Upper Clarion	193,775	109,523	2/54.1	59,204
Lower Clarion	506,402	297,398	2/53.2	158,239
Brookville	113,190	74,370	2/51.5	38,330
Total	1,209,583	790,455	54.2	428,276

Estimates of the coal reserves were made by Reese and Sisler^{5/} in 1922 for Clarion County. This estimate was based on 18 inches minimum thickness, 1,687.5 short tons per acre-foot of coal in place, and a recovery of 64 percent. Ashley^{6/} revised the Reese-Sisler estimates to bring them to the end of 1942. The revisions were based on studies made after 1922, which were assumed to be characteristic of the bituminous-coal field of Pennsylvania as a whole. The previous estimates are compared with the Bureau of Mines estimate in table 9.

TABLE 9. - Comparison of estimates of reserves, Clarion County, Pa.

Estimate made by	Reese and Sisler 1922	Ashley 1942	Bureau of Mines 1952
Year made			
Minimum bed thickness of reserves	18	12	14
Total bed area of reserves,	501,888	501,888	293,606
Total remaining reserves,	1,983	2,165	1,210
Minimum bed thickness of recoverable reserves,	18	24	28
Recoverable reserves as of date of estimate...millions of tons	1,262	710	428
Production of Clarion County from year of estimate to Jan. 1, 1952	61	33	-
Remaining recoverable reserves, Jan. 1, 1952, millions of tons	1,201	677	428

^{1/} Used Reese and Sisler's area of reserves.

^{2/} In addition, are areas that may contain geologically inferred reserves (column 2, tables 1 to 7, inclusive).

^{3/} Original deposit less mined out and lost.

^{5/} Reese, J. F., and Sisler, J. D., Bituminous-Coal Fields of Pennsylvania. Coal Resources: Pennsylvania Geol. Survey Bull. M-6, pt. 3, 1928, 153 pp.

^{6/} Ashley, G. H., Pennsylvania's Mineral heritage. Part 2. Mineral Resources: Commonwealth of Pennsylvania, Dept. of Internal Affairs, 1944, pp. 81-83.

COAL BEDS

The coal beds in Clarion County in which reserves have been estimated are, in descending stratigraphic order:

Upper Freeport
 Lower Freeport
 Middle Kittanning
 Lower Kittanning
 Upper Clarion
 Lower Clarion
 Brookville

All of these beds are in the Allegheny group of the Pennsylvanian system.^{7/}

A map has been prepared for each coal bed for which estimates have been made. (See figs. 2 to 8, inclusive.) The characteristics of the mapped coal beds are shown by bed sections taken from diamond-drill logs, mine selections, and outcrop sections. Every bed thickness given is within the area of recoverable reserves 28 inches and more thick (black areas on the maps). They have been selected to show bed characteristics throughout the areas and to indicate the irregularity of the beds.

Descriptions of the coal beds that have been mapped and the selected bed sections follows:

Upper Freeport Bed

(See fig. 2 and table 1)

The Upper Freeport reserves are in the hill tops in the southern part of the county. The bed ranges in thickness from 28 to 96 inches. Sections of the bed in areas of reserves were not obtainable as the mines were closed many years ago. The highwalls of the strip mines had fallen and covered the coal. Only total thickness measurements were obtainable from old mine maps.

Lower Freeport Bed

(See fig. 3 and table 2)

The Lower Freeport bed usually is thin and impure. All of the mining that has been done in this bed was in the southeastern part of the county. Like the Upper Freeport, there are small areas where the bed is thick and at one place in the southwestern part of the county the upper and the lower bench of the bed each measured 24 inches, but they were separated by 24 inches of shale. Most bed measurements were obtained from old mine maps but none gave the amount nor the location of the partings in the bed.

^{7/} Reese, J. F., and Sisler, J. D., Bituminous-Coal Fields of Pennsylvania.
 Coal Analyses: Pennsylvania Geol. Survey Bull. M-6, pt. 4, 1928, p. 6.

