VOLUME VII NUMBER 1

THE RESOURCES OF TENNESSEE

A MAGAZINE DEVOTED TO THE DESCRIPTION, CONSERVATION AND DEVELOPMENT OF THE RESOURCES OF TENNESSEE

PUBLISHED
JANUARY, APRIL, JULY AND OCTOBER
BY THE
STATE GEOLOGICAL SURVEY
NASHVILLE, TENN.

JANUARY, 1917

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Published by the State Geological Survey
NASHVILLE, TENNESSEE

JANUARY, 1917

State Geological Commission

Gov. TOM C. RYE, *Chairman*

Dr. BROWN AYRES, *Secretary*
President, University of Tennessee

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Commissioner of Agriculture

Dr. J. H. KIRKLAND
Chancellor, Vanderbilt University

BISHOP A. W. KNIGHT
Vice-Chancellor, University of the South

R. A. SHIFLETT
Chief Mine Inspector

Geological Corps

A. H. PURDUE
State Geologist

PAUL C. BOWERS
Chemist

J. A. SWITZER
Hydraulic Engineer

R. S. MADDOX
Forester

C. R. WATKINS, Jr.
Traverseman

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CORRECTION

In Volume VI, No. 4, p. 194, Table I, change "1914" to "1915".

After the year 1915, in the columns under "Total", let 8,246,030, represent the total number of long tons of phosphate produced in Tennessee from 1894 to 1915, inclusive; and let $28,906,894 represent the value of the phosphate for the period named.

LETTERS OF TRANSMITTAL

NASHVILLE, TENN., December 19, 1916

To His Excellency, the Governor, and Members of the Geological Commission:

GENTLEMEN—In compliance with the law establishing the State Geological Survey, I have the honor to transmit the report of the State Geologist for the biennial term ending December 19, 1916.

Very respectfully,

A. H. PURDUE, *State Geologist*

December 20, 1916

To the Members of the Sixtieth General Assembly of Tennessee:

In accordance with the Act creating the State Geological Survey there is submitted for your investigation the administrative report of the State Geologist, covering the period from December 19, 1914, to December 19, 1916. We bespeak your careful consideration of the report, showing the important field occupied by the Survey and the work done by it during the biennial period that has just closed.

Respectfully submitted,

TOM C. RYE, *Governor, Chairman of the Commission*
BROWN AYRES, *Secretary of the Commission*

Administrative Report of the State Geologist, 1916

SOURCES OF WEALTH

Let it be noticed that the subject of this heading is not wealth, but the *sources* of wealth. Their exact number may be a matter of dispute, but all will agree that two of them are the earth's minerals and the soil. "Minerals" as here used, includes all the material that comes out of the earth which man puts to use. If we ask which is the more important to our welfare, the minerals or the soil, it is like asking which is the more important to life, the lungs or the heart. We could not get along without either. Both the minerals and the soil are essential to life, the industries and progress; and the fullness of our commercial development is measured by the extent to which we utilize these two sources of wealth. The richest centers are those about developed mines, those in well-developed agricultural regions, and those where the products of the mine and the soil are brought together and made into articles of general use.

PURPOSE OF A GEOLOGICAL SURVEY

In general. the purpose of a state geological survey is to investigate and report upon its natural resources. The scope of any particular survey is wide or limited, depending upon the statute under which it is organized. It may include investigations upon minerals, soil, surface features, drainage, forestry, water power, water supply, land reclamation, and so on; or it may be limited to any one or more of these. By the statute under which the State Geological Survey of Tennessee is organized, its scope is so wide as to cover all the purposes named. Whether expressed by statute or not, the duty of aiding in the conservation of a state's resources is always an implied one.

WORK OF A GEOLOGICAL SURVEY

Collecting information.—With the above named duties in mind, it will be seen that the work of a state geological survey is to gather information on the resources of the state it serves, and give this out to the public. There are two kinds of information: That which comes incidentally from letters to the Survey, from those who call upon it, from newspaper and magazine items, etc.; and that which is secured from the field work of the geological corps. The first source is incidental, though important, and should be compiled for ready reference. The second source is the more important one, and is considered in the following:

Formerly, geological field work was largely of a general nature, and this answered the purpose very well, for its day. But the demands for detailed information have reached the stage that requires such work to be done with all the exactness that is practicable. For example, in the early days, it was sufficient to say that coal occurs throughout most of the Cumberland Plateau area. This very general information does not meet the demands of today. These call for the number of coal beds in the several parts of the region, and the approximate area, thickness, chemical composition, general mining conditions, etc., of each. The geology of these coal beds is so difficult, that much time is required to work it out. The same statement of necessary detail will apply to zinc, copper, marble, phosphate, oil and gas, and other deposits of value, as well as to soil surveys.

This necessity for exactness in geological work calls for correct maps, which for a large portion of the State are not in existence. In such areas, it therefore becomes necessary to make the maps. In this the Survey has adopted the plan of county maps. These maps show all the roads, farm houses, streams, schools, towns, churches, cemeteries, and railroads. It is the intention to make them exact enough for all practical purposes. The scale adopted is uniform for all the maps, and is one mile to the inch. Aside from forming a base for geological and soil mapping, these county maps are sought by farmers, and professional and business men. There are many calls for them, from persons living both in and out of the counties they represent.

The mapping of geological formations as they outcrop at the surface is a work that requires careful training in the science of the subject, and actual practice in the field. In places the work is comparatively easy, and in others it is very difficult, depending largely on the similarity or dissimilarity of the rocks, and the way they lie beneath the surface. Careful mapping of an area requires that the surface be covered closely, and this requires the geologist to go into the fields, woods and mountains. This makes it necessary for much of the field work to be done on foot, and in some areas all of it must be so done. Geological field work is arduous work.

A map made in this way reliably shows the different formations as they outcrop at the surface and, with the sections accompanying it, how they lie beneath the surface; and the report accompanying the map describes the formations as to their history, character, and economic value.

Giving out information—The information collected by a Geological Survey is given out in printed reports, maps and sections; by correspondence in answer to inquiries by mail; and in interviews with those who come to the office of the Survey for information on the resources of the State. These letters of inquiry and those persons calling at the office for information, come from all parts of the country. No small part of the time of the State Geologist is taken up in attending to them.

POSITIVE AND NEGATIVE INFORMATION

From the economic point of view, the results of geological investigations are both positive and negative. The positive results disclose the location, extent, character and geological occurrence of valuable deposits. The negative results show where deposits of certain kinds can not be expected. As examples of the two kinds of information, we know that oil may occur in some parts of this State, and that it can not occur in other parts; and we have the same information concerning coal, iron, copper, phosphate and other deposits of value. A deposit of one kind may and often does occur in regions where investigation shows there is no possible chance for a deposit of some other kind. Again, deposits of different kinds may and often do occur in the same area.

It is often worth as much to the public to know where a deposit ***can not*** be found as to know where it ***can*** be found, for such knowledge would save money. A great deal of money has been wasted in drilling for oil where there was no possibility of securing it, and much money is wasted in prospecting for other material. The Survey is always pleased to save the expense of hopeless search for deposits of any kind, when application for information is made to it.

That is, we are glad to say where certain deposits *can* be found, or where they *may* be found, or where they can *not* be found.

AN UNJUST CRITICISM

Geological surveys are sometimes criticised for appearing on the ground after mineral discoveries have been made, the inference being that after a discovery is made the geologist is useless. This criticism is unjust for several reasons. In the first place, a geological survey has a large area to cover. The area of the State of Tennessee is 42,022 square miles, much of which is mountainous. It is out of the question for the Geological Survey, without unusually large appropriations, to cover the State thoroughly, in even a score of years. To do so would require that every road, ravine, hill and mountain where there is any possible chance of finding valuable deposits be carefully traversed, some of them several times. It can not be expected that a geological survey, especially a young one, can know where all the valuable deposits occur. Again, after a mineral of worth has been discovered, the geologist, by visiting the prospect, can study the nature of the deposit, of the rocks inclosing it, how they outcrop at the surface and how they lie beneath it. From this he can form an opinion as to whether or not prospecting should be continued, how it should be continued, whether or not similar deposits may be expected elsewhere, and if so where they should be sought. And yet again, a valuable deposit may be known to an individual of the community where it occurs, and even to the whole community, and yet the knowledge of it be only local. Usually, those having knowledge of such deposits have neither the means nor experience for their development. It is the duty of a geological survey to bring such to public notice to the end that they may be developed.

There remains the additional fact that both individuals and companies of experience nearly always seek the opinion of the State Geologist before even venturing upon the field investigation of a new mineral find. A state geological survey is the official clearinghouse of knowledge concerning its natural wealth. It follows that if every acre of the State had been carefully surveyed for mineral wealth, the office of State Geologist would still be necessary to its interests, for official detailed information concerning this mineral wealth will always be sought. This information can be reliably given only by a geologist who is well grounded in the principles of the science and who is familiar with the geology of the entire state.

PUBLIC AND PRIVATE INTERESTS

A geological survey is conducted for the good of the state as a whole. To be most efficient, the work must be systematically planned ahead, and the plans faithfully followed. This requires that the members of the survey keep at the investigations assigned each, until they are finished, unless such unusual conditions arise as to justify a change of plans. Ordinarily, the plans of the Survey can not be interferred with to comply with requests for other work. These requests are of three kinds: Those that are certainly of private nature; those that are as certainly of public nature; and those of uncertain nature. The members of the survey could be kept busy going here and there upon requests of large enough importance to be of general public or at least community interest, but if this were done we should have but little of value at the end of the year to show for the money expended.

The Survey is sometimes embarrassed, and causes embarrassment, by having to refuse requests for work that plainly is of private nature. These requests are made in good faith, on the belief that a public office should make all investigations it is asked to make, the persons making them not stopping to distinguish between interests that are public and those that are private.

It will plainly be seen that the State should not bear the expense of reporting on a tract of phosphate or other mineral land, for a private company, except in such cases as the work will fit in with larger work already in hand. Nor should it bear the expense of reporting on land individually owned. Neither should the State bear the cost of expensive private analyses of minerals, rock or water, except where such analyses are needed to complete investigations that are in progress by the Survey. To do so, would require several chemists, constantly employed. It sometimes happens, however, that mineral specimens sent in to the Survey give promise of general value to the State, and in such cases complete analyses are made. Also, there are similar cases in which the Survey should look into, and give its opinion on deposits privately owned. For example, of such nature would be a deposit of zinc, which if successfully developed by the owners, would give promise of opening up a zinc mining area of greater or less extent.

An exception to the general rule against doing private work is made in the examination of mineral specimens sent to the Survey, post-paid. Such examinations usually require no great amount of time, and consists only in determining the general nature of the mineral. This, with its mineralogical name, the theoretical amount of each element composing it, and the uses to which it is put, are reported to the sender. One or more of such reports are made almost daily.

CONSERVATION

The duty of a state geological survey does not stop with calling attention to material of economic value, but extends to the utilization of material without waste. An idea of what is meant by this will be had from reading the accompanying article in this issue, on "By-product coke oven opportunities in Tennessee".

By statute it becomes the duty of the State Geological Survey to aid in reclaiming waste land. In compliance with this, surveys have been made of certain lowlands in West Tennessee to determine the feasibility of draining them, and for more than two years constant effort has been made toward reclaiming the enormous acreage of gullied land in certain parts of the State. The work of the latter is more fully described under the heading of "Forestry", later in this report.

MINERAL RESOURCES OF TENNESSEE

Perhaps no state in the Union has a greater variety of mineral resources than Tennessee. Of prime importance are barite, bauxite, clay, coal, copper, iron, marble, phosphate, and zinc. Of secondary importance are gold, guano, greensand, lead, manganese, mineral waters, nitrates of caves, and slate. Then there are the more common yet valuable deposits of sand and gravel, building stone, cement material, and road material. Oil and gas are not mentioned in either class because the development of these products has not been extensive enough to determine their importance.

Tennessee has not reached the rank as a mining state that its remarkable mineral resources entitle it to hold, and that there is all reason to expect of it within a few years. Neither are its manufacturing interests, which should go hand in hand with mining, developed as they should be. With its large amount of motive power in the form of coal and waterpower, and with an abundance and variety of raw material right at hand, Tennessee should soon take high rank as a manufacturing state. This phase of the State's development should have all the encouragement it can get.

GEOLOGICAL WORK OF THE SURVEY

Coal.—The work on the coal field of the Cumberland Plateau is under the immediate supervision of Dr. L. C. Glenn. It has been in progress since 1910, but has been interrupted by the duties of Dr. Glenn as Professor of Geology in Vanderbilt University, and by the retirement from the Survey in September, 1914, of Mr. W. A. Nelson, who was assisting him. Part of the summer of 1915 was spent by Dr. Glenn in the northern part of Cumberland Plateau, and in a reconnaissance trip over the southern half of the Cumberland coal field. A few field trips were made by him during the fall and winter of 1915-16. Most of his time given the Survey in 1916 was employed in the preparation of the report.

In the early part of 1915, under coöperative arrangement with the U. S. Geological Survey, F. R. Clark of that bureau collected 411 samples of coal from the mines in all parts of the Cumberland Plateau, for analysis. The analyses were made in the Bureau of Mines' laboratory, at Pittsburg, Pennsylvania, and as elsewhere stated in this report, were published by the U. S. Geological Survey, Bulletin 621-P, pp. 269-365, 1916.

Gravel.—In the work on mapping the Cretaceous formations in West Tennessee, Mr. Bruce Wade gave special attention to the gravel deposits that occur in the vicinity of Tennessee River. These will have attention later in a paper by Mr. Wade, giving their distribution and discussing their economic importance.

Manganese.—As was true of many other minerals, the European war created a demand for manganese far above the average, and numerous inquiries came as to its occurrence in Tennessee. To add to the information the Survey already had, the State Geologist, in the early part of 1916, visited the deposits that occur in Bradley, Monroe, Sevier, Cocke, Hamblen, Unicoi, and Carter counties. His observations on manganese in these counties, with those of Mr. O. P. Jenkins on that mineral in Johnson County, were published in the *Resources of Tennessee*, Volume VI, No. 2, pp. 106-123.

Marble.—During the past two years, Dr. C. H. Gordon, engaged in marble investigations, spent somewhat more than two months, mainly in the preparation of the report on field work previously done, though a few days were spent in the field. With the exception of the preparation of the maps to accompany his report, it is now ready for publication.

Oil and gas.—During the last two years oil has been eagerly sought in all parts of the country, and Tennessee has had its share of attention. Some oil development was made at Oneida, Scott County, in 1915 and 1916. During the months of July and August, 1915, Mr. H. F. Bain was sent to Oneida, where he spent 32 days in keeping logs of wells as they were being drilled. The purpose of this was to enable the Survey intelligently to study the oil conditions of the Cumberland Plateau as these were made known by the drill. In addition, Dr. L. C. Glenn, at different times made trips to the field during the development. His investigations were published in the *Resources of Tennessee*, Vol. V, No. 4, pp. 174-194. More recently, some wells have been brought in at Glenmary, Scott County. These also have been visited by Dr. Glenn, and an account of them appears in this issue of the *Resources of Tennessee*.

In the *Resources of Tennessee,* Vol. VI, No. 1, January, 1916, pp. 1-36, there are two articles by the State Geologist, one on "Oil and gas conditions in the Central Basin of Tennessee" and one on "Oil and gas conditions of the Reelfoot Lake district of Tennessee".

The possibility of oil and gas in the southern part of Cumberland County is set forth in an article, with map, by Charles Butts, of the U. S. Geological Survey, in the *Resources of Tennessee,* Vol. VI, No. 2, April, 1916, pp. 108-110. As a result, a good deal of land southwest of Crossville has been leased for oil by one of the leading oil companies of the country.

Phosphate.—In the summer of 1914, Mr. J. S. Hook spent about three weeks on the investigation of the white phosphate deposits of Perry and Decatur counties, the entire summer of 1913 having been spent by him in the study of the brown and blue phosphates of south-central Tennessee. A preliminary paper by Mr. Hook on the white phosphates appears in the *Resources of Tennessee,* Vol. V, No. 1, pp. 23-33. He has in preparation a more exhaustive general paper on all the productive phosphate deposits of Middle Tennessee.

In January, 1915, phosphate was discovered in Johnson County, Tennessee. The report of the discovery brought a good many inquiries to the office of the Survey, with the result that Mr. O. P. Jenkins was sent to investigate the deposits, and spent the summer of 1915 at this work. His report is published in the *Resources of Tennessee,* Vol. VI, No. 2, pp. 51-106.

In the *Resources of Tennessee,* Vol. VI, No. 4, pp. 193-216, there is an article by W. C. Phalen of the U. S. Geological Survey on "The conservation of phosphate rock in Tennessee". This paper discusses the general nature of the phosphates of Tennessee, and the methods used in this State of mining phosphate rock and preparing it for the markets.

General Geology.—From May 24th to October 24th, 1915, Mr. Bruce Wade was engaged in the detailed field work necessary to mapping the geological formations in McNairy County. According to the plans of the Survey, this was the beginning of the geological mapping of a belt of country lying mainly west of Tennessee River and extending northward across the State, known in geology as the Cretaceous area of Tennessee. The average width of this belt is perhaps forty miles. In the southern part of the State, it extends across Tennessee River, into Hardin County. From October 24, 1915, to June, 1916, Mr. Wade, while a graduate student in geology at Johns Hopkins University, did an aggregate of two months' work, at such times as his studies would permit, on the McNairy County geological report.

On June 1, 1916, Mr. Wade resumed his field work and continued it until November 1st, at which time the mapping of Cretaceous deposits of Hardeman, McNairy, Hardin and Chester counties had been completed. During the present collegiate year, he, while yet a student at Johns Hopkins, will put in such time as he can on the report of his field work.

From June 28 to September 15, 1915, Dr. J. J. Galloway and Mr. H. N. Coryell were employed in studying the areal, stratigraphic and economic geology of Rutherford County. This was done under coöperative arrangement between this survey and the Agricultural Experiment Station, University of Tennessee. In connection with the geological mapping of this county, a part of the field work was done for a soil map. During the winter of 1915-16, Dr. Galloway prepared the report on this county, which is now ready for publication.

County maps.—During the years 1915-16 Mr. C. R. Watkins has been constantly employed in the traverse and office work necessary to the preparation of county maps. His work has been on McNairy, Hardin, Shelby, Decatur, Henderson, Chester, and Hardeman counties. In 1914 Mr. Watkins was associated for a time with F. W. Farnsworth in the work on McNairy County, and in 1915 was assisted in Hardin County by A. P. Miller. The following tables show the mileage traversed, by counties:

McNairy County (complete)		
Roads and railroad	1232 miles	
Streams	350 miles	
Levels run	82 miles	
Total		1664 miles
Hardin County (incomplete)		
Roads	420 miles	
Streams	170 miles	
Levels run	25 miles	
Total		615 miles
Shelby County (complete)		
Roads and railroads	2170*miles	
Streams	230 miles	
Total		2400 miles
Decatur County (complete)		
Roads	680 miles	
Streams	92 miles	
Total		772 miles
Chester County (complete)		
Roads and railroads	820 miles	
Streams	120 miles	
Total		940 miles
Hardeman County (incomplete)		
Roads	240 miles	
Streams	36 miles	
Total		276 miles

Concluded on p. 15.

*Of this amount, 310 miles were traversed by Mr. R. T. Allen, of the U. S. Bureau of Soils.

Henderson County (incomplete)

Roads	685 miles
Streams	95 miles
Total	780 miles
Grand Total traversed	7447 miles

In addition to the traverse work done by Mr. Watkins in the counties named, Messrs. G. M. Ferris and F. M. Maloney were employed in the summer of 1915 in traverse work for the map of Rutherford County. The map of this county was partly compiled from maps of the U. S. Geological Survey. No record is at hand of the mileage traversed by the employes of this Survey, but the area mapped by them covered about one-third of the county.

Soil maps.—During the summer and fall of 1915 Mr. R. T. Allen of the U. S. Bureau of Soils was engaged in mapping the types of soil in Shelby County. This was done under a coöperative agreement between the Bureau of Soils and this Survey, by which the latter was to supply the base map and the former do the soil mapping. Mr. Allen was transferred to another area before the work was completed and it was finished in the early part of 1916 by Mr. Hugh H. Bennett, of the Bureau of Soils, by which the report will be published.

In the summer of 1916, Mr. H. N. Coryell completed the soil map of Rutherford County, which, as above stated, was made in coöperation with the Agricultural Experiment Station, University of Tennessee. Mr. Coryell will prepare the report on the soils of this county during the present winter, as he can spare the time to do so from his studies as a graduate student in geology, University of Chicago.

WORK OF THE CHEMIST

The following is the report of Dr. Paul C. Bowers, Chemist of the Geological Survey, of work done from January 1, 1915, to November 25, 1916:

Determination of mineral specimens sent to the Survey.—Reports made, 373; number of specimens reported, 576; number of mineral contents reported in specimens, 1216.

Quantitative analyses.—Partial chemical analyses, 129 samples; complete chemical analyses, 14 samples; number of determinations in partial and complete analyses, 643.

A little more than two months of the summer of 1915 were spent by Dr. Bowers in the laboratory of the Bureau of Mines, at Pittsburgh, Pennsylvania, assisting in the analyses of 411 samples of Tennessee coal.

WORK OF THE FORESTRY DIVISION

During the years 1915 and 1916, the efforts of the Forester, Mr. R. S. Maddox, were exerted along the lines of practical forestry and educational work.

In practical forestry, 19 experiments in reclamation of gullied land were started under the immediate supervision of the Forester, and many others were undertaken upon his suggestion, but not by his personal assistance. Black locust seed were secured for 18 farmers who were willing to plant them for seedlings. What is equally encouraging, 5,000 black locust seedlings were set out on abandoned land in the spring of 1915, more than 50,000 in the spring of 1916, and 16,000 have already been ordered through this office for next spring's setting, independently of those ordered direct by the farmers themselves. Some farmers are using Bermuda grass and honeysuckle vines in addition to black locust, to reclaim waste land. Roots of the kudzu plant, a little known perennial legume, were sent to 30 farmers to try experimentally on waste land.

In the educational line, Mr. Maddox delivered a week's lectures on forestry during the summer session of the Middle Tennessee State Normal School, and during the two years gave between 50 and 60 talks at different places in the State. A forestry exhibit was made at the State fair, and at the Knoxville and Dresden fairs. Numerous gully and fire posters have been put up, and 7 clubs have been organized in West Tennessee, for the reclamation of gullied land.

Forestry in America is new and the conception of its importance is of slow growth, but the results of the past two years' work of the Forester are encouraging, both in what it promises toward the reclamation of waste land and in the general interest in forest conditions.

GEOLOGICAL CORPS

During the years 1915 and 1916, the following named persons were employed, most of them for only a part of the time, on this Survey:

A. H. Purdue, *State Geologist.*
Wilbur A. Nelson, *Assistant Geologist.*
Olaf P. Jenkins, *Assistant Geologist.*
J. A. Switzer, *Hydraulic Engineer.*
Paul C. Bowers, *Chemist.*
R. S. Maddox, *Forester.*
L. C. Glenn, *Temporary Geologist in charge of coal work.*
C. H. Gordon, *Temporary Geologist engaged in marble studies.*
Bruce Wade, *Temporary assistant in areal geology.*
J. J. Galloway, *Temporary assistant in areal geology.*
Reese F. Rogers, *Assistant on brown iron ore.*
C. R. Watkins, Jr., *Traverseman.*
G. M. Ferris, *Traverseman.*
F. W. Farnsworth, *Traverseman.*
A. P. Miller, *Traverseman.*
E. A. Eubank, *Traverseman.*
J. T. Haden, *Draftsman.*
H. F. Bain, *Assistant.*
Elizabeth Cockrill,* *Secretary.*
Lewis M. Childress, *Secretary.*
Hobart Watson, *Laboratory helper.*

COÖPERATIVE EMPLOYES

The following named persons were employed a part of the time in 1915 and 1916, representing organizations that were coöperating with this Survey:

T. Nelson Dale, *representing the U. S. Geological Survey in marble investigations.*
F. R. Clark, *representing the U. S. Geological Survey in collecting coal samples.*

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*After more than six years of efficient service as Secretary of the Survey, Miss Cockrill retired at the end of September, 1916, and was succeeded by Miss Lewis M. Childress.

Charles Butts and George H. Ashley, *representing the U. S. Geological Survey in the Crossville coal area.*

W. C. Phalen, *representing the U. S. Geological Survey in phosphate investigations.*

Oliver Bowles, *representing the U. S. Bureau of Mines in marble investigations.*

Hugh H. Bennett and R. T. Allen, *representing the U. S. Bureau of Soils, in the soil survey of Shelby County.*

H. N. Coryell and F. M. Maloney, *representing the Experiment Station, University of Tennessee, in the soil survey of Rutherford County.*

PUBLICATIONS

The following is a list of the publications of the Geological Survey from December, 1914, to December, 1916:

The Resources of Tennessee, Volume V, Nos. 1, 2, 3, 4.

The Resources of Tennessee, Volume VI, Nos. 1, 2, 3, 4.

Bulletin 18—Administrative Report of the State Geologist, published December, 1914.

Tennessee coal analyses, published in Bulletin 621-P, U. S. Geological Survey, pp. 269-365, 1916.

Geological map of Tennessee, published 1915.

Map of Lewis County, published 1915.

Map of Rutherford County, published 1916.

Map of McNairy County, published in 1916.

MANUSCRIPTS AND MAPS

Some of the following manuscripts and maps are ready for publication, and the others are in course of preparation:

The Historic Geology of Tennessee, by O. P. Jenkins.

The Marbles of Tennessee, by C. H. Gordon, T. Nelson Dale and Oliver Bowles (in preparation).

The Geology of Rutherford County (with map), by J. J. Galloway and H. N. Coryell (ready for the press).

Elevations in Tennessee, by Elizabeth Cockrill (ready for the press).

The Tennessee Coal Fields, by L. C. Glenn and Wilbur A. Nelson (in preparation).

Tennessee Phosphate, by J. S. Hook (in preparation).

Geology of the Crossville Area, by Charles Butts (in preparation).

Geology of McNairy County, by Bruce Wade (in preparation).

The Cretaceous Geology of Decatur County, by Bruce Wade (in preparation).

The Cretaceous Geology of Hardin County, by Bruce Wade (in preparation).

Map of Decatur County (ready for the press).

Map of Chester County (ready for the press).

Map of Henderson County (in preparation).

Marketing Woodlot Products in Tennessee, by W. D. Sterrett (ready for the press).

TABLE OF EXPENDITURES FROM DECEMBER 19, 1914, TO DECEMBER 19, 1916

	Office Salary	Field Salary	Field Expenses	Printing and Engraving	Equipment	Supplies	Postage	Freight, Drayage Telep., Etc.	Miscellaneous	Total
ADMINISTRATION:										
General	$ 3,695 94	$ 183 32	$ 227 58	$ 49 25	$ 423 85	$ 39 48	$ 52 00	$137 54	$86 39	$ 4,895 35
SURVEY AND REPORT:										
General	90 00	1,412 96	467 82	13 25	1,015 98	154 21	....	4 86	......	3,159 08
LIBRARY	....	....	....	....	362 80	....	....	16 10	......	378 90
LABORATORY	2,836 50	....	....	22 50	4 13	294 05	....	....	......	3,157 18
AREAL GEOLOGY:										
Crossville	....	....	18 00	....	....	....	....	....	......	18 00
McNairy County	200 00	634 90	442 37	....	....	....	....	....	......	1,277 27
Rutherford County	125 00	400 00	39 86	....	....	....	....	3 13	......	567 99
Hardin County	....	343 33	224 03	....	....	17 11	....	....	......	584 47
Decatur County	....	166 67	105 81	....	....	....	....	....	......	272 48
Chester County	....	64 50	51 60	....	....	....	....	....	......	116 10
Hardeman County	....	22 60	18 00	....	....	....	....	....	......	40 60
METALLIC ORES:										
West Tenn. Iron Ore Region	164 50	15 00	8 35	150 00	....	....	....	....	......	337 85
Zinc in East Tennessee	....	....	8 70	....	....	....	....	....	......	8 70
FUELS:										
Coal	1,263 95	348 25	559 64	....	....	....	....	2 25	......	2,174 09
Oil and Gas, Special	....	88 00	27 00	....	....	0 75	....	....	......	115 75
BUILDING STONE:										
Marble	622 45	40 00	11 92	....	....	3 43	4 50	1 02	......	683 32
CHEMICAL ARTS:										
Phosphate	55 00	....	....	....	....	....	....	....	......	55 00
SOIL SURVEY:										
Shelby County	....	614 32	472 27	....	....	....	....	....	......	1,086 59
FORESTRY:										
General	1,719 91	2,083 27	626 02	63 50	5.75	....	20 00	....	......	4,518 45

INFORMATION:										
General	2,732 42	177 66	101 78	7 00	7 50	271 27	199 00	1 31	......	3,497 94
Photographs	....	....	....	....	40 18	4 24	......	......	......	44 42
STATE EXHIBIT	....	....	....	....	4 75	4 80	......	......	......	9 55
RESOURCES OF TENNESSEE	1,077 64	208 00	55 54	2,184 60	....	21 62	68 00	0 50	0 50	3,616 40
STATE MAP	125 00	....	....	1,496 20	....	59 25	21 00	7 47	......	1,708 92
HISTORIC GEOLOGY BULLETIN	616 66	....	....	....	....	......	......	......	......	616 66
COUNTY MAPS:										
McNairy County	....	450 00	408 47	....	....	......	......	1 01	......	859 48
Hardin County	....	276 34	413 08	....	....	......	......	......	......	689 42
Rutherford County	....	134 00	208 60	124 00	....	2 23	......	6 49	......	475 32
Decatur County	....	308 75	394 41	....	....	0 75	......	......	......	703 91
Chester County	....	240 00	191 50	0 85	....	......	......	......	......	432 35
Henderson County	....	145 50	131 21	....	....	......	......	......	......	276 71
Hardeman County	....	57 75	64 57	....	....	......	......	......	......	122 32
ECONOMIC GEOLOGY:										
Johnson County	300 00	565 00	228 68	....	....	......	......	......	......	1,093 68
Total	$15,624 97	$8,980 12	$5,506 81	$4,111 15	$1,864 94	$873 19	$364 50	$181 68	$86 89	$37,594 25

The total amount expended for geological and soil survey work in Tennessee from December 19, 1914, to December 19, 1916, is shown in the following table. With the exception of the first item, this money was expended under coöperative arrangements between this Survey and other organizations:

Table of total expenditures

Expenditures as shown by the preceding Table of Expenditures....		$ 37,594 25
Expended by the U. S. Bureau of Soils in the Survey of Shelby County	$ 1,864 46	
Expended by the Agricultural Experiment Station, University of Tennessee, in the survey of Rutherford County........	1,472 00	
Expended by the Bureau of Mines in marble investigation........	160 00	
Expended by the U. S. Geological Survey in marble investigation..	549 72	
Expended by the U. S. Geological Survey in collecting samples of Tennessee coal	640 00	
Expended by the U. S. Geological Survey in the Crossville coal area	185 63	
Total........	$ 42,466.06	

APPROPRIATION REQUESTED

The following appropriation is requested of the Sixtieth General Assembly and has been approved by the Geological Commission:

For the purpose of carrying on the work of the Survey in accordance with Senate Bill No. 330, Chapter 569, Acts of 1909, from May 1, 1917, to May 1, 1919, salaries and expenses........	$30,000
To be applied toward publishing the *Resources of Tennessee*........	2,000
To be applied toward the publication of bulletins........	6,000
For the maintenance of the Forestry Division of the Survey, salaries and expenses	6,500
Total........	$44,500

ACT ESTABLISHING THE GEOLOGICAL SURVEY

The bill establishing the State Geological Survey was passed by the Fifty-sixth General Assembly of Tennessee in 1909, and is as follows:

CHAPTER 569

SENATE BILL No. 330

(By Messrs. Greer, Huffaker, and Neal.)

A BILL to be entitled An Act to establish and create the bureau to be known as the State Geological Survey; defining its objects, powers, and duties; providing for the appointment of a State Geologist, and defining his powers and duties; permitting coöperation with Federal and State bureaus in furthering the objects of this Act; providing for the publication of the results of the survey; providing for the collection of exhibits of the natural resources of the State, and for the final disposition of the equipment and property of the Survey; authorizing entrance upon private lands in the prosecution of the work of the survey; and making the appropriations for the enforcement of this Act.

SECTION 1. *Be it enacted by the General Assembly of the State of Tennessee,* That there be, and is hereby, created and established a bureau to be known as the "State Geological Survey," which shall be under the direction of a Commission to be known as the "State Geological Commission", composed of the Governor (who shall be ex-officio Chairman of said Commission), the State Commissioner of Agriculture, the State Mine Inspector, the President of the University of Tennessee, the Chancellor of Vanderbilt University, and the Vice Chancellor of the University of the South.

SEC. 2. *Be it further enacted,* That the said Commission shall have general charge of the State Geological Survey and shall appoint as Director a Geologist of established reputation, who shall be known as the "State Geologist," and upon his recommendation such associate geologists, assistants, and employees as may be necessary to carry out successfully and speedily the work of the Survey.

The Director, associates, assistants, and employees appointed under the provisions of this Act shall receive such compensation as shall be determined by the Commission. The said Commissioners shall serve without compensation, but shall be reimbursed for actual expenses incurred in the performance of their official duties.

