Bureau of Mines
Report of Investigations 5263

ESTIMATE OF KNOWN RECOVERABLE RESERVES AND THE PREPARATION CHARACTERISTICS OF COKING COAL IN HAMILTON COUNTY, TENN.

By Robert E. Hershey, Lloyd Williams,
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United States Department of the Interior — October 1956

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UNITED STATES DEPARTMENT OF THE INTERIOR
Fred A. Seaton, Secretary
BUREAU OF MINES
Marling J. Ankeny, Director

Work on manuscript completed February 1956. The Bureau of Mines will welcome reprinting of this paper, provided the following footnote acknowledgment is made: "Reprinted from Bureau of Mines Report of Investigations 5263."

October 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 phase of the investigation, of the preparation characteristics 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 over-all 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, drill-core 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.

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ESTIMATE OF KNOWN RECOVERABLE RESERVES AND THE PREPARATION CHARACTERISTICS OF COKING COAL IN HAMILTON COUNTY, TENN.

by

Robert E. Hershey,[1] Lloyd Williams,[2] William L. Crentz,[3] and James W. Miller[4]

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TABLES

ILLUSTRATIONS

CONCLUSIONS

Reserves

1. Estimates of reserves were made for three coal beds in Hamilton County - the Lantana, Sewanee, and Richland. Nine coal beds have been mined at one time or another in the county, but not enough information was available to estimate reserves in any beds other than the three given.

2. Known measured and indicated reserves for all beds, based on a minimum thickness of 14 inches and on 1,800 short tons per acre-foot of coal in place, are estimated to be 53 million tons as of January 1, 1954. Of this total 35 million tons is in beds 28 inches and more thick. Areas in each bed were omitted from the estimate because available data relative to the bed characteristics were insufficient for making an estimate conforming with the definitions of measured and indicated coal adopted for this study. Should future drilling or development prove reserves in these areas, such reserves should be added to the total estimated reserves determined by this investigation.

3. Recoverable reserves are estimated for beds 28 inches and more thick. This thickness is about the minimum now being mined by hand loading onto conveyors in the Appalachian region. Recovery is based on the total thickness of coal in the bed (less partings three-eighths inch or more thick), rather than on the thickness of the coal mined. The average recovery for all beds in this county for which estimates have been made is estimated at 50 percent. Based on this average, the recoverable reserves of coal in Hamilton County are estimated at 17 million tons.

Analyses

Analyses of the two samples of Sewanee coal, taken in this county for preparation tests, show the coal to be too high in ash and sulfur for use as metallurgical fuel without preparation. Analysis of the Richland sample shows this coal to be a better grade than the Sewanee.

Preparation

Because the coal production in Hamilton County is insignificant and the fuel is produced for local use, there is no need for modern preparation methods. There are no mechanical cleaning facilities at Hamilton County mines. Coal is hand-picked to prepare a marketable product.

Float-and-sink tests of samples of coal from the Sewanee bed indicated that the bed in the southern part of Hamilton County probably would be unsuited for metallurgical use from a chemical standpoint owing to excessive sulfur in the washed coal. One sample of Sewanee-bed coal taken in the northern part of the county near Soddy, Tenn., gave some indication that fine crushing and precise control of washing might upgrade the deposit in this area to meet present-day chemical requirements for

metallurgical coal. In addition to the requirement of fine crushing and the exercise of careful control over the washing operation, the economics of the washing procedure is complicated further by the production of significant amounts of middling material containing about 14 percent ash and 1.7 percent sulfur.

The Richland coal bed was sampled at one location. Float-and-sink data indicated that the Richland bed could be washed to yield a chemically satisfactory metallurgical fuel, assuming that the one sample tested was representative of the deposit remaining in the county.

INTRODUCTION

The investigation to evaluate the reserves of coking coal is being made by the Bureau of Mines in three parts: (1) To estimate known "measured" and "indicated" recoverable reserves of all coking coal; (2) to study upgrading of marginal coal through effective preparation; and (3) to study the carbonizing properties of coals and coal blends not now widely used for metallurgical coke making.

This is the 42d in a series of reports giving the results of studies, by counties, of known minable reserves of coal. (See appendix.) This report covers Hamilton County, Tenn., in the southeastern corner of the Tennessee coal field. The first two parts of the investigation are covered in this report.

Hamilton county comprises all of Daisy, and East Chattanooga 7-1/2-minute quadrangles and parts of Brayton, Graysville, Big Spring, Henson Gap, Soddy, Soddy Island, Birchwood, Ketner Gap, Fairmount, Snow Hill, South Cleveland, Wauhatchie, Chattanooga, Ooltewah, McDonald, Hooker, Fort Oglethorpe, East Ridge, Ringgold and Tiger Creek. (See figure 1.)

Data on the coal beds in this county were obtained by personal reconnaissance and from landowners, mine operators, State agencies, and other authentic sources of information. The samples used for analyses and coal preparation studies were obtained from commercial operations in Hamilton County.

ACKNOWLEDGMENTS

The information contained in this report could not have been obtained without the whole-hearted cooperation of the officials of the companies and individual landowners whose property records were studied, and their cooperation and 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 Tennessee Division of Mines and the Tennessee Division of Geology, and consulting mining engineers are appreciated. The assistance and cooperation of the State geologist, William D. Hardeman, and also of C. W. Wilson, Jr., of Vanderbilt University Department of Geology, have been particularly helpful and are sincerely appreciated.

The Tennessee Valley Authority, through R. A. Kampmeier, assistant manager of power, and E. P. Ericson, chief, Fuels Branch, have made a major contribution to the conduct of this investigation, and their cooperation and assistance are gratefully acknowledged.