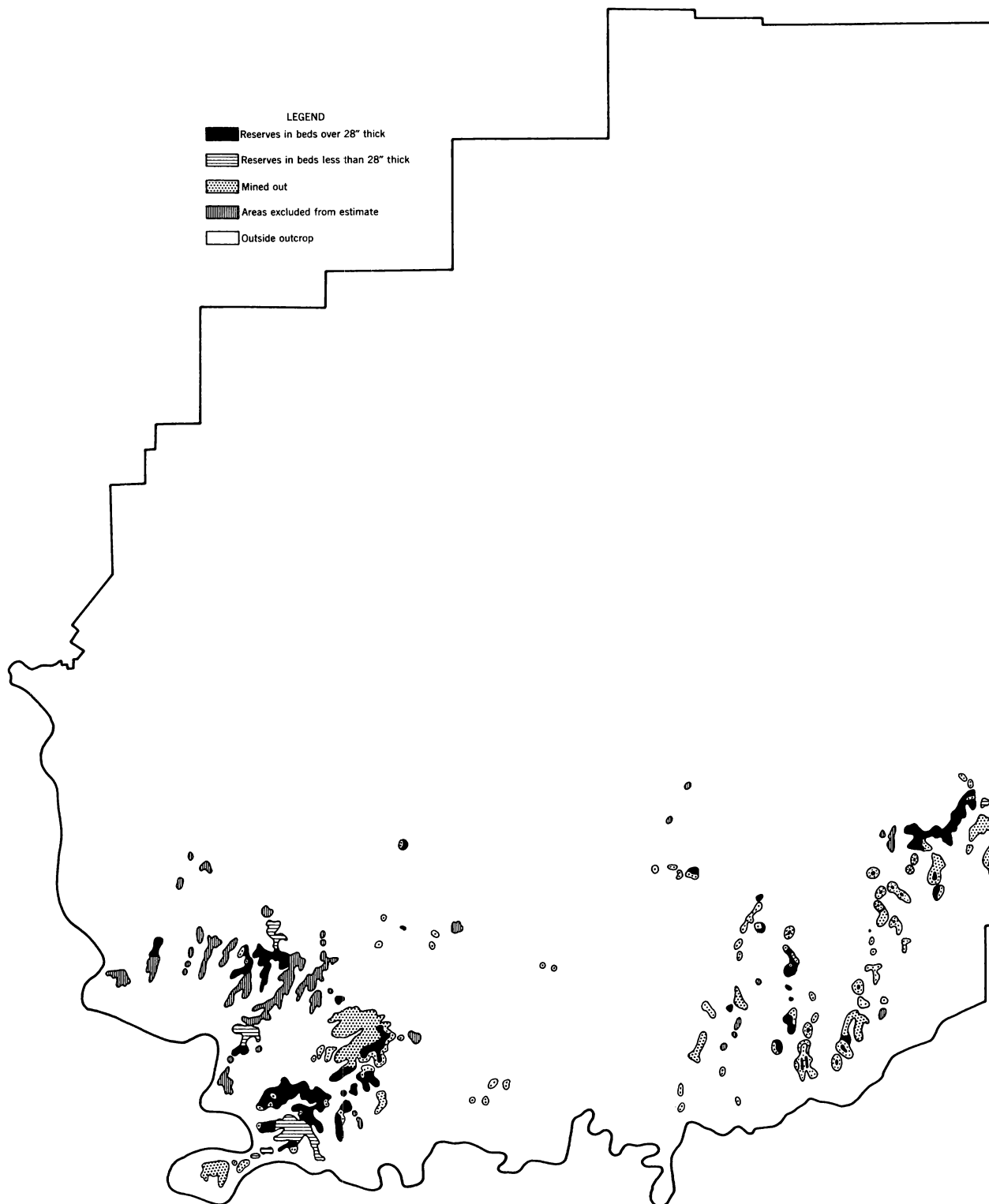


Figure 2. - Upper Freeport bed, Clarion County, Pa., January 1, 1952.

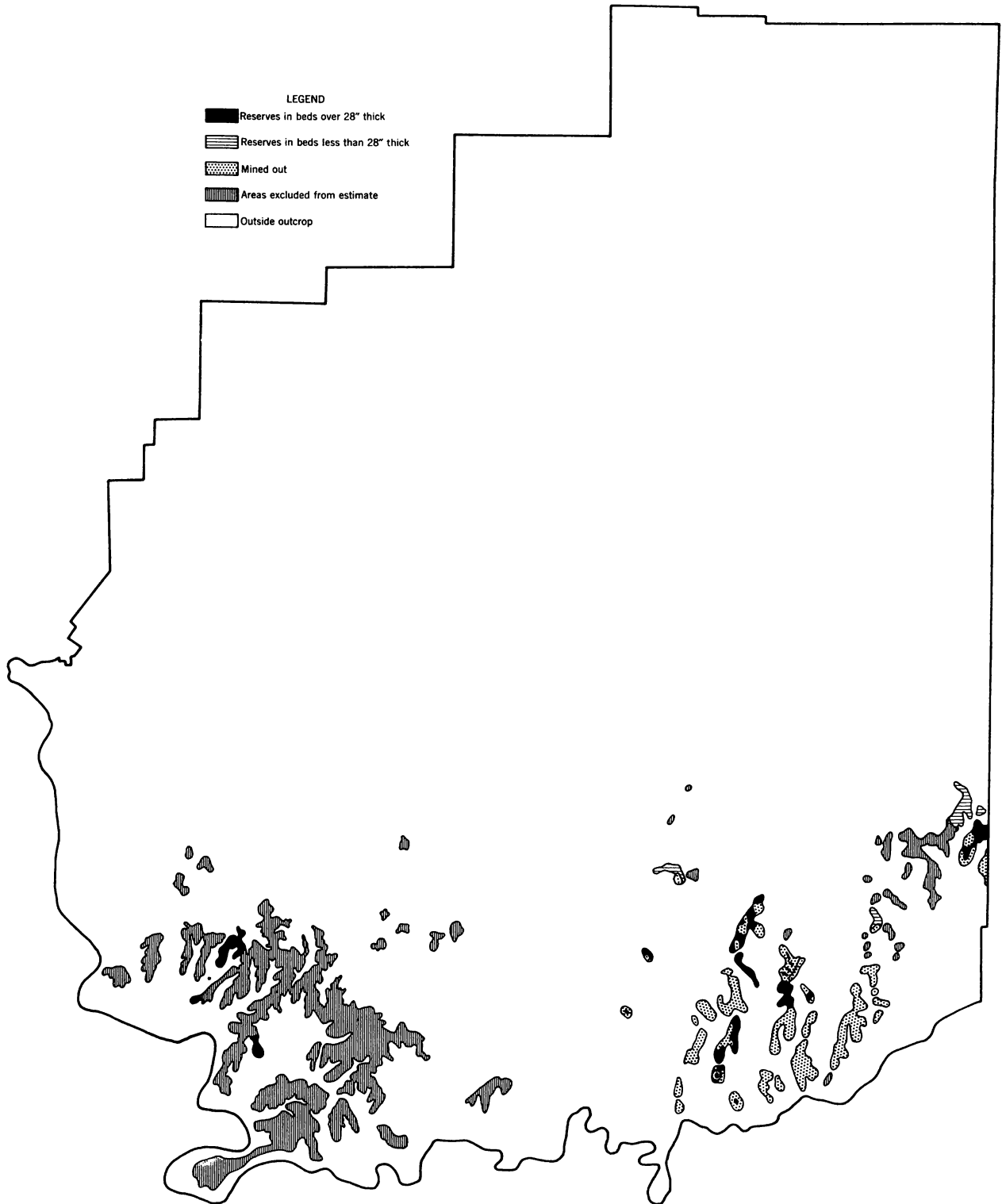


Figure 3. - Lower Freeport bed, Clarion County, Pa., January 1, 1952.