SEC. 3. *Be it further enacted,* That the said Commissioners shall meet for organization within thirty days after the passage of this Act, and shall appoint a Director as soon thereafter as possible. The regular meetings of the Commission shall be held on the first Wednesday in May and the first Wednesday in November of each year in such place as the Commission shall determine.

SEC. 4. *Be it further enacted,* That it shall be the duty of the State Geologist, subject to the approval of the Commission, to organize and direct the work of the State Geological Survey in field and office; to determine the character, order, and time of publication of the reports of the survey, and to direct the preparation, printing, and distribution of the same; to arrange for co-operative work with the various Federal and State scientific bureaus where such work shall redound to the interest of the people of the State; to appoint such associates, assistants, and employees as may be necessary to carry out successfully and speedily the work of the survey; to procure and have charge of the necessary field and office supplies and other equipment, and supervise the acquisition, care, and distribution of the collections of the State Geological Survey; and to perform such other work as may be necessary to the successful conduct of the survey. He shall prepare a report to the General Assembly before each meeting of the same, setting forth the progress and conditions of the survey, together with such other information as the commission may deem necessary and useful.

SEC. 5. *Be it further enacted,* That the said State Geological Survey shall have for its objects and duties the following:

1. A study of the geological formations of the State, with especial reference to their economic products, including coal, oil, gas, ores, fertilizers, building stones, road-making materials, clays, cement materials, sands, soils, forests, mineral and artesian waters, drainage of swamps, streams, and water powers, and other natural resources.

2. A study of the character, origin, and relations of the soils of the State, with especial reference to their adaptability to particular crops, the maintenance of soil fertility, and the conservation and utilization of supplies of natural fertilizers.

3. A study of the road-making materials of the State, with reference to their character, distribution, and the best methods of utilizing the same.

4. A study of the occurrence and availability of underground water supplies.

5. An investigation of the forests, streams, and water powers of the State, with especial reference to their conservation and development for industrial enterprises.

6. A study of the swamps and other nontillable lands of the State, with reference to their reclamation for agricultural purposes.

7. A study of the physical features of the State, with reference to their bearing upon the occupations, physical welfare, and intellectual pursuits of the people.

8. The preparation of special reports with necessary illustrations and maps, which shall embrace both general and detailed descriptions of the geology, topography, and natural resources of the State.

9. The preparation of special geologic, topographic, and economic maps to illustrate the structure, relief, and natural resources of the State.

10. The consideration of such other scientific and economic questions as in the judgment of the Commission shall be deemed of value to the people of the State.

SEC. 6. *Be it further enacted,* That the regular and special reports of the State Geological Survey, with proper illustrations and maps, shall be printed and distributed and sold as the Commission shall deem best for the interest of the people of the State and as said Commission may direct, and all moneys obtained by the sale of said reports shall be paid into the State treasury. The said Commission shall be caused to be prepared a report to the General Assembly before each meeting of the same, showing the progress and condition of the survey, together with such other information as they may deem necessary and useful, or as the General Assembly may require; *provided, however,* that the Commission shall have the right to print and distribute said reports.

SEC. 7. *Be it further enacted,* That after having served the purposes of the Survey, all material collected shall be distributed by the Director to the educational institutions of the State in such manner as the Commission may determine to be of advantage to the educational interests of the State; *provided, however,* that if deemed advisable, the Commission may first use such portion as may be necessary to establish a permanent exhibit of the natural resources of the State. On the completion or discontinuance of the State Geological Survey, the Commission shall cause all records, notes, books, reports, charts, maps, manuscripts, instruments, and other equipment and property of the survey to be placed in charge of a suitable custodian to be held subject to final disposition by the General Assembly; *provided, however,* that any field or other equipment which the Commission shall deem it undesirable to preserve may be sold as the Commission may direct and the money turned into the State treasury; and, *provided further,* that the copies of the reports of the survey left on hand for distribution shall be distributed by the custodian in such manner as shall be for the best interest of the people of the State.

SEC. 8. *Be it further enacted,* That the said Commission is hereby authorized to enter into coöperation with the United States Geological Survey and other scientific bureaus of the Federal and State governments for the prosecution at joint expense of such work in the State as shall be deemed of mutual interest and advantage, and under such conditions as said Commission may deem to be for the best interest of the people of the State.

SEC. 9. *Be it further enacted,* That in order to carry out the provisions of this Act, it shall be lawful for any person or persons employed hereunder to enter and cross all lands within the State; *provided,* that in so doing no damage is done to private property.

SEC. 10. *Be it further enacted,* That for the purpose of carrying out the provisions of this Act, fifteen thousand dollars ($15,000) annually for the years 1910 and 1911, or so much thereof as may be necessary, is hereby appropriated out of any money in the State treasury not otherwise appropriated, and the State Treasurer is hereby authorized to pay out the same on the warrants of the Comptroller upon the presentation of the proper vouchers by the Chairman of said State Geological Commission; *provided,* that the appropriation made herein shall not be available until May 1, 1910.

SEC. 11. *Be it further enacted,* That this Act take effect from and after its passage, the public welfare requiring it.

Passed April 30, 1909.

WM. KINNEY,
Speaker of the Senate.

M. HILLSMAN TAYLOR,
Speaker of the House of Representatives.

Approved May 1, 1909.

MALCOLM R. PATTERSON,
Governor.

By-Product Coke Oven Opportunities in Tennessee

BY A. H. PURDUE.

Products from coal.—When bituminous coal is heated in ovens that do not permit the access of air, the following products are formed: Coke, coal gas, coal tar, liquid ammonia and benzol.

Coke is composed mainly of carbon (C) but it also contains small amounts of hydrogen (H), oxygen (O), nitrogen (N), and sulphur (S). In addition to these it contains more or less mineral matter, as ash. In making coke the other products; namely, coal gas, coal tar, liquid ammonia, and benzol, are driven off, as volatile matter. These are permitted to escape into the air and are wasted, or become by-products, depending upon the kind of oven used. A ton of bituminous coal will produce from .50 to .79 of a ton of coke, the amount also depending mainly upon the kind of oven used, though in part upon the character of the coal.

Coal gas is a complex mixture of gases and vapors, of which hydrogen and marsh gas (CH_4) are the chief constituents. Other constituents are carbon monoxide (CO), carbon dioxide (CO_2), olefiant gas (C_2H_4), tetrylene (C_4H_8), hydrogen sulphide (H_2S), and nitrogen; and there are traces of ammonia (NH_3), carbon disulphide (CS_2), cyanogen (CN), and oxygen. A ton of average bituminous coal will produce about 10,000 feet of gas.

Coal tar is a mixture of many different substances. These are separated into different products by chemical processes, and from these products are made coal-tar dyes, coal-tar medicines, perfumes, etc. The amount of tar that a ton of coal will produce varies roughly between 3 and 5 per cent. of its weight, or between 6 and 10 gallons.

Ammonia is one of the remaining substances after the coal tar has been removed from the volatile matter of the coke oven. It is recovered in forms from crude liquor to nearly chemically pure ammonia and by being converted into ammonium sulphate $(NH_4)_2SO_4$, the principal use of which is in the manufacture of fertilizers. A ton of average coking coal will produce about 20 pounds of ammonium sulphate.

Benzol or benzene (C_6H_6) is obtained from the volatile matter of coke ovens, after the coal tar and ammonia have been removed. From it are made tuluol or toluene ($C_6H_5CH_3$), xylol or xylene $C_6H_4(CH_3)_2$, coal-tar naptha and other compounds of hydrogen and carbon which, like those named, are known as hydrocarbons. The benzol and tuluol, etc., form the basis for the coal-tar dyes, and from them also are made the high explosives.

Value of coal products.—The value of coal products varies with their character, with the local demands, and with the general market conditions, but the following table will perhaps give an idea of their average worth, omitting benzol, upon the value of which the writer is not informed.

Table of the overage value of the products from one ton of coal, treated in a by-products oven

Coke, .70 of a ton, valued at $2.50 a ton	$1.75
Surplus coal gas, 5,000 ft.,* valued at .04 cts	0.20
Coal tar, 10 gallons, valued at 2½ cts. per gallon	0.25
Ammonium sulphate, 20 lbs. at 2½ cts. per lb. (net)	0.50
Total	$2.70
Value without the coke	0.95

It should be repeated that the amount of the by-products from a ton of coal and their value is variable with time and place, but it is thought that the figures given are very conservative. Granted that they are, attention is called to the fact that the value of the by-products in the manufacture of coke is $0.95 for each ton of coal used. That is to say, this value is wasted unless some sort of by-product oven is used. If a company is using the beehive type of oven (which wastes all the by-products), and consumes the moderate amount of only 200,000 tons of coal a year for that purpose, we have the amazing loss of $190,000; and this does not include the benzol. The value of the surplus gas is estimated on a minimum of what it would bring for manufacturing purposes. Where there is domestic consumption, it probably would have a much higher net

*Approximately half the gas produced is used at the plant, in heating the ovens.

value. The gas consumed in heating the ovens, which is approximately 50 per cent of the amount produced, is not here taken into account, but it really should be credited to the plant. Eliminating the gas entirely from the computation, and counting only the coal tar and the ammonium sulphate, their value yet from 200,000 tons of coal would be $150,000.

There is yet another advantage of the by-product over the beehive oven. The former will make from 0.65 to 0.79 of a ton of coke to one of coal, while the latter will produce only from 0.50 to 0.55 of a ton of coke to one of coal. And again, the time required for burning in the former is less than half what it is in the latter.

Coke producers not to be censured.—Amazing as is the waste from the beehive oven in coke manufacture, the producers of coke are not to be censured for having used them in the past nor perhaps under certain conditions at the present time. The past has demanded iron, and the manufacture of iron in turn demanded coke. Until recently it was thought that coke made in the by-product furnace could not be used for metallurgical purposes, and it was mainly for such purposes that coke was manufactured.

The day of permissible wastefulness is past.—But now, there is a demand by the blast furnaces for coke from the by-product ovens, and there is a market for all the by-products. The European war has brought forcibly and painfully to our attention the fact that we have been dependent upon Germany for our dyestuffs; and the scarcity of dyestuffs brought on by the war has aroused our manufacturers and chemists to such activity that plants for their production are rapidly springing up in this country. The outlook is that we shall never again be dependent upon a foreign country for them. That the condition ever obtained is not to be blamed upon our manufacturers and chemists, for there has heretofore been no business incentive to produce dyestuffs. That we have not produced them is not because we could not, but because the business was not profitable.

Now that the domestic demand for by-products from coke exists, and doubtless will continue to do so, there is no longer any excuse for wastefulness, except possibly in isolated cases. This is realized by the producers of coke. They are not asleep to the possibilities open to them. They see that the by-product ovens will pay, and that they can not afford to do without them; but business changes usually have their difficulties, and the one from the beehive to the by-product ovens is no exception to the rule. A company that has been making coke in beehive ovens has a large amount of money invested in them, and the change requires that this be sacrificed. Also, by-product plants are very expensive, and the capitalist hesitates and investigates before putting his money in them. Many coke ovens are located at the coal mines to save shipping, and there is no market for the gas.

These are some of the business considerations that confront the conservationist in his protest against waste. Still, his answer is that the pitiful waste must cease and that the conditions by which it can be stopped without unfairness to producers, must be brought about at the first hour it can be.

As stated above, all the possible by-products from coke go to waste from the beehive oven. The worth of this wasted material may be seen by reference to the above table of its value. The time has come when it seems not only a crime for any coke maker to permit this waste from his plant, but it is doubtful if any one has a moral right even to burn coking coal in the furnace that heats his home, when coke can be had for the purpose. Under normal conditions, this country imports annually about $10,000,000 worth of coal-tar products, to say nothing of the other by-products. With our large supply of coking coal, and with the protection that it appears the by-product industry can now rely upon, these should be produced at home in the future.

With the amount of coal coked in Tennessee in 1915 as 460,354 tons*' and assuming that the average value of the possible by-products from a ton of this is $0.95, then it follows that the waste in the State from that source in the year named was $437,336.30. As already stated, the manufacturers of coke have given more or less attention to saving their by-products. Some of them have even had their plants investigated and reported upon by experts, with the view of making the change, and have decided to make it as soon as practicable. Whatever may be the reasons for not having already made the change, it is certainly hoped that at least the larger coke producers will, at the earliest opportunity, abandon the beehive ovens with their deplorable waste, and substitute those that conserve the valuable products to our needs instead of allowing them to escape into the air to be lost forever.

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*From manuscript of the report of the State Mining Department for 1915.

History of coke ovens.— Most people are familiar with the condition for making charcoal, which is that the wood shall be burned without free access of air. When charcoal is intended for fuel, the wood is arranged in a conical pile around a central aperture, then covered with earth, and fired. In making coke, the same principle governs the process, and it appears that the first coke was made in the same way that fuel charcoal is made, except of course that bituminous coal was substituted for wood.

FIG. 1. Beehive coke ovens at LaFollette, Tennessee.

The first coke oven used was of the beehive type, and this is still common in America, though it seems to have been wholly discarded in Europe. The beehive oven is dome-shaped with a circular opening at the top, through which the oven is charged with coal. Those used in Tennessee hold about 7 tons of coal each. They are arranged in rows, as shown in the figure, and their individual shape does not show from the outside. They are charged through the circular openings, from cars that run along a track on top of the ovens. The time of burning is either 48 or 72 hours. When the process of distillation is complete, the coke is drawn through a door on a level with the floor of the oven. This is kept closed during the process of burning.

In the history of coke ovens, the beehive was followed by the retort oven. This is more complicated than the beehive, and is used in producing coal gas, in which case coke comes to be a by-product. It has the advantages of saving tar and ammonia liquor as by-products, of coking coal low in volatile matter, and in doing it in about half the time required by the beehive oven.

The development of by-product recovery seems to have been a gradual one from that of the retort oven used in the manufacture of coal gas to that of the present efficient by-product plant.

FIG. 2. By-product coke plant, Fairfield, Alabama.

Mr. H. Mansfield, superintendent of the Chattanooga Gas & Coal Products Company, Chattanooga, Tennessee, who has had long experience with by-product ovens, is the authority for the following statements on their introduction in the United States: The by-product industry began in the United States in 1894-5, the Cambra Steel Company at Johnstown, Pennsylvania, being the first to introduce by-product coke for metallurgical purposes. A second plant of 120 ovens immediately followed, and was located at Glassport, a short distance above Pittsburg. This was intended more as an experimental plant to introduce by-product coke to the blast furnace operator. Mr. Mansfield further says that the next plant to be built was one of 400 ovens at Everett, Massachusetts, to supply gas for the city of Boston. This was quickly followed by 50 ovens at Hamilton, Ohio; 212 at Sharon, Pennsylvania; 200 at Sparrows Point, Maryland; 50 at Indianapolis, etc., with the result that perhaps 40 per cent. of the coke now made is from by-product ovens.

By-product ovens in the United States are increasing much more rapidly than the beehive ovens, but it is yet a deplorable fact that perhaps twice as much coal is used in the latter as in the former.

Coke ovens in Tennessee.—The following table gives the number and distribution of coke ovens in Tennessee in 1915:

Coke ovens in Tennessee in 1915*

County	No. of ovens	No. in blast	Name and office of company
Campbell	293	280	LaFollette Coal, Iron & Railway Company, LaFollette, Tennessee.
Grundy	214	90	Sewanee Fuel & Iron Company, Coalmont, Tennessee.
			Tennessee Consolidated Coal Company, Tracy City, Tennessee.
Hamilton	212	105	Durham Coal & Iron Company, Soddy, Tennessee.
Morgan	140	96	Brushy Mountain Coal Mines, Petros, Tennessee.
Roane	340	240	Roane Iron Company, Rockwood, Tennessee.
Total..........	1199	811	

All the ovens named in the above table are of the beehive type. In 1915 a by-product plant was built at Chattanooga, by the Chattanooga Gas & Coal Products Company, and put in operation in 1916. The total amount of coal coked in Tennessee in 1915 was 460,354 short tons. This made 247,571 short tons of coke,† which means that on the average the coke ovens in Tennessee produced .538 tons of coke to a ton of coal.

Example of business opportunities.—Of the coke plants of the State, the writer has seen only those at Rockwood and LaFollette. The conditions are much the same at the two places, but at the latter the geology is the more conspicuous, and for that reason it will be

*From manuscript of the report of the State Mining Department for 1915.
†Loc. cit.

taken as an example of the business opportunities that it would seem are open to the investor at the coke plants in Tennessee.

The LaFollette Coal, Iron and Railway Company has, at LaFollette, 293 beehive ovens. The company has made investigations into the advisability of installing a by-product plant, the report of which was placed in the writer's hands through the courtesy of Mr. A. D. Macfarlane, Assistant Manager and Chief Engineer. This report considers such questions as the general mine conditions, character of the coal, cost of coke production, coke from slack and from mixed coal, amount and value of possible by-products, and general business considerations.

Of these, only the amount and value of the by-products will be considered here. For determining this important matter, 100 lbs. of coal were sent to H. Koppers Company, Joliet, Illinois, to be tested in their ovens. This test showed that for each ton of coal charged into the ovens, the following by-products could be obtained:

Table showing possible products from one ton of LaFollette coal

Tar	63.60 pounds	or 8½ gallons.*
Free ammonia	9.00 pounds	This would produce 34.68 lbs. of ammonium sulphate.
Combined ammonia	.60 pounds	
Water	112.80 pounds	
Carbon dioxide	24.20 pounds	
Hydrogen sulphide	6.00 pounds	
Gas	345.40 pounds	or 11302 cu. ft.
Coke	1438.40 pounds	
Total	2000.00 pounds	

An analysis of the gas was as follows:

Illuminants	4.00 per cent
Carbon monoxide (CO)	7.00 per cent
Hydrogen	49.58 per cent
Marsh gas (CH_4)	32.85 per cent
Nitrogen	6.57 per cent
Total	100.00 per cent

The heat value of the gas is 627 B. T. U. per cu. ft. The value of the by-products is shown in the following table:

*The writer computes this as 6.63' gallons.

Table showing the value of the possible by-products from one ton of LaFollette coal

8½ gallons of coal tar at 2½c per gallon	$0.2125
34 lbs. of ammonium sulphate at 2½c per lb. (net)	.8500
5,000 cu. ft. of surplus gas at 4c per thousand (one-half the amount produced is used in heating the ovens)	.2000
Total value	$1.2625

The officials report that approximately 225,000 tons of coal are used annually by the Company, in making coke. The possible by-products on this coal would be worth, according to the test made, $284,062.50. This is the astonishing amount of 56.81 per cent. on a plant costing $500,000. Doubtless there are incidental losses connected with a by-product plant of which the writer is not aware, though it would appear that after deducting a liberal amount for interest on the investment, taxes, depreciation, labor, administration, and such other losses as might occur, there should remain a good net profit; but this is a business matter upon which the writer can not speak, and into which prospective investors would of course look.

However, it should be remembered that there are two points of gain not considered in the above calculation; namely, the greater amount of coke obtained from a ton of coal from the by-product oven, over that obtained from the beehive, which is from 10 to 20 per cent. On the basis of a consumption of 225,000 tons of coal with the maximum yield of 55 per cent in the beehive oven, the coke produced would be 123,750 tons. The same amount coked in the by-products oven, with the minimum yield of 65 per cent, would give 146,250 tons of coke—a gain of 22,500 tons. The other point of gain is that the by-product oven will take a charge of 13½ tons of coal, which will coke in 18 hours, while the beehive oven will take a charge of about 7 tons, which it requires either 48 or 72 hours to coke.

Possible use for surplus gas.—The tests show that a ton of the LaFollette coal will produce 11,302 cu. ft. of gas. Approximately half of this would be consumed in heating the ovens. In looking for a possible use for the other half, some officials of the company have suggested that it could be used in a central power station. Possibly this is the best use to which it could be put; but there are two raw materials in abundance, right at hand, that are staring the man in the face who is looking for a place to put money, asking him for investigation. These are as follows:

(1) The rocks immediately down the creek from the coke ovens consist of massive sandstone beds of Pennsylvania or Upper Carboniferous age, standing on edge, with beds of dark shale between them. Advantages for quarrying the shale could not be better, for it could be handled by gravity, there would be no water in the pit, and the sandstone beds on either side are strong enough to stand up, unsupported after the shale is removed from between them. A sample of this shale was taken by the writer from all parts of a bed, 40 feet thick. This bed had been exposed at the side of the railroad cut, so that the sample can be considered representative of it. The analysis is as follows:

*Analysis of shale 100 feet south of bridge at the coke ovens, LaFollette, Tennessee**

Soluble silica	27.4 per cent
Insoluble silica	31.9 per cent
Al_2O_3 (aluminum oxide, or alumina)	21.1 per cent
FeO / Fe_2O_3 (iron oxides)	5.7 per cent
Mn_3O_4 (manganese, as manganous-manganic oxide)	0.1 per cent
TiO_2 (titanium dioxide)	0.1 per cent
CaO (calcium oxide, or lime)	0.4 per cent
MgO (magnesium oxide, or magnesia)	1.4 per cent
Na_2O / K_2O (sodium and potassium oxides)	2.6 per cent
P_2O_5 (phosphoric oxide)	trace
S (sulphur)	trace
CO_2 (carbon dioxide)	0.7 per cent
Water and organic matter	1.4 per cent
Loss on ignition—water and CO_2	7.2 per cent
	100.00

So far as can be judged from an analysis, this would make good paving brick and sewer pipe. For purposes of comparison, there is herewith presented a table by Wheeler giving the chemical composition of paving brick shale as "deduced from fifty reliable sources":

*Analysis by Dr. Paul C. Bowers, Chemist of the Survey.

Composition of paving brick shales. (Wheeler)*

	Minimum per cent	Maximum per cent	Average
SiO_2	49.0	75.0	
Al_2O_3	11.0	25.0	
Ignition loss (H_2O, S, CO_2)	3.0	13.0	
Moisture (H_2O)	0.5	3.0	
Total non-fluxing constituents			87.0
Fe_2O_3	2.0	9.0	
CaO	0.2	3.5	
MgO	0.1	3.0	
Na_2O / K_2O	1.0	5.5	
Total fluxing constituents			13.0
Grand total			100.0

Perhaps 250 feet down the creek from where the above LaFollette sample was taken, there is a bed of shale 150 feet thick, also on edge and with equally good quarrying advantages. This was covered with a thin layer of soil, and it was not convenient to take a representative sample for analysis, but in all probability it is equal to the sample taken, for the purposes named.

(2) About 200 yards south of the 150-foot bed of shale, and running parallel with it, there is a bed of limestone, known in geology as the Newman limestone, that supplies the flux for the blast furnace of the LaFollette Coal, Iron and Railway Company. This limestone, like the shales and sandstone, stands on edge and is 150 feet thick. The quarry is dry and all mining conditions are ideal, except for the unimportant fact that the beds being on edge make blasting less effective than if they were flat. Eight analyses of this limestone, taken from the records of the company, are as follows:

Analyses of limestone at LaFollette

1910	SiO_2	CaO	MgO	Al and Fe
March 5	2.04	51.2	2.98	2.76
March 12	1.72	50.8	2.85	3.19
March 19	2.60	50.6	2.64	3.10
March 26	2.76	51.2	2.36	3.08
April 9	2.26	51.2	6.20	0.80†

Concluded on p. 37.

*Mo. Geol. Surv., Vol. XI, p. 456.

†It appears that in this analysis there must have been a mistake in calculating the MgO and the Al and Fe. A. H. P.

April 17	2.68	54.7	3.41	1.80
April 23	2.40	51.05	2.45	2.00
April 30	3.18	50.92	2.74	1.11

A sample carefully taken by the writer across the quarry, was analyzed by Dr. Paul C. Bowers, with the following result:

Analysis of Newman limestone at LaFollette

SiO_2 (silica)	2.7 per cent	
Al_2O_3 (alumina)	.3 per cent	
FeO, Fe_2O_3 (iron oxides)	.5 per cent	
MnO (manganous oxide)	trace	
CaO (lime)	51.8 per cent	=92.4 per cent $CaCO_3$
MgO (magnesia)	2.7 per cent	= 5.6 per cent $MgCO_3$
SO_3 (sulphur trioxide)	trace	
CO_2 (carbon dioxide)	41.9 per cent	
Moisture (H_2O)	.1 per cent	
Total	100.0	

Adaptability of the materials for Portland cement.—For use in the manufacture of Portland cement, shales, "should be free from gravel and sand, as the silica present as pebbles or grit is practically inert in the kiln unless ground more finely than is economically practicable. In composition they should carry not less than 55 per cent of silica, and preferably from 60 to 70 per cent. The alumina and iron together should be not more than half as great as the silica, and the composition will usually be better if they are only one-third. Nodules of lime carbonate, gypsum, or pyrite, if present in any quantity, are undesirable, though the lime carbonate is not absolutely injurious. Magnesia and the alkalies should be low, preferably not above 3 per cent".*

No sandstone layers, pebbles, pyrite, or other injurious material was noted in the bed from which the sample of shale was taken for analysis, though gypsum and pyrite may occur in small amount. As may be seen by referring to the analysis, the amount of silica (soluble and insoluble), in this shale is 59.3 per cent. The amount of alumina and iron oxide is 26.8 per cent, which is only .45 as great as the amount of silica. Magnesia and the alkalies are low. It appears that this shale is admirably adapted to the manufacture of Portland cement.

*Eckel, Edwin C., U. S. Geol. Surv., Bull. 522, p. 56.

The limestone is gray, coarsely crystalline to compact, and in beds from 1 foot to 4 feet or more thick, these standing almost on edge. It probably would crush easily. The amount of silica, alumina and iron oxide combined is only 3.5 per cent, according to the above analysis by Dr. Bowers. The 51.8 per cent of CaO (lime) is equivalent to 92.4 per cent of $CaCO_3$ (calcium carbonate); the 2.7 MgO (magnesia) is equivalent to 5.6 per cent. of $MgCO_3$ (magnesium carbonate). The only constituent that throws doubt upon the adaptability of this limestone to Portland cement is the amount of magnesia which, according to the analysis made by Dr. Bowers, as well as those furnished by the Company, is a little high. As a rule, 2.5 per cent. is considered the maximum amount of magnesia, which is .2 per cent. below the amount carried by this limestone, as determined in this survey's laboratory. The disadvantage of this small excess probably could be overcome.

It will be seen from the above, that there probably are two possible uses for the surplus gas, one in the manufacture of brick and sewer pipe, and the other in the manufacture of cement, though a company contemplating the erection of a plant for either purpose should have a sufficient number of analyses and other tests made to thoroughly satisfy themselves about the adaptability of the material for the purpose desired. It is probable that both common brick and paving brick could be made of the shale. These products would not come in competition with the brick and cement manufactured at Kingsport, for they are on different lines of railroad, and would find a market in different territory. The Southern and the Louisville and Nashville railroads enter LaFollette.

Cost of installation.—The size of the plant that could be supplied by the surplus gas would of course depend upon the amount of coal consumed in making coke. This might be sufficient to accommodate both a cement and a brick plant, or only one. It is thought that a liberal estimate for the cost of installing a by-product plant is $500,000; a brick and sewer-pipe plant, $300,000; a cement plant, $1,500-000; the first two, $800,000; all three, $2,300,000.

Mineral products assembled at LaFollette and elsewhere.—It is very unusual for different mineral products that must be used in combination to occur together, as they do at LaFollette. Here, red iron ore, coal for coke and limestone for flux in the blast furnace, all occur within a belt only a few hundred yards in width. The limestone and shale for cement, and the shale for brick and sewer pipe, occur in the same belt, making the assemblage of raw materials the more remarkable. The same conditions occur at Rockwood and, with the exception of the iron, at Soddy, at both of which coke is now manufactured in beehive ovens.

Shipping coal for coke manufacture.—In all probability there are good coking coals in Tennessee at points where there is no raw material for manufacture into finished products, and consequently no possible use for the surplus gas. In such cases the question comes up as to whether it would pay to ship the coal to the cities where it could be used in by-product plants, the surplus gas finding a market with the manufacturer and domestic consumer. The answer to this question depends upon such important considerations as the freight on the coal to the city plant, the freight on the coke from the plant to the iron furnaces, the quality of the coke and the demand for it, the value of the surplus gas, etc. If the price of coke for domestic use could be put low enough to attract the home consumer, and people could become educated to its general use, the result would not only be an economic saving in the broad sense, but the smoke nuisance would be stopped. Most of the smoke of which we so bitterly complain comes from the chimneys of our own residences.

As an example of the coal thus used and the waste from it, we might take the amount consumed annually in Nashville which, roughly approximated, amounts to 220,000 tons. According to the table given above, the value of the gas, coal tar, and ammonia from each ton of this coal, all of which goes into the air, is 95 cents a ton, or $209,000 for the whole amount consumed. This would be saved in a by-product plant.

With coke heating the home and gas the factory, our cities would rest beneath clear skies, our nostrils be relieved of the unpleasant odors of coal smoke, our lungs of its injurious effects, and the housekeeper made happy.

Recent Oil Development at Glenmary, Tennessee

By L. C. Glenn

During the past summer an oil well was drilled on the creek flats about three-quarters of a mile northwest of Glenmary, Scott County, Tennessee. The drilling began June 5th and was finished August 31st. The elevation of the well mouth is 1248 feet and is about five feet below the top of the Lee conglomerate which appears in good development in a low bluff on the north side of the creek a few rods west of the well. As seen here and traced for a mile and a half west, the top of the Lee is a typical soft, light colored to pinkish sandstone of medium coarseness and evenly laminated to cross-bedded. The log of the well shows this top member of the Lee to be 42 feet thick in the well. To this should be added about 8 feet for the upper part of the sandstone, making the bed about 50 feet thick in all. The base of the Lee was reached at a depth of 730 feet, making that formation 735 feet thick, when the five feet above the well mouth are added to the log. Then follow, in descending order, 220 feet of Pennington rocks, mostly red to dark calcareous clay shales with a subordinate amount of limestone. At a depth of 950 feet the St. Louis limestone was reached and 294 feet of it was penetrated, the well reaching the depth of 1244 feet from the surface, the 8 feet from 1232 to 1240 feet being oil-bearing. This oil-bearing layer is given in the log as "gray sand and small pebble". No sample of it could be secured to learn whether it is really a thin sandstone or not. It is suspected by the writer from analogy with the wells drilled in the last year at Oneida that the oil "sand" is really a limestone, that is perhaps dolomitic.

The log as given by the drillers, Sackrider and Fuller, is as follows:

Record of Pemberton Well No. 1

	Thickness	Top	Bottom
Soil	3 ft.	0 ft.	3 ft.
Hard white sand	42 ft.	3 ft.	45 ft.

Black slate	105 ft.	45 ft.	150 ft.
Hard white sand	155 ft.	150 ft.	305 ft.
Slate	130 ft.	305 ft.	435 ft.
Coarse loam sandstone	105 ft.	435 ft.	540 ft.
Black slate	7 ft.	540 ft.	547 ft.
Hard white sandstone, base of Lee	183 ft.	547 ft.	730 ft.
Slate and lime shells, top of Pennington	45 ft.	730 ft.	775 ft.
Red shale	20 ft.	775 ft.	795 ft.
Black slate	27 ft.	795 ft.	822 ft.
Dark lime	73 ft.	822 ft.	895 ft.
Red shale	13 ft.	895 ft.	908 ft.
Dark lime	22 ft.	908 ft.	930 ft.
Black slate, base of Pennington	20 ft.	930 ft.	950 ft.
Limestone, top of St. Louis	98 ft.	950 ft.	1048 ft.
White slate	3 ft.	1048 ft.	1051 ft.
Dark lime	93 ft.	1051 ft.	1144 ft.
Black slate	3 ft.	1144 ft.	1147 ft.
Gray sand	8 ft.	1147 ft.	1155 ft.
Hard white lime	77 ft.	1155 ft.	1232 ft.
Gray sand and small pebble, oil-bearing	8 ft.	1232 ft.	1240 ft.
Hard white lime	4 ft.	1240 ft.	1244 ft.

Salt water was struck at 505 feet and a little show of gas at 1045 feet. On August 30th there were 640 feet of oil in the well and on August 31st, 700 feet. There was little or no gas with the oil.

The oil.—The oil is dark green in color. An examination by a private laboratory is reported as follows:

Distillation table of Glenmary oil

	Per cent	Gravity Baumé
Crude oil		38.4
Fraction up to 302°F	19	65.2
Fraction 302° to 380°	10	51.5
Fraction 380° to 550°	19	42.3
Residue at 550°	50	23.8
Loss	2	

Gasoline from crude Glenmary oil, refined

Up to 194°	30 per cent
212°	46 per cent
230°	58 per cent
248°	72 per cent
266°	78 per cent
284°	84 per cent
302°	88 per cent
320°	91 per cent

Concluded on p. 42.

338°	93 per cent
356°	95 per cent
374°	96 per cent
420°, end point	98 per cent

This examination shows the oil to contain a good percentage of high grade and intermediate gasoline. No test for sulphur seems to have been made. The Oneida oil, from about the same geological horizon, contained one-sixth of one per cent. sulphur. The oil doubtless has a paraffin base.

Yield.—A 250 barrel tank was provided and from the slight test so small a tank would furnish, the well will probably pump between 10 and 20 barrels a day.

Geological horizon.—The oil comes from an 8-foot bed in the St. Louis limestone 282 feet below the top of the formation.