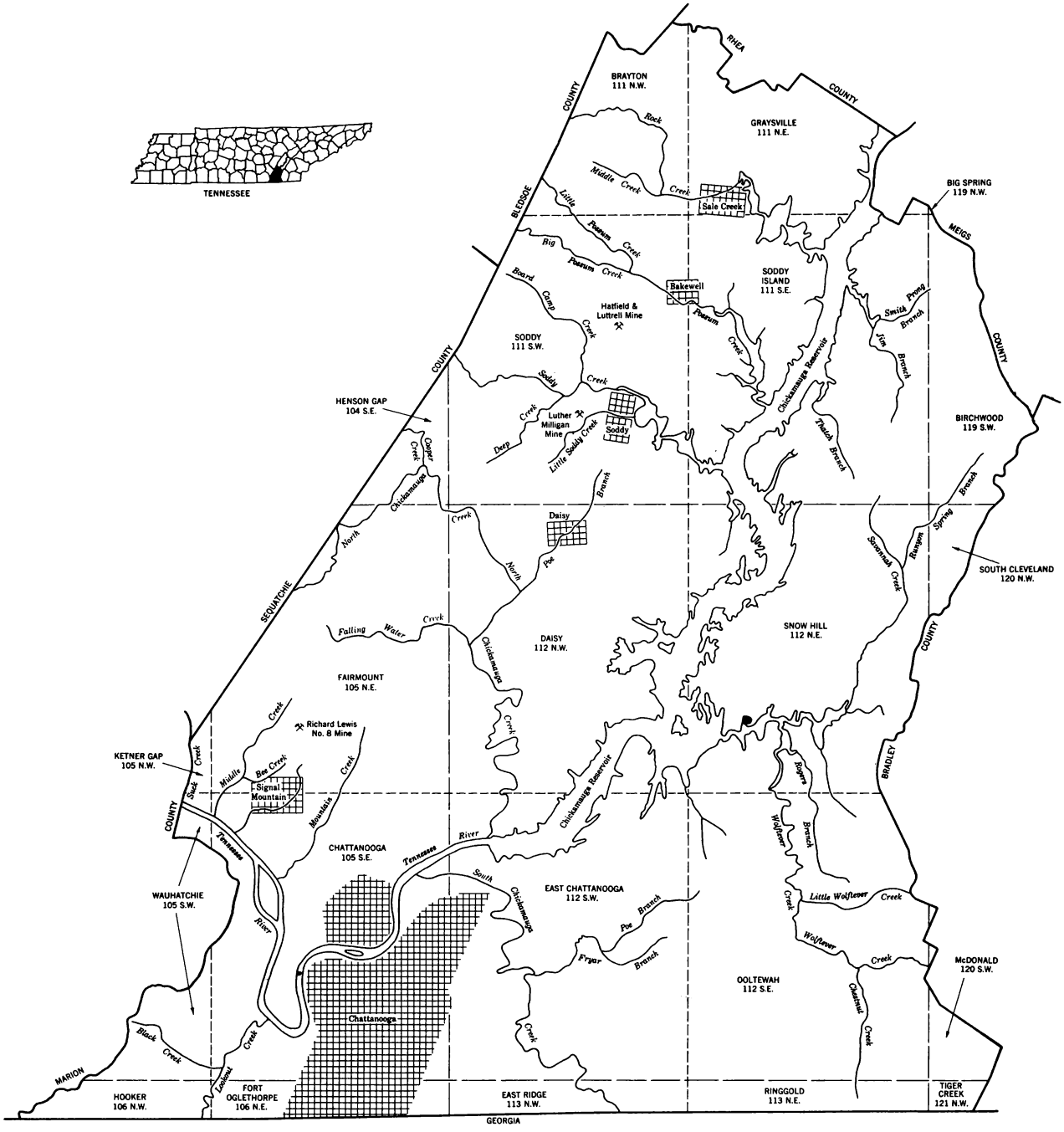

Figure 1. - Key map of Hamilton County, Tenn.

PART I - ESTIMATION OF KNOWN RECOVERABLE RESERVES

by

Robert E. Hershey and Lloyd Williams

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 compare 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. All known reserves of coal in the county are considered as coking coal in preparing the reserve estimates. The results of this survey establish the coking qualities of the coal. The possibilities of using these coals for metallurgical coke making are discussed in part II of this report.

Unit area. - The unit area used in estimating reserves is the 15-minute topographic quadrangle. All unit area estimates within the county are combined to give the county total estimates.

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 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 accurate 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, roughly 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 1/4 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 1/2 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.

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 correspond approximately to areas of inferred reserves and frequently contain significant quantities of coal.

Overburden. - This includes all of the material that overlies the coal bed. All known reserves in Hamilton County are under less than 800 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 in the computation of volume of reserves. A weighted average thickness in each thickness category is computed to be used for limited areas, not to exceed a 7-1/2-minute quadrangle.

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 usually is computed for each bed in each 15-minute 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 Tennessee Division 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, 1954, 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 15-minute 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 and unavoidable losses. Included in these losses is some coal considered too thin to mine and 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 by hand-loading onto conveyors. Certain areas in some of the beds in this county may not be considered economically minable at present because of conditions considered adverse today.

Methods Used to Compute Reserves

A base map for each coal bed for each 15-minute quadrangle area was prepared to the scale of 1 inch equals 2,000 feet. This scale was adopted as it is the scale of both the Tennessee Valley Authority and Federal Geological Survey 7-1/2-minute quadrangles, which are the latest topographic maps available. A 15-minute quadrangle is composed of four 7-1/2-minute quadrangles, each covering an area 7-1/2 minutes of longitude by 7-1/2 minutes of latitude. The TVA 15-minute quadrangles are identified by number; the corresponding 7-1/2-minute quadrangles are identified by directional quarter of the 15-minute quadrangle number. The 7-1/2-minute quadrangles are also identified by name.5/ Names for the 15-minute quadrangles are available only on special Federal Geological Survey index maps for administrative planning. These names are used in this report to identify the 15-minute areas which are not identified by a TVA number. The key map is divided into 7-1/2-minute quadrangles. (See fig. 1.)

Hamilton County comprises parts of the following 15-minute areas with the corresponding 7-1/2-minute quadrangles:

15-minute area		7-1/2-minute quadrangle names
Number	Name	
104	Dunlap	Henson Gap
105	Lookout Mountain	Ketner Gap, Wauhatchie, Fairmount, Chattanooga
106	Rossville	Hooker, Fort Oglethorpe
111	Dayton	Brayton, Soddy, Graysville, Soddy Island
112	Apison	Daisy, East Chattanooga, Snow Hill, Ooltewah
113	Rock Spring	East Ridge, Ringgold
119	Texas Knobs	Big Spring, Birchwood
120	Blue Spring	South Cleveland, McDonald
121	Dalton	Tiger Creek

Mine workings, locations of drill holes, outcrops and thicknesses of bed, and total clean-coal thicknesses were plotted on the base maps. Isopach lines then were drawn to limit areas of known unmined coal 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 that have been excluded from the estimate but may contain reserves based only on geologic inference, and areas outside the outcrops were measured by planimeter on the base maps. These areas were adjusted to conform to the theoretical area based on United States Coast and Geodetic Survey data for each quadrangle. Estimates of total reserves 14 inches and more thick for individual beds were prepared from these data. A map was prepared

5/ Geological Survey, Index to Topographic Mapping in Tennessee.

from the work maps for each bed. On these maps areas of known coal up to 14 inches thick and 14 to 28 inches thick were combined and shown as reserves in beds less than 28 inches thick. Areas of known coal 28 to 42 inches thick and over 42 inches thick were combined and shown as reserves in beds over 28 inches thick. In Hamilton County pillars have not been recovered generally, therefore most areas shown as "mined-out" reserves that have not been included in the tabulations remain in pillars.

Description of Coal Measures

Hamilton County is in the southeastern part of Tennessee and is adjacent to Georgia. The coal measures underlie Lookout Mountain, Racoon Mountain, and Walden Ridge.

All coal reserves in beds 14 inches and more thick underlie Walden Ridge, a synclinal mountain. The axis of the syncline corresponds roughly with the northwestern Hamilton County line. The coal beds dip steeply away from the southeastern escarpment of Walden Ridge, then decrease rapidly in amount of dip until, at the northwestern county line, the beds are relatively horizontal.

The vertical relationship of the beds is shown in figure 2. All of the beds in this report are in the Lower Pottsville series of the Pennsylvanian system. All bed names shown in figure 2 and used in this report are those adopted by the Tennessee Division of Geology. In the three mining districts of the county, comprising areas surrounding the towns of Signal Mountain, Daisy, and Soddy, local names for the beds do not always coincide with those used by the State. The names of the coal beds used by the State, together with the corresponding names used locally in each of the three mining districts follow:

Statewide names	Local names		
	Signal Mountain area	Daisy area	Soddy area
Morgan Springs	Not present	Not present	Morgan Springs
Lantana	No. 11	Unnamed	No. 12
Sewanee	No. 10	No. 10	No. 9
Unnamed	Not present	Not present	No. 8
Richland	No. 9	No. 9	No. 7
Unnamed	Not present	Unnamed	No. 6
Nelson	Nelson	Nelson	Nelson, No. 5
Goodrich	Goodrich	Goodrich	Goodrich
U. Sale Creek	U. Sale Creek	U. Sale Creek	U. Sale Creek
L. Sale Creek	L. Sale Creek	L. Sale Creek	L. Sale Creek

Coal was mined from all beds in the preceding list at one time or another, except the No. 8 bed at Soddy.