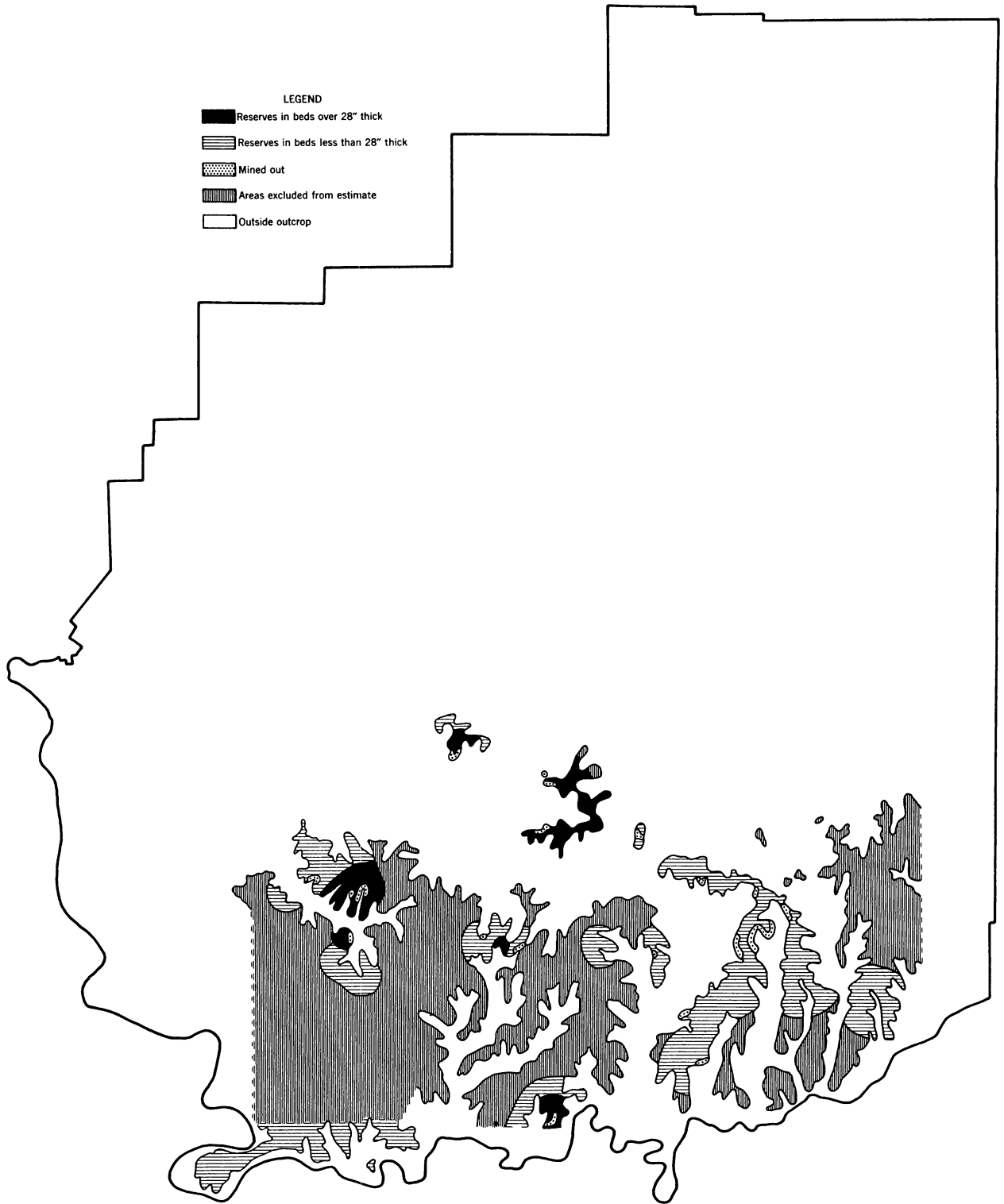


Figure 4. - Middle Kittanning bed, Clarion County, Pa., January 1, 1952.

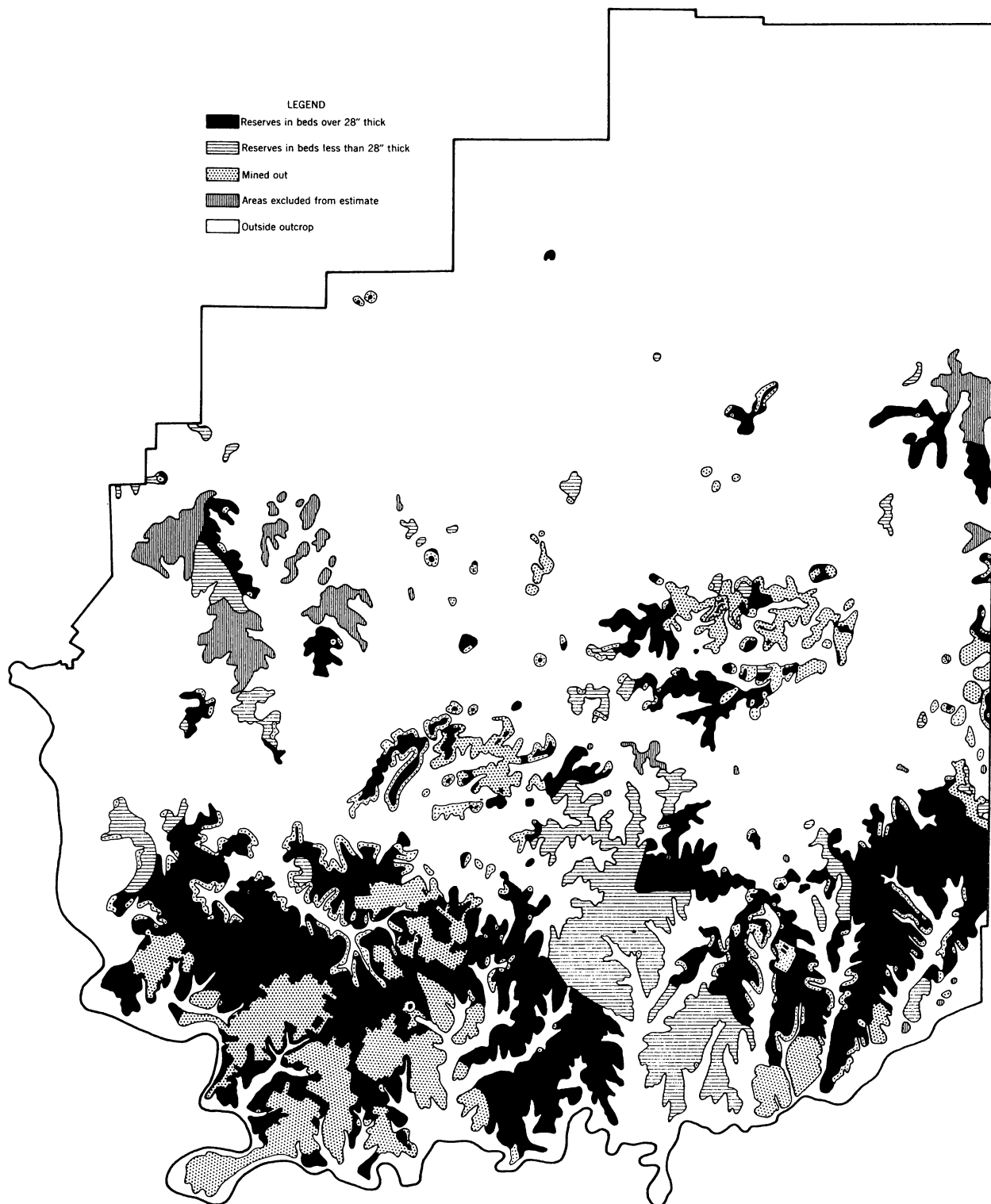


Figure 5. - Lower Kittanning bed, Clarion County, Pa., January 1, 1952.