Geological structure.—The rocks at Glenmary are part of a long monocline rising slowly to the west or west northwest. The rate of rise at Glenmary is between 30 and 40 feet per mile. No evidence was found of any fold or flattening or other interruption of this general rise of the rocks northwestward. No anticlinal or synclinal structure was discovered. The oil would seem to occupy a certain level in the rocks, having possibly been driven to its present position by salt water back of or below it. If so we would expect wells drilled down the dip of the rocks, that is to the east of the present well, to run into salt water sooner or later while wells drilled in a general northerly or southerly direction from the present well and so along the strike of the rocks, would reach the oil-bearing stratum at the same elevation as the Pemberton well and would have a better chance to strike oil. The safest rule to follow in making further development is undoubtedly to "feel out" the productive territory from the present well by other wells some 600 to 800 feet away and preferably on the same stratigraphic level rather than up or down the dip.

It is too early to predict just what will be the size or yield of the pool, but there would seem to be a chance for the development of an oil area at Glenmary. If the well now down proves on continuous pumping to hold up to a steady yield, there is no antecedent reason why much more productive territory may not exist there, for in much other territory in that general vicinity conditions are equally as favorable for the accumulation of oil, so far as any one can see, as at the well here described.

In this connection a comparison may be made of the record and log of the Strubbe well drilled in 1891 about one and a fourth miles nearly due west of the Pemberton well. This Strubbe well found some oil at 1233 feet depth but was not regarded as a paying well. Its elevation is about 1240 feet, and the well mouth is about 45 feet below the top of the Lee formation, or the conglomerate division of the coal measures. At 65 feet depth, 2 inches of coal was struck, and at 506 feet, there were 4 inches of coal. At 1128 feet a little gas was struck. The log is as follows:

Log of Strubbe Well, about two miles northwest of Glenmary, Tenn.

	Thickness	Top	Bottom
Alluvium	15 ft.	0 ft.	15 ft.
Shale, gray and black	55 ft.	15 ft.	70 ft.
Sandstone, gray	100 ft.	70 ft.	170 ft.
Sandstone and shale, dark gray	10 ft.	170 ft.	180 ft.
Sandstone, gray	40 ft.	180 ft.	220 ft.
Sandstone and shale, black	40 ft.	220 ft.	260 ft.
Sandstone, dark gray	60 ft.	260 ft.	320 ft.
Sandstone and shale, black	55 ft.	320 ft.	375 ft.
Sandstone, gray, base of Lee	305 ft.	375 ft.	680 ft.
Limestone, dark gray, top of Pennington	10 ft.	680 ft.	690 ft.
Shale and limestone, red and black	65 ft.	690 ft.	755 ft.
Limestone, gray	5 ft.	755 ft.	760 ft.
Shale and limestone, black	20 ft.	760 ft.	780 ft.
Limestone, black	25 ft.	780 ft.	805 ft.
Shale, black	20 ft.	805 ft.	825 ft.
Shale, red and black	25 ft.	825 ft.	850 ft.
Shale, black, base of Pennington	35 ft.	850 ft.	885 ft.
Limestone, gray and black, top of St. Louis	185 ft.	885 ft.	1070 ft.
Limestone, dark	166 ft.	1070 ft.	1236 ft.

The shale in the above log described by the driller as black is really the very dark gray shale characteristic of a part of the Pennington and is not a black carbonaceous shale, such as the Devonian or Chattanooga shale. The mouth of the Strubbe well is some 40 feet lower stratigraphically than the Pemberton well. In each well oil was found at almost exactly the same depth, but the oil in the Strubbe well came from a slightly lower horizon stratigraphically than that from the Pemberton well.

Properties of Molding Sand

By Robert E. Wendt*

Men engaged in the foundry business select their sand according to the class of work they wish to make. For light or thin castings, in order to make them smooth, the sand grains should be small; for large or heavy castings, the sand must be coarse, in proportion to the size or bulk of the casting.

Good molding sand is not uncommonly found along rivers and lakes in all parts of the United States. New York, Ohio and Kentucky are known as molding sand centers.

The composition of molding sand is about 80 per cent. sand and 10 per cent. clay. The sand grains should have sharp corners. There are always such other ingredients as lime, magnesia and some metallic oxides.

The sand must be cohesive when it is moistened to the proper degree and rammed about the pattern to sufficient hardness. It must stick together so as to stand handling in the flask, and must hold the metal in shape when poured; must be porous enough to allow the free escape of steam and gases that are generated when the molten metal is poured into the mold; must be refractory enough to stand the high temperature of melted cast iron, without fusing, but must bake a little from the heat, without fusing with the metal; and must readily peel from the casting, leaving it with a smooth, clean surface.

New sand, that is sand that has not been used for molding, is stronger than it need be. After the sand has been used awhile and burned a little, it will give better results. Generally castings made in partly burned sand will be smoother and the sand will leave them more freely than when it is new.

*Mr. Wendt is Foundry Instructor, Purdue University. The purpose of this paper is to assist the members of the Survey and others in recognizing deposits of sand that may be used for molding. A. H. P.

The molder must look after his sand carefully when preparing it for use. After it has been used many times, the sharp edges become rounded, partly from wear and partly from the high temperature of the molten metal which causes slight fusing. Also, the clay will burn out. These two changes cause the sand to become weak unless new sand is added.

When castings are taken from the sand, some of it will adhere to them, and is therefore lost. This decreases the moulder's supply, he adds new sand to his heap, mixing it with the old. This builds up his sand and keeps it suitable for molding, and in this way he can use it over and over again, every day.

In order to make some castings smooth, it is necessary to make a special facing, which is put next to the pattern. For this purpose, such material as soft coal ground fine, resin, wheat flour, molasses, core compound and other materials are mixed with sand. After the mold is finished, it is painted or dusted with finely powdered graphite before it is poured.

Publications of Geological Survey of Tennessee Issued.

The following publications have been issued by the present Survey, and will be sent on request *when accompanied by the necessary postage.* Gaps in the series of numbers are of reports still in preparation:

Bulletin No. 1—Geological Work in Tennessee.

A. The establishment, purpose, object and methods of the State Geological Survey; by Geo. H. Ashley, 33 pages, issued July, 1910, postage, 2 cents.

B. Bibliography of Tennessee Geology and Related Subjects; by Elizabeth Cockrill, 119 pages; postage, 3 cents.

Bulletin No. 2—Preliminary Papers on the Mineral Resources of Tennessee, by Geo. H. Ashley and others.

A. Outline Introduction to the Mineral Resources of Tennessee, by Geo. H. Ashley, issued September 10, 1910; 65 pages; postage, 2 cents.

D. The Marbles of East Tennessee, by C. H. Gordon; issued May, 1911; 33 pages; postage, 2 cents.

E. Oil Development in Tennessee, by M. J. Munn; issued January, 1911; 46 pages; postage, 2 cents.

G. The Zinc Deposits of Tennessee, by S. W. Osgood; issued October, 1910; 16 pages; postage, 1 cent.

Bulletin No. 3—Drainage Reclamation in Tennessee; 74 pages; issued July, 1910; postage, 3 cents.

A. Drainage Problems in Tennessee, by Geo. H. Ashley; pages 1-15; postage, 1 cent.

B. Drainage of Rivers in Gibson County, Tennessee, by A. E. Morgan and S. H. McCrory; pages 17-43; postage, 1 cent.

C. The Drainage Law of Tennessee; pages 45-74; postage, 1 cent.

Bulletin No. 4—Administrative Report of the State Geologist, 1910; issued March, 1911; postage, 2 cents.

Bulletin No. 5—Clays of West Tennessee, by Wilbur A. Nelson; issued April, 1911; postage, 4 cents.

Bulletin No. 9—Economic Geology of the Dayton-Pikeville Region, by W. C. Phalen, for sale only, price 15 cents.

Bulletin No. 10—Studies of the Forests of Tennessee.

A. **An Investigation of the Forest Conditions in Tennessee, by R. Clifford Hall; issued April, 1911; 56 pages; postage 3 cents.**

B. **Chestnut in Tennessee, by W. W. Ashe, issued December, 1911; postage, 2 cents.**

C. **Yellow Poplar in Tennessee, by W. W. Ashe, issued January, 1914; 55 pages; postage, 3 cents.**

Bulletin No. 13—A Brief Summary of the Resources of Tennessee, by Geo. H. Ashley; issued May, 1911; 40 pages; postage, 2 cents.

Bulletin No. 14—The Zinc Deposits of Northeastern Tennessee, by A. H. Purdue; issued September, 1912; 69 pages; 30 illustrations, postage, 3 cents a number.

Bulletin No. 15—Administrative Report of State Geologist, 1912.

Bulletin No. 16—The Red Iron Ores of East Tennessee, by E. F. Burchard; issued November, 1913; 172 pages; postage, 8 cents.

Bulletin No. 17—The Water Powers of Tennessee, by J. A. Switzer; issued April, 1914; 137 pages; postage, 8 cents.

Bulletin No. 18—Administrative Report of the State Geologist, 1914.

Maps—Map of Lewis County, 1915; postage, 2 cents.
Geological Map of Tennessee, 1915; postage, 15 cents.
Map of Rutherford County, 1916; postage, 2 cents.
Map of McNairy County, 1916; postage, 2 cents.

"THE RESOURCES OF TENNESSEE."—This is a quarterly magazine, devoted to the description, conservation and development of the State's resources. Postage, 2c a number. The following are the volumes and numbers issued, with the titles of the principal papers in each number:

Vol. I. No. 1—The utilization of the small water powers in Tennessee, by J. A. Switzer and Geo. H. Ashley.

No. 2.—The Camden chert—an ideal road material, by Geo. H. Ashley.
The Fernvale iron ore deposit of Davidson County, by Wilbur A. Nelson.
Cement materials in Tennessee, by C. H. Gordon.

No. 3—The gold field of Coker Creek, by Geo. H. Ashley.

No. 4—Coal resources of Dayton-Pikeville area, by W. C. Phalen.

No. 5—Economic aspects of the smoke nuisance, by J. A. Switzer.
Watauga Power Company's hydro-electric development, by Francis R. Weller.
The coal fields of Tennessee, by Geo. H. Ashley.

No. 6—Bauxite Mining in Tennessee, by Geo. H. Ashley.
A New Manganese Deposit in Tennessee, by Wilbur A. Nelson.
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Vol. II. No. 1—The Utilization of the Navigable Rivers of Tennessee, by Geo. H. Ashley.
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The Rejuvenation of Wornout Soil Without Artificial Fertilizers, by Geo. H. Ashley.
Tennessee to Have Another Great Water Power, by George Byrne.
Manufacture of Sulphuric Acid in Tennessee in 1911, by Wilbur A. Nelson.

No. 2—The Ocoee River Power Development, by J. A. Switzer.
Exploration for Natural Gas and Oil at Memphis, Tenn., by M. J. Munn.

No. 3—The Power Development at Hale's Bar, by J. A. Switzer, Notes on Lead in Tennessee, by Wilbur A. Nelson.

No. 4—The Tennessee Academy of Science.
The Preliminary Consideration of Water Power Projects, by J. A. Switzer.
Lignite and Lignitic Clay in West Tennessee, by Wilbur A. Nelson.

No. 5—The Growth of Our Knowledge of Tennessee Geology, L. C. Glenn.

No. 6—On the Impounding of Waters to Prevent Floods, by A. H. Purdue.
Drainage Problems of Wolf, Hatchie, and South Fork of Forked Deer Rivers, in West Tennessee, by L. L. Hidinger and Arthur E. Morgan.
The Waste From Hillside Wash, by A. H. Purdue.

No. 7—Where May Oil and Gas Be Found in Tennessee? By Geo. H. Ashley.
Spring Creek Oil Field, by M. J. Munn.

No. 8—The Monteagle Wonder Cave, by Wilbur A. Nelson.
Cave Marble (Cave Onyx) in Tennessee, by C. H. Gordon.

No. 9—The Valley and Mountain Iron Ores of East Tennessee, by Royal P. Jarvis.

No. 10—The Iron Industry of Lawrence and Wayne Counties, by A. H. Purdue.
Some Building Sands of Tennessee, by Wilbur A. Nelson.

No. 11—Tests on the Clays of Henry County, by F. A. Kirkpatrick. Introduction, by Wilbur A. Nelson.
Barite Deposits in the Sweetwater District, by Herbert B. Henegar.

No. 12—The Soils and Agricultural Resources of Robertson County, by Reese F. Rogers.
The Iron Ore Deposits in the Tuckahoe District, by C. H. Gordon and R. P. Jarvis.

Vol. III. No. 1—The General Features of the Tennessee Coal Field North of the Tennessee Central Railroad, by L. C. Glenn.
The Tennessee Coal Field South of the Tennessee Central Railroad, by Wilbur A. Nelson.

No. 2—State Supervision of Forestry, by L .C. Glenn.
Conservation of the Water Powers of Tennessee, by J. A. Switzer.
Water Supplies for Cities and Towns, by A. H. Purdue,
Types of Iron Ore Deposits in Tennessee, by C. H. Gordon.
The Causes and Nuisance of Smoke, by Wilbur A. Nelson.
Geology and Engineering, by A. H. Purdue.

No. 3—The Gullied Lands of West Tennessee, by A. H. Purdue.
White Rock Phosphate of Decatur County, Tennessee, by T. Poole Maynard.
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Relations of Water Supply to Health, by J. A. Switzer.

No. 4—Minerals of Tennessee, Their Nature, Uses, Occurrence and Literature, by A. H. Purdue.
Building Precautions Against Earthquake Disasters, by Olaf P. Jenkins.

Vol. IV. No. 1—Relation of Water Supply to Health, by J. A. Switzer.
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No. 2—The Brown and Blue Phosphate Deposits of South-Central Tennessee, by J. S. Hook.
Discussion, Lucius P. Brown.
Bauxite in Tennessee, by A. H. Purdue.

No. 3—Economic Geology of the Waynesboro Quadrangle, by N. F. Drake.
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The Geology of Perry County and Vicinity, by Bruce Wade.
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Vol. V. No. 1—The Hydro-Electric System of Tennessee, by J. A. Switzer.
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No. 2—Physiographic Influences in the Development of Tennessee, by L. C. Glenn.
Care and Protection of Forests, by R. S. Maddox.
Two Natural Bridges of the Cumberland Mountains, by Wilbur A. Nelson.

No. 3—The Iron Ore Deposits of Lewis County, Tennessee, by Reese F. Rogers.

No. 4—The Soils of Tennessee, by C. A. Mooers.
Recent Oil Development near Oneida, Scott County, Tennessee, by L. C. Glenn.

Vol. VI. No. 1—Oil and Gas Conditions in the Central Basin of Tennessee, by A. H. Purdue.
Oil and Gas Conditions in the Reelfoot Lake District of Tennessee, by A. H. Purdue.
An Interesting Case of Spontaneous Combustion, by Paul C. Bowers.
Sketch of the Work Done by the State Geological Survey in 1915.

No. 2—Phosphates and Dolomites of Johnson County, by Olaf P. Jenkins.
Structure of the Southern Part of Cumberland County, Tennessee, in Relation to the Possible Occurrence of Oil and Gas, by Charles Butts.
Notes on Manganese in East Tennessee, by A. H. Purdue.

No. 3—The General Features of the Tennessee Coal Field North of the Tennessee Central Railroad, by L. C. Glenn.
The Tennessee Coal Field South of the Tennessee Central Railroad, by Wilbur A. Nelson.

The supply of Vol. 1 Nos. 1 and 2, Vol. III No. 1, and Vol V Nos. 1 and 2 is exhausted.

No. 4—The Conservation of Phosphate Rock in Tennessee, by W. C. Phalen.

Progress in Reclaiming Waste Lands in West Tennessee, by R. S. Maddox.

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VOLUME VII NUMBER 2

Tennessee. Geological survey

THE RESOURCES OF TENNESSEE

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CONTENTS

The Gravels of West Tennessee Valley

By Bruce Wade

INTRODUCTION

Important deposits of gravel and clayey sands occur along the West Valley of Tennessee River in a belt stretching from the southern to the northern border of the State. Their distribution in unconnected areas extends about 40 miles east and 12 to 20 miles west of the river. They range in elevation from the top of the western edge of the Highland Rim of Tennessee, which is about 1100 feet above sea level, down to the bed of Tennessee River, approximately 300 feet above sea level, at the northern border of the State. As to age, these deposits may be separated into two major divisions. The older is correlated with the Tuscaloosa formation, the earliest of the Upper Cretaceous series in the Mississippi Embayment; the later was formed during a period extending from the time when the Tennessee River became fixed in its present course down to present time; that is, probably from Pliocene to Recent.

The gravels of this area have often attracted the attention of geologists, and their age has been variously assigned. Safford* gives a concise account of their occurrence and distribution, and considers them all as formed in one epoch and at least younger than the Cretaceous. Chamberlin and Salisbury† call attention to the fact that there are widespread gravel deposits on high levels in many regions in the Southern Gulf and Atlantic States, and say that these deposits are Pliocene in age. In 1905, L. C. Glenn made a study of the water resources of West Tennessee and Kentucky for the U. S. Geological Survey and in his report‡ on the geology of this area Professor Glenn gives a good account of the occurrence and distribution of these gravels and refers them to the Lafayette formation of the Pliocene. In 1913, H. D. Miser and N. F. Drake, while engaged in the

*Safford, J. M., 1869, Geology of Tennessee, pp. 434-438.

†Geology, Vol. III, pp. 301-308, 1906.

‡Glenn, L. C., 1906, U. S. Geological Survey, Water Supply Paper 164, pp. 40-43.

field work on the areal geology of the Waynesboro Quadrangle* showed that the thick gravel beds on the extreme eastern side of West Tennessee valley and in the southern part of the State are Upper Cretaceous in age. Recently an article by the present writer has been submitted for publication giving some observations on the occurrence of Tuscaloosa gravels as far north as Kentucky.†

During the summers of 1915 and 1916, while engaged in a study of the post-Paleozoic deposits of West Tennessee for the State Geological Survey, the writer had an opportunity of examining most of the important exposures of gravel in West Valley of Tennessee River. It is the purpose of the present preliminary paper to call attention to the extensive deposits of gravel in this area and to give a few observations on its occurrence, origin and age; and further to call the attention of highway engineers, who are interested in building roads in West Tennessee, to the widespread inexhaustible supply of material which may be used for the construction of gravel roads. A detailed account of these deposits can not be given here, but the State Geological Survey is engaged at present in preparing geologic maps of each county in this area, which will be published in the future, together with county reports, that will give in detail the location of all the important gravel deposits in the area herein considered, as well as numerous sections showing the stratigraphic relations of the various occurrences and other information that may be included in such reports.

On submitting this paper for publication the writer wishes to acknowledge his indebtedness to Professor E. W. Berry of Johns Hopkins University; Dr. A. H. Purdue, State Geologist; Professor L. C. Glenn of Vanderbilt University; and L. W. Stephenson, E. W. Shaw and H. D. Miser of the U. S. Geological Survey, for information and assistance given in the class-room, in the field, and in personal conferences for interpreting the relationships of these gravel deposits. Mr. C. R. Watkins, Jr., of the Tennessee Geological Survey, has furnished traverse maps of McNairy, Decatur and, in part, Hardin counties and the elevations of many points which have been of importance in this investigation. Mr. De Long Rice, Superintendent of the Shiloh National Park, has kindly given information in

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*Drake, N. F., 1913, Resources of Tennessee, Vol. IV, No. 3, p. 107.

†Manuscript submitted to the Johns Hopkins Circular 1917.

regard to the cost and construction of gravel roads in the military park on the grounds of the Shiloh Battlefield.

GENERAL STATEMENT

Area discussed.—The region described lies for the most part in the eastern portion of West Tennessee, but includes adjoining areas of western Kentucky, northwestern Alabama and northeastern Mississippi. *West Tennessee Valley* is a name frequently applied to this region. Tennessee River rises in western Virginia, flows southwest across East Tennessee, then west across northern Alabama and finally north across West Tennessee and Kentucky, thus making two distinct valleys across the State, the eastern one sloping to the south and the western one to the north. The gravel deposits to be discussed in this paper lie for the most part on the side slopes of the western one of these valleys.

Basis for the paper.—As a basis for a report on the gravel deposits of the area named, the writer assisted in the field work for a folio report on the Waynesboro quadrangle conducted under coöperative arrangements between the U. S. Geological Survey and the Tennessee Geological Survey, and headed by H. D. Miser, in 1913. In 1914 the writer did areal mapping in Perry, Lewis, and Humphreys counties for the geologic map of the State compiled by Olaf P. Jenkins in 1915. During the summer of 1915 the writer was engaged in working out the areal geology of McNairy and Hardin counties. In connection with that work reconnaissance trips were taken into Tishomingo County, Mississippi, and Lauderdale County, Alabama. In the summer of 1916 he did areal work in Decatur County and made reconnaissance trips into Benton, Henry, and Dickson counties of this State and into Calloway, Trigg, Marshall, and McCracken counties of Kentucky.

Topography.—As regards topography, the region under discussion is highly dissected and uneven. The elevations range from about 1100 feet down to 286 feet above sea level. The area lies along the northeastern edge of the Mississippi Embayment along the border where the unconsolidated Cretaceous and post-Cretaceous clays, sands and gravels overlap the Paleozoic limestones and cherts. The eastern edge of this area includes the western margin of the Highland Rim of Tennessee. The Highland Rim stands about 1000 feet above sea level and is probably a remnant of a plain that was worn down to nearly a common level before the deposition of the Cretaceous, and again in Tertiary times. This plateau, before the present physiographic conditions took form, probably extended westward into the region now constituting the plain of West Tennessee. The Tennessee River system in its northward course has intrenched itself (cut its bed down) more than 400 feet beneath this ancient plateau. remnants of which now remain only on the east side of the valley. The western side of the valley has been eroded more than the eastern side because it was composed of softer rocks (Cretaceous and Tertiary) and because it was unfavorably located between two master streams, the Mississippi and the Tennessee. It has consequently been cut down to a rolling plain which has a general elevation along the eastern margin from 400 to 680 feet above sea level. So under the present physiographic conditions West Tennessee Valley extends northward across the State and separates the plain of West Tennessee from the Highland Rim of the central part of the State.

In its northward course across the State, Tennessee River crosses the southern boundary about the middle of the southern limit of Hardin County and about 12 miles west of the eighty-eighth meridian. From this point it bears to the northwest and then to the northeast to the northwest corner of Wayne County, where it intersects the eighty-eighth meridian, which it follows in a general way from this locality to the northern limit of the State, passing between Decatur, Benton and Henry counties on the west and Perry, Humphreys, Houston and Stewart counties on the east.

Numerous creeks and small rivers flow into the Tennessee from both east and west. The largest and most important tributary in this part of its course is Duck River, which rises in the eastern part of the Highland Rim and empties into the Tennessee near the southern border of Humphreys County. On the western side the largest tributary is Big Sandy River which rises in Henderson County, flows nearly parallel to the Tennessee and empties into it near the northern border of the State.

Tennessee River and its tributaries are deeply intrenched; that is, they have cut deep valleys into the formations over which they flow. That part of the system which lies wholly in the Cretaceous and Tertiary formations has broad valleys with well developed terraces at different levels, while that part which lies in the areas where the rocks are almost wholly the Paleozoic limestones and cherts, has narrow valleys. These two types of valley topography are well illustrated in both the master stream itself and in its tributaries. In central Hardin County the Tennessee is cutting through an area where the Cretaceous-Paleozoic contact is for the most part below the present drainage, and the valley there is wide. Hills that stand up 200 feet or more above the river are very rare near it and are not frequent as isolated hills nor as a continuous valley wall for 8 or 10 miles on either side of the river. The present flood-plain itself is from 2 to 5 miles wide in the vicinity of Savannah. But even in this region the valley is not so wide as further south, for both up and down stream the Paleozoic rocks rise and the valley narrows into a canyon-like one with a flood plain often less than a quarter of a mile wide and with no broad terraces. Hills 300 feet above the river stand within a mile or less of either bank. Many vertical clifts of limestone and chert rise 150 feet or more from the edge of the water and form interesting scenery from northern Hardin County almost to the northern border of Houston County. In the extreme northern part of the State and in western Kentucky the valley becomes wider again, for in that region the soft rocks form the valley. As a result, there is a broad development of terraces west of the river extending as far west as Puryear in Henry County and still farther west in Kentucky.

The tributaries of the Tennessee that flow in from the east have narrow valleys in the Paleozoic rocks. On the west side of the river, the streams flowing into it rise on the Cretaceous and Tertiary formations but become intrenched in the Paleozoic rocks near their mouths. This is true of all the creeks except those in the west-central part of Hardin County. As a result of this the upper parts of the creeks and rivers in the unconsolidated sediments have wide bottoms. "Second bottoms", and other terrace levels are also widely developed. Examples of such secondary streams are White Oak Creek, Beech River and Big Sandy River.

Geology.—The above remarks on the topography are only general. The valleys and terraces will be described in greater detail in considering their history. As stated above, the formations of West Tennessee and extreme western Kentucky may be divided for discussion into two major groups— the consolidated Paleozoic rocks and the unconsolidated post-Paleozoic rocks. A general subdivision of these two groups is as follows:

Unconsolidated Rocks	Recent	Alluvial clays, sands and gravels
	Pleistocene, Pliocene	Stream clays, sands, gravels
	Eocene....	Wilcox sands
	Eocene....	Midway clays
	Upper Cretaceous......	Ripley sands
	Upper Cretaceous......	Selma clays
	Upper Cretaceous.....	Eutaw clays and sands
	Upper Cretaceous....	Tuscaloosa gravels
Consolidated Rocks	Mississippian......	shales, cherts and limestones
	Devonian..........	shales, cherts and impure limestones
	Silurian...........	limestones
	Ordovician.........	limestones

Gravels.—The gravels of West Tennessee Valley fall naturally into two groups, the Tuscaloosa group and the Pliocene-Pleistocene-Recent group. These two groups, though widely different in age, occupy the same general section of the State. Deposits of the younger group in a few localities may be seen resting upon beds of the older group; however, the occurrence of the Tuscaloosa gravels is for the most part farther east than that of the latter ones.

TUSCALOOSA GRAVELS

Age and general description.—The Tuscaloosa formation is the basal or oldest member of the Upper Cretaceous series in the eastern Gulf Region of the Mississippi Embayment. In western Alabama and eastern Mississippi this formation consists of irregularly bedded clays, sands and gravels having an estimated total thickness of 1000 feet. In Professional Paper 81 of the U. S. Geological Survey, L. W. Stephenson has readjusted the names of the Upper Cretaceous formations in this region and has defined the Tuscaloosa with reference to the other formations (Eutaw, Selma and Ripley) of this series.

Toward the north the Tuscaloosa deposits become much thinner and are made up almost entirely of conglomerates which contain little sand and clay. Professor E. W. Berry has made a study of this series and has found evidence in the fossil plants that the clays, in the basal part of the formation in the region of maximum thickness, are more ancient than plant-bearing clays that occur in the conglomerates about Iuka, Mississippi, where the formation becomes much thinner. He shows that an Upper Cretaceous estuary existed for a long time in western Alabama before it transgressed northward.

Distribution in Tennessee and Kentucky.—Until recently the Tuscaloosa formation was thought to thin out entirely in the vicinity of the Tennessee-Alabama line. In 1913 H. D. Miser mapped the areal Geology of the Waynesboro Quadrangle of Tennessee and found that the Tuscaloosa was 150 feet* thick and extended over a large part of Wayne County. Subsequent work by the Tennessee Geological Survey showed that remnants of the Tuscaloosa gravel occur in places on the Highland Rim of Tennessee as far

FIG. 1. View of Tuscaloosa gravel on the Savannah-Gillis Mill road, 4 miles west of Gillis Mill, Hardin County.

north as northern Lewis County.† Farther north the writer, during the past summer, observed undescribed occurrences of the Tussaloosa formation which show that the sediments of this transgressive phase of the Upper Cretaceous exist in a chain of local outlying areas across the State of Tennessee and as far north as a point on the ridge west of Canton, Kentucky.

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*Drake, N. F., "Economic Geology of the Waynesboro Quadrangle", *Resources of Tennessee*, Vol. IV, No. 3, p. 107, 1913.

†Wade, Bruce, "Geology of Perry County and Vicinity", *Resources of Tennessee*, Vol. IV, No. 4, p. 173, 1914.

An important link in this chain are the gravels which occur locally along the Nashville, Chattanooga and St. Louis Railway between McEwen and Tennessee City and capping the higher hills in this part of Dickson County, Tennessee. A cut on the railroad about two miles east of McEwen shows, resting on chert of the St. Louis formation, about 30 feet of very compact hard white chert gravel which is typical of the Tuscaloosa occurring in the belt across the State. No paleontological evidence has been obtained from the gravels about McEwen to determine the age of these deposits, but after a study of the lithology as well as the geographic and topographic relations, the Tuscaloosa age of the McEwen gravels can hardly be doubted. These gravels are made up of well rounded water-worn pebbles, most of which are 1 inch or less in diameter, but many are larger, ranging up to cobbles 6 inches in diameter. Many are spherical, and in this respect they differ from the river gravels which are common in terraces along the western Tennessee Valley, and which are often flat, elongated, and subangular. Small discoidal quartzite pebbles are often conspicuous in the terrace conglomerates. The Tuscaloosa conglomerates consist for the most part of pebbles and boulders derived from the Mississippian cherts which are common in this part of the Mississippi basin. Water-worn sandstone and iron oxide pebbles have not been observed in the Tuscaloosa gravels. This is another feature which serves to distinguish the Upper Cretaceous gravels from the more recent terrace ones in this part of the Embayment Region, even though the latter may rest directly on the former as is frequently the case in West Tennessee Valley.

South of McEwen, as stated above, the isolated Tuscaloosa gravel areas may be traced along the Highland Rim across Lewis County into Wayne and Hardin counties and farther into Mississipppi and Alabama where they are overlain by marine Eutaw deposits and fossil evidence may be obtained.

As above stated, the Tuscaloosa extends also north of McEwen. About 3 miles west of Canton in Trigg County, Kentucky, at a point just east of where the Fulton and Nashville Highway crosses the divide between the Tennessee and Cumberland rivers, is an exposure of about 30 feet of Tuscaloosa gravel overlain by 10 feet of Eutaw sand. The locality is about 7 miles east of the Upper Cretaceous belt as shown on the Geological Map of Kentucky.* This exposure

*Sellier, L. M., "State Map" Kentucky Geological Survey, 1915.

is probably more than 300 feet above the waters of the Tennessee and Cumberland rivers. This divide is a northern extension of the western part of the Highland Rim of Tennessee and it is probable that further study of the plateau between the Canton and McEwen localities will reveal isolated occurrences of Tuscaloosa that would form an almost unbroken chain of the remnants of this formation from Kentucky across Tennessee into Mississippi and Alabama, where it is normally developed.

A study of a map of the Upper Cretaceous belt of the eastern Gulf Region* shows that the Tennessee River flows from the east into the Cretaceous area in northwestern Alabama and then takes a northerly course just east of the Cretaceous area across Tennessee and Kentucky. The geological map shows that the wide Tuscaloosa belt in western Alabama and eastern Mississippi disappears entirely just north of where this river flows into the area. In the same part of the State the Eutaw belt is shown to become abruptly narrow and disappears much before it reaches the Southern border of Kentucky. Recent observations of the Tennessee Geological Survey have shown the occurrence of the Eutaw and Tuscaloosa farther north. These occurrences indicate that the Tuscaloosa formation, though probably not so thick and widespread as in western Alabama and eastern Mississippi, was at one time an important formation and covered large areas in Tennessee and Kentucky, and that the Eutaw formation also extended farther north and east. But during the erosion of West Tennessee Valley the Tuscaloosa has been almost entirely removed toward the north. The Eutaw formation has also been much eroded but to a less extent.

The accompanying sketch map shows the general areas across the State once occupied by the Tuscaloosa formation, which is now represented by only isolated occurrences except in the extreme southern part of the State.

POST-CRETACEOUS GRAVELS

Origin.—The post-Cretaceous group of gravels lies on the slopes of the valleys of the West Tennessee drainage system and is of stream origin. These gravels occur for the most part as terrace deposits which mark various flood plain stages of the Tennessee and

*Stephenson, L. W., "Cretaceous Deposits of the Eastern Gulf Region". U. S. Geological Survey 1914, Prof. Paper 81, map.