The Morgan Springs bed occurs only in the north corner of the county where it underlies a very small area. This bed is more extensive in the adjoining counties, Bledsoe and Rhea.

The No. 6 bed of the Soddy area occurs in a shale lens approximately halfway between the top and bottom of the Sewanee conglomerate and is restricted to a small area around Daisy and Soddy. A few small mines were opened in this bed but there is not sufficient information to estimate reserves.

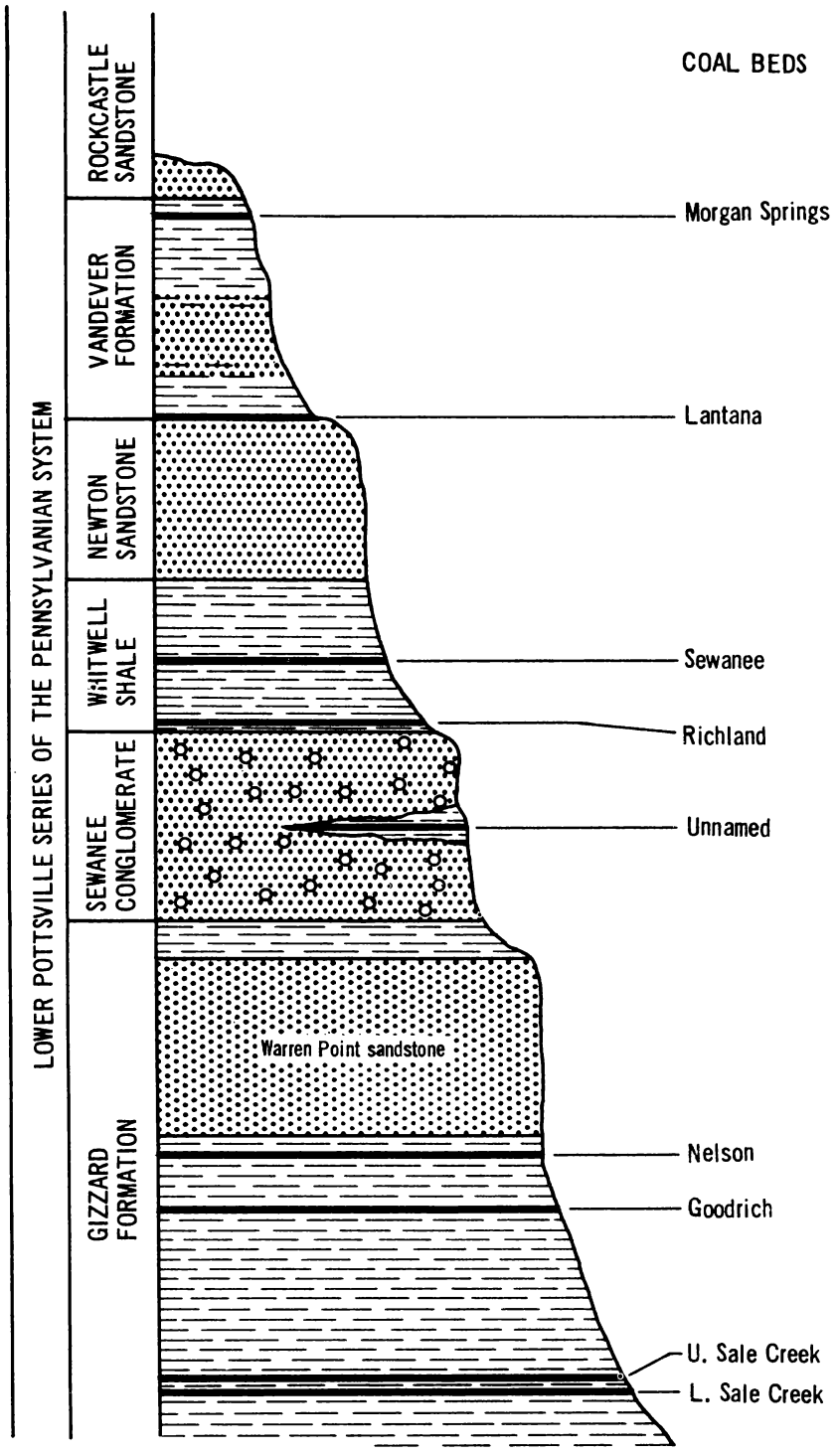

Figure 2. - Composite section of coal measures in Hamilton County, Tenn.

The Nelson and Goodrich beds were mined to a small extent many years ago and were irregular in thickness. The few known exposures of these coals at other than the places mined show thicknesses less than 14 inches.

The Upper and Lower Sale Creek coals have been mined at several places near Sale Creek and at one place near the Rhea County line.

Reserve estimates have been made only for the Lantana, Sewanee, and Richland beds in Hamilton County because there was not enough information known about the other beds.

Lantana Bed

(See fig. 3 and table 1)

This bed occurs near the base of the Vandever formation and just above the prominent bench at the top of the Newton sandstone. The bed has not been prospected extensively but has been deep- and strip-mined near Bakewell. Sections of the bed in the area of recoverable reserves follow:

Western Part of County

Material	Inches
COAL	19
Coal with pyrite	1/2
COAL	13
Coal with pyrite	1
COAL	5
Pyrite	1/2
COAL	6-1/2
Thickness	45-1/2

Material	Inches
COAL	14
Rash	3
COAL	24
Thickness	41

Sewanee Bed

(See fig. 4 and table 2)

This bed occurs in the Whitwell shale 30 to 80 feet above the Sewanee conglomerate. The bed is irregular in thickness; and the minable thicknesses of coal occur in small lenses, except at Signal Mountain, where it is more continuous.

The Sewanee was mined many years ago in the Soddy area, but the present production is mainly from the Signal Mountain area. A sample taken from the Richard Lewis No. 8 mine was 35 inches thick, and a sample taken from the Luther Milligan No. 1 mine was 32 inches thick. These sections follow:

Western Part of County

Material	Inches
Coal with fusain and sulfur streaks	35
Thickness	35

Material	Inches
Bone and coal	4
Coal with sulfur streaks	28
Thickness	32

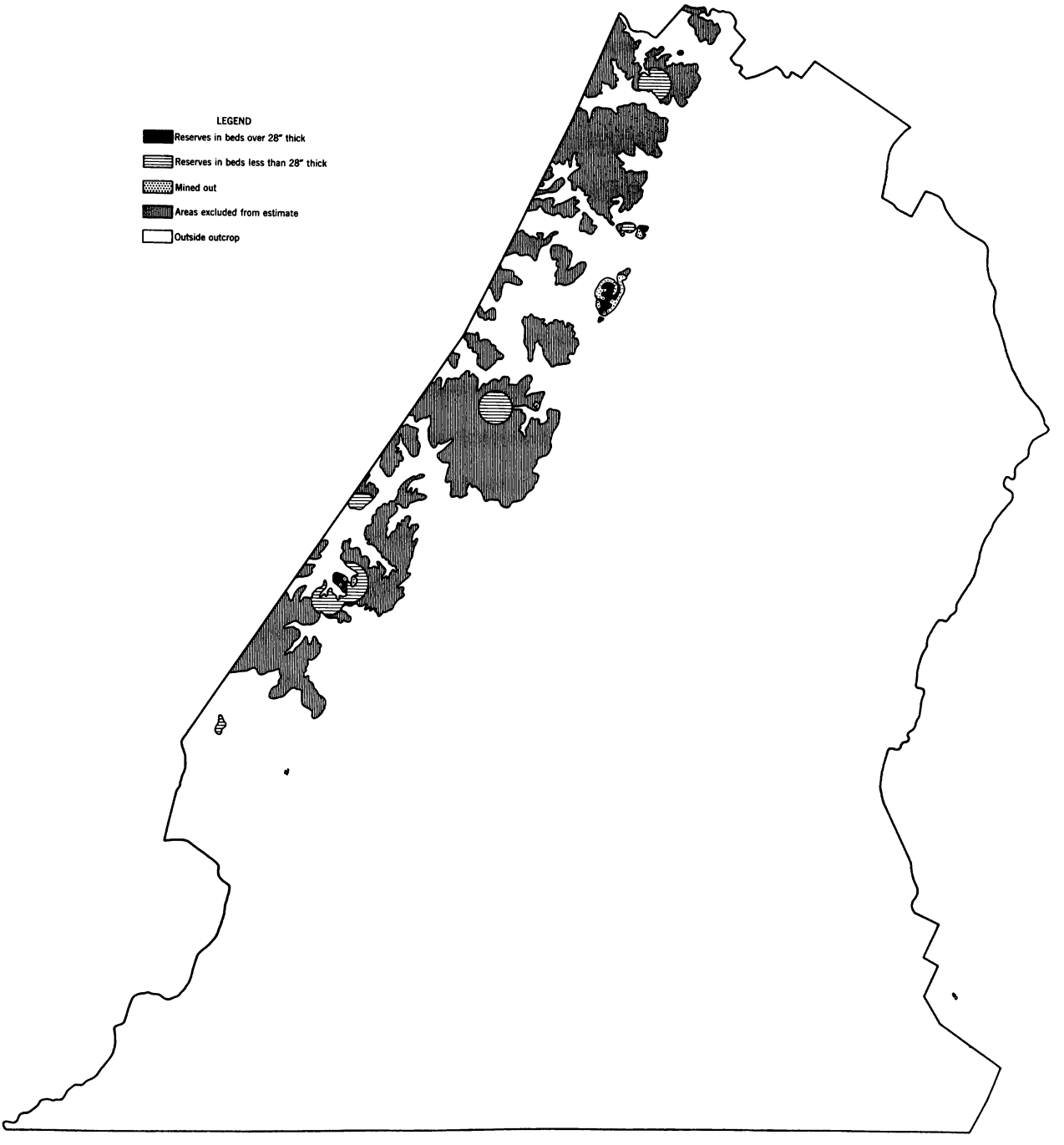

Figure 3. - Lantana bed, Hamilton County, Tenn., January 1, 1954.

Figure 4. - Sewanee bed, Hamilton County, Tenn., January 1, 1954.

HAMILTON COUNTY

TABLE 1. - RESERVES IN LANTANA BED, January 1, 1954

15-minute 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		
105 Lookout Mountain	76,154	5,166	70,042	388	558	24	534	Measured	91	300	77	347	-	-	168	647	77	347		174
								Indicated	366	1,208	-	-	-	-	366	1,208	-	-		-
								Total	457	1,508	77	347	-	-	534	1,855	77	347	2/50.0	174
111 Dayton	102,380	14,372	86,588	873	547	197	350	Measured	31	112	-	-	-	-	31	112	-	-		-
								Indicated	50	180	157	845	112	706	319	1,731	269	1,551		775
								Total	81	292	157	845	112	706	350	1,843	269	1,551	2/50.0	775
104 Dunlap	4,303	2,243	2,003	-	57	-	57	Measured	-	-	-	-	-	-	-	-	-	-		-
								Indicated	57	188	-	-	-	-	57	188	-	-		-
								Total	57	188	-	-	-	-	57	188	-	-	-	-
Remaining quadrangles	184,711	24	184,687	-	-	-	-	Measured	-	-	-	-	-	-	-	-	-	-		-
								Indicated	-	-	-	-	-	-	-	-	-	-		-
								Total	-	-	-	-	-	-	-	-	-	-	-	-
								Measured	122	412	77	347	-	-	199	759	77	347		174
								Indicated	473	1,576	157	845	112	706	742	3,127	269	1,551		775
Total	367,548	21,805	343,320	1,261	1,162	221	941	Total	595	1,988	234	1,192	112	706	941	3,886	346	1,898	2/50.0	949

TABLE 2. - RESERVES IN SEWANEE BED, January 1, 1954

15-minute 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		
105 Lookout Mountain	76,154	10,119	61,617	948	3,470	377	3,093	Measured	177	352	1,078	5,643	-	-	1,255	5,995	1,078	5,643		2,821
								Indicated	395	1,201	1,227	6,336	216	1,361	1,838	8,898	1,443	7,697		3,849
								Total	572	1,553	2,305	11,979	216	1,361	3,093	14,893	2,521	13,340	2/50.0	6,670
111 Dayton	102,380	28,101	71,710	386	2,183	251	1,932	Measured	-	-	-	-	-	-	-	-	-	-		-
								Indicated	1,095	3,827	837	4,262	-	-	1,932	8,089	837	4,262		2,131
								Total	1,095	3,827	837	4,262	-	-	1,932	8,089	837	4,262	2/50.0	2,131
104 Dunlap	4,303	3,351	892	-	60	-	60	Measured	-	-	-	-	-	-	-	-	-	-		-
								Indicated	-	-	-	-	60	378	60	378	60	378		189
								Total	-	-	-	-	60	378	60	378	60	378	2/50.0	189
Remaining quadrangles	184,711	882	183,859	-	-	-	-	Measured	-	-	-	-	-	-	-	-	-	-		-
								Indicated	-	-	-	-	-	-	-	-	-	-		-
								Total	-	-	-	-	-	-	-	-	-	-	-	-
								Measured	177	352	1,078	5,643	-	-	1,255	5,995	1,078	5,643		2,821
								Indicated	1,490	5,028	2,064	10,598	276	1,739	3,830	17,365	2,340	12,337		6,169
Total	367,548	42,453	318,048	1,334	5,713	628	5,085	Total	1,667	5,380	3,142	16,241	276	1,739	5,085	23,360	3,418	17,980	2/50.0	8,990