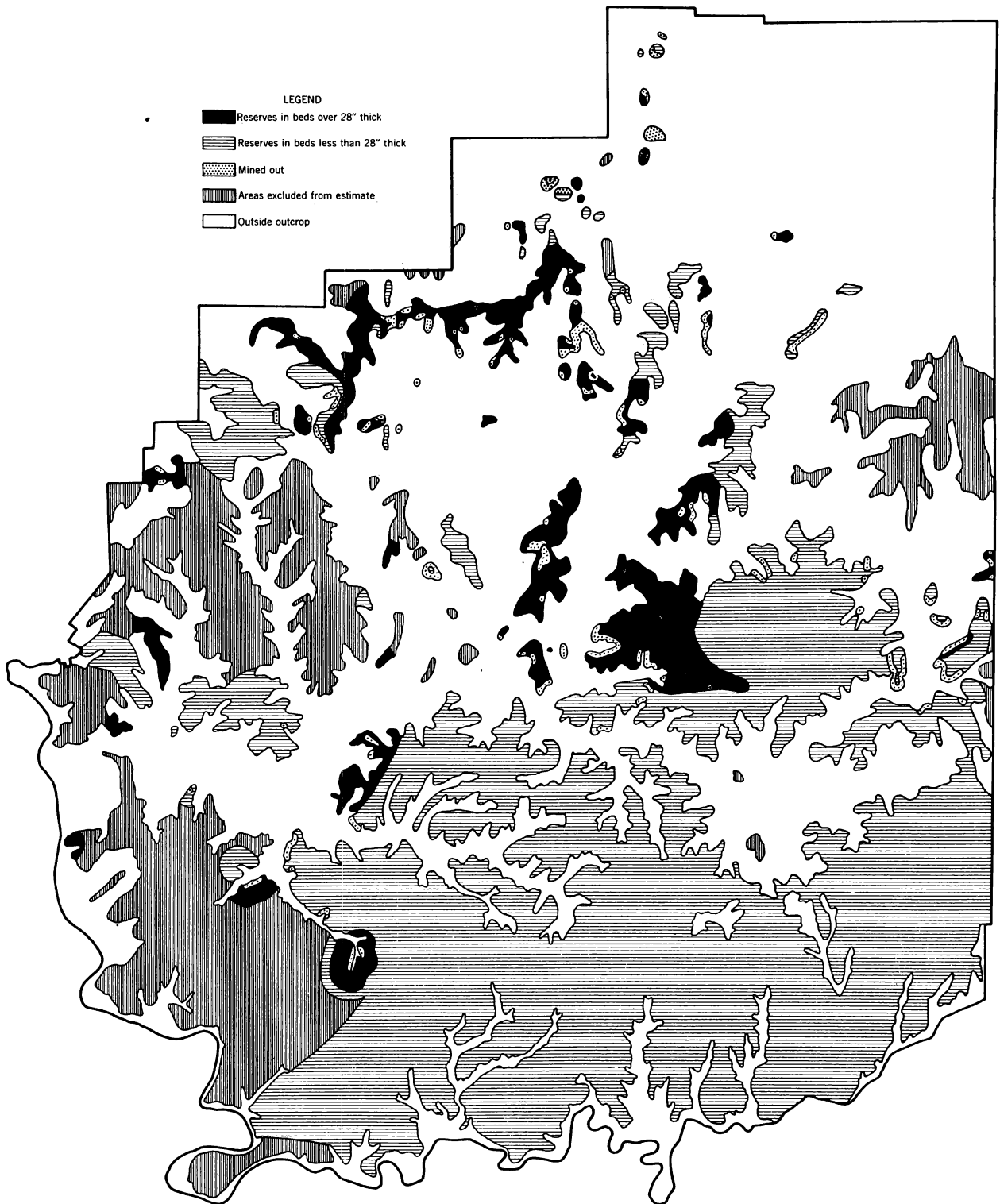


Figure 6. - Upper Clarion bed, Clarion County, Pa., January 1, 1952.