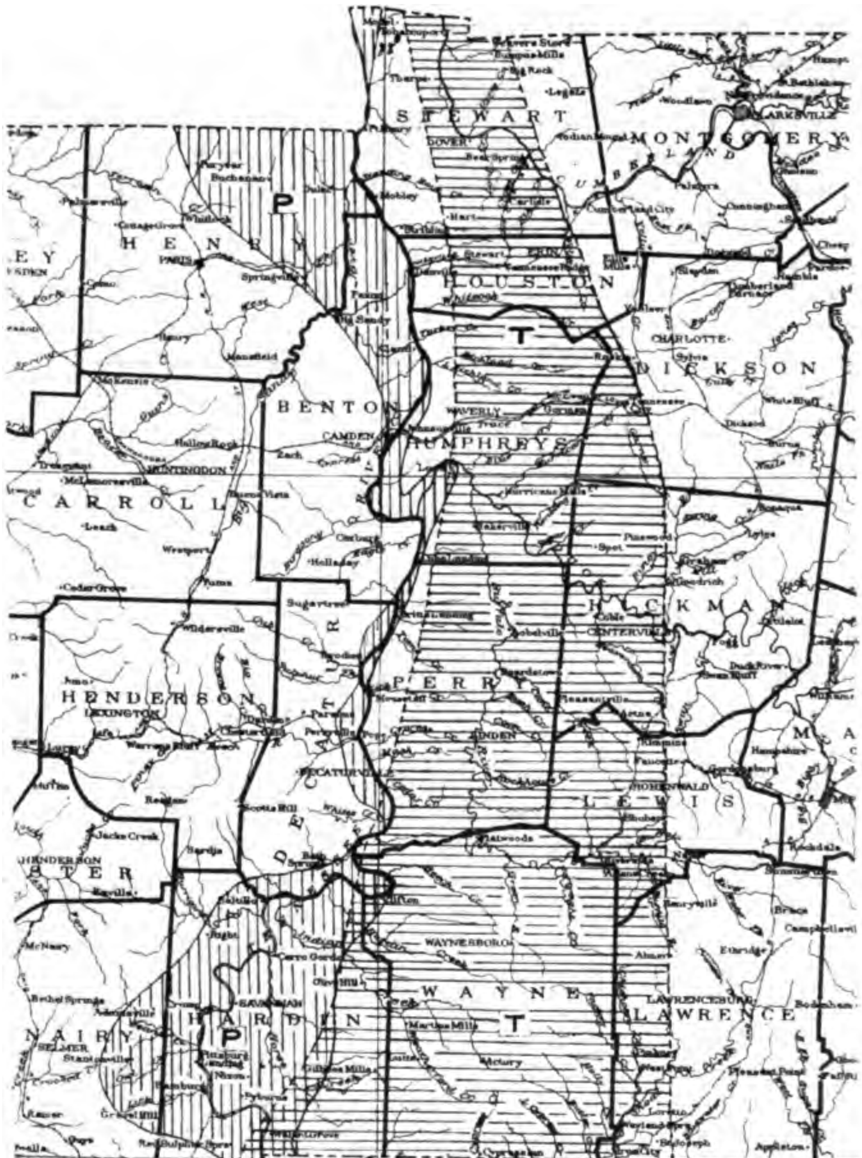

FIG. 2. Map showing the distribution of the Tuscaloosa and post-Cretaceous gravels in West Tennessee and adjacent part of Middle Tennessee. TT, area in which the Tuscaloosa gravel occurs, in isolated patches. PP, area of post-Cretaceous gravel.

its tributaries dating probably from late Tertiary to Recent. The streams of the Coastal Plain are regarded as having taken their present general courses in Pliocene time.* After Miocene time the Coastal Plain was eroded into broad shallow valleys having approximately the same positions as those of the present streams. These valleys were filled by the deposition of Pliocene alluvial sands and gravels, and near the coast the deposits were extended across the interstream areas. This filling formed broad plains at successively lower levels as the erosion proceeded. The recent work of Matson, Berry and Shaw shows that important deposits mostly of stream origin occur in the southern part of the Gulf Coast Plain states, covering wide areas and extending far up the valleys of the streams which empty into the Gulf. In the West Tennessee Valley there are isolated occurrences of river gravels on the outer-most and upper walls of the valley, that were deposited probably during the Pliocene when the Tennessee had a much wider valley. These isolated terraces have an elevation of as much as 800 feet above sea level in some localities. They have suffered much from erosion but are no doubt remnants of once very broad flood plains.

FIG. 3. Showing the surface of the Paleozoic rocks along West Tennessee Valley.

1. Tennessee-Mississippi line 3. Perryville. 5. Fort Henry
2. Savannah 4. Camden 6. Kentucky-Tennessee line

In the above discussion of the Tuscaloosa group of gravels, it was shown that the unconsolidated post-Paleozoic deposits extended farther east than their present general distribution. And, further, when the Tennessee was first fixed in its present course across this part of the State it was eroding the unconsolidated Cretaceous sediments, and it was not until subsequently that erosion brought the bed of the river down on and into the hard Paleozoic strata that now hold most of its course in a narrow canyon-like valley. The wide outlying Plio-

*Matson, G. C., U. S. Geological Survey, 1916, Paper 98, L., p. 173.

cene terraces on the highest points in the area, formed before and soon after the river began its intrenchment in the Paleozoic rocks, show that the Tennessee at this period had a wide valley in which it meandered back and forth like a typical coastal plain river.

Successive elevations during late Pliocene and Pleistocene soon caused the river to cut through the thin unconsolidated Cretaceous sediments capping the middle Tertiary peneplain in this region. The surface of the Paleozoic rocks beneath the Cretaceous is a broad dome with its highest points in the middle of the northward course of the Tennessee through the State, as shown in Fig. 3. For this reason, and also from the fact that the river bears a little eastward in northern Hardin County and west again near the northern border of the State, it began first to cut into the hard Paleozoic strata in the intermediate portion of its northward course across the State. Thus early in its history the Tennessee fell to the lot of having to cut a channel through chert and siliceous limestone in the region of the northern part of Hardin and Wayne counties, and Decatur, Perry, Benton, Humphreys and Houston counties, while in the southern part of Tennessee and again in the northern part of the State and in western Kentucky, it was cutting unconsolidated gravels, sands and clays. In the latter regions wide valleys were eroded in the less resistent sediments. An erosion progressed and the channel become more deeply intrenched in the hard rocks, the bed of the river came to lie less and less on the Cretaceous deposits and more and more on the Paleozoic rocks, so that now, almost the entire northern course of the Tennessee is hemmed in by these. At present, the Paleozoic-Cretaceous contact is nowhere below the water of the Tennessee in its northward course, except in the local acreas in middle Hardin County, Tennessee, and just southeast of its mouth in McCracken County, Kentucky.

This relation and areal distribution of the hard and soft rocks explain the existence of the two wide valley regions in West Tennessee Valley, and why the earlier stages of these valleys were much wider than the more recent ones, as mentioned above under the discussion of the topography. Such relations are well adapted to the development of terraces. And a preliminary study of the distributions of the stream gravels along the western Tennessee shows that their development is greatest in the two areas which coincides with the two wide valley regions.

Occurrence.—Thus the post-Cretaceous gravels fall naturally into two groups for discussion: Those in the McNairy-Hardin county region and those of the northern Tennessee and western Kentucky region. Both groups are of river origin and, though they owe their origin to slightly different physiographic conditions, the results produced are essentially the same.

The McNairy-Hardin county gravels were deposited in terraces of different levels in wide plains formed in this region of soft sediments while the river was laboriously cutting a narrow gorge in hard rock both up and down stream from this area. The lower narrow walls of hard rock on either side of the trough-like channel served as a barrier which hindered the widening of the valley in that part of the river's course. This produced a ponding effect of the waters rushing into the wide valley region and bringing with them heavy loads of gravel gathered from the siliceous trata in regions of high gradient, up-stream in northern Alabama. This ponding and retarding of the stream's velocity caused a deposition of load at various levels, according as the lowering of the valley continued. The waters of the Tennessee thus unloaded in the wide valley region of McNairy and Hardin counties were drawn off through the narrow trough-like channel across the middle part of the State. This channel led into the lower wide valley region in the northern part of Tennessee and western Kentucky. As the river cut its bed down through the rocks of this narrow cannel, its velocity and carrying power in the ponded part of its course increased so that a part of the great loads of gravel that were at first put down in that area was easily transported down-stream through the channel and deposited in the relatively quiet water of the lower, expanded portion of the valley, in Kentucky and Tennessee.

This lower wide valley region, at the time the river was around the 600-foot contour, more than 200 feet above the present channel, included much of western Kentucky and extended beyond Puryear in Henry County, Tennessee. Later stages were more restricted, since the stream soon became intrenched in the Mississippian chert of that region.

The ponding effect which produced the deposition of so much detritus in this lower wide valley was not due to any barrier of hard rocks, as in the McNairy-Hardin county area, but merely to the normal wide valley conditions near the mouth of a large mature stream flowing in soft sediments. The Tennessee empties into the Ohio not a great distance from the locality where the latter flows into the Mississippi, so all three of these streams have had an effect, either directly or indirectly, upon the alluvial deposits that cover most of western Kentucky and extend up the Tennessee Valley into Henry and Benton counties, Tennessee.

It is not the purpose of the present paper to give a detailed account of the areal, stratigraphic and topographic relations of the Tennessee River terraces, but mainly to call attention to the fact that there are important economic gravel deposits along West Tennessee Valley. Their general distribution has been given in Fig. 2, and an attempt is made to explain the origin and distribution from their relation to the hard and soft country rocks in the valley region. The State Survey plans to prepare maps and reports of the various counties in and adjoining Tennessee Valley that will give in detail the areal and stratigraphic relations of these gravels, which have already been mapped in McNairy, western Hardin and Decatur counties.

The terraces of West Tennessee Valley are discontinuous. Stream terraces are more complex than those formed along the sea-shore, and can not be correlated up and down stream with great certainty. When a stream sinks its channel into its flood-plain, it does not follow that a terrace remains on each side. Where the stream's deepened channel is in the middle of its flood-plain, there is, temporarily, a terrace on either side; but whenever the deepened channel is at one margin of its flood-plain, a terrace remains on the other side only. The latter has no doubt been the case in the formation of many of the terraces along West Tennessee Valley. Even where continuous at the outset, terraces soon become discontinuous, for all processes of erosion on land conspire to destroy them. A stream is likely to meander on its second and later flood-plains as on its first and highest one. Whenever the meanders on its second flood-plain reach the borders of the first flood-plain, the terrace at that point disappears, and since the meanders are continually migrating, terraces are continually disappearing‡. Owing to the underlying hard strata many

‡Chamberlin and Salisbury, Geology, 1914, vol. 1, p. 199.

of the early wide terraces that were laid down on the post-Paleozoic strata have been defended* as the streams became further intrenched in the hard rocks.

Regarding the age of the post-Cretaceous gravels, those occurring at the highest levels are probably Pliocene, as has been stated above, ranging down through Pleistocene to the Recent deposits now being formed as gravel bars and islands at the mouths of the large creeks and rivers flowing into the Tennessee from the east. Very few fossils have been found in the stream terraces of West Tennessee, and as yet no paleontological evidence has been obtained from terraces above the 500-foot contour. It is probable that the age of the various terraces can not be determined with assurance until they are shown on topographic maps, which have not yet been made.†

PRELIMINARY GROUPING AND CORRELATION OF THE TERRACE GRAVELS

For the purpose of a short preliminary discussion the terraces of the wide valley region, lying for the most part in Hardin and McNairy counties, may be divided into the following groups. The oldest and highest are given at the bottom of the column which reads up through the successively younger deposits to the recent alluvium at the top:

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*Davis, Bull. Mus. Comp. Zool., Geol. Ser., Vol. V, pp. 282-346.

†With such maps, the problem of the age of the stream deposits of the whole of West Tennessee, whether put down by the Tennessee or Mississippi or their tributaries, would be simplified. The terraces in West Tennessee Valley should be readily correlated with those of the lower Ohio and the Mississippi, and these in turn tied up with the definitely known Pliocene and Pleistocene terraces of the Gulf Region. Another line of evidence which would aid in this correlation would be obtained by tracing the river terraces northward up the Mississippi and Ohio and observing their relations with the glacial deposits. The reconnaissance work of E. W. Shaw for the U. S. Geologcal Survey, for the purpose of studying the physiography of the Mississippi Embayment region, will no doubt yield valuable information in regard to the stream deposits of this part of the United States.

Table of Tennessee River terraces

		Locality of typical exposure
Recent	Flood plains or aluvium	Tennessee bottoms
Pleistocene	Plain a little above the average high water mark or second bottoms	Hamburg
	Terraces about 420 feet in elevation	Saltillo Savannah
	Terraces about 500 feet in elevation	Stantonville Adamsville
	Terraces about 600 feet in elevation	Pebble Hill Michie
Pliocene	Terraces between 620 and 800 feet in elevation	Pine hills in eastern and southern Hardin County

Pliocene gravels.—The terraces between 620 and 800 feet in elevation have been much eroded and occur only in isolated areas far out from the river in the wide valley regions but comparatively close to it where the valley is narrow. The highest gravels observed by the writer where elevation was definitely known in the area under discussion, are just below the Tennessee line in Lauderdale County, Alabama, on the dividing ridge between Bumpus Creek and Manbone Creek. Along this ridge there are deposits of sand and small gravel up to 30 feet thick, resting uncomfortably upon the lower strata of the Eutaw sand. On the ridge east of Manbone Creek similar deposits occur and here they rest upon the Tuscaloosa gravels. The distinguishing features of these conglomerates, even though they are in contact, have been pointed out under the discussion of the Tuscaloosa gravels. The elevation of these deposits as shown by the Iuka topographic sheet of the U. S. Geological Survey is from 780 to 800 feet above sea level. Similar deposits, situated at elevations a little lower may be traced at irregular intervals across the eastern side of Hardin County.

On the western side of the valley along the Tennessee-Mississippi divide no such elevations occur, so that the ancient divide between these streams, which at one time must have been greater than 800 feet, has been lowered by erosion, and the highest terraces have been destroyed. The highest river terraces known to the writer on the western side of the valley occur along the Hamburg and Iuka road and in the region north of Yellow Creek in Tennessee, and southward in Mississippi to Short Creek. These deposits are made up of sands and small quartzite pebbles, and occur at an elevation from 630 to 650 feet above sea level. It seems reasonable to believe that higher terrace deposits at one time occurred west of the 630-650 foot terrace—deposits that would match up in general elevation with the 780-800 foot terraces in the eastern part of Hardin County and

FIG. 4. Pliocene terrace gravel on a ridge 700 feet high, two miles west of Lowryville, Hardin County, on the Savannah-Florence road.

northeastern Lauderdale County, Alabama. In a few places in McNairy and Chester counties, points in the Tennessee-Mississippi divide stand up above 650 feet in elevation. Some of these points are capped with surficial material consisting of reworked Ripley sands, many deposits of which contain a noticeable layer of small quarzite pebbles near the base. It is the opinion of the writer that these quartzite pebbles were derived by reworking processes of small streams from a once existing high terrace on the west side of the valley, comparable with the 780-800 foot terrace on the eastern side. Such a terrace situated, as it must have been, on a basement of unconsolidated post-Paleozoic sediments, with tributaries of such master streams as the Mississippi and Tennessee, working toward it on both sides, would be destroyed more readily than the defended high terraces on the eastern side of the valley.

Terrace deposits between 620 and 700 feet in elevation are well developed on the hills east of Nixon and Pyburns in eastern Hardin County. Farther north in the same county they occur at a greater distance from the Tennessee on the hills east of Horse Creek. A few isolated occurrences of river gravels are known farther north in the narrow valley regions in Decatur and Perry counties. In this region their development is not extensive and the known occurrences are relatively very near the river.

The material of these terrace deposits consists largely of small quartz and quarzite pebbles and clayey sand. The pebbles as a rule are well-rounded and some are discoidal like beach shingle. There are no quartzite or quartz country rocks in the vicinity of West Tennessee Valley, so these gravels were probably derived from the conglomerate horizons in the Pennsylvania series occurring in the northern part of Alabama and East Tennessee. The work of H. E. Gregory shows that gravel in quantity is carried 30 to 40 miles by streams of high gradient, and under favorable conditions, portions of a gravel bank may be transported a few hundred miles*. The size and shape of the pebbles in the high terrace deposits were probably little effected in transportation by the river. The well rounded and discoidal shapes no doubt were determined before their deposition in the Pennsylvanian. The similarity brought out by a comparison of pebbles from these highest terraces with pebbles from the Lee conglomerates of the Cumberland Mountains of Tennessee and Alabama is striking. So it seems reasonable to think that the highest terrace deposits in West Tennessee Valley represent in part reworked Lee conglomerate gathered by the Tennessee River and its tributaries farther up stream.

Pleistocene gravels.—In both the lower and upper wide valley regions there are important terrace deposits around the 600 foot con-

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*Gregory, H. E., 1915, "The Formation and Distribution of Fluviatile and Marine Gravels"; Am. Jour. Sci., Fourth Series, vol. XXXIX, no. 233, p. 494.

tour. They are best developed on the west side of the river in west Hardin and McNairy counties, and in Henry County in the northern part of the State. There are isolated occurrences in the counties on the east and in the intermediate regions, but no very extensive ones. This group of fluviatile deposits ranges from about 620 feet in the southern part of the State to about 575 feet or less in the northern part. There are typical occurrences of these deposits at Michie and Pebble Hill in McNairy County, the ridge west of Coffee Bluff and Right in Hardin County, and east of Cerro Gordo in the same county; also, in the broad flatwoods region about Puryear, west of Buchanan, and in a ridge about three miles southwest of Dulac, all of which are in Henry County. The Henry County terraces of this group are about 600 feet in elevation and are as high or nearly as high as some of the terraces of the same group in the upper wide valley region.

The lithology of the terraces around the 600 foot contour is quite different from that of the older ones. The pebbles of the younger gravel deposits are much coarser and the per cent of chert is much greater than in the higher terraces. Many of the chert fragments are angular and subangular. Large boulders are common, and angular fragments of St. Louis chert, with maximum dimensions as great as 18 inches, have been observed in the base of the terrace material on the southern part of Pebble Hill, a locality more than 15 miles away from any occurrences of St. Louis chert in place. In the same Pebble Hill locality limonite geodes commonly 12 inches in diameter, that were probably derived from the Ridley ferruginous clays occurring a few miles to the west, are common. Chert cobbles four or five inches in diameter are common, but the majority of the pebbles average less than 2 inches. Small quartz and quartzite pebbles are common and probably are derived from the reworking of the older terraces. Sand and clay form a good portion of the 600 foot terraces, especially on the western side of the valley where it was brought in by creeks from the western sand and clay hills.

The 600 foot terrace deposits are often 50 feet in thickness. They rest on an uneven surface of rocks ranging from Eocene to Ordovician in age. The coarsest sediments occur near the base, and toward the top they are finer. From 2 to 6 feet of clayey loam on the top of these deposits indicates a rather extended stage of quiet flood plain deposition.

The coarse sediments at the base of the 600 foot terrace may be interpreted as formed under conditions of steep gradient and rigorous climatic changes. Freezing no doubt was a factor in the breaking up of the chert beds into fragments that are of transportable dimensions. Floating ice may be proposed to explain the occurrence of the very large fragments at great distances from their normal occurrences. There seem to have been considerable changes in conditions of sedimentation between the 600 foot terrace deposits and those of the 630-800 foot group. And further the deposits of the latter group seem to have been formed at a time when the climate was milder and more uniform. For these reasons the group of ter-

FIG. 5. Pleistocene terrace deposits in Hardin County, showing a lens of sand in the gravel, and a thick layer of soil above the gravel. This is characteristic of Pleistocene terraces in West Tennessee.

race deposits occurring in the vicinity of the 600 foot level are regarded as the initial stage of the Pleistocene and should be separated from the higher terraces which are probably Pliocene in age.

The next lower and younger group of terraces are those that occur near the 500 foot level, ranging from about 470 to 530 feet in elevation. These deposits are typically exposed in the lower wide valley region of McNairy and Hardin counties and may be correlated with widespread river deposits in the lower wide valley region of western Kentucky. Terraces about this elevation are common in the upland regions of the creeks and rivers that head on the west side of the Tennessee-Mississippi divide and flow westward into the Mississippi. The terraces of this group are typically developed in Shiloh National Park, Hardin County, on a plateau about 475 feet in elevation, that extends westward to beyond Stantonville in McNairy County. Farther down-stream on the western side of the river is another plateau of this group of about 500 feet in elevation extending from Crumps westward beyond Adamsville. Other terraces of this group occur both to the north and south in the western valley and on both sides of the river.

This group of terraces occurs farther "streamward" than the older ones and have not been so much eroded as the higher benches, yet these Pleistocene flood-plains are greatly dissected by streams that have sunk their channels as much as 80 or 100 feet into them. In thickness and lithology, this group of terraces is very similar to those about the 600 foot level. On the west, the 500 foot terraces extend up the creek valleys, and in those regions they are made up entirely of sand and clay with perhaps a few pebbles that may have been derived from one of the more ancient terraces lying farthermost from the river, and not entirely obliterated at that time. The few pebbles occurring in the sand and clay terraces along the streams flowing west on the western side of the divide probably originated from the same source, as the head waters of the tributaries of the Mississippi pushed farther eastward across the ancient divide and into the highest terraces of the Tennessee.

A few fragments of fossil plants were collected from the base of the terrace on which Adamsville is situated, from a locality just west of the town. These were submitted to Professor Berry of Johns Hopkins University, for study. Only one species was determinable and that was a Pleistocene oak.

The third group of Pleistocene terraces occurs at an elevation of about 420 feet, or a little less, above sea level. A typical representative of this group is the plain on which Savannah is located. This plain is in the central part of Hardin County and is about 5 miles wide and 10 miles long. The deposits making up this terrace are from 20 to 40 feet in thickness and consist of gravels, sands and clays. Erosion has injured this less than either of the preceding Pleistocene terraces, yet it has been dissected by streams which have sunk their channels 10 to 30 feet below the base of the terrace material. Down-stream from the Savannah plain there are various other terraces that may be correlated with this group. The region about Saltillo in Hardin County, Husksburg in Humphreys County and wide areas in western Kentucky represent flood-plain stages of the Tennessee at this cycle. Many of the plains of this group are about 400 feet in elevation.

A fourth terrace group and the youngest of those regarded as Pleistocene in age in the upper wide valley region are the "second bottoms". These are relatively young terraces that occur only 10 to 25 feet above present high water stage of the river. The plain

FIG. 6. Erosion in the Savannah terrace, one-fourth mile east of Paulk, Hardin County. This view shows the stratification of the gravel and the thick deposits of sandy soil overlying it.

about Hamburg in Hardin County is very typical of this group. The second bottoms are little dissected and the base of the river deposits is rarely exposed. In many localities they slope gradually toward the river and merge into the flood-plain with no intervening scarp. They are covered by a thick deposit of fertile loam which conceals the underlying gravel. Second bottoms are widely distributed up-and-down West Tennessee Valley.

An important feature of all the Pleistocene terraces in the West Tennessee Valley is the thick accumulation of soil on top of the coarse sand and gravel. The origin of this soil can be explained as an accumulation during a silt-forming stage of deposition which persisted for a greater or less time before the stream lowered its channel and drew its waters away. This soil which caps the various terraces is porous and easily tilled. It is productive but not extremely fertile, for it lacks the strength which characterizes bottom soils even though it was once an alluvium, because it has been exposed to leeching processes so long that much of its fertility has been removed. It is a soil that can be built up readily by the proper agricultural methods and is in general more desirable for farming purposes than much of the land of the surrounding regions. For such reasons the areas of the Pleistocene plains have been important

FIG. 7. The Savannah plain, three miles southeast of Savannah.

in the settlement of this part of the State. Most of the villages and towns in West Tennessee Valley are situated on these various terraces. Some of these are Savannah, Saltillo, Crump, Right, Pittsburg Landing, Hamburg, Nixon, etc., in Hardin County; Adamsville, Stantonville, Michie and others in McNairy County; Thurman in Decatur County; Hucksburg in Humphreys County; Puryear in Henry County; and many of the towns in western Kentucky, among which are Murray, Benton and Paducah.

In concluding this discussion on the Pliocene-Pleistocene terraces, it should be stated that in this area, terraces occur intermediate in elevation and not fitting into any of the groups given above, due to the complexity of river terracing. After this preliminary study, however, it is the opinion of the writer that some such grouping as that proposed above will be borne out when the terraces are shown on good topographic maps.

The Recent deposits include the present flood-plains along the Tennessee and its tributaries. These plains are more or less developed either on the one side or the other of the river throughout its northward course across the State. These plains are generally known as "bottoms" and are very fertile. The bottoms are practically all in cultivation and produce good crops except when a midsummer flood occurs and this is very rare. The widest development of the bottoms is in central Hardin County about Savannah where the alluvian plain is, in places, four or five miles wide. The upper portion of the alluvial plains is made up of a rich loam deposited as silt. Well borings in the alluvium show gravel and coarse detritus in the bottom of these recent deposits which are often 30 feet in thickness. At the present stage the Tennessee is not depositing gravel widely over its flood-plain but only in its channel near mouths of large creeks and rivers, where they form islands or bars in the bends of the river. In the upper portions of the creeks and rivers that empty into the Tennessee from the east, great thicknesses of gravels are accumulating. A typical example of this is on Indian Creek just east of the Hardin County line in Wayne County. In this region there is a wide valley of gravel with practically no soil on it and every freshet brings down tons of new gravel. Such conditions on a larger scale no doubt existed along the Tennessee in the earlier stages of the formation of the present alluvial plains and at various times during the Pleistocene in the formation of the several groups of terraces at different elevations. In general the present stage of the Tennessee seems to be that part of the cycle favorable for the accumulation of silt—a stage similar to those in which the thick soil accumulations on top of the gravels took place in the various Pleistocene terraces.

GRAVELS OF WEST TENNESSEE VALLEY AS ROAD MATERIAL

Quantity and character of the gravel.—The gravel deposits of West Tennessee Valley contain an almost inexhaustible supply of road material. All the counties lying along this valley are rich in this product and in this respect have a very great advantage over the counties farther west where sands and clays prevail. In the latter counties the problem of road rock is a serious one and can only be solved by transporting gravel or other material into these counties from distances of a hundred miles or more at very great expense. The counties along the Tennessee, on the other hand, have excellent material for constructing highways, widely distributed. Every road in Hardin County might be made into a good gravel road without having to haul the gravel more than one or two miles except possibly in the northwestern part where it might in places may be necessary to haul it four or five miles. The quality is good, and many of the deposits are of such nature as to be applied to the road beds without screening or crushing. The supply is enormous. Hardin County alone might supply road material for all of West Tennessee and then hardly miss the gravel from its vast deposits. The same statement might well apply to more than one of the other counties along the Tennessee.

The Tuscaloosa group of the gravels is most extensively developed in Wayne and Hardin counties, but these extend northward in isolated occurrences in a broad belt across the State. The gravel of this formation in places is coarse and free from clay and in some pits it is often necessary to screen the material before applying it to a road. The screening separates the boulders and larger pebbles from the fine pebbles, making two grades of material which serve for the first and second application in constructing a gravel road. In most localities the Tuscaloosa gravel is so sorted naturally that coarse and fine material occur in separate parts of the exposure and screening is unnecessary. On account of the lack of clay and sand in the Tuscaloosa gravel, it makes an excellent railroad ballast and has been used extensively for this purpose in northern Mississippi and to some extent along the N., C. and St. L. Railway in Humphreys and Dickson counties. In general, however, the Tuscaloosa gravels have not been extensively utilized either in building roads or railroads in Tennessee, as they have in northern Mississippi.

The post-Cretaceous terraces along the river in the West Tennessee Valley are of great importance in road building in that part of the State. These terraces not only furnish material for the road itself, but on account of the even surface of the terrace plain and the sub-stratum of gravel, roads can be built and maintained at little cost. As a rule, the best roads in this valley today occur along the terrace plains and are very much in contrast to the roads in the same region along the several other geologic formations. This is not because the roads on the terrace plains have received more attention, but because good roads have almost been made by nature along the terrace plains. The excellent gravel roads in the Shiloh National Park in Hardin County were made of the Pleistocene gravel taken directly from the terrace deposits upon which they were built.

Besides their use for roadbeds, these gravels may be used as a filler for concrete in building bridges and culverts. The use of steel and wood for such purposes may be abandoned except for reinforcement, in which case gravel would become the main constituent in the construction of some roads. Much of the gravel of the region is clean and free from clay and may be used as it occurs for concrete. But other deposits are mixed with sand and clay and should be washed or screened before being used as a filler for concrete.

What can be accomplished in the way of road building with these gravels is well shown by the roads in Shiloh National Park. These roads might well be taken as models and should be studied by those considering the building of gravel roads in this part of the State. Mr. De Long Rice, Superintendent of Shiloh Park, who has kindly furnished the Survey with the information on the roads of that park given in the letter below, will no doubt be glad to answer any further inquiries from those interested in building roads in counties adjoining Hardin County:

WAR DEPARTMENT

OFFICE OF THE SHILOH NATIONAL MILITARY PARK,
Pittsburg Landing, Tenn.
Jan. 24, 1917

Bruce Wade, Asst. Geologist,
State Geological Survey,
Nashville, Tenn.

My dear Sir:—

I have your letter of 8th instant. The graveled roads of this Park, 27 miles in all, are made entirely of gravel just as nature mixed it. There has never been a rock crusher on the Reservation, nor has one been needed.

The quality of gravel which we consider the very best, is that which has sufficient clay in the mixture to make it cement well when rolled. This we find in abundance on the grounds of the Park.

The only preliminary work necessary to get into the average pit is to find where it faces out in the side of a hill, and dig in. As the work progresses, it is usually necessary to move anywhere from one to five feet of dirt from the top of the ground.

I think our roads, when properly shaped and rolled may be justly called first class highways. They do not give off the offensive dust which is peculiar to the limestone road. A good rain rather improves them, than hurts them.

I think about $2100.00 would cover the average cost per mile of our 27 miles.

The cost of up-keep is comparatively small. If a watchful system of break prevention is followed the cost is surprisingly low—that is, to be on the lookout for the little breaks in the surface caused by washes or sand pockets or ill use, and mend them before they become serious, always taking advantage of the proper weather conditions to reroll, and above all things, to so drain on either side that water can not stand and soak into the margins of the roads and make them soft.

The greatest enemy we have to meet is the deep freeze, to which no road is impervious. Such freezes, however, are very rare in this section. When they come, the only remedy is to drag and roll as soon as the road is dry enough for the roller not to pick up.

Drainage is the best weapon against the freeze, as the wetter the road is when the freeze comes, the greater the damage.

The roads of Shiloh are constantly praised and appreciated by those who use them, not alone because they are facilities for seeing and studying the battlefield, but also because they are driveways as beautiful as may be found in the greatest parks of the country. Lying mostly in the shadows of this historic forest, they are ideal throughout the summer, and as good as the best in the winter.

Sincerely yours,
(signed) De Long Rice,
Secretary and Superintendent.

GRAVEL ROADS

The following discussion of gravel roads is compiled largely from text books on highway engineering and a few personal observations:

General characteristics—Gravel roads seem to occupy an intermediate place between those of earth and broken stone, in the tractive force required, character of surfacing, and cost of construction.

On a well-made gravel road a horse is able to pull just twice the load he can draw on a dirt road, while this is only about one-half of what may be drawn on a macadam pavement. Gravel well applied makes a surface far superior to dirt, but does not possess the wearing qualities of broken chert, and for this reason gravel roads are most frequently built where gravel is accessible, where a covering other than earth is required, where the loads and traffic are light, and where the cost of broken stone is prohibitive. That is to say, gravel roads are best suited to country highways and park drives.

When stone roads are either impossible or impracticable, either because of the lack of suitable material in the vicinity, the excessive cost of the stone, or from some other reason, gravel, if properly laid, will make a very superior substitute.

Selection of gravel.—The gravel selected for road-building will generally be that most conveniently located, thereby introducing the possibility of great variety, for with hauls, greater than a mile and one-half, the item of transportation so increases the cost of construction that in such a case highway engineers recommend crushed chert. For this reason the Camden chert, which is a superior road rock to the water worn gravels, has been used in building roads in Madison and other counties in the western part of the State where all the rock has to be transported for a long distance.

The gravels of West Tennessee Valley consist of small stones of chert, quartz and quartzite, more or less worn and rounded by water action, and varying in size from that of a pea to pebbles two or more inches in diameter, and usually associated with ferruginous sand and clay that acts as a binder to hold the stones together. To be a serviceable and satisfactory road metal, it should possess the following characteristics:

The pebbles themselves must be hard, to resist the abrasive action of horses' hoofs and wagon wheels, and tough to withstand the blows of the horses' feet. The tougher and harder the stones, therefore, the longer will they wear. For this reason, whenever possible, care should be taken to select gravel pits where the gravel is not disintegrated, which is rarely the case with the gravels under discussion.

Between pebbles and binder there should be such a relation that all the voids in the stones are completely filled, and in a manner to give the maximum cementing effect. If this disposition of material or ratio is exceeded, the binder must necessarily take some of the wear, a function which it is not supposed to perform, and to which it is unsuited, while if not maintained, the bond will be weak and fail to hold the stones together.

Finally, the binder itself must possess to a marked degree the property of cementing the stones together, as otherwise the smooth pebbles move under traffic, similar to a mass of loose stone, and there is little stability in the pavement.

The binder may consist of loam, clay, iron oxide, silica, sand, or one of a number of other materials, but that most generally found mixed with the stone is clay. Where the climatic conditions are favorable, this forms a very satisfactory bond, but with excessive rains or continued dry spells the cementing properties are quickly lost. In hot dry weather the lack of moisture and heat causes the clay to crack, leaving the pebbles as so many loose stones on the surface, while in wet weather the rain turns the clay to mud in which the stones soon disappear under pressure of the wheels.

Probably the best loam binder is one in which the clayey cement is very tenacious, and used in such quantity that the gravel will stick to the shovel enough to bother the workmen in handling it. If the gravel contains from three to ten per cent. of chert as well, the binding power will be further augmented as the latter is easily crushed and possesses superior cementing qualities.