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

HAMILTON COUNTY

TABLE 3. - RESERVES IN RICHLAND BED, January 1, 1954

15-minute 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		
105 Lookout Mountain	76,154	14,517	59,908	-	1,729	41	1,688	Measured	-	-	-	-	-	-	-	-	-	-		-
								Indicated	867	2,617	821	4,164	-	-	1,688	6,781	821	4,164		2,082
								Total	867	2,617	821	4,164	-	-	1,688	6,781	821	4,164	2/50.0	2,082
111 Dayton	102,380	23,899	70,707	974	6,800	2,643	4,157	Measured	-	-	-	-	-	-	-	-	-	-		-
								Indicated	2,213	8,033	1,939	9,338	5	32	4,157	17,403	1,944	9,370		4,685
								Total	2,213	8,033	1,939	9,338	5	32	4,157	17,403	1,944	9,370	2/50.0	4,685
104 Dunlap	4,303	3,564	674	-	65	-	65	Measured	-	-	-	-	-	-	-	-	-	-		-
								Indicated	-	-	65	358	-	-	65	358	65	358		179
								Total	-	-	65	358	-	-	65	358	65	358	2/50.0	179
112 Apison	152,058	581	151,040	-	437	264	173	Measured	-	-	-	-	-	-	-	-	-	-		-
								Indicated	-	-	173	933	-	-	173	933	173	933		467
								Total	-	-	173	933	-	-	173	933	173	933	2/50.0	467
Remaining quadrangles	32,653	-	32,653	-	-	-	-	Measured	-	-	-	-	-	-	-	-	-	-		-
								Indicated	-	-	-	-	-	-	-	-	-	-		-
								Total	-	-	-	-	-	-	-	-	-	-	-	-
								Measured	-	-	-	-	-	-	-	-	-	-		-
								Indicated	3,080	10,650	2,998	14,793	5	32	6,083	25,475	3,003	14,825		7,413
Total	367,548	42,561	314,982	974	9,031	2,948	6,083	Measured	-	-	-	-	-	-	-	-	-	-		-
								Indicated	3,080	10,650	2,998	14,793	5	32	6,083	25,475	3,003	14,825		7,413
								Total	3,080	10,650	2,998	14,793	5	32	6,083	25,475	3,003	14,825	2/50.0	7,413

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

Richland Bed

(See fig. 5 and table 3)

Four coal beds are present in the Whitwell shale; and the thickest bed formerly was called the Richland, regardless of its position in the shale. As used in this report, the bed just above the Sewanee conglomerate is referred to as the Richland.

The Richland bed was mined extensively many years ago, but now only one small mine is active. A sample taken from the Hatfield & Luttrell mine was 29-1/4 inches thick. This section and another follow:

Western Part of County

Material	Inches	Material	Inches
Coal with fusain and sulfur streaks	5-3/4	COAL	20-1/4
Rash (bone and clay)	2-1/2	Coal with sulfur balls	12
COAL	21	Rash	1/8
Thickness	29-1/4	COAL	3-7/8
		Thickness	36-1/4

COAL RESERVES

The location and extent of coal reserves by beds are shown in figures 3 through 5. Detailed estimates of known measured and indicated reserves as of January 1, 1954 are given in tables 1 through 3. Table 4 is a recapitulation of reserves. Total reserves 14 inches and more thick are estimated at 52,721,000 tons. Of this total, 34,703,000 tons is in beds 28 inches and more thick. The weighted average recovery for all beds in the county is estimated at 50 percent. Based on this recovery, the known recoverable reserves 28 inches and more thick are estimated at 17,352,000 tons as of January 1, 1954.

TABLE 4. - Recapitulation of reserves, Hamilton County, Tenn., January 1, 1954

Bed	Thousands of tons		Recoverable 1/	
	In beds 14" and more thick	In beds 28" and more thick	Percentage	Thousands of tons
Lantana	3,886	1,898	2/50.0	949
Sewanee	23,360	17,980	2/50.0	8,990
Richland	25,475	14,825	2/50.0	7,413
Total	52,721	34,703	2/50.0	17,352

1/ Based on reserves 28 inches and more thick.
2/ Estimated.

The total coal production for Hamilton County during 1953 was 57,978 tons.[6] This production is near the annual average for the county with the exceptions of 1951 and 1952, when 102,246 and 209,051 tons respectively, was mined. The county ranked 13th in the State in production for 1953 and 8th in overall production from

6/ Bureau of Mines, Bituminous Coal and Lignite in 1953: Mineral Market Summary 2339, p. 120.

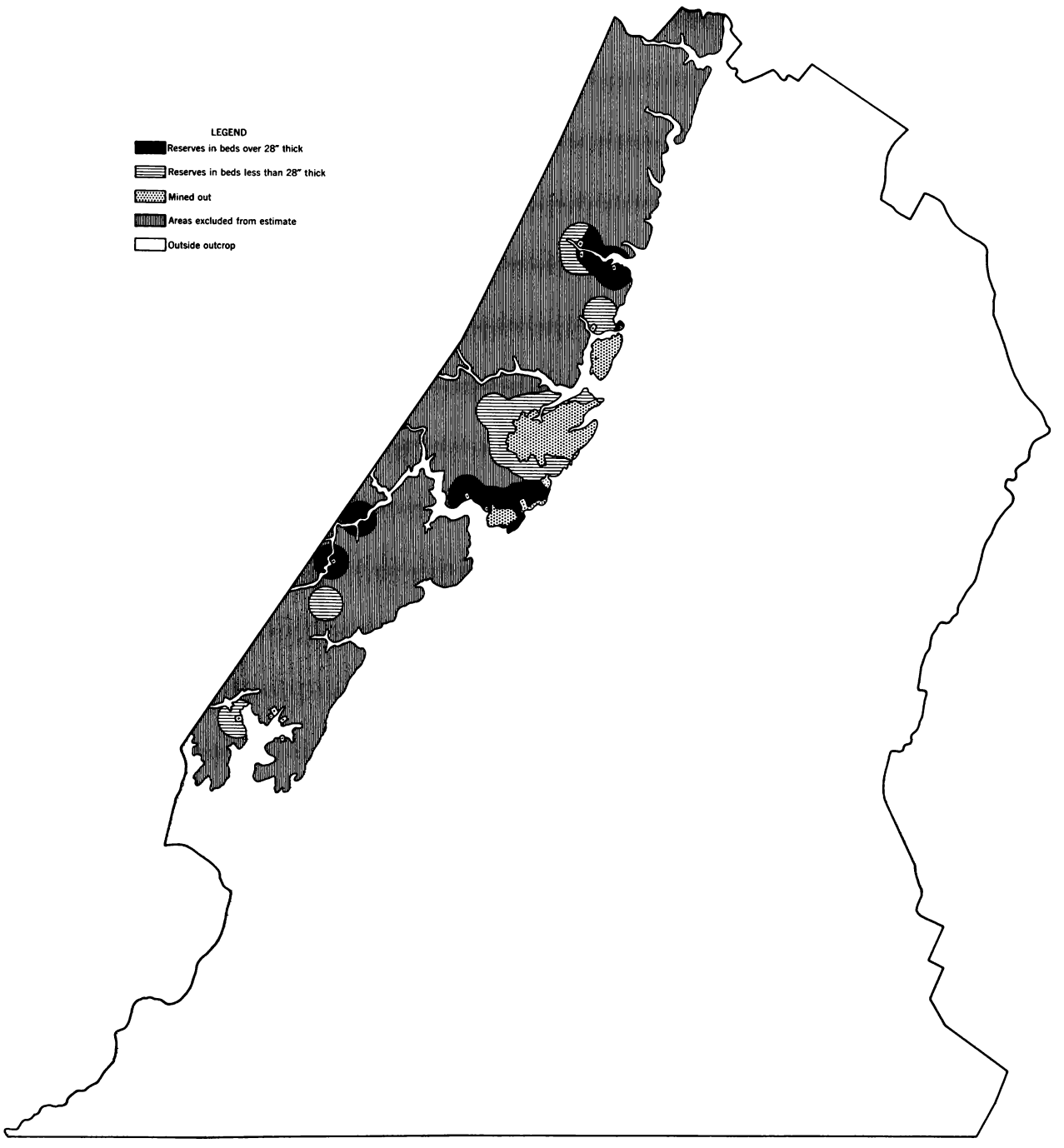

Figure 5. - Richland bed, Hamilton County, Tenn., January 1, 1954.