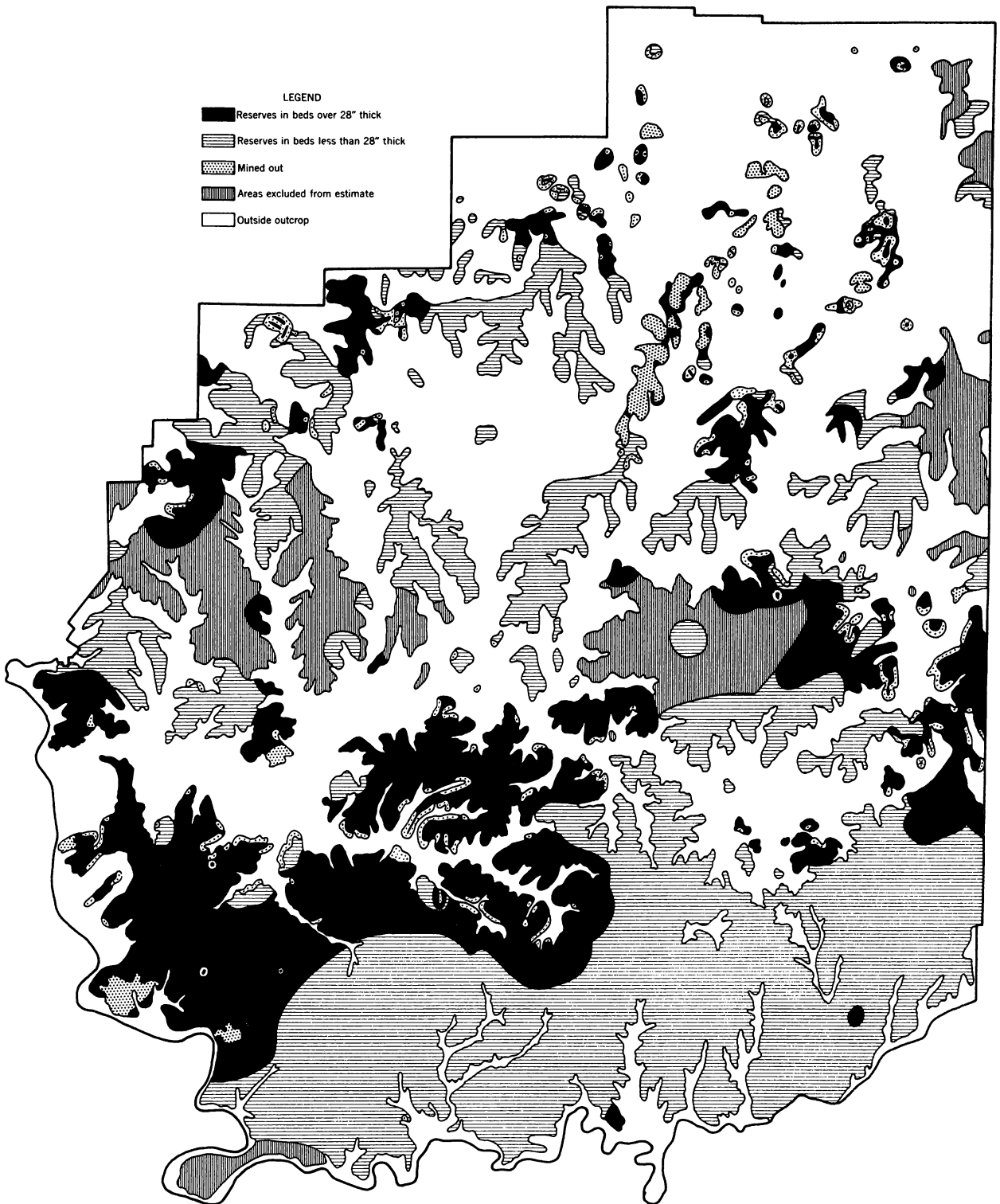


Figure 7. - Lower Clarion bed, Clarion County, Pa., January 1, 1952.

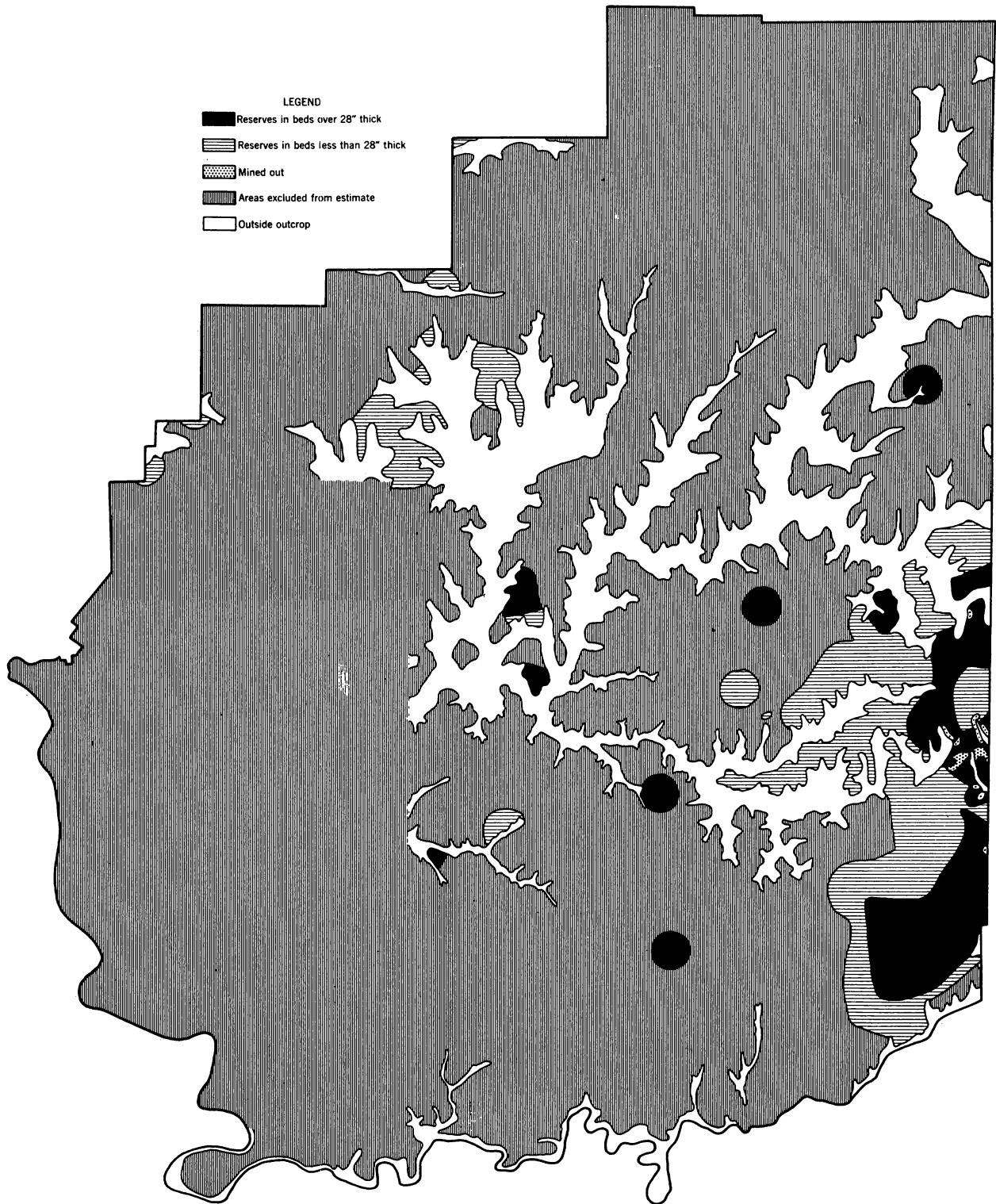


Figure 8. - Brookville bed, Clarion County, Pa., January 1, 1952.