The mechanical bond in material composed of angular fragments, is an important factor in the consolidation of either gravel or broken stone roads, the reason being that the irregularities and corners adjust themselves to each other in such a manner as to become wedged or locked together. For a somewhat similar result, in using gravel, the size may vary between about ½ inch and 3 inches, so that the smaller particles may fit into the interstices formed by the larger. Material smaller than ½ inch is too easily crushed in the pavement to be of much service, and larger than 3 inches tends to make the road rough. For this reason much of the Tuscaloosa gravel had best be screened and the coarser portion applied first and then covered over with the finer portion.

Gravel will be found to vary quite considerably, both in regard to the character of the stone and the quality and quantity of the binder present. River and seaside gravel are hardly ever so good as that from pits, because the smoothness of the stones permits them to turn under pressure, even when associated with a good binder. A gravel deposit may be passed upon by an inspection of it in the pit. If it stands with a vertical face, is compact, free from strata of sand (except a highly ferruginous sand), hard, needs a pick to dislodge it, and breaks in chunks, it will make an excellent road surfacing and require no further treatment. That containing ferruginous clay, together with sharp angular stones, is exceptionally good, as exposure to the air hardens the binder and produces the more complete consolidation of the material.

Usually the gravels of Tennessee River occur in beds containing pebbles fairly uniform in size so that no screening is necessary, but where this is not true, screening is necessary to remove the larger stones or the excess of earthy material or both. Two screens are employed, one passing material under 2¾ inches in diameter, and the other ¾ inch diameter. That which passes the smaller screen may be advantageously used as a final dressing while that retained from the larger screen may be used as a foundation, or crushed to smaller sizes. Screening, however, has a marked tendency to remove more of the binder than is desirable, and should be resorted to only when absolutely necessary. In the state-aid roads of Massachusetts where screening has been employed, the material is sized into ½ inch, 1¾ inch, 2¾ inch stone. These are spread in courses, the larger on the bottom, each layer being separately sprinkled and rolled as in the building of stone roads. Pebbles failing to pass the largest screen are sent to the crusher and again sized with the other gravel.

Drainage.—The complete and satisfactory drainage of a gravel road is essential and perhaps more important than with any other class, as the material, particularly the binder, is so easily displaced by water flowing over the road.

The purpose of the covering should be to form a smooth, hard, impervious surface, and so distribute the load that the foundation may be able to resist the pressure without failure and consequent rutting of the surface.

If water is allowed to remain in the ruts and hollows, the subgrade soon becomes softened, the binder loses its properties, the pebbles become loosened and the wheels cut through the subgrade. The drier the subsoil the firmer it will be and the better able to perform its function as a foundation. In fact, gravel on a soft wet base is practically useless, as it is readily forced into the mud below. Because a gravel road is less pervious, and sheds more water than one of dirt, the side ditches or drains should be both wide and deep—deep so that they may drain the subgrade of the roadbed well, and wide so that they may successfully care for the water diverted toward them. On steep grades the ditches are paved with cobble to prevent erosion. In Shiloh National Park, thin layers of conglomerate, formed by the cementing of pebbles by iron oxide in the shape of rough flagstones or thick crusts, have been successfully utilized in making curbs on steep grades.

The longitudinal grade, from the standpoint of drainage, should be as small as possible, as gullies are quickly formed by the water flowing along the axis of the road and the binder and pebbles are washed away. In such cases, the crown is made correspondingly high, to get the water off the roadway and into the side ditches as soon as possible.

Under normal conditions the crown need not be so great as that employed in earth roads, for the water meets less resistance on the smooth surface of the gravel and reaches the ditches with a much smaller grade. A crown of ¼ to ¾ inch per foot of width or a rise at center of 1-50 the half width of wheelway is quite satisfactory.

The crown, however, depends very largely on the traffic, grade, and method of repairs, and for each set of conditions should be modified to suit. For example, on highways where the traffic is excessive, the crown is proportionally increased; first, because the greater the haulage the greater the amount of wear to the surface between periods of repair, and second, because ruts are more quickly made, retarding the flow of water which the crown must counteract.

Construction.—There are two general methods of building gravel roads, known as "surface construction" and "trench construction".

Surface construction is perhaps very much less satisfactory than the other because it requires less care in the work. In its crudest form it simply means that upon the old and unprepared roadbed a certain amount of gravel is dumped or strewn with the hope that traffic will consolidate it into an impervious pavement. This may be the case with very exceptional conditions; that is, where the roadbed is dry, hard, and well drained, and where the gravel is of such character that it binds well and quickly under the action of wagon wheels and horses' hoofs. This is often the case along the terrace plains of West Tennessee Valley, where the roadbeds are hard and well drained and much of the gravel is so ferruginous that it binds readily. Highway engineers are inclined to regard the surface method of construction a bad practice and only a makeshift at best. It is true that the Massachusetts Highway Commission has found gravel roads thus built in excellent repair after twelve years of surface, but this is unusual. The factors there have been carefully studied and found extremely favorable, as is true with many of the terrace plains of Tennessee.

On the contrary, the more care and preparation the original dirt road receives for the reception of the gravel covering, the better will it serve its purpose and the less it will cost for maintenance and repairs. The roadway, therefore, should first be properly graded, crowned and rolled to secure a firm, even surface, and the drainage carefully inspected, both as to the side ditches and surface drains, to see that the water is capable of being carried away as soon as possible. With such assurance, the gravel may be placed upon this as a foundation, being distributed over the surface in successive layers three to six inches deep. Each course is liberally sprinkled with water to insure speedy consolidation, and a road roller of ten tons is then used to perfect this. Should depressions develop during the rolling, more material must be spread upon such places, until, after a continuance of the process, the entire surface has been brought to the proper grade. If the consolidation is satisfactory, a second layer may be applied and treated in the same manner, the operation being repeated until the pavement is of the required thickness.

In some cases the traffic alone is allowed to perform the function of consolidating each course of material, but is not nearly so satisfactory, as it introduces foreign matter between the different layers, thus preventing a firm bond, and requiring much time to produce bonding. Unless the subgrade is drained properly and prepared to receive the gravel, frost and rain easily affect the foundation so that some months may elapse before the road comes to a very satisfactory condition.

The most critical period in the life of a gravel road is when traffic is first admitted to it, as then ruts are quickly and easily formed to remain as permanent defects unless repaired at once.

Some highway engineers adopt the following method in the construction of gravel roads: The bed is examined for low, wet and weak spots, and carefully prepared as a foundation, by removing objectionable material, laying drains, digging ditches, and thoroughly rolling, to receive the gravel to be placed upon it. This consists of a bottom course of screenings of the required depth, with a surfacing coat of one-inch gravel mixed with considerable binder above it. The whole road is then rolled until it becomes hard and smooth, being well watered during the operation to assist consolidation.

Trench construction varies but little from the other form except in the fact that a trench is excavated of the required width and from eight to ten inches deep for the purpose of holding the gravel in place by means of the shoulders at the sides. The bottom of the trench or foundation for the gravel, prepared as in the previous case, may be flat or correspond in section to that of the surface of the road, the latter requiring less material.

The advantage of this over the other method is in the fact that the shoulders hold the gravel in place and prevent its thinning out at the center by working over to the sides. The material is applied as in surface construction.

In either form of construction, it is better that the gravel vary uniformly between ½ inch and 3 inches so that the voids between the larger pebbles may be filled by the smaller ones. If this is not the case, screening should be resorted to, so that material over 2½ or 3 inches and less than ½ inch may be rejected. The larger size may be used as a foundation upon which the other is placed, and when so used should be rolled and consolidated to a depth of about 4 inches before the smaller size is applied. This is put in layers, each being thoroughly sprinkled and rolled, while the top layer is mixed with an excess of binder.

Experience of authorities on road construction has shown that where the gravel is screened, excellent results are obtained, and that while the roads wear more quickly than macadam, due to ravelling, this is not serious. Such roads are more easily maintained than others.

Gravel on earth roads.—Frequently the application of a three or four-inch layer of gravel to an earth road will greatly improve the surface. It should be remembered, however, that this will not be the case if the soil is wet, and if this is true the subsoil must in some way be underdrained. If the material is clay instead of loam, gravel to a depth of six inches will be necessary. Under any circumstances the gravel should be thick enough to prevent the traffic from forcing it into the clay below, and at the same time prevent the surface water from percolating to the soil beneath, saturating it and weakening it.

It is needless to dump the gravel into ruts, mudholes, etc., and look for traffic to consolidate this and produce a superior highway. Drainage must be attended to first, last and all the time, or the results will be anything but satisfactory.

Maintenance and repairs.—(1) After a newly constructed gravel road has been thrown open to traffic, it should be carefully watched in order that any defect may be remedied at once. Shallow ruts and depressions should be repaired without delay, or serious damage will be the result. In repairing a new road the gravel on the sides of the depression may be raked back in place; but after a time it will be necessary to fill the depression with new material. In the latter case the old hardened surface should be slightly loosened with rakes in order to get a bond between the old and new material. The gravel used should be smaller in size and should also contain more binding material than that used in the construction. This material should be stored in piles along the road-side, containing fifteen to twenty cubic yards each. Smaller piles are soon scattered and wasted. (2) Loose stones should be raked off the road surface as soon as they appear. They are uncomfortable for the travelling public, spoil the beauty of the road, and help to destroy it. (3) Care should be taken to fill all the hollows and depressions in the center, made by horses' feet, in order to avoid having water remain on the surface. If the gravel becomes saturated and soft, it wears more rapidly and will soon rut. It is important that the crown of the road should be preserved and that water should not be allowed to run down the center, but should have an unobstructed flow to the side ditches. In cases where the center has been worn hollow the crown should be restored by adding the proper amount of suitable material. This work should be done when the road is wet and soft and the gravel will easily compact and bind together. The ditches and culverts should be kept free from obstructions at all times, to secure an easy flow of water.

Maintenance of this nature may best be accomplished by careful and constant supervision, aided by the use of an ordinary garden rake, to remove the larger pebbles and to smooth the surface. After the road has become compacted such constant attention will not be necessary.

Repairs differ from maintenance in that they are more extensive in character, the surface having to be practically rebuilt. This should be accomplished by the application of one or more layers of gravel, two inches thick, as a greater thickness does not pack or bind so quickly.

One of the chief advantages of gravel roads, is that they are so easily repaired. Unlike dirt roads, gravel highways may be repaired in the fall without hinderance to traffic or injury to the road. The gravel, except in very extensive and complete repairs, should be applied in patches rather than in great stretches, and then in small quantities as it will more readily combine with the old surface, and at the same time offer less obstructions to traffic. This application may be continued until the entire road has been covered.

The material used for repairs should not be that which is taken from paring down the shoulders or that which has been washed to the sides, but rather new material kept for that particular purpose. Repairs with loam, sand, etc., are bad because such material only serves to put the surface in a sandy or miry condition. The shoulders should always be kept true to the section and the gutters kept open.

For gravel roads, perhaps more than any other, the method of continuous repairs is the most advisable.

Besides the water-worn gravels, there occur along the West Tennessee Valley other vast resources of road material in the form of limestones and cherts which are not discussed above. The Camden chert is famous in West Tennessee and its use as road metal has already been described by the State Geological Survey.*

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*Ashley, Geo. H., The Camden chert—an ideal road material, *The Resources of Tennessee*, Vol. 1, No. 2, pp. 34-43.

The Boundary Lines of Tennessee*

By Park Marshall

Introduction—The boundary lines of Tennessee are characterized by unusual irregularities which not only puzzle the people of the State but give rise to frequent inquiries from elsewhere. Some of these irregularities will be explained in the following pages, but as to others there seems to be no solution that is much better than guess-work, or hazy tradition.

There are five distinct deflections in the course of the north boundary that are large enough to be indicated on maps of ordinary size, the first instance being the northward position of the line of Johnson County, and part of Sullivan, in the extreme northeast part of the State. When this part of the line was re-marked the last time (in 1914), the surveyors in running east from Bristol, were surprised to find that the course of the line changes to north 66° 10′ east, which course it follows 8715.6 feet, then runs east to the corner of the State, some 18 miles. Here is an offset something like a mile and a half wide and 18 miles long that is north of the course of the State line as it runs along the rest of the north side of Sullivan County, and the reason for this is not apparent. The east end of this line is eastward and northward from the western termination of the North Carolina line, thus causing the formation of the "triangle" of Virginia territory at that point.

Leaving this portion of the line for the time being, it is best now to follow the boundary in a westerly direction; and, so running, it is found that at the southwest corner of Virginia the line suddenly drops one mile to the south.

Proceeding westward it will be found that at the point where the dividing line between Sumner and Robertson counties, Tennessee, strikes Simpson County, Kentucky, a small V-shaped area of Kentucky is projected southward about a mile.

*The recently issued map of Tennessee by the Geological Survey brings into notice the irregularities of the State boundaries. As few people know how these came about, this article was solicited from Mr. Marshall. It is a matter of regret that it is not practicable to insert a State map. A. H. P.

Again, upon reaching Stewart County, the line changes from nearly west and runs north 5 degrees east for a distance of more than 11,000 feet. This point is 2 or 3 miles east of Cumberland River; there the direction again changes and at first follows a course about north north 85 degrees west, but runs with various changes of direction until it reaches the Tennessee. The area of this offset north of the general course of the State boundary is about 25 square miles.

The boundary west of the Tennessee is definitely fixed as north latitude 36° 30° straight from the Tennessee to the Mississippi, and this is 12½ miles south from where the boundary strikes the east bank of the Tennessee. At the southwestern point of Kentucky, there is a loop in the river in such a form that the Kentuckians therein can not reach any other part of their State unless they travel down the river, or cross it twice, or pass through Tennessee territory.

The eastern boundary, coincident with the boundary of North Carolina, is extremely irregular except along the border of Polk County, and being projected on a map suggests the promontories and bays of a rough and eroded sea coast.

The southern boundary is peculiar in that, according to the most accurate observation, it is not, except at one point, coincident with the 35th parallel as it was intended to be.

The western boundary is the Mississippi River, yet there are several small tracts of land which appear to be cut off by the river, from the states to which they belong. It may as well be stated at once that this is due to changes in the channel of the river. There have been several lawsuits to determine the jurisdiction over such tracts, and the courts hold that the jurisdiction of the State, to which a tract originally belonged, holds good in cases where the river changes its course. It is otherwise in the case of *accretions*, which is the situation where a body of water recedes, or land is formed by deposition.

The northern boundary.—The discussion of the north boundary of the State is naturally considered in two parts: first, the part between Tennessee and Virginia as those states are now constituted, and, secondly, that between Tennessee and Kentucky. It is, in a way, germane to the first of these to give an account of the establishment of the line along North Carolina, inasmuch as the Tennessee-Virginia line was originally meant to be a prolongation thereof.

The reasons and causes of particular deviations in any of the boundaries will not be discussed at great length, as the main purpose is to state how the boundary lines run; the more inquisitive reader is advised to consult the authorities which are referred to.*

It is not necessary to recite the several charters from England before 1665, except to say that on March 24, 1662, Charles II granted a charter to the Lords Proprietors of Carolina, and that on June 30, 1665, he issued a second patent to the same favored courtiers, enlarging the former grant. It is with this that we are mainly concerned. In this grant Charles II confirmed to the Lords Proprietors of Carolina "All that province, territory, or tract of ground * * * * extending north and eastward as far as Carahtuke [Currituck] river, or inlet, upon a straight line to Wyonoke Creek, which lies within or about the degrees of thirty-six and thirty minutes, northern latitude, and so west in a direct line as far as the South Seas."

The controversies which disturbed three states, on the boundary question, were based upon the interpretation of this provision, as well as upon the manner of locating the line, considering the first principles as fixed. The beginning point on Currituck River could not be accurately agreed upon without reference to the given latitude; and when the given latitude is taken it is found to be somewhat indefinite, because the words are that the boundary shall be a "straight westerly line to Wyonoke Creek which lies within, *or about,* 36° 30′". The boundary was to run to the "South Seas". It is well understood that this expression refers to the Pacific Ocean, the distance of which was not known at the time, and which was so

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*The writer has freely used the "History of the South Carolina Cession, and the Northern Boundary of Tennessee", by W. R. Garrett, A.M., (a pamphlet of 32 pages published by the Tennessee Historical Society, 1884. This pamphlet is an excellent production in every way. Prof. Garrett refers to "Byrd's History of the Dividing Line);" "Thomas Jefferson's Works"; "Cooke's History of Virginia"; "Wheeler's History of North Carolina;" "Ramsey's History of South Carolina;" "Marshall's History of Kentucky;" "Haywood's History of Tennessee;" "Ramsey's Annals;" "Ridpath's History of the United States;" "Charters and Constitutions;" Statutes, Journals, etc., of Virginia, Tennessee, North Carolina and Kentucky; manuscript report of Joint Commission of Tennessee and Kentucky, of November 11, 1859. These references contain much interesting and unique matter which the limits of this paper will not permit the present writer to use.

called because the first glimpse of it by the Spaniards at the Isthmus was to the southward.

After the long series of French and Indian conflicts came to a close, the treaty of 1763 fixed the British west boundary at the Mississippi River, which was reaffirmed in the treaty of 1783; and this, of course, controlled in the case of Tennessee.

When the population of the Atlantic seaboard became larger controversies arose between the Crown and Carolina about the boundary, Virginia being a royal province and Carolina a proprietary province. Attempts were made previous to 1710 to fix the boundary, but no agreement could be reached. On March 1, 1710, an order in Council (of the Crown) was made appointing commissioners on the part of Virginia, and under its terms the Carolina proprietors were "to do what on their part does appertain". This joint commission in 1710 and 1711 met with no better success.

In 1727 the governors of Virginia and Carolina came to a tentative agreement to set the compass on the north shore of the mouth of Currituck River or inlet, and to definitely fix the boundary by running a course due west from that point.

This was approved by the King and privy council, and, the proprietors having appointed a commission, a cedar post was placed at the point stated, on March 6, 1728. The place was found to be in latitude 36° 31′ though some parts of the east and west line are as high of 36° 34′ 25.5″.* The variation of the compass was agreed to be 3° west, and a line was run westward with this allowance for variation, which caused "a deviation from true west". The line passes through the Great Dismal Swamp, it being the first time this swamp had been traversed. It reached Peter's Creek, a tributary of Dan River, 241 miles and 30 poles from the coast. This is called the Byrd survey. Colonel William Byrd, of Virginia, certainly one of the ablest Americans of his time, was a member of the commission, and wrote a very readable book, "The History of the Dividing Line", which has already been referred to in a foot note. The Carolina commissioners abandoned the work at 169 miles.

*Encyclopedia Britannica, "North Carolina". The U. S. Coast and Geodetic Survey finds the starting point on Currituck Inlet to be 36° 33′ 15″.

In 1749 further progress was made, the line being run from Peter's Creek to Steep Rock Creek, 88 miles, making a total of 329 miles from the coast.*

It is clear that it was not understood that the line was to stick rigidly to latitude 36° 30', but was only meant to approximately follow that latitude; this understanding is important as a partial explanation of the deviations which occurred.

The charter itself is indefinite, for it says the line shall run to Wyonoke Creek "which lies within, *or about,* latitude 36° 30'". Moreover, the provisional agreement between the two governors, approved in the King's Council, fixed the beginning point at what they believed to be 36° 31'; and it provided that the line should change at certain points according to what streams it should strike. One of these was the Blackwater, about 60 miles from the Atlantic, at which the line should turn and run to the mouth of the Nottoway, which caused it there to run south 176 poles. The agreement goes on to say "If a due west line shall be found to pass through islands, or cut out small slips of land, which might much more conveniently be included in the one province or the other, by natural water bounds, in such case the persons appointed for running the line shall have power to settle natural bounds, provided the commissioners on both sides agree thereto".

This gave the commissioners a clear power and discretion to divert the line within reasonable limits. In his book Byrd says that he made concessions to a width of at least a mile, out of consideration for residents who preferred to be placed in North Carolina.

The constant, but slight, deviation northward all the way to the east border of West Tennessee, is understood to be due to errors in astronomical observation and to mistakes in attempted corrections of the compass variation. The method described by Daniel Smith in his diary seems to be fairly correct, but the quadrant used was made by the commissioners and was, no doubt, a rather crude instrument. The compass, at least along the Tennessee part of the line, varied from place to place, and at every observation for latitude it was found that the surveyors were more or less off the line.

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*Peter Jefferson, father of Thomas Jefferson, was a member of this commission. Several prominent men were at different times connected with these boundary surveys, including Wm. Byrd, Gen. Daniel Smith, Gov. John. Sevier, Hon. Felix Grundy, John J. Crittenden, Robert Trimble and Wm. L. Brown. General James Winchester was connected with the south boundary of West Tennessee.

All that can be said then for the northward projection along Johnson and part of Sullivan counties is that no exact reason seems ever to have been given therefor, but that it probably is due to the fact that the land there is of little value and very rough; also the commissioners considered that they had discretion in the matter, and possibly followed Byrd in the way of accommodating the inhabitants.*

There are many other singular deviations not relating to Tennessee, a remarkable one being the north boundary of South Carolina along a course intended to be on the 35th parallel and which consequently would have been a straight line if instructions had been followed. The line wanders north of the parallel to the extent of 17 miles, causing a loss of from 500 to 1000 square miles from North Carolina. Professor Kerr† says, "These lines were run and the latitude observations taken with very imperfect instruments, and the variations of the compass was little understood, so it was not possible to trace a parallel of latitude". He also says, "The northern boundary of the State as run is not only not the parallel of 36° 30', but is far from coincident with any parallel of latitude, and must be a succession of curves, with their concavities northward and connected at their ends by north and south offsets".

The above remarks are probably true as to the constant drift of the line from the intended course, but can not apply to a case where the line deviates at a startling angle; there is no explanation for this in any published report except in the two instances mentioned in this paper.‡

*A story of this kind is told: A "contrary" man had settled in that section, who insisted that he had to live in Carolina in order to have any health, and to please him the line was run north of his place. In the vicinity of several of the striking angles there are stories on a par with this. They have a certain value, as they appear to be inventions to explain things that really have no recognized explanation.

†Geology of North Carolina, Vol. 1, p. 2.

‡In the case of Virginia vs. Tennessee, U. S. Supreme Court, 1893, the surveyors thought it necessary to speak specifically about the part of the line just referred to. They took the trouble to examine the country in the direction of the line as it passes Bristol and within the offset, but found no marks; they found, on the other hand, many old marks along the more northerly line as given on our maps.

In 1728 George II appointed the commission on which William Byrd was first named. This commission, in connection with one from North Carolina, ran the line 169 miles to Buzzard Creek, at which point the Carolinas abandoned this work. Colonel Byrd and Wm. Dandridge continued the line 72 miles further, to Peter's Creek, near "Sauratowns"; total, 241 miles 30 poles.

In 1749 Peter Jefferson and Joshua Fry on the part of Virginia, and Daniel Weldon and William Churton on the part of North Carolina, ran the line from Peter's Creek to Steep Rock Creek, 88 miles, a total distance from the coast of 329 miles.

The Southwest Territory, later Tennessee, had not been thought of at this date, the survey stopping at a natural barrier west of which there were no settlers, which barrier was used to delimit the territory which is now Tennessee, ceded by North Carolina forty years later.

By the year 1779 a number of immigrants had come into the country west of the Unaka Mountains and settled both north and south of latitude 36° 30''. It was very important to decide the citizenship of these people, so additional acts were passed for running the line from Steep Rock Creek* (extreme East Tennessee), to the second crossing of the Tennessee River† Virginia appointed Dr. Thomas Walker and Daniel Smith, and North Carolina appointed Col. Richard Henderson and Maj. Wm. B. Smith, to run this line. They met in September, 1779, on Steep Rock, but failed to locate the place where Fry and Jefferson, Weldon and Churton ended their survey in 1749.‡ They agree that they were in latitude 36° 31′ 25″, longitude 81° 12′, and 329 miles from the sea by chain, or 317 miles on a level. They ran south 201½ poles with a view to getting at what they figured to be 36° 30′. There were a number of observations taken and considerable doubt existed as to the exact latitude within limits of a mile or two. A due west line was run about 45 miles to Carter's Valley, and here the dispute became so sharp that the commissions separated, Walker and Smith asserting that the line the commissioners were running was too far north. The Carolina commissioners continued their line westward to Cumberland Mountain, while the Virginia commissioners ran due south two miles, then ran their line both east and west from that point, and ran it westward all the way to Tennessee River, at what is now the northwest

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*The writer is not able to identify this creek.

†What is now the eastern, or first crossing, was then called the Holston River.

‡See diary of Gen. Daniel Smith, in possession of Mrs. Horatio Berry, a descendant; also printed in full in the Tennessee Historical Magazine for March, 1915, the print being accompanied by an excellent preface and notes by Dr. St. George L. Sioussat, of Vanderbilt University.

corner of Stewart County, Tennessee. Thus the two lines were about 2 miles apart, the north line from Steep Rock Creek to the Cumberland Mountain being known as the Henderson line, the south line, from Steep Rock Creek to the Tennessee River (said to be about 361 miles), being the Walker line. Walker did not in fact survey the entire distance, but left a gap of what he thought was 109 miles through the mountains, but which in fact was only 97 miles; his guards became tired of the mountainous country, so he made a detour from Clear Creek into Kentucky and took up the survey again when he thought he had reached the proper latitude below on the Cumberland. This gap was supplied by a line run across it in 1821.

Although the Virginians contended for the south line, it has been found that their starting point is in fact in 36° 34′ 53″; also as they progressed their line tended still more to the north until at its termination on Tennessee River it was in latitude 36° 40′ 45″. Just before it reaches the angle in the Stewart County line it is about 36° 37′.

In addition to this the line along Kentucky contains innumerable small angles too minute to show on the map.*

The legislature of Carolina passed a resolution in 1790 adopting the Walker line, but it was non-effective, as the cession to the United States had already been made at the same session. In 1802 commissions of the two states agreed on a compromise and had a line marked out widway between the Walker and the Henderson lines, one mile from each, as far west as Cumberland Gap. It was marked with five hacks in the form of a diamond. This was the "Diamond Line", and it was adopted by the legislatures of both states in 1803, and carried into their codes of laws. Under acts of 1858 commissions re-marked this line in 1859, but their report was not adopted by either State.

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*The Peebles and Cox report of the survey and the re-marking of the line, made in 1859, the calls of which are published in the Act of 1860, (Tenn. Acts), shows many printed pages of calls and needle readings, every call showing a different angle from the preceding one. Nearly all of these angles are very obtuse, and hence as a rule do not affect much territory except in the aggregate. This survey was run east from the Tennessee River in West Tennessee, to the northeast corner of the State, and the rule was to trace, in a backward course, the original surveys, and to run to the old marks if to be found, and where these were not found to accept the reputed line and mark it.

Virginia brought the matter up again in 1870, with a view to getting a new survey and a change of the compromise line of 1803. No action on this was taken by Tennessee until 1872 when the proposition was positively rejected.* During Governor Bate's term, in 1885, a resolution from the legislature of Virginia was received requesting Tennessee to appoint commissioners to join those of Virginia and rerun the line, and providing that, in case Tennessee should refuse, then the Attorney-General of Virginia should bring suit in the U. S. Supreme Court. Governor Bate replied that the question had been settled in 1803; that the claim was stale; and that he did not think it wise to disturb the amity so long existing between the two states.

The same request was made of Gov. R. L. Taylor, and was similarly treated. Virginia then brought suit in the U. S. Supreme Court. In the bill Virginia claimed that the agreement of 1803 was void because it was without the consent of Congress, and also showed that the line was miles further north than had been intended or was justified by the grant of Charles II or by the direction of George II.

This case was decided April 3, 1893, in favor of the Diamond Line claimed by Tennessee, the court holding that this was not such a compact as requires the consent of Congress; that Congress did give an implied consent; that the language "within, *or about,* 36° 30′" justified deviations from that latitude; and that it was competent for states to agree on lines; that they had done so in this case, and to demand a change now is to make a stale claim. Other decrees were made, later, providing for placing stone markers at frequent intervals, and for finding the line of 1803. It was all wound up by 1901.†

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*A committee of the Tennessee legislature made an able report in opposition to the reopenings of the controversy. See Appendix to Journal 1872.

†Supreme Court decree, 148 U. S., p. 503, being Lawyers' Edition, Vol. 37, p. 537:

Decree for markers, U. S. 158, p. 976, L. Ed. 39;

Appointing commissioners, U. S. 177, p. 501, L. Ed. 44, p. 863;

The full report of the surveyor in U. S. 190, p. 63, L. Ed. 47, p. 956.

This case also confirms an agreement between Virginia and Tennessee about the State line along the main street in Bristol. The diamond line ran with the sidewalk on the north side of the street, but it was moved to the center of the street all the way across Bristol, a change of 30 feet. See Acts of Tenn., 1901. This makes it incumbent on Bristol, Va., to pave half of this street.

It has been stated that the Walker line was several miles further north at its beginning than was intended; and trended northward still more; the Henderson line was still further north by 2 miles. A compromise line half way between was made along the Virginia border. Still the Walker line, continued to Tennessee River and at the west border of Middle Tennessee, drifted northward until it was 12½ miles north of 36° 30′.

Kentucky strongly resisted this through the years 1803-1819, the details of which contention are given by Professor Garrett in the paper referred to. She sent her surveyors, Alexander and Munsell, in 1819 and ran a line from the Tennessee to the Mississippi River at 36° 30′.*

The basis of the line was on February 2, 1820, fixed by a treaty between the two states, to which treaty Congress gave its consent. Tennessee was represented by Felix Grundy and William L. Brown, and Kentucky by John J. Crittenden and Robert Trimble. The people east of Tennessee River strongly desired to remain in Tennessee, largely because of their land title papers. The treaty provided that the Alexander and Munsel line and the Walker line should stand as the true lines. Nevertheless there was further dispute in 1831, Kentucky claiming that the Walker line should run straight through southward of the puzzling deviation lying in north Stewart County, Tennessee, and south of Trigg County, Kentucky, but nothing came of this.

Under acts of 1858 by both states, commissioners and surveyors re-ran and re-marked the Alexander and Munsell line from the Mississippi east to the Tennessee, and thence re-ran and re-marked Walker's line to the northeast corner of Tennessee, a distance of about 432 miles, altogether. They started at "Compromise", in 36° 29′ 55.7″, and ran a slightly wobbling line to the Tennessee in 36° 29′ 54″. They then ran down the Tennessee (north) to a point not given, but in fact about 36° 40′ 45″, and ran thence to the northeast corner of the State in 36° 34′ 53.48″, thence about a mile and a half southwest to the North Carolina line at 36° 36′ 0.92″. There was much argument as to the manner of running the line, but it was

*It will be recalled that the Chickasaw treaty ceding West Tennessee and western Kentucky was not made until 1818, hence no titles could be perfected there until that time. So it had not to that time, become necessary to run this part of the line.

finally decided to run to the old Walker marks wherever to be found, and, in all cases where marks could not be found, to run as the Walker line was *reputed* to be. This survey was ratified. A reading of the calls will show that the line is irregular. This is due to the manner of re-running it, and to both errors and concessions that had been made by Walker and Smith. No one seems to know why the Stewart County detour, or the Robertson-Sumner County angle, was made; but the drop of one mile at the southwest corner of Virginia is due to adopting the Walker line instead of the Compromise line of 1802-3.

Strange to say, the Tennessee Constitution states that the north boundary is in latitude 36° 30′, but adds that jurisdiction shall extend to any land acquired by compact, etc.*

The eastern boundary.—The eastern boundary was established by the Act of North Carolina, 1789, ch. 3, ceding to the United States the territory now known as Tennessee. This boundary is described in the act as beginning at the extreme height of Stone Mountain, where the Virginia line intersects; thence along the extreme height to the place where the Watauga River breaks through. It runs along the mountain chain, known by different designations, in a general southwest direction; and finally along the Unaka Mountain to the sourthern border of the State. The greater part of this line was run in 1821. At the northeast corner of what is now Polk County, Tennessee, the commissioners, for some unknown reason, ceased to follow the mountain and ran a due south course to the Georgia line. From the map it would look as if Tennessee was the gainer by this, and North Carolina authorities so consider, but Haywood says the contrary, for it leaves the upper part of the Hiwassee country in North Carolina, "contrary to what was expected".†

There have been a number of disputes along this line, one of which was decided by Turner, Special Judge, in the Supreme Court of Tennessee, in March 1916, on a question of jurisdiction. It is a very carefully prepared and lengthy decision and seems to go over the whole eastern boundary subject. It will soon be published in the State reports.‡

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*The original report is in the Tennessee Archives, and the calls are in "Acts of Tennessee", 1860.

†Haywood, 1891, pp. 27-29.

‡Caroline Lumber Co. vs. McCarthy. It will probably be printed in 6 Thompson (Tennessee).

The main point decided is that the line was designed to run in a general way the main course of the mountains, and is not controlled by the watershed, since as many as five streams break through, carrying water from both sides of the mountains to the eastern limb of Tennessee River.