1852 to January 1, 1954, with a total production of 12,962,980 tons or 3.7 percent of the total coal produced in the State, as compiled from Annual Reports of Tennessee Division of Mines, Bureau of Mines Mineral Market Summaries, and some unpublished records.

TABLE 5. - Analyses of Hamilton County coals

Town and mine	Bed	Kind of sample[1/]	As-received moisture	Dry basis				
				Vol.	F.C.	Ash	Sul.	B.t.u.
1	2	3	4	5	6	7	8	9
Signal Mountain								
Richard Lewis No. 8	Sewanee	M	3.0	28.2	57.7	14.1	3.1	13,070
Soddy								
Luther Milligan	do.	M	1.6	30.1	58.6	11.3	3.5	13,620
Hatfield & Luttrell	Richland	M	2.4	31.3	60.9	7.8	1.7	14,150

1/ M = mine sample.

PART II - PREPARATION CHARACTERISTICS OF HAMILTON COUNTY COAL

by

William L. Crentz and James W. Miller

Test Procedure

To determine the washability of Hamilton County coal 2 face samples were collected in the Sewanee bed, and 1 face sample was taken in the Richland bed. The location of mines from which washability samples were collected is shown in figure 1.

The face samples were collected in the conventional manner except that binders and partings in the mined section of the bed were included in the sample, even though the extraneous matter normally would be removed on the picking table.

To prepare the face sample for float-and-sink separations, the test lot was crushed to 1-1/2-inch top size. After crushing, a riffled portion of the 1-1/2-inch by 0 sample was screened at 100-mesh. The 1-1/2-inch by 100-mesh coal was float-and-sink tested. To determine the effect of crushing upon the release of impurities, the remainder of the 1-1/2-inch by 0 sample was crushed to 3/8-inch top size and riffled. One-half of the 3/8-inch by 0 crushing was dedusted over a 100-mesh sieve, and the 3/8-inch by 100-mesh coal was float-and-sink tested. The duplicate portion of the 3/8-inch by 0 test lot was crushed to 14-mesh top size and dedusted to remove the 100-mesh by 0 dust, and the 14- by 100-mesh sample was tested. The flow diagram (fig. 6) shows the steps taken in preparing samples for the float-and-sink test. As the difficulty of cleaning coal usually increases with a decrease in particle size, crushing to finer than 1-1/2-inch top size was confined to those samples that failed to yield a coarse-coal float product that would be chemically suitable for metallurgical use.

All samples were tested on specific gravities of 1.30, 1.35, 1.40, 1.45, 1.50, 1.55, and 1.60. Tests were made with carbon tetrachloride mixed with white gasoline or bromoform, depending upon the desired specific gravity.

The float-and-sink test for determining the washing characteristics of coal has been used for many years, and descriptions of the procedure have appeared frequently

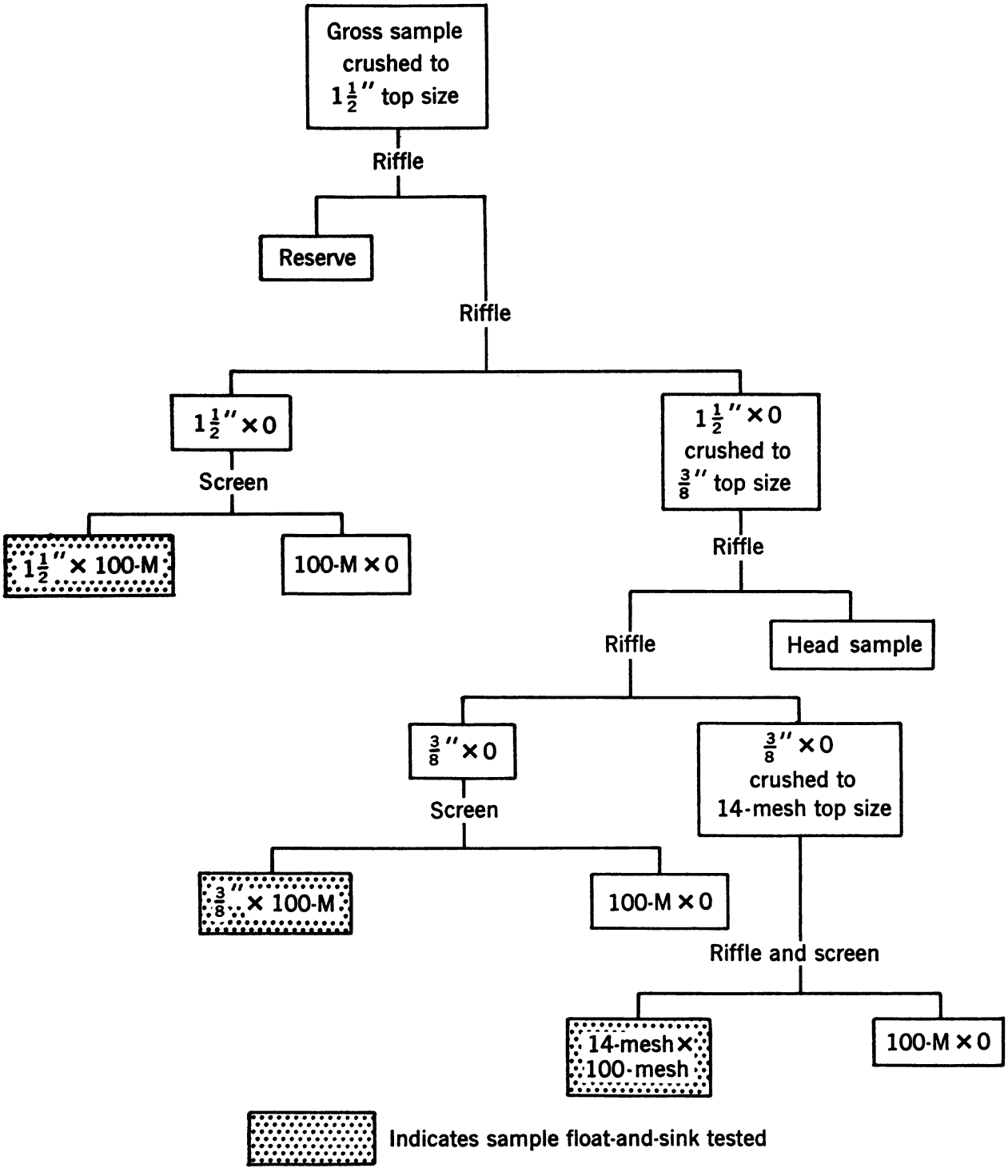

Figure 6. - Flow diagram showing preparation of samples.

in literature. Coe[7] has explained the compilation and interpretation of washability data. In examining the float-and-sink data on face samples, it must be emphasized that these data are not to be construed as representative of the quality of product loaded at the operation where the sample was taken, but rather as an indication of bed quality in the general geographical area. The face sample in some instances represents full seam recovery. At some mines certain inferior portions of the bed are left in place to improve the quality of output, especially where a band of inferior coal occurs between the shale roof and the top of the better coal.