Middle Kittanning Bed

(See fig. 4 and table 3)

Although some recoverable reserves are listed in the estimate of reserves, most of the Middle Kittanning coal is thin. Very little mining has been done in it, and the outcrop of the bed is difficult to locate in the southwestern part of the county. Sections of the bed in the reserve areas were unobtainable, as no mines were in operation, and the coal in the highwalls of the strip mines had been covered by slides.

Lower Kittanning Bed

(See fig. 5 and table 4)

This bed is the most important bed in the county from the standpoint of production. Probably more coal has been mined from it than from all other beds in the county combined. The Lower Kittanning bed probably is the most uniform bed in thickness in the county, although the average is about 33 inches. Sections of the bed in areas of remaining recoverable reserves follow:

Southwestern Part of County

<u>Material</u>	<u>Inches</u>	<u>Material</u>	<u>Inches</u>
COAL	8	COAL	<u>36</u>
Parting	3/4	Thickness	36
COAL	<u>24</u>	COAL	<u>34</u>
Thickness	32-3/4	Thickness	34
COAL	11	COAL	6-1/2
Parting	1/2	Parting	1-1/4
COAL	<u>18</u>	COAL	<u>24</u>
Thickness	29-1/2	Thickness	31-3/4
COAL	<u>38</u>		
Thickness	38		

Upper Clarion Bed

(See fig. 6 and table 5)

The Upper Clarion bed probably is the upper bench of the Clarion bed. It has been mined locally, but the extreme irregularities in thickness and the impure quality of the coal are not conducive to extensive mining. Sections of the bed in areas of reserves follow:

Southwestern Part of County

<u>Material</u>	<u>Inches</u>	<u>Material</u>	<u>Inches</u>
COAL	5-1/2	COAL	16
Parting	1/2	Parting	1/2
COAL	33-1/2	COAL	<u>11-1/2</u>
Parting	1/2	Thickness	28
COAL	2		
Parting	2		
COAL	<u>7-1/4</u>		
Thickness	51-1/4		

Central Part of County

<u>Material</u>	<u>Inches</u>	<u>Material</u>	<u>Inches</u>
COAL	7	Bone	7
Parting	1-1/2	COAL	31-3/4
COAL	16-1/2	Parting	1
Parting	1/4	COAL	<u>2-1/2</u>
COAL	10-1/2	Thickness	42-1/4
Parting	3-1/2		
COAL	<u>2</u>	COAL	40
Thickness	41-1/4	Parting	2-1/2
		COAL	<u>4</u>
		Thickness	46-1/2

There were no sections measured in the reserves in the northern part of the county.

Lower Clarion Bed

(See fig. 7 and table 6)

This bed has the largest reserve of recoverable coal in Clarion County, but, like the Upper Clarion, there is not extensive mining in it. Usually it is multi-bedded, with 3 partings. Some of the thickness measurements were taken from drill-hole logs, and these measurements did not show the thickness or the location of the partings. In these instances it is not certain that partings were not in the coal.

Sections of the bed in areas of reserves follow:

Southwestern Part of County

<u>Material</u>	<u>Inches</u>	<u>Material</u>	<u>Inches</u>
Bone	4	COAL	9
COAL	12	Parting	1/2
Shale	1	COAL	29
COAL	29	Parting	1
Parting	1	COAL	<u>6</u>
COAL	<u>2</u>	Thickness	45-1/2
Thickness	49		

Southwestern Part of County (Con.)

<u>Material</u>	<u>Inches</u>	<u>Material</u>	<u>Inches</u>
COAL	8	COAL	10
Parting	1	Parting	1/2
COAL	23-1/2	COAL	30
Parting	2	Bone	3
COAL	4	COAL	<u>6</u>
Parting	1	Thickness	49-1/2
COAL	<u>5</u>	COAL	10
Thickness	44-1/2	Parting	1/2
COAL	35	COAL	<u>23-1/2</u>
Bone	7	Thickness	34
COAL	<u>6</u>		
Thickness	48		

Central Part of County

<u>Material</u>	<u>Inches</u>	<u>Material</u>	<u>Inches</u>
COAL	<u>32</u>	COAL	<u>36</u>
Thickness	32	Thickness	36
COAL	7		
Parting	1/2		
COAL	12		
Parting	1		
COAL	<u>8</u>		
Thickness	28-1/2		

Eastern Part of County

<u>Material</u>	<u>Inches</u>	<u>Material</u>	<u>Inches</u>
COAL	10	COAL	30
Sulfur	5	Parting	5
COAL	9	COAL	5
Parting	4	Parting	6
COAL	12	COAL	<u>5</u>
Sulfur	3	Thickness	51
COAL	<u>5</u>	COAL	19
Thickness	48	Parting	3
COAL	27	COAL	8-1/2
Parting	2	Parting	2
COAL	<u>11</u>	COAL	<u>2-1/2</u>
Thickness	40	Thickness	35
COAL	<u>30</u>	COAL	<u>33</u>
Thickness	30	Thickness	33
COAL	<u>40</u>	COAL	<u>36</u>
Thickness	40	Thickness	36

Brookville Bed

(See fig. 8 and table 7)

The Brookville bed contains important reserves of coal, but so long as better quality coal is plentiful, there will be no great demand for this coal. The reserves are in the eastern part of the county where the bed thickness ranges up to 76 inches.

Sections of the bed in the areas of reserves follow:

Eastern Part of County

<u>Material</u>	<u>Inches</u>	<u>Material</u>	<u>Inches</u>
COAL	6	COAL	16
Bone	2	Parting	4
COAL	11	COAL	18
Bone	3	Parting	5
COAL	<u>38</u>	COAL	<u>33</u>
Thickness	60	Thickness	76
COAL	8	COAL	11
Bone	3	Bone	2
COAL	29	COAL	27
Bone	2	Bone	3
COAL	<u>2</u>	COAL	<u>2</u>
Thickness	44	Thickness	45

ANALYSES OF CLARION COUNTY COALS

The chemical analyses in table 10 are arranged stratigraphically for major producing beds, and alphabetically to the nearest town to the mine. They represent mine and run-of-mine tippie samples, and in most instances were previously reported in Bureau of Mines publications as indicated by footnotes to table 10. The coal, classified according to rank, belongs in the high-volatile A bituminous group.