The southern boundary.—At an early date, the southern boundary of North Carolina was run from a point on the Atlantic northwestward to the thirty-fifth parallel, or at least it was supposed to have been so run; thence to run west. For this reason it was always understood that the 35th parallel was the boundary of Tennessee, Georgia, Alabama, and Mississippi, except that for a time South Carolina claimed a strip 12 to 14 miles wide along the north border of the three last named states. The boundary between Tennessee and Georgia was run under Act of November 10, 1817, of the former, and December 16, 1817, of the latter State. Tennessee was represented by Gen. John Cocke, commissioner, and James S. Gaines, mathematician, while officers for Georgia were Capt. Thomas Stock and J. Camack. Under agreement they met at the Indian village of Nickajack, as near as possible to the lines of the states of Georgia and Tennessee, and the territory of Alabama, on May 15, 1818. They made careful observations and on June 1st placed a durable stone 1 mile and 28 poles south of the center of Nickajack, that point being agreed on as lititude 35°. From that point they ran east to the southwest corner of North Carolina in the same latitude. This line was unanimously agreed to and was at once adopted by both states. It was said to be 109 miles long, though the actual distance is greater.

In 1826 Mr. Camack re-ran this line with better instruments, and found it to be 37.9 chains, (834 yards), south of the parallel, which amounts to over 51½ square miles, or 33,000 acres as compared to the line of 1818. Georgia has expressed dissatisfaction with this line on several occasions, particularly along the borders of Hamilton and Marion counties, Tennessee, where the line seems to vary, and once, (1889), Tennessee passed an act reciting that the line at that point was in doubt. Nothing has been done about it, and the line as fixed in 1818 will undoubtedly stand.* The recent map of the Ten-

*All of these matters are fully discussed by Charles E. Battle, Esq., of Columbus, Ga., in a lengthy paper in Report 19 of the Georgia Bar Association, and reprinted by Franklin Printing & Publishing Co. of Chattanooga. He insists that Georgia can demand that the line be placed at parallel 35°, but in this he is mistaken, for land-marks on agreed lines control. The case of Va. vs. Tenn. settles this. The report and letters are in the Tennessee Archives.

nessee Geological Survey shows the boundary to be southward of the parallel.

The line along Alabama has never been a subject of much contention; only one or two very small areas, where it was lost, having been in controversy on the question of court jurisdiction. The line is continuous with that of Georgia, hence is not at all points on the 35th parallel. Going west it drifts northward and gradually runs to a knife-edge and merges with the parallel for a short distance along the south border of Lawrence County, Tennessee; then crosses the parallel at a very acute angle and so runs until it touches the Tennessee River several hundred yards north of the parallel. There the line runs up the river (south) half a mile, more or less, to the mouth of Bear Creek, and on the west side of the river follows a steady course a few hundred feet south of the parallel. This angle is due to the fact that the West Tennessee observations and survey were not made until many years after the other line was fixed.*

The line along Mississippi, from the Tennessee to Mississippi River, was surveyed, soon after the Chickasaws ceded that country, by Gen. James Winchester.† This line was not believed to be correct by either Tennessee or Mississippi. In 1831 Governor Carroll of Tennessee appointed I. Thompson to locate the 35th parallel, which he did with much care, using a mercurial horizon in making his observations. He found the parallel to be "on the eastern bank of the eastern chute of Island No. 47, known as Cow Island" (of Mississippi River), a point nearly five miles south of the survey that had been made by General Winchester in 1819. This line, however, was not the one finally adopted, though very near it. Governor Brandon of Mississippi sent a message to the legislature in 1829, contending that the Winchester line was too far south. Why he assumed this view is not known, but he raised the question rather vigorously. It was claimed that Memphis was in Mississippi. After Thompson's

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*The Alabama-Tennessee line was run and marked by General Coffee, Surveyor-General, in 1818. The boundary crosses the 35th parallel at the middle of the south boundary of Lawrence County, east of which point the boundary is south of the parallel, and west it is north of it. There is not much loss to either State.

†See article on Gen. Winchester in Tennessee Historical Magazine for September, 1915. Gen. Winchester was appointed by President Monroe in 1819 to run this line on latitude 35°, being the Chickasaw boundary.

observations were made, in 1831, Mississippi was in favor of dropping the subject, and asserted that the Thompson survey was wholly *ex parte,* therefore not binding. Under authority of acts passed by both states a new survey of the Mississippi-Tennessee line was made in the year 1837. The commission making the survey was composed of B. S. Ludlow, Surveyor of Public Lands; D. W. Conolly and W. Pietrie on the part of Mississippi; and J. D. Graham and Austin Miller on the part of Tennessee. The result was a line commencing on the Tennessee River "six four-pole chains south, or above, the mouth of yellow creek, and about three-quarters of a mile north of the line known as "Thompson's line * * * * and terminating on the east bank of Mississippi River (opposite Cow Island), 16 chains north of Thompson's line. This line was agreed to by both states. It gives Tennessee 200 square miles more than did the Winchester line. After all this the recent government surveys show that this line is something like half a mile south of the latitude they were trying to find.*

In his report in 1819 Thompson uses an argument to explain in part the errors made by Winchester and others. He says that every survey is made on a great circle, and if not corrected in this respect, would on a long line amount to a considerable error. It would seem, however, that an error due to this cause would carry the line to the southward, not to the northward, of the desired course.†

The western boundary—There is not much to be said about the western boundary more than has been said in the first part of this paper. As before stated the treaty of 1763 fixed the west boundary of the British colonies at Mississippi River. This has been held to mean the middle of the channel as the channel ran at the time of the treaty, or as it ran at the most remote period since that time of which we have proof. These questions are discussed in the case of W. D. Alexander vs. W. F. Woodruff, decided by the Tennessee Supreme Court at Jackson, Tenn., in 1910.

As a net result of the manner of running the boundary lines of the State, Tennessee gained about 2,500 square miles of territory over what it would have had under surveys accurately following the rules laid down. This did not in any case arise from design. Indeed the

*See Acts of Tennessee 1837-8. Also see Encyclopædia of Mississippi, Vol. I.

†The papers are in the Tennessee Archives.

lines adopted were, generally, not the lines run by the commissioners and surveyors on the part of Tennessee.*

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*Professor Garrett's article on "The South Carolina Cession," (which has been referred to in a foot note), really has no bearing on the boundary of Tennessee, as the strip once claimed by South Carolina is south of the recognized boundary of Tennessee. The "Boundaries of the United States", issued by the U. S. Geological Survey, 1904, being Bulletin 226, Series F, Geography, 37, may be here referred to, although its citations are not complete.

The Glenmary Oil Field

By A. H. Purdue

Since the last issue of the *Resources,* the Glenmary field has produced its second well. This is known as the Todd well and is located less than a mile north of the town, a half mile east of the Cincinnati, New Orleans and Texas Pacific R. R., and just north of Black Wolf Creek. It perhaps is a mile east of Pemberton well No. 1 described by Dr. L. C. Glenn in Vol. VII, No. 1, of the *Resources.* It was begun October 30, 1916, and completed January 25, 1917.*

Lack of cars for shipping is said to have prevented continued pumping for sufficient time to test the strength of this well. The last day it was pumped, it is reported to have produced 105 barrels. The capacity previous to that time was not learned. It is also reported that after the last day's pumping, the shale below the casing caved in and shut off the flow. At the time of the writer's visit, this shale had not been cleaned out. When the well was first brought in, there was an escape of gas that blew oil above the top of the derrick.

The elevation of the mouth of the Todd well, according to Mr. R. A. Shiflett, Chief Mine Inspector of Tennessee, is 1255 feet (aneroid). That of the Pemberton well is given by Dr. Glenn as 1248 feet. The oil is reported by Mr. Shiflett as coming from sand containing small pebbles, just as in the Pemberton well, the sand of both being in the St. Louis limestone. The Todd well is 1249 feet deep; the Pemberton well, 1244 feet.

The contractors for both wells were the same parties (Sackrider and Fuller) and according to their records the top of the St. Louis (Newman) limestone in the Pemberton well was struck at 950 feet; in the Todd well, at 1045 feet. Reducing the mouths of both wells to the same level, this makes an apparent difference in the elevation of the top of the St. Louis at the two wells of 87 feet. This difference may in part be accounted for in the general rise of the rocks to

*The drillers report that there were many mishaps; that with good luck the well could have been drilled in about 28 days.

the west, which according to Dr. Glenn is between 30 and 40 feet per mile, in the vicinity of Glenmary.*

According to a log of the Todd well, furnished the writer by Mr. R. A. Shiflett, the sequence of rocks above the St. Louis limestone in the two wells does not agree, but below the top of the St. Louis, they are in general the same, as shown by the following section:

Sections of Pemberton and Todd wells, below the top of the St. Louis limestone

Pemberton well†		Todd well	
St. Louis limestone	98 ft.	25 ft.	St. Louis limestone
White slate	3 ft.	8 ft.	Slate
Dark lime	93 ft.	42 ft.	Black lime
Black slate	3 ft.	3 ft.	Black slate
Gray sand	8 ft.		
Hard white lime	77 ft.	96 ft.	White lime
Gray sand and small pebbles, oil	8 ft.	11 ft.	Oil sand, small pebbles
Hard white lime	4 ft.	19 ft.	Lime

It will be seen that the distance from the top of the St. Louis limestone to the oil "sand" in the Pemberton well is 282 feet. In the Todd well, the distance is 174 feet. From the comparison, made easy by the table, it appears that this difference is due to the varying thickness of the beds penetrated. Should such variation be typical of the St. Louis formation in this locality, the depth of the oil-bearing layer below its top will of course be everywhere uncertain.

Subsequent to the publication of the article by Dr. Glenn on the Pemberton well, it was drilled 40 feet deeper, making the total depth 1284 feet. It is reported that in this increased depth the drill went through 28 feet of pebbly sand, and that the well now pumps 7½ barrels a day.

The oil men who are familiar with the geology of the Irvine and Scottsville fields of Kentucky very naturally ask the question "What is the chance for oil below the Chattanooga shale in the Glenmary field " To this question the geologist can only reply that the source of the oil in the Kentucky fields mentioned is almost certainly the Chattanooga shale. The Chattanooga shale is everywhere quite uniform in nature. These things being true, oil can reasonably be

*Res. of Tenn., Vol. VII, No. 1, p. 42, 1917.

†Res. of Tenn., *Loc. cit.*

expected either just above or just below this shale, provided that at these levels there are open rocks to serve as reservoirs; provided also that the open rock above the shale is itself covered by another bed of shale or some other "tight" rock; and provided again, that the structure is suited to oil accumulation.

So far as the writer is informed, no oil has been secured from the horizon immediately above the Chattanooga shale, and this fact reduces the hope of striking it at that level in the Cumberland Plateau.

There may be a bed of sand beneath the Chattanooga shale in parts of Cumberland Plateau, as there is in the Western Highland Rim of Tennessee, but it has not been observed in the outcrops along the eastern escarpment of Cumberland Plateau, nor is it indicated in the available well records. In Toomey Nell No. 1, 4 miles northwest of Oneida, Scott County, the Chattanooga shale is followed by a limestone* and the same order of occurrence would be expected at Glenmary, though with our present want of knowledge of the extent of these beds, this can not be relied upon.

The beds mentioned probably are of Silurian age, and disappear somewhere east of the west escarpment of the Cumberland Plateau, for they are wanting there. However, the rocks below those of Silurian age in Cumberland Plateau are also mainly limestone, so in any case limestone is the probable rock beneath the Chattanooga shale; and inasmuch as this is true, oil if struck, probably would come from fissures.

The question of the depth of the Chattanooga shale in the Glenmary field is also a practical one. In Toomey well No. 1, Oneida field, above referred to, the top of the St. Louis (Newman) limestone, was struck at 750 feet. The base of the Chattanooga shale was reached at 1540 feet, making the distance from the top of the St. Louis to the base of the Chattanooga 790 feet. According to this, the base of the Chattanooga shale in the Pemberton well would be reached at 1740 feet, and in the Todd well at 1835 feet. But again, these figures cannot be relied upon except as a general indication of what may be expected, for the thickness of the St. Louis limestone and the underlying Ft. Payne chert probably varies from place to place.

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*Res. of Tenn., Vol. V, No. 4, p. 176, 1915.

It is understood that if oil is sought in association with the Chattanooga shale, drilling should not cease until the limestone beneath it has been penetrated for some feet. If oil is not then struck, the well should be shot before it is abandoned.

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THE RESOURCES OF TENNESSEE

A MAGAZINE DEVOTED TO THE DESCRIPTION, CONSERVATION AND DEVELOPMENT OF THE RESOURCES OF TENNESSEE

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JULY, 1917

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THE RESOURCES OF TENNESSEE

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JULY, 1917

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Traverseman

CONTENTS

Marketing Woodlot Products in Tennessee

BY W. D. STERRETT

Forest Examiner, U. S. Forest Service *

CONTENTS

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*Published by the Forestry Division of the State Geological Survey, in co-operation with the U. S. Forest Service. Photographs taken by W. R. Mattoon of the States Relations Service.

THE WOODLOT SITUATION IN TENNESSEE

A permanent woodlot is an essential part of a well equipped farm. In heavily wooded states like Tennessee,† however, farmers are likely to overlook this fact and recklessly cut, misuse, or clear up their forest areas.

The reduction in woodlot area which is continually going on might often profitably be held in check. It is always possible to hold timber crops for more favorable market conditions. As a rule it is advisable to allow thrifty immature timber to mature, rather than to remove it at a total loss; and it is often better to practice intensive agriculture on areas already cleared than to clear additional areas which are in growing timber. Farmers who give a little consideration to the direct and indirect advantages of having a woodlot on the farm will generally see the importance of keeping certain areas permanently in timber and of handling these permanent woodlots so as to increase their productivity and value.

The one direct economic reason for the use of land as woodlot is that on some areas timber is the most profitable crop which can be grown. This, of course, is especially true of poor and rough land, such as is found mostly in the mountainous sections of the State.

Most frequently, woodlot occupation of farm land can be justified only by indirect economic considerations because the land is usually adaptable to more valuable crops; and for this reason the woodland should form but a small part of the total farm area. The important indirect reasons, a number of which are active in any particular case, are: (1) for convenience of home use for fuel, posts, and

†In 1910, 40 per cent of the total farm area of the State was in woodland. No county in the State has less than 20 per cent of its farm area in woodland, while in some of the mountain counties over 70 per cent of it was wooded. (See map.)

other farm needs; (2) as a windbreak for buildings or crops; (3) as a shelter for stock; (4) for protection of land from erosion; (5) as a temporary, soil-renewing crop on worn out land; (6) as furnishing work for man and teams during spare time; (7) for purely esthetic reasons and for recreation purposes, for which reasons alone a farm with a well-located grove of trees, however small, will sell for more than one without; (8) as a temporary crop on intrin-

Fig. 1.—Woodlot kept as a windbreak and wood supply. Lawrence County.

sically good agricultural land, which it is wished to hold for future clearing and development.

Determination of location and size of woodlots should be largely influenced by the above considerations, and especially by the relative value of particular parcels of land for agricultural as compared with forest crops.

The chief obstacles to proper consideration by the farmer of the economic possibilities of a woodlot on his farm are his lack of knowledge: (1) of the market possibilities for various woodlot products and of how to market them; and (2) of the rate of growth of and possible yields per acre from properly cared for stands of different species and ages. This article is intended to give the farmer in

Tennessee information in regard to marketing; and it is hoped that by showing him how he can most profitably dispose of forest products which he already has on hand his interest in the possibilities of permanent woodlots may be aroused.

Woodlot products resulting from clearing of land for agriculture are being wasted in large quantities every year, not only because of lack of immediate local demand, but also because of lack of knowledge of values, specifications, and possible markets for different classes of materials. Information on marketing will help the farmer to dispose of such material at a profit.

WOODLOT REGIONS

The character of the woodlots in the six natural regions (see map) into which Tennessee is divided varies considerably. The kinds and quality of timber trees and the size and economic usefulness of the woodlots are very different in different parts of the State, as are also the markets which are available for the sale of woodlot products.

The Unaka Mountain Region and the Cumberland Region have only about one-third of their area in farms; and nearly two-thirds of the farm land is forested. Heretofore, the timber industry has been all important, the rough physiography, the large proportion of thin soils, and the shortness of the growing season having retarded agricultural development. There are no large towns or cities and no great variety of wood-using industries, transportation is deficient, and the supply of timber is abundant, so that the market for woodlot products is poor. Nevertheless, permanent woodlots should be retained on a large portion (probably one-half) of the forested farm land, either because the land is too poor or rough for agriculture or because the forest cover is needed as a protection against erosion.

Lying between the Unaka and Cumberland Mountains is the valley of East Tennessee. Eighty-five per cent of the total area is in farms, and thirty-seven per cent of the farm area is woodland. This is a prosperous agricultural and manufacturing region, with two large cities (Chattanooga and Knoxville) and a number of small cities and large towns. There are, accordingly, good markets for forest products. Transportation facilities are fair. At least half of the area at present in farm woodlots should remain forested, either because the rough, steep land is chiefly valuable for timber growing or because the forest is needed for protective purposes.

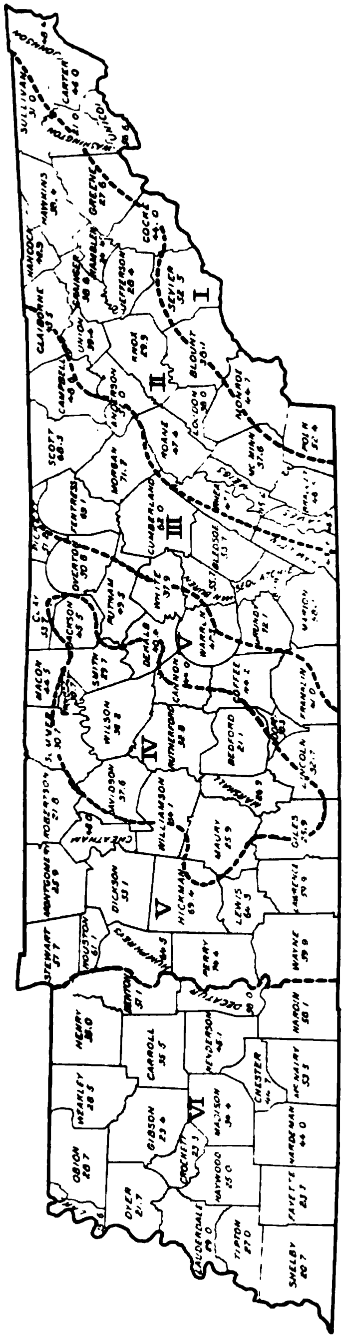

Fig. 2.—Farm woodlot regions in Tennessee. The figures show per cent of woodland on the farms in each county in the State.

I. Unaka Region
II. Valley of East Tennessee
III. Cumberland Plateau
IV. Central Basin
V. Highland Rim
VI. West Tennessee Plateau and Bottom Lands

The Highland Rim is a broad shelf-like region surrounding the Central Basin. It is less developed, as a whole, than the valley of East Tennessee, and has 47 per cent of its farm area still in woodland. Seventy-four per cent of the area of the region is in farms, and most of the remainder is in comparatively small, isolated timber tracts; about one-fourth of the area is steep and rough, and not well suited to agriculture. The remaining three-quarters lies well and has large agricultural possibilities at present little developed. Probably one-third of the total farm area should be permanently held in woodlots. There are no large cities in the region; but it is, as a whole, easily accessible to Nashville. There are also a number of large towns, so that local market conditions for forest products are fair. Transportation facilities, however, are often very poor.

The Central Basin is a limestone region and is the richest and most prosperous part of the State, with the highest average value per acre of farm land, the lowest proportion of its farm area in woodland, and the highest proportion of its total area in farms. The small proportion of woodland and the presence of the large city of Nashville and a number of small cities and large towns, make the market for forest products excellent. Transportation facilities are usually good. About one-quarter of the land is steep and rough, but on account of the limestone formation will usually grow blue grass for pasture. Over half of this rough land, however, should be permanently held in woodlot for protective and other purposes.

The West Tennessee Region is the largest of the six, and amounts to one-quarter of the total area of the State. Thirty-five per cent of its farm area is in woodland, and 85 per cent of its total area is in farms. There are scattered timber tracts, chiefly in undrained bottom lands of the Mississippi and Tennessee rivers and their tributaries; but most of this land will finally be drained and become available for agriculture. There is comparatively little rough, steep land; and most of the land has good agricultural possibilities which are but little developed, so that not over half of the present area in forest should remain in permanent woodlots. The city of Memphis, located in the southwestern corner, and a number of large towns scattered over the region furnish very fair markets for forest products. Transportation facilities by rail or by water are usually good.

TABLE 1.—*Commercial trees in the different woodlot regions in Tennessee, arranged in order of their relative importance as indicated by the proportion which each formed of the total lumber cut of all species in the region in* 1912.

Entire State		I Unaka Mountain Region		II Valley of East Tennessee		III Cumberland Region	
Species	Per cent of total lbr. cut	Species	Per cent of total lbr. cut	Species	Per cent of total lbr. cut	Species	Per cent of total lbr. cut
Oak	40.6	Yellow Pine	25.5	Oak	46.3	Oak	39.5
Poplar	11.5	Oak	19.5	Yellow pine	21.8	Poplar	18.6
Yellow pine	10.1	Hemlock	14.1	Poplar	13.6	Yellow pine	16.3
Red gum	7.5	Poplar	9.9	Chestnut	4.2	Chestnut	7.4
Chestnut	5.0	Chestnut	9.7	White pine	3.7	Cedar	4.0
				Hemlock	3.5		
				Cedar	1.6		
Hickory	4.5	White pine	8.5	Hickory	1.2	White pine	3.6
Cedar	3.4	Maple	4.5	Red gum	.8	Hemlock	3.0
Hemlock	3.3	Spruce	1.8	Walnut	.8	Hickory	2.5
White pine	2.5	Basswood	1.7	Maple	.7	Basswood	1.9
Ash	2.0	Buckeye	1.5	Basswood	.5	Ash	.7
Maple	1.6	Ash	1.0	Beech	.4	Buckeye	.7
Beech	1.3	Birch	.7	Ash	.4	Beech	.5
Cypress	1.1	Beech	.3	Buckeye	.2	Maple	.5
Basswood	1.0	Hickory	.3	Birch	.1	Walnut	.4
Cottonwood	1.0	Bellwood	.3	Sycamore	.1	Cherry	.2
Sycamore	.7	Cherry	.2	Elm	.1		
Elm	.7	Walnut	.1				
Tupelo	.5						
Buckeye	.5						
Walnut	.4						
Spruce	.3						
Birch	.2						
Cherry	.1						
Persimmon	.1						
Dogwood	.1						
Bellwood	*						
Others (Hackberry, sassafras, mulberry, butternut)—locust	*						

*Less than one-twentieth of one per cent.

TABLE 1.—*Concluded.*

IV Central Basin Species	Per cent of total lbr. cut	V Highland Rim Species	Per cent of total lbr. cut	VI West Tennessee Species	Per cent of total lbr. cut
Oak	32.3	Oak	54.4	Oak	42.2
Cedar	28.2	Poplar	14.6	Red gum	26.3
Poplar	13.4	Hickory	9.6	Poplar	5.3
Hickory	7.9	Chestnut	8.2	Hickory	5.3
Chestnut	4.2	Beech	2.5	Ash	4.7
Beech	4.2	Tupelo	1.6	Cypress	4.2
Ash	2.7	Red gum	1.3	Cottonwood	3.4
Basswood	1.5	Ash	1.1	Sycamore	2.2
Elm	1.5	Maple	1.0	Maple	1.8
Red gum	.9	Basswood	.9	Elm	1.5
Walnut	.8	Elm	.7	Tupelo	.8
Sycamore	.7	Walnut	.6	Yellow pine	.5
Maple	.6	Buckeye	.6	Dogwood	.3
Buckeye	.4	Cedar	.4	Persimmon	.2
		Sycamore	.3	Beech	.1
		Cottonwood	.3	Walnut	.1
		Persimmon	.3	Birch	.1
		Dogwood	.2		
		Cherry	.1		

NATIVE TREE SPECIES

The seven most important commercial trees on farm woodlots in Tennessee are, in order of their importance, oak, poplar, hickory, cedar, chestnut, sweet gum, and yellow pine. (See also Table 1.) From these seven trees is cut over four-fifths of the lumber produced annually in the State. Oak is the most important of all and enters all mixtures and types, while the others are often absent. Oak and poplar are important throughout the State. Hickory is important everywhere except in the Unaka Mountain Region. Cedar has its chief importance in the Central Basin Region where it ranks next to oak in the amount cut into lumber. It also has some importance in the Highland Rim, the Cumberland, and the Valley of East Tennessee regions. Chestnut is important east of the Tennessee River but of no importance in West Tennessee. Much more of it is found on and cut from rough timber tracts than farmers' woodlots. Yellow pine (shortleaf) is important only in the eastern half, and red (or sweet) gum only in the western half of the State. Most of the yellow pine cut in the State is from large timber tracts in the mountains.

Of secondary importance on farm woodlots are the valuable woods, walnut, cherry, and ash, and the less valuable woods, basswood, elm, maple, sycamore, buckeye, beech, and black gum. Ash, maple, beech, black gum, walnut, and cherry are rather widely distributed over the State; basswood and buckeye occur commercially only east of the Tennessee River; sycamore and elm occur everywhere except in the mountain regions. Trees usually too small for lumber but of considerable value and occurring in small quantities in woodlots are black locust, dogwood, and persimmon, all of which have a wide distribution throughout the State. Hemlock, white pine, spruce, cypress, and tupelo gum seldom occur on farm woodlots and for this reason are not considered in this report.

USES OF NATIVE WOODLOT TREES

The market in which woodlot material may be sold depends upon both the species of the wood and the product that is to be derived from it. Furthermore, certain industries use logs, bolts, and billets; while others require lumber for their raw material. Those which use logs, bolts, and billets are of most importance to the farmer because he is seldom prepared to turn out sawed lumber.

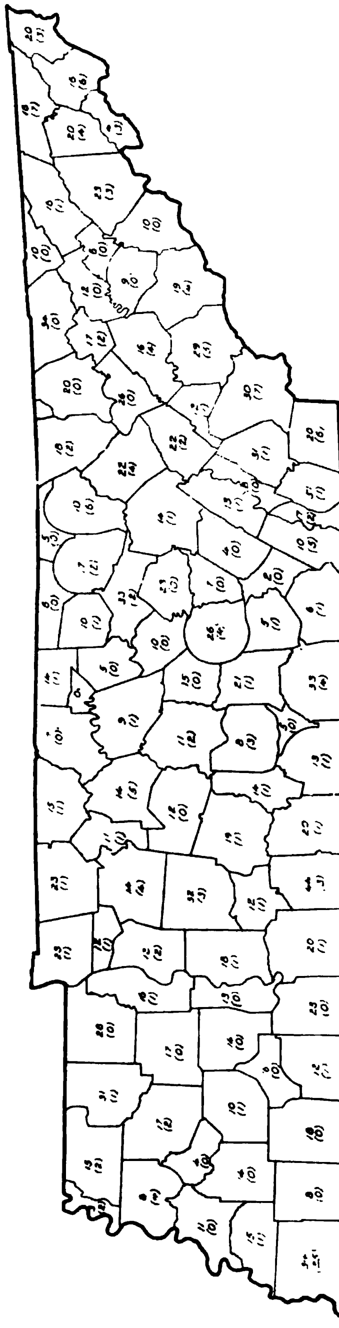

Fig. 3—Showing by counties the total number of sawmills cutting lumber in Tennessee in 1912, and (in parenthesis) the number of mills cutting over 1,000,000 board feet.

1. Markets According to Product

Lumber.—About one-half of the lumber manufactured in Tennessee in 1912 (932,572,000)* was cut from woodlot timber. All species were used. The importance of the various native woodlot tress in the lumber industry is shown for each of the natural regions of the State in Table 1.

Other products made directly from logs, bolts, and billets.—The industries using logs, bolts, and billets, and the approximate amount of raw material consumed by each are shown in Table 2. The remarks in the table on the kinds of material used and the proportion cut from farmers' woodlots are intended to give an idea of the possibilities of a particular industry as a market for woodlot products. Bolts are short round logs six feet or less in length, usually with bark left on, but sometimes peeled as in the case of pulp bolts. Billets are short pieces of rived stock, less than four feet in length; such as rived spoke stock, rim stock, whiffletree stock, tight stave and heading stock, which have been roughly hewed into the form in which they are to be finally used. At points remote from the market material in the form of billets can often be gotten out at a profit where the cost of transporting logs or bolts would be too great.

Firewood forms nearly half the total volume of woodlot products, but it has little or no stumpage value. Where coal is cheap, more cut wood, suitable for burning, is left in the woods, than is used, and the farmer's problem is to decrease the proportion which is left to rot.

About 90 per cent of all the wood taken from woodlots, except that which goes into firewood, is used for saw and veneer logs, railroad ties, and material for use on the farm. Trees of good size and quality are usually cut into saw logs; small and medium sized trees and the rough tops of larger ones yield ties, two-thirds of which are hewed. White oak, chestnut oak, and post oak ties may be sold for nearly twice as much as red oak, black oak, and chestnut ties, and more than twice as much as softwood ties. Since the cost of hauling to the railroad or river cuts down the profit more than anything else, a one trip a day haul can be made profitably only with ties of the first three species mentioned.

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*See Table 2.

TABLE 2.—*Wood-using industries in Tennessee (classified according to their products) using logs, bolts, and billets, and the approximate amount of raw material consumed by each.*

Product	Number of board feet, or its equivalent, used	Remarks
1. Rough lumber	932,572,000[1]	All species used. About half cut from farmers' woodlots.
2. Firewood	4,730,524[2] (cords) in 1908	Mostly cut and used on farms.
3. Ties	150,000,000[3]	75 per cent white oak, including chestnut oak and post oak; 20 per cent red and black oaks; 5 per cent others.
4. Tight cooperage	150,000,000[4]	White oak, from choice logs and bolts. Over half from farmers' woodlots.
5. Fence posts, rails, and hewed pieces used on farm	100,000,000[5]	Chiefly cedar, locust, chestnut, and oak. Mainly from farmers' woodlots.
6. Slack cooperage	75,000.000[4]	All species. About half from farmers' woodlots. Medium to small trees.
7. Wheel parts (spokes and rims)	40,000,000[3]	Hickory, white oak, and red oak. All choice logs down to 10 inches in diameter.
8. Veneer	30,000,000[4]	All species. Choice and common logs—variable requirements.
9. Extract wood and bark		
Chestnut wood	(50,000 cords)[4]	
Oak bark	(25,000 cords)[4]	
10. Handles	15,000,000[3]	Chiefly hickory, some white oak and ash. Mainly from farmers' woodlots.
11. Poles and piles	10,000,000[5]	Cedar and chestnut, for poles; miscellaneous species for piling; largely from farmers' woodlots.
12. Pulpwood	10,000,000[4]	Mostly poplar; some red and black gum; half from farmers' woodlots.
13. Mine timbers (not including sawed lumber used)	8,000,000[5]	Chiefly oak. Very little from farmers's woodlots.
14. Shuttle stock	5,000,000	Dogwood and persimmon. Mostly from farmers' woodlots.
15. Pump rods and boat oars	3,000,000[3]	Ash and hickory. Choice logs, medium to large in size. About half from farmers' wooalots.
16. Sporting goods stock	3,000,000[3]	Hickory and ash. Choice second-growth, small to medium size. Half from farmers' woodlots.
17. Excelsior	2,000,000[3]	Poplar, pine, cottonwood, and willow. One-half from farmers' woodlots.
18. Butchers' blocks and skewers	1,500,000[3]	Hickory.
19. Turned porch columns	500,000[5]	Poplar—small, clear sap logs.

[1]1912 Census returns. [2]According to estimate in Circular 181 of the Forest Service. (1910.) [3]1911 Census returns. [4]Special investigation by the Forest Service. [4]1911 Census returns. [5]Estimate by the author.

Good markets for certain classes of woodlot materials are furnished by the tight cooperage, vehicle, and handle industries. Supplying the bolts and rived stock for these markets often gives opportunity for the employment of farm labor during lax periods. The tight cooperage stock industry is confined chiefly to rough and inaccessible parts of the Cumberland, Highland Rim, and West Tennessee regions; but the vehicle stock and handle industries are more generally distributed throughout the State. White oak alone is used for standard heading stock for spirituous liquors. This brings a much higher price than does oil barrel stock, which is made also from chestnut oak and red oak. Large trees are required for tight

Fig 4.—Chestnut wood and chestnut oak bark at the tannic acid or extract plant. Elizabethton.

cooperage; and, since only a small part of the tree can be used, there is much waste unless the remainder of the tree is used for some other purpose. Vehicle and handle stock comes chiefly from small and medium sized hickory, white oak, red oak, and ash trees of good quality.

Mining timbers are of some importance as a woodlot product for farmers in a number of counties in the Cumberland region, although these are mostly taken from large timber tracts owned by coal operators.

The tanning industry furnishes a fair market for chestnut oak bark and hemlock bark in the eastern half of the State, wherever these species occur in any quantity. At present, however, it pays in most cases to take the bark only from comparatively large trees, 15 or 20 inches in diameter. There is a market for chestnut wood for tannic extract plants throughout its range in the State.

The market for chestnut and cedar poles is good throughout the State. That for cypress, oak, and gum piling for shipping purposes is good in the extreme western part of the State near the railroad, and occasionally a local market can be found.

Products made from lumber.—Of the total lumber cut in Tennessee, about one-third goes into various wood-using industries in the State. A directory of the largest consumers of lumber in these various industries will be found on page 178. It will sometimes be possible to get more for lumber by selling it direct to these wood-using industries than by selling it to the local lumber trade or to general dealers and shippers. The following are the products made from sawed lumber arranged in order of the amount of lumber used. The principal kinds of native woods used for each are also shown.