To expedite the float-and-sink test, the 100-mesh by 0 dust was removed from all samples before separation into specific-gravity fractions. It would be uneconomical to discard this dust, and to include the material in the washed coal would increase somewhat the ash and sulfur percentages shown in the washability data for the dedusted coal. Usually the quantity of fine dust produced during crushing does not become a serious problem unless the coal is crushed finer than 1-1/2-inch top size.

In interpreting washability characteristics of coal from float-and-sink data, it must be remembered that these data are based on precise specific-gravity separations, which are approached but not equaled in commercial practice. Washing efficiency usually decreases with a decrease in the particle size of the washery feed. During washing, even in an efficient, modern preparation plant, it is to be expected that some refuse will be misplaced in the clean coal and that some clean coal will be rejected with the refuse.

Experimental Results

Sewanee Bed

The Sewanee bed is 1 of 2 important known coal deposits present in Hamilton County. The bed is about 3 feet thick and is relatively free of persistent shale partings. Sulfur streaks and balls are present frequently in the bed and usually are clearly visible upon inspection of the coal in place. Two large face samples were collected in the Sewanee bed to determine the washing characteristics of the coal in Hamilton County.

Table 6 shows the float-and-sink data on a sample taken in the Richard Lewis No. 8 mine, operated by Richard Lewis, 2 miles north of Signal Mountain, Tenn. Here the bed comprises 35 inches of solid coal. The face sample was crushed to 1-1/2-inch top size and the 100-mesh by 0 dust was removed before float-and-sink testing. Separating the 1-1/2-inch by 100-mesh size at 1.60 specific gravity yields a float coal containing 11.3 percent ash and 2.03 percent sulfur. Further examination of the float-and-sink data reveals that the sample cannot be upgraded to meet present metallurgical standards. Sulfur determinations on the individual specific-gravity fractions showed that only the 2 lightest specific-gravity fractions contained less than 2.00 percent sulfur. Once the 1.60-specific-gravity sink material is removed, further significant reduction in float coal sulfur can be achieved only by an inordinate rejection of intermediate-density material. To determine the effect of fine crushing upon the release of impurities, the sample was crushed to 3/8-inch top size and washed. The float-and-sink data on the 3/8-inch by 100-mesh size are shown in table 7. Separating the sample at 1.60 specific gravity yields a float coal containing 11.3 percent ash and 1.97 percent sulfur, a product very similar in quality to the 1.60-specific-gravity float coal after crushing to 1-1/2-inch top size.

7/ Coe, G. D., An Explanation of Washability Curves for the Interpretation of Float-and-Sink Data on Coal: Bureau of Mines Inf. Circ. 7045, 1938, 10 pp.

TABLE 6. - Washing characteristics of face sample, Richard Lewis No. 8 mine, Sewanee bed. Sample crushed to 1-1/2-inch top size; data in percent

Size	Specific-gravity fraction	Weight		Ash		Sulfur	
		Direct	Cumulative	Direct	Cumulative	Direct	Cumulative
1-1/2-inch by 100-mesh (96.7 percent of sample)	Under - 1.30	7.5	7.5	3.3	3.3	1.43	1.43
	1.30 to 1.35	38.2	45.7	8.5	7.6	1.64	1.61
	1.35 to 1.40	26.9	72.6	12.5	9.4	2.11	1.79
	1.40 to 1.45	11.6	84.2	16.1	10.4	2.66	1.91
	1.45 to 1.50	4.7	88.9	20.1	10.9	3.08	1.97
	1.50 to 1.55	2.4	91.3	23.8	11.2	3.72	2.02
	1.55 to 1.60	.6	91.9	26.2	11.3	4.29	2.03
	Over - 1.60	8.1	100.0	48.2	14.3	14.06	3.01
100-mesh by 0 (3.3 percent of sample)				14.7		3.87	

TABLE 7. - Washing characteristics of face sample, Richard Lewis No. 8 mine, Sewanee bed. Sample crushed to 3/8-inch top size; data in percent

Size	Specific-gravity fraction	Weight		Ash		Sulfur	
		Direct	Cumulative	Direct	Cumulative	Direct	Cumulative
3/8-inch by 100-mesh (94.5 percent of sample)	Under - 1.30	10.1	10.1	3.5	3.5	1.40	1.40
	1.30 to 1.35	34.6	44.7	8.4	7.3	1.62	1.57
	1.35 to 1.40	26.6	71.3	12.5	9.2	2.02	1.74
	1.40 to 1.45	11.4	82.7	16.1	10.2	2.50	1.84
	1.45 to 1.50	5.7	88.4	19.2	10.8	2.81	1.91
	1.50 to 1.55	2.6	91.0	23.2	11.1	3.46	1.95
	1.55 to 1.60	1.2	92.2	25.1	11.3	3.79	1.97
	Over - 1.60	7.8	100.0	46.8	14.1	13.65	2.88
100-mesh by 0 (5.5 percent of sample)				13.1		3.22	

Comparing the float-and-sink data in table 7 with that in table 6 shows that fine crushing has no significant effect upon the release of impurities and that this method of product improvement cannot be used to upgrade the Richard Lewis No. 8 mine sample to metallurgical use. Even crushing to flotation size has but minor effect upon the release of impurities. Table 8 shows the float-and-sink data on the face sample after crushing to 14-mesh top size. While significant reduction in both ash and sulfur can be achieved by mechanical cleaning, the resultant washed coal would not be chemically suitable for metallurgical use.

Another washability sample in the Sewanee bed was taken at a small domestic mine, operated by Luther Milligan, 1 mile west of Soddy, Tenn. This operation is about 15 miles northeast of the Richard Lewis No. 8 mine. At the Luther Milligan mine the bed is 32 inches thick. After the sample is crushed to 1-1/2-inch top size and the fine dust removed, the coal was float-and-sink tested. These data are given in table 9. Separating the sample at 1.60 specific gravity yields a float coal containing 9.3 percent ash and 1.61 percent sulfur. Although the preparation of a

clean coal, containing a maximum of 1.25 percent sulfur, is possible theoretically, the procedure is commercially infeasible. Table 10 shows the float-and-sink data on the face sample crushed to 3/8-inch by 100-mesh size. Separating the sample at 1.60 specific gravity yields a float coal containing 9.2 percent ash and 1.42 percent sulfur. At this crushing a float coal containing 1.25 percent sulfur might be obtained by a precise separation at about 1.35 specific gravity. Even though a commercial washing procedure of this type cannot be considered too practical, over 50 percent of the raw feed can be upgraded to the desired quality with respect to sulfur content. Table 11 shows the float-and-sink data after the sample is crushed to 14-mesh top size. These data show that little improvement in float coal quality can be achieved by crushing the sample finer than 3/8-inch top size. In addition to the difficulty of handling the minus 14-mesh coal in the preparation plant, crushing to this fine size produces a significant amount of minus 100-mesh dust that was removed from the sample before float-and-sink testing. Chemical analysis of this fine material indicates that it is a high-sulfur product that probably would adversely affect the quality of the clean coal if it were permitted to remain in the washery feed.