COKING PROPERTIES OF CLARION COUNTY COALS

Clarion County coals rank as high-volatile A bituminous and are classified as coking. They have never been important in the metallurgical industries because they generally contain more sulfur than coals from most Pennsylvania fields. However, as preparation methods are improved and the reserves of low-sulfur coals are depleted, coals higher in sulfur will be mined for carbonization. Lowry^{8/} has stated that, with better control of certain furnace variables, the increasing sulfur content of remaining reserves of coking coals may not necessarily increase the cost of producing pig iron of acceptable quality.

^{8/} Lowry, H. H., Coke Ash and Coke Sulfur in the Blast Furnace: Ind. Eng. Chem., vol. 41, 1949, p. 502; Carnegie Inst. Tech., Coal Res. Lab., Contr. 155, 1949, 21 pp.

TABLE 10. - Analyses of Clarion County, Pa., coals

Location	Bed	Kind of sample ^{1/}	As-received Moisture	Dry basis				
				Vol. Mat.	F.C.	Ash	Sul.	B.t.u.
1	2	3	4	5	6	7	8	9
Hawthorne	Upper Freeport	T ^{2/}	4.0	35.5	53.6	10.9	1.4	13,440
New Bethlehem	do.	T ^{3/}	4.0	34.9	52.3	12.8	1.9	13,070
Limestone	Lower Freeport	T ^{4/}	4.1	37.2	54.3	8.5	2.8	13,740
Kaylor	Lower Kittanning	T ^{2/}	2.8	39.4	52.7	7.9	3.1	13,870
Limestone	do.	T ^{5/}	3.0	35.4	54.1	10.5	1.1	13,470
Do.	do.	T ^{4/}	2.8	37.5	52.6	9.9	2.7	13,600
Do.	do.	TS ^{4/}	5.5	36.0	53.1	10.9	1.2	13,140
Do.	do.	TS ^{2/}	2.7	37.1	54.3	8.6	.8	13,840
Do.	do.	T ^{2/}	3.0	37.4	52.4	10.2	2.1	13,550
Rimersburg	do.	T ^{2/}	3.0	38.7	50.9	10.4	4.3	13,480
Do.	do.	TS ^{4/}	3.0	39.5	50.3	10.2	3.7	13,530
Sligo	do.	TS ^{6/}	3.4	39.2	49.0	11.8	3.8	13,170
Do.	do.	TS ^{2/}	6.0	37.3	54.2	8.5	1.8	13,570
Do.	do.	TS ^{2/}	3.6	38.7	52.5	8.8	2.4	13,640
Clarion	Clarion	M ^{7/}	3.8	39.8	49.5	10.7	5.2	13,360
Knox	do.	TS ^{5/}	4.0	42.6	50.4	7.0	4.5	14,030
St. Petersburg	do.	M ^{7/}	3.5	40.5	51.0	8.5	3.6	13,760
Sligo	do.	TS ^{2/}	3.0	39.8	49.9	10.3	4.0	13,520

^{1/} M = mine sample; T = tipple sample from deep mine; TS = tipple sample from strip mine.

^{2/} Published first time in this report.

^{3/} Published in Bureau of Mines Bulletin 516.

^{4/} Published in Bureau of Mines Report of Investigations 4934.

^{5/} Published in Bureau of Mines Report of Investigations 4972.

^{6/} Published in Bureau of Mines Report of Investigations 5085.

^{7/} Published in Bureau of Mines Technical Paper 590.

The Lower Kittanning bed, which is well known as a coking coal in Pennsylvania and West Virginia, is the most important bed in Clarion County. It is a coking coal, and, in accord with its high-volatile A rank, contracts during carbonization. In this respect it differs markedly from most Lower Kittanning coals of Cambria and Somerset Counties, which rank higher and expand strongly when carbonized. Two samples from the vicinities of Clarion and Rimersburg contained moderate proportions of ash and sulfur and yielded well-fused coke in Bureau of Mines pilot-scale tests. Coal as represented by both samples could be used in blends with low- or medium-volatile coals to produce metallurgical coke because it is not excessively high in sulfur.

Reserves of Upper Freeport coal in Clarion County are too limited for the bed to become an important source of metallurgical coke. However, it may be used to some extent because it is suitable for carbonization if blended properly. Representative samples from strip mines near East Bruin and Rimersburg yielded moderately

strong coke in Bureau of Mines pilot-scale tests.^{9/} Neither sample contracted enough to recommend carbonization of this coal in binary blends with higher ranking expanding coals, although it could be used in ternary blends with expanding and contracting coals.

Preparation studies have demonstrated that fine crushing of the Upper and Lower Freeport coals of adjacent Armstrong County releases some of the sulfur impurities, whereas the Lower Kittanning does not respond similarly.^{10/} Inasmuch as the southern part of Clarion County contains most of the coal reserves and adjoins Armstrong County, the preparation characteristics of its coals probably are similar to those of coals from the latter county. Reduction in the sulfur content of the Lower Kittanning bed to meet metallurgical standards may be difficult or impractical even by modern methods of preparation.

APPENDIX

Completed reports giving results of studies by counties:

Estimation of Known Recoverable Reserves

DOWD, JAMES J., TURNBULL, LOUIS A., TOENGES, ALBERT L., COOPER, H. M., ABERNETHY, R. F., REYNOLDS, D. A., and FRASER, THOMAS, Estimate of Known Recoverable Reserves of Coking Coal in Cambria County, Pa. Bureau of Mines Rept. of Investigations 4734, 1950, 25 pp.

DOWD, JAMES J., TURNBULL, LOUIS A., TOENGES, ALBERT L., COOPER, H. M., ABERNETHY, R. F., REYNOLDS, D. A., and CRENTZ, WILLIAM L. Estimate of Known Recoverable Reserves of Coking Coal in Indiana County, Pa. Bureau of Mines Rept. of Investigations 4757, 1950, 22 pp.

DOWD, JAMES J., TURNBULL, LOUIS A., TOENGES, ALBERT L., ABERNETHY, R. F., and REYNOLDS, D. A. Estimate of Known Recoverable Reserves of Coking Coal in Pike County, Ky. Bureau of Mines Rept. of Investigations 4792, 1951, 34 pp.

DOWD, JAMES J., TURNBULL, LOUIS A., TOENGES, ALBERT L., ABERNETHY, R. F., and REYNOLDS, D. A. Estimate of Known Recoverable Reserves of Coking Coal in Armstrong County, Pa. Bureau of Mines Rept. of Investigations 4801, 1951, 16 pp.