1. Planing mill products—all kinds and grades of lumber.
2. Boxes and crates—chiefly cottonwood, gum, poplar, and pine.
3. Furniture—chiefly oak, gum, and poplar, of all grades.
4. Sash, doors, and blinds and general mill work—chiefly pine, oak, poplar, and chestnut of good grades.
5. Car construction—pine and oak.
6. Vehicle construction—select hickory and white oak dimension stock, and wide boards of poplar and gum of good grade.
7. Caskets and coffins—pine (yellow and white), chestnut, and poplar of medium grade.
8. Chairs—low-grade oak lumber.
9. Trunks and valises—poplar, pine, basswood, chestnut, and buckeye, of medium grades.
10. Agricultural implements—oak, poplar, and pine of good grade.
11. Refrigerators and kitchen cabinets—oak, poplar, and pine, chiefly of the lower grades.
12. Curtain poles—chestnut, poplar, oak, pine, beech, medium grade.

Fig. 5.—Mature white oak worth about $25 standing.

2. Markets According to Species

The oaks.—The oaks are by far the most important of the native woodlot trees, since they are found in all kinds of woodlots throughout the State. From the standpoint of utilization two general kinds are recognized: (1) white oak (including white oak, post oak, chestnut or rock oak, bur oak, cow or basket oak, and swamp white oak); and (2) red oak (including red oak, black or yellow oak, scarlet or spotted oak, pin oak, Spanish or southern red oak, water oak, shingle oak, willow oak, and black jack oak). White oak is more

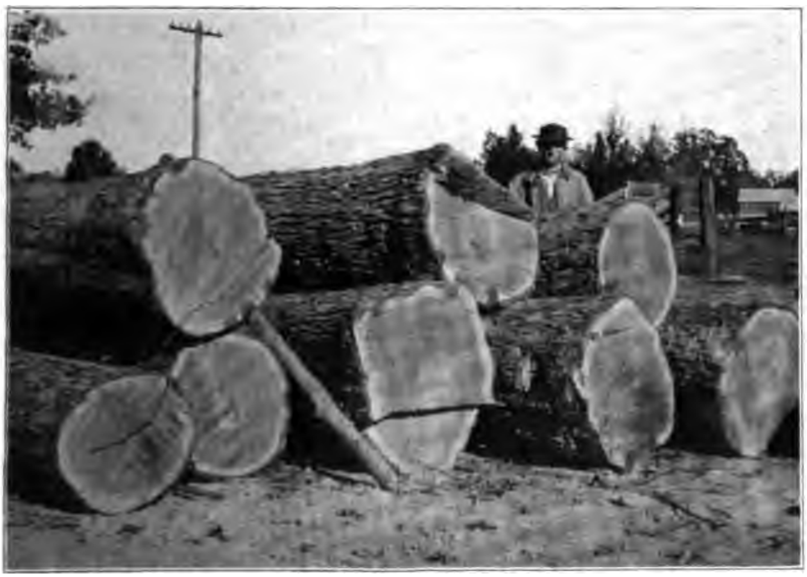

Fig. 6.—White oak for quarter-sawed and veneer stock for Memphis mills.

valuable than red because it is stronger, tougher, more durable, and therefore adapted to a greater number of uses. White oak trunks are usually more clear of branches and less apt to be defective than those of red oak. For certain uses not requiring durability, red oak often brings the same price as white. White oak is more valuable in small sizes for ties, spokes, tight staves, vehicle dimension stock, and handles; and smaller trees of white than of red oak can thus be utilized. Red oak lumber is often discriminated against in the market as not being so strong as white oak, which is not uniformly true.

1. *White oak.*—The important uses to consider in marketing white oaks are: saw and veneer logs, ties, vehicle stock, and logs and bolts for tight and slack cooperage and handles. For clear or practically clear logs 18 inches and over in diameter at the top end, the most profitable markets are sawmills and veneer mills. Such logs always bring good prices at large plants which specialize in them. Clear logs less than 18 inches top diameter are most profitably sold to local mills manufacturing vehicle stock, tight cooperage, or handles; or they may be cut up on the farm into rough billets, according to specifications furnished by the prospective buyers, and shipped to the mills in that form. Large logs of lower grades will pay best if sold to sawmills, provided two hauls a day per team can be made to the mill, shipping point or river; otherwise they should either be sold to small local mills or cut into ties. Small "common" and large "cull" or low grade logs may best be disposed of to local mills, hewed into ties, or cut into bolts and sold to slack cooperage plants.

A summary (based on prices existing in 1914) showing what different classes of white oak material should be worth when delivered on cars, at the river, or at local mills

Large select saw and veneer logs	
28 inches and up in diameter at top end	$30 to $50 per 1,000 bd. ft.
24 to 28 inches	$20 to $30 per 1,000 bd. ft.
18 to 24 inches	$15 to $25 per 1,000 bd. ft.
Large common logs, 1-3 off above prices	
Small clear and common saw logs	$12 to $20 per 1,000 bd. ft.
Cull saw logs	$ 5 to $10 per 1,000 bd. ft.
22-inch (length) heading bolts clear, 8 to 20 inches in diameter	$15 to $20 per 1,000 bd. ft.
35-inch (length) stave bolts, clear 8 to 20 inches diameter	$15 to $20 per 1,000 bd. ft.
24-inch (length) rim bolts, clear, 8 to 20 inches in diameter	$15 to $20 per 1,000 bd. ft.
28-inch (length) spoke bolts, clear, 8 to 20 inches diameter	$15 to $25 per 1,000 bd. ft.
40-inch (length) handle bolts, 6 inches and up	$ 8 to $14 per 1,000 bd. ft.
Railroad ties, (6"x8"x8'; 7"x8½" to 9"x8½')	$12 to $15 per 1,000 bd. ft.
Slack cooperage bolts, 3 to 6 feet in length	$ 5 to $10 per 1,000 bd. ft.
Chestnut oak* bark	$ 8 to $10 per cord

(1,000 feet of saw logs will yield from half a cord to a cord of bark.)

*Chestnut oak seldom produces select logs, but it is the only oak whose bark is valuable for tanning material. Otherwise it is not different from white oak in its utilization.

2. *Red oak.*—Large, clear, red oak logs should go to saw and veneer mills; medium sized and small clear logs and bolts should go into rim stock (usually sawed), spoke stock (both sawed and rived), and oil barrel staves and heading; common and cull logs should usually be sold to local sawmills or slack cooperage plants, or should be hewed into ties.

Fig. 7.—Oak bolts for tight barrel staves, worth $7 to $9 per cord. Dresden, Weakley County.

A summary (based on prices existing in 1914) *of the values of different classes of red oak material delivered f. o. b. cars, or on water, or to local mills*

Large select saw and veneer logs	
28 inches and up in diameter	$25 to $40 per 1,000 bd. ft.
24 to 28 inches in diameter	$20 to $25 per 1,000 bd. ft.
18 to 24 inches in diameter	$15 to $20 per 1,000 bd. ft.
Large common logs 1-3 off of above prices	
Small saw logs of all grades	$ 5 to $15 per 1,000 bd. ft.
22-inch oil heading bolts 24-inch rim bolts 36-inch oil stave bolts 20 to 30-inch wagon and auto spoke bolts	$10 to $15 per 1,000 bd. ft.
Slack cooperage bolts	$ 4 to $ 8 per 1,000 bd. ft.
Railroad ties, finished (where there is a market)	$ 7 to $10 per 1,000 bd. ft.

Fig. 8.—Large, clear red oak, suitable for veneer logs.

Poplar.—The leading use of yellow poplar is for saw and veneer logs. Poplar saw logs will always net more money than oak logs of similar size and quality because they are much lighter and cheaper to handle and transport. Furthermore, poplar logs, both small and large, cut out a much higher average of upper grades of lumber than do oak logs. The average value of poplar lumber cut in Tennessee mills in 1911 was $7.54 higher per 1,000 board feet than oak, and from $12 to $18 higher than chestnut, gum, and shortleaf (or yellow) pine. This usually makes it profitable to saw much smaller

Fig. 9.—High grade oak and poplar logs to be shipped to outside markets. Jonesboro.

logs of poplar than of other species. Poplar bolts of a minimum diameter of 12 inches are utilized for fruit package veneers; of six inches, for crating; and of 4 inches, for excelsior and wood pulp. The length of the bolts varies from 4 to 5 feet. Small straight and clear poplar logs 10 feet long and from 6 to 16 inches in diameter at the top end can sometimes be sold profitably for turned porch columns, for which purpose they bring from $10 to $15 per 1,000 board feet.

Value of poplar logs and bolts (based on prices existing in 1914) delivered f. o. b. cars or on water or at local mills on railroad or water transportation

Large select saw and veneer logs	
28 inches and up in diameter	$25 to $35 per 1,000 bd. ft.
24 to 28 inches in diameter	$20 to $25 per 1,000 bd. ft.
20 to 24 inches in diameter	$15 to $20 per 1,000 bd. ft.
(1-3 off of above prices for common logs.)	
(1-2 off of above prices for cull logs.)	
Small select and common saw logs	$10 to $20 per 1,000 bd. ft.
(Poplar yields few, if any, small cull logs.)	
Wood pulp, excelsior, and small veneer and crating bolts	$ 8 to $14 per 1,000 bd. ft.

Hickory.—The chief uses of hickory timber should be for vehicles, handles, sucker rods (for wells), skewers, and parts of agricultural and textile machinery. Large hickory timber can most

Fig. 10.—Hickory bolts for handle stock, worth $7 to $9 per cord, for Nashville market. Williamson County.

profitably be sold as saw logs to be cut into vehicle and wagon dimension stock, for axles, shafts, poles, cross bars, reaches, singletrees, doubletrees, neck yokes, etc. Medium-sized trees can be marketed as saw logs or as spoke or singletree and doubletree bolts and billets.

Small trees, 15 inches or less in diameter, can best be marketed as logs or bolts for ax handles.

Value of hickory logs and bolts (based on prices existing in 1914) delivered at factories and mills in Tennessee

Large clear logs	$20 to $30 per 1,000 bd. ft.
Small clear logs	$15 to $25 per 1,000 bd. ft.
Common logs and bolts	$10 to $15 per 1,000 bd. ft.

Cull logs and bolts have no value.

Hickory logs always cut out a large per cent of unmerchantable cull lumber, frequently 50 per cent from apparently select logs, which keeps down the prices.

Cedar.—The value of cedar for posts and small squares makes possible its utilization down to smaller sizes than any other tree. It is sold chiefly as saw logs, posts, and poles. Most of the cedar left

Fig. 11.—Red cedar from farm woodlots, College Grove, Franklin County.

on farmers' woodlots is comparatively small sap or white cedar, which can often be marketed if cut into from 7 to 10-foot lengths for posts and for squares 2x4 inches and up. These pieces bring from $10 to $20 per 1,000 board feet (mill scale) for logs down to 3 inches in diameter at top end and 7 feet long. The posts and squares when sawed out sell for from $30 to $60 per 1,000 board feet on cars at local stations, the best being sold for turned porch columns. The next most important use for cedar, and the most profitable where it is large enough, is for poles (peeled), which bring about the following prices delivered at local stations:

$1.60 for 20-foot poles, 6 inch top $2.00 for 25-foot poles, 6 inch top $2.30 for 28-foot poles, 6 inch top	Equivalent to $40 per 1,000 board feet mill cut of squares and posts which could be cut from the same tree.
$ 3.50 for 30-foot poles, 6 inch top . $ 8.00 for 40-foot poles, 6 inch top $28.00 for 60-foot poles, 8 inch top	Equivalent to $50, $70, and $90, respectively, per 1,000 board feet of possible squares.

Fig. 12.—Red cedar posts at Telford, in East Tennessee.

The manufacture of red cedar pencil stock is an important industry in the State. This requires practically all red or heartwood, which occurs only in comparatively large and very old trees. Pencil factories will, however, purchase old red cedar rails and stumps of large trees. Material for pencil stock brings from 15 to 20 cents per cubic foot of red wood or from $20 to $30 per 1,000 board feet mill scale. Cedar logs for other purposes, such as lumber for chests, wardrobes, cabinets, coffin boxes, and buckets bring about the same prices.

Chestnut.—Chestnut is sold in Tennessee chiefly as saw logs, shingle bolts, poles, extract wood, and slack cooperage logs and bolts. Large and clear chestnut logs (20 inches and over in diameter) and shingle bolts (in any lengths down to 14", and 12" and up in diameter) seldom bring over from $15 to $20 per 1,000 board feet, delivered at local mills, and small logs from $7 to $15. Logs suitable for poles (straight logs 20 feet and up in length and from 6 to 8 inches top end, with bark removed) bring better prices delivered at the railroad, ranging from $20 to $40 per 1,000 board feet.

Fig. 13.—Several thousand cords of chestnut acid wood worth $4.50 per cord at the plant.

In parts of the eastern half of the State extract wood brought, in 1914, from $3 to $4 per long cord (5x4x8 feet) f. o. b. cars, but there is no market for it in the western half. For slack cooperage logs and bolts chestnut is worth, delivered at plants, nearly as much as for small saw logs. Chestnut is lighter and cheaper to handle than oak, although there is often much waste in its manufacture, which is due to unsoundness.

Sweet (or red) gum.—Most of the sweet gum on woodlots in the State is sap gum and only exceptionally is old growth to be found which will cut out red gum lumber. The chief market is for saw and veneer logs (the latter peeled), bolts for veneer, crating, slack cooperage, and pulpwood, and railroad ties.

Gum logs and bolts are worth about as follows delivered at mills and factories in the State, or in rafts ready for water transportation:

Large select logs (20 inches and up in diameter) from $15 to $20 per 1,000 board feet, f. o. b. cars or at local mills. Common and select logs, 14 to 20 inches and up in diameter, are worth from $8 to $15 in rafts on the Tennessee River, or delivered at local sawmills, or at basket, package, and cooperage plants.

Common logs and bolts from 6 to 14 inches in diameter are worth from $8 to $9 per 1,000 board feet delivered at sawmills and crate and cooperage plants.

Red gum ties delivered on the bank of the Tennessee River are worth from $5 to $7 per 1,000 board feet or from 17 to 25 cents apiece.

Yellow pine.—There is very little yellow pine in woodlots in the State that will make good shipping lumber, and its chief market is a local one. The saw logs may be sold to local mills; and the small stuff, to slack cooperage, box, and crating plants, if there are any in the locality. Common pine dimension lumber and boards for local construction and planing mills bring from $10 to $15 per 1,000 board feet; and select boards, $20, which makes the logs delivered at mills worth $5, $10, and $15 per 1,000 board feet. It is much cheaper to handle pine than oak, and it will usually net a better price than common oak logs when sold to local mills. Large clear pine logs can sometimes be more profitably sold to veneer mills, which pay from $15 to $20 per 1,000 board feet delivered.

Basswood, beech, elm, maple, sycamore, buckeye, and black gum.—Basswood, beech, elm, maple, sycamore, buckeye, and black gum are unimportant in farm woodlots in the State either because of their scarcity or low value. Table 3 (page 140) indicates their relative value for lumber.

Basswood is the most valuable, and beech, which is the most common of these species in woodlots, is the least valuable and can seldom at present be profitably cut into shipping lumber in Tennessee. It is often defective and suitable only for firewood. Good logs from these species can be most profitably marketed as saw logs wherever large enough; small common stuff can be used for slack cooperage. Basswood is as valuable as poplar for pulpwood and excelsior. Bolts of these species for crating and for fruit and vegetable packages of different kinds, and for veneer, are worth from $5 to $10 per 1,000 board feet, log scale, at factories. Black gum is also used for veneer and crating bolts and for wagon hubs.

Ash, walnut, and cherry.—Ash, walnut, and cherry are always most valuable for saw logs in Tennessee (see Tables 3 and 4, pages 140 and 141). Ash is also used locally for pump sucker rods, boat oars, handles, and butter tub staves and heading, chiefly in the western part of the State, for which purposes it is purchased in the form of saw logs and bolts, down to 4 feet in length and 6 inches in diameter.

Fig. 14.—Walnut log, containing 720 board feet, resold on the spot for $72.10 and $97.34. Worth in the tree about $65. The farmer got only $26.

Black locust, dogwood, and persimmon.—As a rule black locust, dogwood, and persimmon are too small for lumber, but they are of considerable value for other purposes. Black locust, when large enough, is chiefly valuable for posts and poles. Black locust posts are worth from 15 to 20 cents apiece delivered, which, figuring 6 board feet per post, is equivalent to from $25 to $35 per 1,000 board feet of lumber. Black locust bolts can sometimes be sold very profitably for insulator pins, for which they bring a little more than for posts. Dogwood and persimmon are valuable chiefly for shuttle stock, for which they bring from $8 to $12 per cord of 160 cubic

Fig. 15.—Twenty-year-old planted black locust, yielding 1,800 posts per acre, worth $300 on the stump.

feet; sticks as small as 4 inches at the top end and 5 feet in length are accepted. This is equivalent to from $16 to $24 per 1,000 board feet of lumber sawed out in the form of small squares.

LUMBER AND LOG VALUES

1. Lumber

Most of the Tennessee lumber shipped out of the State goes to Cincinnati or to the big lumber markets north and east of Cincinnati. At Cincinnati the average prices of one inch lumber of different kinds, grades, and widths during the months of July, August, and September, 1916, were as shown in Table 3, according to a report of the Lumberman's Bureau. These prices usually run from $3 to $6 higher than they do at Tennessee points, since they cover a greater freight charge. The farmer can use current Cincinnati prices, after deducting this freight charge, as a basis for figuring the value of his logs or stumpage in the way described on pages 162 to 172, under "Cost of Production and Net Profits." It would be necessary to estimate the proportion of different grades his timber would cut, as well as cost of producing the lumber from the stump to f. o. b. railroad. Where this can be done it gives the stumpage owner a substantial basis for negotiating with mill men or other purchasers so as to secure the full value of his timber. It should be borne in mind that timber which cuts out an average of No. 1 common in grade is above the average in quality.

2. Logs

Table 4 gives average prices paid for select logs of different kinds and sizes delivered at veneer mills, based on data collected by the Forest Service in 1914; and Table 5 gives the range in price paid by large sawmills f. o. b. local stations for select logs. It should be borne in mind that the prices given in Table 4 are not actual market prices, but are merely a basis for judging the value of select woodlot trees. Ash, which is not included in the table, is usually between white and red oak in price. Common logs are usually worth about two-thirds and cull logs one-half as much as select logs of the same kinds and sizes.

TABLE 3.—*Prices*[1] *of hardwood lumber, one inch and up in thickness, f. o. b. Cincinnati. Variations in price within grades are due to difference in widths and thicknesses*[2].

	1sts and 2nds	No. 1 Common	No. 2 Common	No. 3 Common	Log Run (Mill culls cut)
Ash	$46.00-$72	$31.50-$51.50	$22.00-$28.00	$14.00-$17.00	....
Basswood	39 50- 44.50	27.50- 34.50	20.50- 26.50	17.50- 19.50	$30.50-$35.50
Beech	24.50- 28.50	18.00- 22.00	14.50- 18.50	....	19.00- 23.00
Birch (1915 prices)	42.00- 56.00	28.00- 31.00	18.50- 19.50	....	29.00- 32.00
Buckeye	33.50	21.50	14.00	.....	21.50
Butternut	56.50	26.50	15.00	.....	26.50
Cherry	81.00-123.00	42.00- 73.00	24.00- 26.00	.....	.....
Chestnut	45.00- 48.50	32.00- 35.00	21.00- 24.00	12.00- 13.00	.....
Hickory	52.00- 77.50	31.00- 47.00	19.00- 31.00	.....	.....
Walnut	117.00-151.00	57.00- 80.50	32.00- 42.00	.....	.....
Sycamore—plain	31.50	22.50	16.00	.....	22.50
Sycamore—quartered	46.00	36.00	.....	.....	.....
Plain oak[3]	53.00- 76.50	33.00- 45.00	23.00- 29.00	15.00- 16.00	.....
Quartered white oak[3]	76.50-119.50	46.50- 50.50	27.50- 31.50	.....	.....
Quartered red oak[3]	62.50- 67.00	39.50- 43.50	25.50- 29.50	.....	.....
	1sts and 2nds	Sap and Select	No. 1 Common	No. 2 Common	No. 3 Common
Poplar	$53.00-$65.00	$41.50-$53.50	$31.50-$45.00	$20.50-$27.50	$17.00
	Panel 18-27 inches wide		Wagon box 8-17 inches wide		
Poplar	$62.00-$102.00		$39.50-$58.00		
	Red 1sts and 2nds	Red No. 1 Common	Sap 1sts and 2nds	Sap No. 1 Common	Sap No. 2 Common
Gum	$34.00-$40.00	$24.00-$30.00	$25.00-$29.00	$19.50-$23.00	$17.50-$18.50
	8-12 inches wide	13-17-inch. wide	18-23-inch. wide	24-27-inch. wide	28 inch. and up
Wide gum (wagon box and panel stock)	$26.50	$31.50	$32.50	$51.50	$61.50

[1]According to market report, Lumbermen's Bureau, September 15, 1916.

[2]The first and lower price given in each case for one inch thick lumber. The higher prices are largely for thicker lumber, for which there is not such a ready market as for inch stock, and on which the carrying charges are usually greater.

[3]Not including oak lumber 2½-5½ inches wide of the 1st and 2nd and No. 1 Common grades, the prices of which is $10 to $20 less.

TABLE 4.—*Average prices for veneer logs of different kinds and sizes delivered at factories in Tennessee, Kentucky, and Indiana per 1,000 feet log scale.*

	17 inches and under	18-24 inches	25-28 inches	29-34 inches	35 inches and up
Yellow poplar					
Tennessee	$20.00	$25 50	$28.00	$34.50	$37.50
Kentucky	22.00	32.00	34.65	38.50	45.50
White Oak					
Tennessee	19.00	24.50	28.00	33.00	36.00
Kentucky	20.00	30.00	36.50	41.65	46.00
Indiana	25.50	37.50	49.00	55.50	.....
Red oak					
Tennessee	19.00	21.00	23.50	.....	.....
Indiana	22.60	25.00	37.50	45.00	.....
Walnut					
Kentucky	42.00	60.00	71.00	.....	135.00

Yellow pine and chestnut
Tennessee........$15 to $20 for select logs of all sizes.

Gum, maple, sycamore, cottonwood, elm
Tennessee........$10 to $12 for all sizes of log run common and select logs.
Kentucky........$15 to $20

TABLE 5.—*Range in prices f. o. b. railroads in Tennessee of select saw logs of different sizes per 1,000 feet log scale.*

Diameter in inches at top end	White oak[1] poplar and ash	Walnut
12-15	$.....	$30-40
16-17	12-16	40-50
18-19	14-18	50-60
20-21	16-20	60-70
22-23	18-22	70-80
24-25	20-24	80-90
26-27	22-26	90-100
28-29	24-28	100-110
30-31	25-30	110-120
32-33	30-35	110-120
34 and up	35-45	110-120

[1]The range in price for red oak logs $5 to $10 less for those 30 inches and over in diameter and $1 to $5 less for those under 30 inches in diameter.

HOW TO INCREASE PROFITS FROM WOODLOT SALES

Success in woodlot sales, as in marketing agricultural crops, depends upon thorough acquaintance with the various markets, requirements, and prices, and businesslike attention to the details of estimating or measuring, grading, negotiating, and contracting. The farmer who owns timber should not part with it without being satisfied that he is getting the best possible price for every bit of each kind sold. There is usually no need for haste in harvesting and marketing trees. When the market is down, they may be held for more favorable conditions; and in any event there is time for a thorough consideration of the marketing possibilities. The farmer who increases his store of information along any of the following lines will increase his chances of more profitably disposing of his woodlot products: (1) methods of sale, (2) log and lumber scaling and grading, (3) estimating standing timber, (4) knowledge of markets, (5) cost of producing and delivering the different kinds and classes of material, (6) the making of contracts, (7) coöperation with neighbors.

1. Methods of Sale

There are four general ways in which woodlot products may be sold: (1) by the boundary, for a lump sum; (2) by scale measurement of rough products, using the different log, cord, and rick scales; (3) by the piece, for such products as ties and poles; and (4) by lumber scale of sawed products. When conditions are favorable, especially when a portable mill is available and the farmer has some knowledge of lumbering, the last is by far the most profitable method.

To sell advantageously by the boundary for a lump sum requires a careful estimate of the amount and value of the standing timber. Otherwise, sale by scale measurement or by the piece is preferable. Selling by the boundary, however, gives the seller the least trouble, except where restrictions are made in regard to the number, kinds, and size of trees to be cut; these would necessitate supervision to prevent violations.

Profitable selling by scale measurement requires a thorough knowledge of the scale to be used, of the size and grade specifications of the kinds of material which are to be sold, and an agreement in writing in regard to the application of the scale. In small timber, selling by the cord or rick is preferable to selling log scale because of the unfairness of most log rules in the scaling of small logs. It is a comparatively simple way of marketing. With some classes of material, such as firewood, pulpwood, and excelsior wood, it is used exclusively.

Selling by the piece is also comparatively simple and it is the only method under which some classes of material such as ties, poles, piles, etc., are sold. The important thing is to know the specifications and relative values of the different grades of each class of products so as to utilize the timber cut to the best advantage.

Fig. 16.—Sawmill cutting 8 to 12 thousand board feet daily of logs from farm woodlots.

Selling by lumber scale includes both selling logs at local mills on the basis of the actual amount of lumber they cut out and the selling of lumber itself which the farmer has himself sawed out or had sawed by a portable-mill operator. It is especially advantageous to sell small logs in this way. Selling lumber sawed out by a portable mill set up in the woodlot should be much more used by farmers than it now is, especially where they have disposed of all their high grade saw logs. It is, probably, the surest way of getting the most out of the timber, provided they have the necessary knowledge of the subject. It dispenses with the necessity of grading logs or making an accurate estimate of the standing timber, and may result in a considerable saving, especially on common and cull logs which can not be hauled out of the woodlot at a profit. The low grades of lumber, of little or no market value, can be kept for use on the farm or for local disposal, and the better grades can often be sold for shipping lumber at prices which will often net as much as if all the timber were sold standing or in the log. Or special orders may be filled for local house construction, or for special stock for shipment to wood-using factories and dealers in hickory whiffletree squares, spoke squares, or handle stock, oak felloe stock, tight cooperage stock, or car and bridge timbers, ash baseball bat or long handle stock, dogwood and persimmon shuttle blocks, cedar squares and posts, and locust insulator pins. It will usually be possible to have the milling done by contract, but the owner should attend to the logging himself and keep an eye on the milling.

When selling by lumber scale, it is decidedly advantageous to have as complete a knowledge as possible of sawing, scaling, and grading lumber. Scaling is relatively simple, but grading is a complicated subject, requiring considerable experience. If the lumber is sold at the tail of the mill, it is best to employ an experienced grader or to study the grading rules to an extent sufficient to detect gross errors. The standard grading rules in Tennessee are those of the Hardwood Manufacturers' Association, a copy of which can be secured on application to the Secretary of the Association, Cincinnati, Ohio; and the National Hardwood Lumber Association, of Chicago, Ill.

2. Scaling and Grading Logs and Bolts

Scaling logs.—For obtaining the lumber contents of logs of different sizes there are a number of log rules, of which the Doyle-Scribner* is the one most generally used in Kentucky. It is a combination of the Doyle rule, for logs 28 inches and under, and the Scribner rule, for logs over 28 inches. The volumes which it gives are those indicated by heavy faced type in Table 6. It will be seen that this combination of the two is in the interest of the buyer of logs, as it gives a lower scale than either rule does taken separately. It would be fairer to combine these rules the other way around,

*This Doyle-Scribner rule is often erroneously called the Doyle rule, and sometimes the Scribner rule.

making a Scribner-Doyle rather than a Doyle-Scribner combination, in which case the seller of logs would get from 25 to 100 per cent more scale for logs 12 inches and under in diameter than he does by the Doyle-Scribner rule.

For scaling logs rafted by river the Cumberland River rule* is commonly used in the State. This rule is even more unfair to the seller than the Doyle-Scribner, except on logs less than 12 inches in diameter.

For comparison with the Doyle-Scribner and Cumberland River rules the Champlain rule, which is not in use in the State, is also given in Table 6. This rule is made for sound and straight logs and shows what it is possible for the mill man to saw out of such logs with careful manufacture. It is especially important to note in this table that the scale for small logs from 6 to 10 inches in diameter by the commonly used Doyle rule is from one-half to one-fifth as much as by the Champlain rule. In using the Doyle rule for small logs the mill man, or purchaser of logs, may argue that the great overrun in mill scale which he gets from them, no more than counterbalances the greater cost of manufacture and the lesser value of the lumber produced from small than from large logs, in which statement there is a certain amount of truth. But the difference in value of large and small logs is often fully provided for by difference in price, in which case there is no reason for the very much too small scale allowed for them by the Doyle rule.

The scaling is done by measuring the length of the log and its average diameter inside bark at the top end, and then recording from the log rule the lumber contents given for the dimensions of the log. Buyers often scale logs on the basis of the smallest diameter, instead of the average, which is obviously to their advantage. Logs are scaled to full inches in diameter inside bark; a fraction of one-half inch and less is thrown out, a greater fraction is read as a full inch. The contract of sale (pp. 172 to 176) should be definite in

*This rule was constructed for measurement of hardwood logs in the water in the Mississippi River and its tributaries. These logs are often defective and in the water it is impossible to distinguish the defects hidden by the water itself, and by mud, sand, plugs, etc. This log rule is supposed to allow for all such hidden defects, and it would be manifestly unfair when applied to fairly sound and good logs.

Table 6.—*Log rules for board feet measure of logs of different lengths and diameters.*

Length of log and name of rule	DIAMETER BETWEEN BARK AT SMALL END OF LOG IN INCHES																									
	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	22	24	26	28	30	32	34	36	38	40
	CONTENTS OF LOG IN BOARD FEET																									
Eight-foot logs																										
Doyle	0	0.5	2	4.5	8	12	18	24	32	40	50	60	72	84	98	112	128	162	200	242	288	338	392	450	512	578	648
Scribner	4	6	9	12	16	21	27	32	39	49	58	71	79	93	106	120	140	167	202	250	290	329	368	400	462	535	602
Cumberland ..	4	6	9	11	15	19	24	29	34	40	47	53	61	69	77	85	95	115	137	160	186	213	243	274	314	343	379
Champlain ...	4	7	11	16	21	28	35	43	52	62	73	84	97	110	124	139	154	188	225	266	310	357	407	462	519	580	643
Ten-foot logs																										
Doyle	0	0.6	2.5	5.6	10	16	23	31	40	50	62	75	90	106	122	141	160	202	250	302	360	422	490	562	640	723	810
Scribner	6	8	11	15	20	26	34	40	49	61	72	89	99	116	133	150	175	209	252	313	363	411	460	500	577	669	752
Cumberland ..	5	7.5	11	14	19	24	30	36	43	50	58	67	76	86	96	107	118	148	171	200	232	267	303	348	384	428	474
Champlain ...	5	9	14	20	27	35	44	54	65	78	91	105	121	137	155	173	193	235	282	332	387	446	509	577	649	724	804
Twelve-foot logs																										
Doyle	0	0.8	3	6.8	12	19	27	37	48	61	75	91	108	127	147	169	192	243	300	363	432	507	588	675	768	867	972
Scribner	7	10	14	18	24	32	40	48	59	73	86	107	119	139	160	180	210	251	303	375	436	493	552	600	692	801	903
Cumberland ..	6	9	13	17	23	29	36	43	51	60	70	80	91	103	115	128	142	172	205	240	279	320	364	411	461	514	569
Champlain ...	6	10	17	24	32	42	53	65	78	93	109	126	145	165	186	208	231	282	338	399	465	535	611	692	778	869	965
Fourteen-foot logs																										
Doyle	0	0.9	3.5	7.9	14	22	32	43	56	71	88	106	126	148	171	197	224	283	350	423	504	591	686	787	896	1,011	1,134
Scribner	8	11	16	21	28	37	47	56	69	85	100	125	139	162	187	210	245	292	353	439	509	575	644	700	807	934	1,053
Cumberland ..	7	10.5	15	20	27	34	41	50	60	70	81	93	106	120	134	149	166	201	239	280	325	373	425	479	538	599	664
Champlain ...	7	12	19	28	38	49	62	76	92	109	127	147	169	192	217	243	270	329	394	465	542	625	712	808	908	1,014	1,126
Sixteen-foot logs																										
Doyle	0	1	4	9	16	25	36	49	64	81	100	121	144	169	196	225	256	324	400	484	576	676	784	900	1,024	1,156	1,296
Scribner	9	13	18	24	32	42	54	C4	79	97	114	142	159	185	213	240	280	334	404	500	582	657	736	800	923	1,068	1,204
Cumberland ..	8	12	17	23	31	39	47	57	68	80	93	107	121	137	153	171	190	229	273	320	372	427	485	548	614	685	759
Champlain ...	8	14	22	32	43	56	70	87	105	124	146	168	193	219	247	277	308	376	450	532	620	714	814	923	1,038	1,159	1,287

these particulars, as well as in those relating to grading the logs, deducting for defect, etc., which follow.