TABLE 8. - Washing characteristics of face sample, Richard Lewis No. 8 mine, Sewanee bed. Sample crushed to 14-mesh top size; data in percent

Size	Specific-gravity fraction	Weight		Ash		Sulfur	
		Direct	Cumulative	Direct	Cumulative	Direct	Cumulative
14- by 100-mesh (80.4 percent of sample)	Under - 1.30	18.9	18.9	3.2	3.2	1.38	1.38
	1.30 to 1.35	26.4	45.3	7.7	5.8	1.71	1.57
	1.35 to 1.40	20.7	66.0	12.1	7.8	1.95	1.69
	1.40 to 1.45	11.9	77.9	15.6	9.0	2.21	1.77
	1.45 to 1.50	6.7	84.6	18.9	9.8	2.52	1.83
	1.50 to 1.55	3.8	88.4	21.9	10.3	2.89	1.88
	1.55 to 1.60	1.2	89.6	23.5	10.5	3.02	1.89
	Over - 1.60	10.4	100.0	44.6	14.0	10.69	2.81
100-mesh by 0 (19.6 percent of sample)				13.0		3.32	

TABLE 9. - Washing characteristics of face sample, Luther Milligan mine, Sewanee bed. Sample crushed to 1-1/2-inch top size; data in percent

Size	Specific-gravity fraction	Weight		Ash		Sulfur	
		Direct	Cumulative	Direct	Cumulative	Direct	Cumulative
1-1/2-inch by 100-mesh (98.5 percent of sample)	Under - 1.30	9.5	9.5	4.6	4.6	1.17	1.17
	1.30 to 1.35	59.7	69.2	8.4	7.9	1.40	1.37
	1.35 to 1.40	18.2	87.4	11.5	8.6	1.78	1.45
	1.40 to 1.45	3.9	91.3	14.9	8.9	2.65	1.51
	1.45 to 1.50	1.7	93.0	18.3	9.1	3.88	1.55
	1.50 to 1.55	1.1	94.1	22.2	9.2	5.67	1.60
	1.55 to 1.60	.4	94.5	25.9	9.3	5.67	1.61
	Over - 1.60	5.5	100.0	47.7	11.4	15.93	2.40
100-mesh by 0 (1.5 percent of sample)				16.6		2.68	

TABLE 10. - Washing characteristics of face sample, Luther Milligan mine, Sewanee bed. Sample crushed to 3/8-inch top size; data in percent

Size	Specific-gravity fraction	Weight		Ash		Sulfur	
		Direct	Cumulative	Direct	Cumulative	Direct	Cumulative
3/8-inch by 100-mesh (91.2 percent of sample)	Under - 1.30	14.8	14.8	4.1	4.1	1.12	1.12
	1.30 to 1.35	49.1	63.9	8.1	7.2	1.30	1.26
	1.35 to 1.40	20.5	84.4	12.0	8.3	1.56	1.33
	1.40 to 1.45	5.9	90.3	14.5	8.7	1.92	1.37
	1.45 to 1.50	2.5	92.8	17.5	9.0	2.37	1.40
	1.50 to 1.55	1.1	93.9	22.1	9.1	3.19	1.42
	1.55 to 1.60	.3	94.2	22.1	9.2	3.19	1.42
	Over - 1.60	5.8	100.0	48.6	11.5	17.41	2.35
100-mesh by 0 (8.8 percent of sample)				12.3		2.34	

TABLE 11. - Washing characteristics of face sample, Luther Milligan mine, Sewanee bed. Sample crushed to 14-mesh top size; data in percent

Size	Specific-gravity fraction	Weight		Ash		Sulfur	
		Direct	Cumulative	Direct	Cumulative	Direct	Cumulative
14- by 100-mesh (85.9 percent of sample)	Under - 1.30	20.7	20.7	3.3	3.3	1.07	1.07
	1.30 to 1.35	34.0	54.7	7.4	5.8	1.37	1.26
	1.35 to 1.40	22.9	77.6	11.2	7.4	1.45	1.31
	1.40 to 1.45	9.4	87.0	14.1	8.1	1.55	1.34
	1.45 to 1.50	4.2	91.2	16.8	8.5	1.85	1.36
	1.50 to 1.55	1.8	93.0	19.3	8.8	2.26	1.38
	1.55 to 1.60	.4	93.4	19.3	8.8	2.26	1.38
	Over - 1.60	6.6	100.0	44.8	11.2	13.39	2.18
100-mesh by 0 (14.1 percent of sample)				11.2		2.45	

Assuming that the two Sewanee-bed samples are representative of the bed quality in the area around the sampling locations, there is some indication that sulfur in the coal decreases as the bed extends northward. Although the deposit in the southern part of Hamilton County appears totally unsuitable for the needs of the metallurgical industry, the problem of preparing a chemically satisfactory washed coal from the Sewanee bed at the northern sampling location is not quite so formidable. Even at the more favorable location, fine crushing and precise washing would be necessary together with the separate disposal of a significant amount of middlings.

Richland Bed

Other than the Sewanee bed, the Richland is the only bed of commercial importance in Hamilton County. The Richland bed has been exploited actively in the past; but, at the time of the field investigation, only one location could be found where the collection of a satisfactory washability sample could be made. A face sample

was taken in the Hatfield & Luttrell mine, Hatfield & Luttrell Coal Co., 2-1/2 miles north of Soddy, Tenn., in the northern part of Hamilton County.

The bed at the Hatfield & Luttrell mine is about 30 inches thick and is overlain by several inches of draw slate under a hard shale roof. The washability sample did not include the draw slate. Table 12 shows the float-and-sink data after crushing the face sample to 1-1/2-inch top size and removing the 100-mesh by 0 dust. Separating the coal at 1.60 specific gravity yields a float coal containing 6.5 percent ash and 1.26 percent sulfur with a 96.3-percent recovery of raw-coal feed as float product.

If the sample taken at the Hatfield & Luttrell mine is representative of the Richland bed in Hamilton County, it appears that this bed can be upgraded by mechanical cleaning to yield a washed coal that is well-suited chemically for metallurgical use.

TABLE 12. - Washing characteristics of face sample, Hatfield and Luttrell mine, Richland bed. Sample crushed to 1-1/2-inch top size; data in percent

Size	Specific-gravity fraction	Weight		Ash		Sulfur	
		Direct	Cumulative	Direct	Cumulative	Direct	Cumulative
1-1/2-inch by 100-mesh (98.3 percent of sample)	Under - 1.30	49.5	49.5	3.1	3.1	0.86	0.86
	1.30 to 1.35	29.7	79.2	7.1	4.6	1.46	1.09
	1.35 to 1.40	8.7	87.9	12.0	5.3	1.71	1.15
	1.40 to 1.45	4.2	92.1	15.6	5.8	2.16	1.19
	1.45 to 1.50	2.3	94.4	19.7	6.1	2.37	1.22
	1.50 to 1.55	1.4	95.8	24.0	6.4	2.97	1.25
	1.55 to 1.60	.5	96.3	26.2	6.5	4.07	1.26
	Over - 1.60	3.7	100.0	41.7	7.8	12.57	1.68
100-mesh by 0 (1.7 percent of sample)				9.0		2.07	

APPENDIX

Completed reports giving results of studies by counties:

Estimation of Known Recoverable Reserves

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