DOWD, JAMES J., TURNBULL, LOUIS A., TOENGES, ALBERT L., ABERNETHY, R. F., and REYNOLDS, D. A. Estimate of Known Recoverable Reserves of Coking Coal in Westmoreland County, Pa. Bureau of Mines Rept. of Investigations 4803, 1951, 16 pp.

DOWD, JAMES J., TURNBULL, LOUIS A., TOENGES, ALBERT L., ABERNETHY, R. F., and REYNOLDS, D. A. Estimate of Known Recoverable Reserves of Coking Coal in Fayette County, Pa. Bureau of Mines Rept. of Investigations 4807, 1951, 19 pp.

^{9/} Brown, R. L., and Carman, E. P., Reports of Research and Technologic Work on Coal and Related Investigations July 1, 1952 to December 31, 1953: Bureau of Mines Inf. Circ. 7699, 102 pp. (especially p. 67).

^{10/} Crentz, William L., Steele, Fern, and Bailey, A. L., Preparation Characteristics of Coal Occurring in Armstrong County, Pa.: Bureau of Mines Rept. of Investigations 4788, 1951, 25 pp.

DOWD, JAMES J., TURNBULL, LOUIS A., TOENGES, ALBERT L., ABERNETHY, R. F., and REYNOLDS, D. A. Estimate of Known Recoverable Reserves of Coking Coal in Floyd County, Ky. Bureau of Mines Rept. of Investigations 4813, 1951, 16 pp.

DOWD, JAMES J., TOENGES, ALBERT L., ABERNETHY, R. F., and REYNOLDS, D. A. Estimate of Known Recoverable Reserves of Coking Coal in Jefferson County, Pa. Bureau of Mines Rept. of Investigations 4840, 1952, 18 pp.

DOWD, JAMES J., TOENGES, ALBERT L., ABERNETHY, R. F., and REYNOLDS, D. A. Estimate of Known Recoverable Reserves of Coking Coal in Raleigh County, W. Va. Bureau of Mines Rept. of Investigations 4893, 1952, 37 pp.

DOWD, JAMES J., TOENGES, ALBERT L., ABERNETHY, R. F., and REYNOLDS, D. A. Estimate of Known Recoverable Reserves of Coking Coal in Knott County, Ky. Bureau of Mines Rept. of Investigations 4897, 1952, 20 pp.

WALLACE, JOSEPH J., DOWD, JAMES J., TAVENNER, WILLIAM H., PROVOST, JOHN M., ABERNETHY, R. F., and REYNOLDS, D. A. Estimate of Known Recoverable Reserves of Coking Coal in McDowell County, W. Va. Bureau of Mines Rept. of Investigations 4924, 1952, 26 pp.

WALLACE, JOSEPH J., DOWD, JAMES J., TAVENNER, WILLIAM H., ABERNETHY, R. F., and REYNOLDS, D. A. Estimate of Known Recoverable Reserves of Coking Coal in Wyoming County, W. Va. Bureau of Mines Rept. of Investigations 4966, 1953, 39 pp.

WALLACE, JOSEPH J., DOWD, JAMES J., WILLIAMS, LLOYD, ABERNETHY, R. F., and REYNOLDS, D. A. Estimate of Known Recoverable Reserves of Coking Coal in Allegany County, Md. Bureau of Mines Rept. of Investigations 4970, 1953, 18 pp.

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WALLACE, JOSEPH J., DOWD, JAMES J., TRAVIS, RAYMOND G., ABERNETHY, R. F., and REYNOLDS, D. A. Estimate of Known Recoverable Reserves of Coking Coal in Letcher County, Ky. Bureau of Mines Rept. of Investigations 5016, 1953, 26 pp.

WALLACE, JOSEPH J., DOWD, JAMES J., PROVOST, JOHN M., ABERNETHY, R. F., and REYNOLDS, D. A. Estimate of Known Recoverable Reserves of Coking Coal in Allegheny County, Pa. Bureau of Mines Rept. of Investigations 5003, 1953, 16 pp.

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WALLACE, JOSEPH J., DOWD, JAMES J., TRAVIS, RAYMOND G., ABERNETHY, R. F., and REYNOLDS, D. A. Estimate of Known Recoverable Reserves of Coking Coal in Harlan County, Ky. Bureau of Mines Rept. of Investigations 5037, 1954, 26 pp.

WALLACE, JOSEPH J., DOWD, JAMES J., TAVENNER, WILLIAM H., ABERNETHY, R. F., and REYNOLDS, D. A. Estimate of Known Recoverable Reserves of Coking Coal in Mingo County, W. Va. Bureau of Mines Rept. of Investigations 5068, 1954, 57 pp.

WALLACE, JOSEPH J., DOWD, JAMES J., TAVENNER, WILLIAM H., PROVOST, JOHN M., ABERNETHY, R. F., and REYNOLDS, D. A. Estimate of Known Recoverable Reserves of Coking Coal in Mercer County, W. Va. Bureau of Mines Rept. of Investigations 5077, 1954, 20 pp.

WALLACE, JOSEPH J., DOWD, JAMES J., TRAVIS, RAYMOND G., ABERNETHY, R. F., and REYNOLDS, D. A. Estimate of Known Recoverable Reserves of Coking Coal in Perry County, Ky. Bureau of Mines Rept. of Investigations 5083, 1954, 26 pp.

WILLIAMS, LLOYD, JAMES, CURTIS W., GANDRUD, B. W., and REYNOLDS, D. A., Estimate of Known Recoverable Reserves and the Preparation and Carbonizing Properties of Coking Coal in Anderson County, Tenn. Bureau of Mines Rept. of Investigations 5185, 1956, 52 pp.

WILLIAMS, LLOYD, HERSHEY, ROBERT E., and GANDRUD, B. W. Estimate of Known Recoverable Reserves and the Preparation and Carbonizing Properties of Coking Coal in Marion County, Tenn. Bureau of Mines Rept. of Investigations 5159, 1955, 30 pp.

HERSHEY, ROBERT E., WILLIAMS, LLOYD, and GANDRUD, B. W. Estimate of Known Recoverable Reserves of Coking Coal in Grundy County, Tenn. Bureau of Mines Rept. of Investigations 5148, 1955, 16 pp.

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