TABLE 7.—*Number of cords of round wood bolts (4 feet long) contained in 1,000 board feet of 16-foot logs of different top diameters when scaled by Doyle, Scribner, and Champlain log rules.*

Top diameter of logs, inside bark, in inches	Number of cords in 1,000 board feet of logs		
	Logs scaled by Doyle rule	Logs scaled by Scribner rule	Logs scaled by Champlain rule
	A. Cords of unpeeled wood		
4	....	5.0	5.6
5	59.2	4.6	4.2
6	18.4	4.1	3.3
7	9.8	3.7	2.8
8	6.6	3.3	2.5
9	4.9	2.9	2.2
10	3.9	2.6	2.0
11	3.3	2.5	1.8
12	2.8	2.3	1.7
	B. Cords of peeled wood		
4	....	3.8	4.3
5	46.0	3.5	3.3
6	14.7	3.3	2.7
7	8.1	3.0	2.3
8	5.6	2.8	2.1
9	4.2	2.5	1.9
10	3.4	2.3	1.8
11	2.9	2.2	1.7
12	2.5	2.1	1.6

Scaling bolts in log measure.—When the wood is to be sold as stock for cooperage, veneer, handles, pulp, or excelsior, the farmer will often have the choice of selling it as small logs by log scale, or by the cord of short bolts. In order to determine the comparative advantage of selling small logs, 12 inches and less in diameter at the top end, by the standard cord (4x4x8 feet in size, containing 128 cubic feet), the figures in Table 7 may be used. These will apply only when the length of the bolt which would be required if the wood were cut into bolts is 4 feet. If greater or less than 4 feet, so that a stack 4 feet high and 8 feet long would contain more or less than 128 cubic feet, the figures should be proportionately increased or reduced. The decision whether to sell in logs or bolts must, of course, take into account the greater cost of cutting into bolts than into logs.

Grading logs.—There is considerable variation in the practice of grading logs. They are commonly graded as select, common, and cull, depending on their relative clearness and the proportion of different grades of lumber which they will produce. A common log brings at the mill about two-thirds as much as a good log, and a cull log half or even less. Sometimes the cull logs are rejected entirely. In general, the three classes may be defined as follows:

1. *Select logs.* Logs which will saw out 75 per cent of No. 1 Common or better, or 50 per cent 1 and 2 Select lumber. Small logs must be practically clear and free from defects; from one to three small or medium sized knots are admitted on medium sized or large logs, or one large knot if near the end of the log.

2. *Common logs.* Logs which will cut 75 per cent No. 2 Common and better, or 50 per cent No. 1 Common and better. This includes logs with from one to three large knots, depending upon the size of the log, or with a number of small tight knots whose total area will not exceed that of from 1 to 3 large knots.

3. *Cull logs.* Logs which will not cut 75 per cent No. 2 Common and better. This includes all large knotted logs which will cut out only No. 2 Common and cull lumber.

At large mills located in large towns and cities more grades are often recognized; and the prices paid for logs of the good or select grade of valuable species vary greatly according to the size of the logs. (See Table 5.)

The following grades and prices, in use at one of the large mills in Nashville in 1914, may be taken as representative of log grading by large mills in the State:

Poplar, clear or nearly so

	Price paid per 1,000 bd. ft. log scale
(One-third off for common and one-half off for culled logs)	
No. 1 log, 28 inches and up in diameter	$30 to $35
No. 2 log, 24 to 28 inches	$25
No. 3 log, 20 to 24 inches	$20

Poplar, common logs

No. 4 log, 15 to 20 inches	$12.50

White oak and ash, clear or nearly so

(One-third off for common and one-half off for culled logs)

No. 1 log, 28 inches and up in diameter..................	\$35 to \$45
No. 2 log, 24 to 28 inches..............................	\$27.50
No. 3 log, 18 to 24 inches..............................	\$22.50

White and red oak, common logs

No. 4 log, 13 to 18 inches..............................	\$12.50
No. 5 log, 12 inches and under..........................	\$5 to \$10

Red oak \$3 to \$5 less per 1,000 than white oak No. 1, No. 2 and No. 3 logs and about the same on lower grades.

Inferior species, such as beech, maple, and sycamore were classified by this mill as No. 5 logs at from \$5 to \$10 per 1,000 board feet, log scale, regardless of size.

Deduction for defect.—In the contract of sale, stipulations should be made as to the amount to be deducted from the log scale in allowing for visible defects, such as crookedness and unsoundness. The U. S. Department of Agriculture Forest Service Manual for Scaling Timber (1915) contains the following instructions for deducting for defect:

Deductions should not be made for defects outside of the cylinder represented by the top end and total length of the log or for defects in the portion of the log which will be slabbed off. Otherwise deductions should be made in scaling for all visible defects which will actually reduce the yield of lumber from the log. This includes crooks and any defective or waste material whose presence is plainly indicated on the surface of the log by conks, rotten knots, pitch seams, etc. There must, however, be an unmistakable surface indication of the defect. The scale should never be reduced simply because hidden defect frequently appears in sawing.

The total scale of the log will be reduced in each instance by the estimated loss in lumber from the defects present in the cylinder as compared with a sound cylinder of the same dimensions. Reductions will not be made for defects in the swell of the log outside of the cylinder. Scalers should reduce the scale for all other defects regardless of overrun.

Deductions will not be made for "sound" defects, such as sound knots, however large, and firm rot, which affect the grades of lumber but do not reduce the total cut from the log. Deductions will be made only for crooks, curve or sweep, and checks, worm holes, and pitch rings.

The percentage of waste from sweep or curve varies with the diameter of the log. A curve of 3 inches in a 10-inch log will cause approximately twice the proportionate waste as the same curve in a 20-inch log. Sweep which would cull a very small log would not necessarily cause the rejection of a large log.

The scaler should sight along a curved log, noting where the saw will square it sufficiently to cut boards on both sides affected by the curve. In determining the amount of loss it should be remembered that material near the slab saws out narrow boards containing fewer feet than those cut from any other part of the log..

No deduction should be made for curve or sweep in logs over 16 feet long.

3. Estimating the Standing Timber

A proper estimate of the woodlot involves the determination of the contents of all the trees in it in terms of the most common forms in which timber is marketed, such as logs, bolts, poles, ties, etc. The determination of the units in which to estimate the timber requires some general knowledge of the market requirements as to form, size, etc., for the different kinds of trees. Often two or more units should be used for a single tree. Thus a large white oak might yield a fine, clear veneer log, valuable enough to be shipped a long distance, and in addition, one or two common logs suitable for local manufacture, some railroad ties, and some posts and cordwood. Again, the same part of the tree might appear to be about equally valuable for several purposes, in which case a separate estimate should be given it for each purpose. Hickory, for example, can advantageously be estimated in terms both of cords of handle material and of board feet of vehicle stock, provided it is marketable for both of these uses. Usually, however, the purpose for which the tree is most valuable can be determined in advance and the estimate made with reference to this one use.

A simple method of estimating is to record the diameter and length of each piece or tree and from these two figures determine the volume of the piece in the desired form by the use of the log rule and volume tables. The work is not difficult, but it is impossible to put too much care into it; a careless estimate will mislead and is likely to be worse than none. For recording the estimated diameters and lengths, a form similar to that shown in Table 12 is convenient. It provides spaces for recording dimensions by both the log rule and the volume table method. The log rule method is the more accurate and it should be used for valuable timber. The diameter and lengths of the logs of different grades and sizes are recorded separately for each tree. When, as is sometimes the case, only one grade or one class of material is contained in the woodlot, the recording is simplified; as, for example, when the logs are fit only for common or small lumber, or when the material is suitable or is to be used entirely for ties, poles, piles, etc.

The diameter breasthigh (outside bark at 4½ feet from the ground) is important, since it affords a good basis for judging the diameters at the log ends. On valuable timber at least, it should be actually measured rather than estimated.* Top diameters of logs, bolts, etc., must, of course, be estimated. The double bark thickness should be deducted and the estimate recorded as inside bark. In estimating top diameters it is useful to have in mind an idea of the approximate rate at which the tree tapers. A good general rule for ordinary trees over 12 inches breasthigh is to assume that the diameter inside bark at stump height is the same as that outside bark at breasthigh, and then allow about 3 inches taper for the first 8 feet of log length above the stump and 1 inch taper for each succeeding 8 feet. For trees under 12 inches breasthigh, one-half this amount should be allowed. Often, of course, there will be trees which obviously have greater or less taper than these average figures allow for, and the observer's judgment must guide him in deducting for the taper.

The merchantable lengths of especially valuable timber should be measured, if possible, with some instrument designed for this purpose, or at least by holding a 12 or 16 foot pole against the tree. The lengths of select logs are most important to determine accurately, and these are usually limited to the lower part of the tree, which can be measured with a pole.

Since defects of different kinds often cut down the scale a good deal, the observer should keep special notes of all observable injuries, malformations, or signs of rot likely to influence the amount and quality of the product.

The volume table method of estimating requires only a record of the diameter breasthigh of each tree, and either the number of 16-foot logs it contains or its total height. With these data the volumes can be obtained from the appropriate volume table (Tables 8-11). When it is desired to estimate the more valuable trees in log lengths and the less valuable as entire trees, the record for both can be made on the same sheet, as illustrated in Table 12. To assist the eye in estimating total heights and log lengths, the measurement of a few felled trees will be helpful.

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*The measuring can be done by means of tape, caliper, or measuring stick. For a description of the use of these implements, see U. S. Dept. of Agriculture, Farm. Bul. 715, "Measuring and Marketing Woodlot Products."

TABLE 8.—*Contents in board feet of hardwood trees of different diameters and merchantable heights.*

(Stump height, 2 feet. Trees over 75 years old. Scribner Decimal C rule.)

Diameter breasthigh Inches	NUMBER OF 16-FOOT LOGS. 1	1½	2	2½	3	3½	4	4½	5	Diameter inside bark at top. Inches	Number of trees measured as a basis for this table
	VOLUME—BOARD FEET.										
8	20	27	35	43	....	....	....	....	....	6	..
9	20	32	42	53	....	....	....	....	....	6	1
10	20	36	52	64	81	....	....	....	....	6	2
11	21	43	62	78	98	120	....	....	....	6	4
12	23	50	73	93	120	140	180	....	....	6	3
13	25	58	86	110	140	170	200	....	....	7	4
14	27	67	100	130	160	190	230	260	....	7	9
15	30	77	120	150	180	220	260	300	....	8	15
16	34	89	130	170	200	250	290	340	390	8	18
17	38	100	150	190	230	280	320	380	440	9	40
18	43	120	170	210	260	310	360	420	490	9	56
19	48	130	200	240	290	350	400	470	540	10	65
20	54	150	220	270	330	390	450	520	590	10	75
21	62	170	250	300	370	440	500	580	650	11	86
22	69	190	270	340	410	480	550	640	720	11	90
23	77	210	300	380	450	530	610	700	790	12	67
24	85	230	340	420	500	580	670	770	860	12	80
25	93	250	370	460	550	640	740	840	940	13	56
26	100	280	410	510	600	700	810	910	1,020	13	89
27	110	300	450	560	660	770	880	990	1,110	14	68
28	120	330	490	610	720	830	960	1,080	1,200	14	81
29	130	360	530	660	780	900	1,030	1,160	1,300	15	61
30	140	390	580	720	850	980	1,120	1,250	1,400	15	47

31	420	630	770	910	1,050	1,200	1,350	1,510	16	45
32	450	690	830	980	1,130	1,290	1,450	1,620	16	40
33	480	740	890	1,050	1,211	1,380	1,560	1,730	17	49
34	..	800	950	1,120	1,290	1,480	1,670	1,860	17	30
35	..	860	1,010	1,180	1,380	1,570	1,790	1,990	18	22
36	..	920	1,070	1,250	1,460	1,680	1,910	2,140	18	17
37	..	..	1,130	1,320	1,550	1,780	2,040	2,290	19	24
38	..	..	1,190	1,390	1,640	1,890	2,170	2,450	19	11
39	..	..	1,250	1,460	1,730	2,000	2,300	2,600	20	16
40	..	..	1,311	1,540	1,820	2,120	2,430	2,760	20	15
41	..	..	....	1,610	1,910	2,240	2,570	2,930	21	6
42	..	..	....	1,680	2,000	2,360	2,720	3,100	21	3
43	..	..	....	1,750	2,090	2,470	2,860	3,270	22	3
44	..	..	....	1,830	2,180	2,590	3,010	3,450	22	2
										1,300

Correction factors for different species:

Chestnut—For diameters up to 40 inches, subtract 10 per cent.
Chestnut oak—For diameters of 32 to 40 inches, add 10 per cent.
Red oak—For all diameters use the table without change.
White oak—For diameters of 18 to 40 inches, add 10 per cent.
Yellow poplar—For diameters of 8 to 40 inches, use table without change.

TABLE 9.—*Contents in board feet of coniferous trees of different diameters and merchantable heights.*

(Stump height, 2 feet. Diameter (inside bark) of top, 6 inches. Trees over 75 years old Scribner Decimal C rule.)

Diameter breasthigh	Total height of tree—feet: 60	70	80	90	100	110	120	130	140	150	Number of trees measured as a basis for this table
Inches	Volume—board feet										
8	27	31	38	46	63	....	....	....	....	....	12
9	38	47	54	64	80	....	....	....	....	....	9
10	51	63	71	84	100	110	....	....	....	....	12
11	65	80	91	110	120	140	....	....	....	....	13
12	80	98	110	130	150	170	....	....	....	....	8
13	96	120	140	160	180	200	....	....	....	....	4
14	110	140	160	180	210	240	270	....	....	....	7
15	130	160	190	220	250	280	310	....	....	....	11
16	160	190	220	250	280	320	350	380	....	....	20
17	180	210	250	290	320	360	400	440	....	....	21
18	210	240	290	330	370	410	450	490	....	....	20
19	240	280	320	370	410	460	500	550	....	....	34
20	270	320	360	420	470	520	560	620	680	....	27
21	310	360	410	470	520	580	630	690	750	....	33
22	350	410	460	520	580	640	700	760	830	....	40
23	390	460	520	580	640	710	770	840	910	....	37
24	440	510	570	640	710	780	850	920	1,000	1,090	37
25	..	570	640	700	780	850	930	1,000	1,090	1,190	47
26	..	630	700	770	840	920	1,010	1,090	1,190	1,290	52
27	..	690	770	840	920	1,000	1,090	1,180	1,290	1,400	43
28	..	760	840	910	990	1,080	1,180	1,280	1,390	1,510	45
29	..	830	910	990	1,070	1,160	1,260	1,370	1,500	1,630	39
30	..	900	990	1,070	1,150	1,240	1,350	1,470	1,610	1,760	47

31.............. ..	...	1,070	1,150	1,230	1,330	1,450	1,580	1,730	1,900	40
32.............. ..	...	1,160	1,230	1,320	1,410	1,540	1,690	1,860	2,050	44
33.............. ..	...	1,240	1,320	1,400	1,500	1,640	1,800	1,990	2,180	39
34.............. ..	...	1,320	1,400	1,490	1,600	1,740	1,920	2,120	2,330	36
35.............. ..	...	1,410	1,490	1,570	1,690	1,850	2,040	2,250	2,470	34
36.............. ..	...	1,490	1,570	1,660	1,790	1,950	2,160	2,380	2,610	29
37.............. ..	...	....	1,650	1,740	1,880	2,060	2,270	2,510	2,760	25
38.............. ..	...	....	1,740	1,830	1,980	2,170	2,390	2,640	2,900	18
39.............. ..	...	....	1,820	1,910	2,070	2,270	2,500	2,770	3,050	18
40.............. ..	...	....	1,900	1,990	2,170	2,380	2,630	2,910	3,210	24
41.............. ..	...	....	1,990	2,080	2,270	2,490	2,750	3,050	3,360	11
42.............. ..	...	....	2,070	2,170	2,360	2,600	2,880	3,200	3,530	11
43.............. ..	...	....	....	2,260	2,460	2,710	3,010	3,350	3,700	11
44.............. ..	...	....	....	2,350	2,560	2,830	3,150	3,510	3,880	3
45.............. ..	...	....	....	2,430	2,660	2,960	3,300	3,670	4,060	7
46.............. ..	...	....	....	2,520	2,760	3,090	3,450	3,850	4,250	5
										973

Correction factors for different species:

Hemlock—For diameters of 8 to 10 inches......add 10 per cent.
Hemlock—For diameters of 11 to 20 inches......add 22 per cent.
Hemlock—For diameters of 21 inches and up......add 20 per cent.
Red spruce—For diameters of 8 to 10 inches......add 5 per cent.
Red Spruce—For diameters of 11 inches and up......add 25 per cent.
Shortleaf pine—For diameters of 10 inches and under......add 15 per cent.
Shortleaf pine—For diameters of 11 to 19 inches......add 25 per cent.
Shortleaf pine—For diameters of 20 to 23 inches......add 35 per cent.
Shortleaf pine—For diameters of 24 inches and over......add 40 per cent.
White pine—For all diameters, use the table without change.

TABLE 10.—*Contents in cubic feet, and number of cubic feet per cord in hardwood trees of different diameters and total heights.*

Diameter breasthigh Inches	Total height of tree—Feet									*No. cu. ft. per cord
	20	30	40	50	60	70	80	90	100	
	Peeled volume—cubic feet									
2	.2	.3	....	....	....	....	....	....	....	63
3	.4	.6	.8	....	....	....	....	....	....	70
4	.7	1.1	1.5	1.8	....	....	....	....	....	75
5	1.1	1.7	2.3	2.9	3.4	....	....	....	....	79
6	1.6	2.5	3.3	4.1	4.9	5.8	....	....	....	83
7	2.2	3.4	4.5	5.6	6.7	7.9	9.0	....	....	85
8	2.9	4.4	5.9	7.3	8.8	10.3	11.7	13.2	....	88
9	3.7	5.6	7.4	9.3	11.1	13.0	14.8	16.7	18.6	89
10	4.6	6.9	9.2	11.5	13.7	16.0	18.3	21	23	91
11	...	8.3	11.1	13.9	16.6	19.4	22	25	28	92
12	...	9.9	13.2	16.5	19.8	23	26	30	33	93
13	...	11.6	15.5	19.4	23	27	31	35	39	94
14	...	13.5	18	22	27	31	36	40.	45	94
15	...	15.5	21	26	31	36	41	46	52	95
16	...	....	23	29	35	41	47	53	59	95
17	...	....	26	33	40	46	53	60	66	95
18	...	....	30	37	45	52	59	67	74	95
19	...	....	33	41	50	58	66	74	83	96
20	...	....	37	46	55	64	73	82	92	96

Per cent of bark to total volume for trees of different species and diameters

Species	Diameter breasthigh—Inches				
	6	12	20	30	40
	Per cent of bark				
Ash, black	18	16	13	10	..
Ash, green	22	17	13	10	9
Ash, white	22	19	15	11	..
Basswood	..	20	18	16	14
Beech	8	7	7	..	..
Birch, yellow	..	13	13	13	..
Maple, sugar	..	17	17	17	..
Hemlock	15	17	18	19	..
Hickories	21	17	15	13	..
Poplar, yellow	21	17	..	..	..

*From Forest Service Bulletin 96, p. 64.

TABLE 11.—*Contents in cubic feet, and number of cubic feet per cord in the tops (exclusive of branches), of hardwood trees of different diameters and total heights. By top is meant the portion of the stem above the merchantable length.*

Diameter breasthigh	Diameter at top of merchantable length	Total height of tree—Feet 50	60	70	80	90	100	110	120	Number cu. ft. per cord of topwood
		Peeled volume of top—Cubic feet								
Inch.	Inch.									
8	6	1.2	1.5	1.8	....	....	....	....	....	66
9	6	1.3	1.6	1.9	....	....	....	....	....	66
10	6	1.4	1.7	2.0	2.1	....	....	....	....	66
11	6	1.5	1.9	2.2	2.3	....	....	....	....	66
12	6	1.7	2.1	2.4	2.5	3.1	....	....	....	66
13	7	1.9	2.4	2.7	3.0	3.6	....	....	....	69
14	7	2.1	2.7	3.1	3.5	4.2	4.7	....	....	69
15	8	2.3	3.1	3.5	4.0	4.8	5.4	....	....	71
16	8	2.6	3.5	4.0	4.7	5.5	6.2	6.7	....	71
17	9	2.9	3.9	4.6	5.4	6.3	7.0	7.6	....	74
18	9	3.2	4.4	5.2	6.1	7.2	8.0	8.6	9.2	74
19	10	3.6	4.9	5.9	6.9	8.1	9.0	9.8	10.4	77
20	10	4.0	5.4	6.6	7.8	9.0	10.0	11.0	11.7	77
21	11	4.4	5.9	7.3	8.7	10.0	11.1	12.3	13.1	79
22	11	4.8	6.5	8.0	9.6	11.0	12.2	13.6	14.5	79
23	12	5.3	7.1	8.8	10.6	12.2	13.4	15.0	16.0	81
24	12	5.8	7.7	9.6	11.6	13.4	14.7	16.5	17.6	81
25	13	6.3	8.3	10.4	12.6	14.6	16.0	18.0	19.2	83
26	13	6.8	9.0	11.3	13.7	15.8	17.3	19.5	21	83
27	14	....	9.7	12.2	14.8	17.1	18.8	21	23	85
28	14	....	10.4	13.2	16.0	18.5	20	23	24	85
29	15	....	11.1	14.2	17.2	20	22	24	26	87
30	15	....	11.9	15.2	18.5	21	24	26	28	87
31	16	....	12.7	16.2	19.8	23	25	28	30	88
32	16	....	13.5	17.3	21	25	27	30	32	88
33	17	....	....	18.4	23	26	29	32	35	90
34	17	....	....	19.5	24	28	31	34	37	90
35	18	....	....	21	26	30	33	36	39	91
36	18	....	....	22	27	31	35	38	41	91
37	19	....	....	....	29	33	37	40	44	93
38	19	....	....	....	30	35	39	42	46	93
39	20	....	....	....	....	37	41	45	49	94
40	20	....	....	....	....	39	43	47	51	94

TABLE 12.—*Form for recording measurements of standing timber. Location and area: One-quarter acre at east end of woodlot, and representative of ten acres.*

Best Timber Trees	Diameter Breast-high Inches	MERCHANTABLE LOGS						REMARKS
		Select		Common		Cull		
		Length Feet	D.I.B.* Inches	Length Feet	D.I.B.* Inches	Length Feet	D.I.B.* Inches	
White Oak	24	16	20	32	16	12	14	Plus 3 ties; 6 posts.
Red Oak	30			50	20			
Hickory	20	32	14					Whiffle tree stock
Walnut	25	16	20	16	18			Plus 20 posts
White Oak	30	24	24	30	18			Plus 10 ties
White Oak	16			50	6			Piling only
Red Oak	20			32	14			
Hickory	25	16	20					Remainder Firewood
Chestnut	20			60	6			Pole only
Cedar	15			40	6			Pole only.
Etc.								

* D.I.B. diameter inside bark at top end of log.

Less Valuable Trees.

Diameter Inches	White Oak	Red Oak	Hickory	Walnut	MISCELLANEOUS
4	/// (50)†	//	///		/// (25)
6	//	/	//		~~////~~ (30)
8	/ (50)	/	/		/// (35)
10	~~////~~			~~////~~ (60)	// (40)
12		/	/// (50)		// (45)
14	// (60)	//			// (50)
16		/	/		/ (55)
18	/	/			/ (60)
20					/ (70)

† Circled Figures indicate average heights.

Fig. 17.—Large size hickory oak and red gum on second bottoms Carroll County.

Sizing up every tree in the woodlot or at least each of the more valuable ones will as a rule give closer results than basing the estimate of the whole tract on one or more carefully estimated sample areas. The work does not have to be done all at once; and by marking the point where he is compelled to stop, the farmer may do only part of the estimating at a time and thus cover his entire woodlot without neglecting other duties. Where it is necessary to employ the sample plot method, the area of all the plots together should be as large as possible, though the plots themselves may be small. They should be scattered through the woodlot so as to represent as closely as possible average conditions. A convenient size for a single plot is one-quarter acre (roughly a square measuring 104x104 feet, a strip 52x209 feet, or a circle 20 paces—59 feet—in radius). The yield on the sample plots should be totalled for each of the kinds and classes of material, the average amount per acre of each kind determined, and this amount multiplied by the total number of acres in the woodlot.

4. Knowledge of Markets.

The woodlot owner must secure detailed information on markets in order to sell most profitably. Examination of local markets should come first, and should be the most detailed, as a large proportion of woodlot products can only be shipped outside the local market in manufactured or partially manufactured form. Investigation should then be extended in increasing circles to outside markets for more valuable products, such as high grade logs or specially sawed or rived stock, which can often be shipped long distances and sold at a greater profit than if disposed of near by. Local markets, where the net profits may be the same, are preferable to outside markets because of the closer relationship possible between buyer and seller. They also offer, as a rule, a much wider range of utilization and require a less degree of manufacture.

The following kinds of markets should be investigated:

1. High grade logs,—large saw and veneer mills, local or at a distance.

2. Common and cull logs,—chiefly local sawmills and slack cooperage plants.

3. Ties.—near-by railroad and local and outside dealers.

4. Poles,—local and outside dealers and telephone and telegraph companies.

5. Piling,—railroads, dock companies, and dealers in large cities.

6. Posts,—the local market, and dealers in large cities.

7. Bolts (for vehicle stock, handles, cooperage, shuttles), near-by factories, or points within a very cheap railroad haul.

8. Sawed or rived stock (for vehicles, handles, cooperage and shuttles),—wide range of factories, local or distant.

9. Lumber,—local market, and dealers and wood-using plants, especially planing mills, in large towns and cities. Much the larger part of the lumber cut from woodlots will be of low grade, which

Fig. 18.—White oak logs for the Memphis market. Fayette County.

it will not pay to try to sell at any great distance on account of freight charges.

10. Cordwood,—consumers, local dealers, or dealers within a very cheap railroad haul.

11. Tanbark,—local dealers, local or distant tanneries.

12. Mining timbers,—local mines only, as the mines are located in regions of abundant local supply of forest products.

The chief market possibilities of the different species of trees are indicated on pp. 120 to 125, under "The Uses of Native Woodlot Trees." Reference to these topics will assist the prospective seller in narrowing down the field of his investigations, and in avoiding useless correspondence. On pages 178 to 195 of this bulletin are given the names of a large number of wood-using plants and dealers in forest products. From this list the woodlot owner can select those which appear likely to be in the market for the particular classes of products he has for sale, and which do not appear to be at a prohibitive distance. In writing to these, state as clearly and briefly as possible the kind and amount of products for sale, and ask that prices and specifications be sent in case the firm is in the market for the products mentioned. It is well to ask also for the favor of any information regarding other possible markets in case the addressee can not purchase.

5. Costs and Profits

There is often a variety of ways of marketing each kind and size of tree in the woodlot. The choice depends not only upon the prices offered, but also upon the cost of getting the material out in the required form. The real basis on which decisions should be made is the net or stumpage value of the product. This is obtained by subtracting the total (estimated) cost of production, including haul to the point of delivery, from the price anticipated. When the timber is sold on the stump, this computation is of course unnecessary. Otherwise it may include the costs of felling, cutting up, peeling, splitting or riving, stacking, swamping and skidding, hauling, loading, sawing and handling lumber, and freight. On pages 163 to 166 are listed the approximate costs of these operations for different kinds of products.

The following example illustrates the use of these figures in computing the possible net profits (or stumpage values) which could be obtained from the same material if sold for different uses. A farmer living eight miles from a railroad wishes to sell some "common" oak timber. The distance and roads are such as to permit of but one round trip haul per day for one team. He finds two possible purchasers; one, a dealer in a near-by town who offers $20 per 1,000 board feet, delivered, of oak dimension lumber; the other, a local mill at a distance permitting one haul per day, which offers $10 per 1,000 board feet, log scale, delivered, for the common run of oak saw logs. To produce the dimension lumber he could have a portable mill set up in his timber, so that the cost of hauling the logs to the mill would be avoided; and he would estimate his costs of cutting and skidding the logs and manufacturing, handling, hauling, and loading the lumber as being equal to those given as average on page 164. In addition, there would be the item of railroad shipment at, say, 10 cents per 100 pounds, or $4 per 1,000 board feet. If he sold to the sawmill, his costs would include cutting and hauling (say 600 board feet of logs per load), but no skidding. In addition, there would be a mill overrun* amounting to 33 per cent, which would make the price offered for the logs by lumber scale $7.50 per 1,000 board feet, as the mill operator would get 1,333 board feet of lumber for his $10.

The net or stumpage value for the timber in the two cases would be figured as follows:

1. *Timber sold as lumber at $20 per 1,000 board feet, lumber scale.*

Cutting and skidding to sawmill	$ 4.25
Manufacture, handling, hauling, loading	8.50
Freight	4.00
Total cost of production	$16.75
Net or stumpage value per 1,000 feet lumber scale	3.25

2. *Timber sold as saw logs, at $10 per 1,000 feet, log scale.*

	Per 1,000 board feet	
	Log scale	Lumber scale
Cutting and hauling logs	$6.25	$4.68
Net profit or stumpage value	3.75	2.82

In the above case the farmer would get more for his stumpage by selling sawed lumber.

Itemized costs.—The following figures show the range in costs of producing different kinds of woodlot products:

*Due to the fact that the lumber sawed out of a sound log nearly always exceeds the amount which the ordinary log scale designates as the contents of a log of its diameter and length.

Cost of Logging (Hardwoods)

	Cost per 1,000 board feet		
	Low	High	Average
Felling and cutting into logs	$ .75	$ 1.75	$ 1.25
Skidding (often omitted or included with hauling expenses, including swamping)	2.00	4.00	3.00
Hauling, 1 trip a day:*			
1,000 feet per load	2.00	4.00	3.00
800 feet per load	2.50	5.00	3.75
600 feet per load (average)	3.33	6.67	5.00
400 feet per load	5.00	10.00	7.50
200 feet per load	10.00	20.00	15.00
Loading	.....	1.00	.50

Manufacture and handling of lumber

	Cost per 1,000 board feet		
	Low	High	Average
Sawing and sticking	$ 3.00	$ 4.00	$3.50
Planing and finishing	1.00	2.00	1.50
Handling lumber in yard (including grading and loading)	1.00	1.00	1.00
Hauling, 1 trip a day* (1,000 board feet per load)	2.00	4.00	3.00
Loading on cars	.50	1.50	1.00

Cost of tie production

(For 7x9 ties; 6x8 ties one-fifth less)

	Costs per tie		
	Low	High	Average
Cutting and hewing ties	$ .12	$ .18	$ .15
Cutting and sawing ties (by portable mill)	.15	.20	.18
Hauling, 1 trip a day:*			
10 ties	.20	.40	.30
15 ties	.15	.30	.23
20 ties	.10	.20	.15
Loading on cars	.03	.05	.04

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*For more than one trip a day divide these amounts by the number of trips per day. For less than one trip a day multiply these amounts by the number of days per trip.

Cost of pole and pile production

(35-feet length, 6 inches top)

	Costs per pole or pile		
	Low	High	Average
Cutting and trimming	$ .20	$ .40	$ .30
Hauling, 1 trip a day:*			
3 poles per load	.66	1.33	1.00
4 poles per load	.50	1.00	.75
5 poles per load	.40	.80	.60
Loading on cars	.05	.15	.10

Cost of producing material per cord and per rick

Firewood

	Cost per cord		
	Low	High	Average
Cutting (per stacked cord of 4-foot wood)	$ .75	$ 1.25	$ 1.00
Hauling, 1 trip a day	2.00	4.00	3.00

Handle bolts

(Hickory)

	Cost per rick		
	Low	High	Average
Cutting	$ 1.00	$ 1.50	$ 1.25
Hauling, 1 trip a day	2.00	4.00	3.00

Slack cooperage, veneer, and excelsior bolts

	Cost per rick (sticks 30 inches long)		
	Low	High	Average
Cutting	$ .50	$ 1.00	$ .75
Hauling, 1 trip a day	1.50	3.50	2.50

Pulpwood (peeled)

(Poplar, basswood, gum)

	Cost per rick (sticks 5 feet long)		
	Low	High	Average
Felling, peeling, and stacking	$ 1.25	$ 1.75	$ 1.50
Hauling, 1 trip a day	2.00	4.00	3.00

*For more than one trip a day divide these amounts by the number of trips per day. For less than one trip a day multiply these amounts by the number of days per trip.

Extract wood

	Cost per rick (160 cu. feet)		
	Low	High	Average
Cutting and splitting	$ 1.00	$ 1.50	$ 1.25
Hauling, 1 trip a day	2.50	4.50	3.50

Extract or tan bark

	Cost per cord of 2,240 lbs., dry
Cutting, peeling, and curing	$1.25 to $1.50
Loading	.50 to .50
Hauling, 1 trip haul	2.00 to 3.00

TABLE 13.—*Cost per 1,000 board feet of shipping different kinds of seasoned lumber at the freight rates given in the table.*

Kinds of wood	Thickness of lumber	Weight Per 1,000 bd. ft.	Freight rate in cents per 100 pounds[1] 1	2	3	4	5	6	7	8	9	10
			Cost per 1,000 board feet at above rates									
Hickory	1 inch and up	5,000	$0.50	$1.00	$1.50	$2.00	$2.50	$3.00	$3.50	$4.00	$4.50	$5.00
Oak, beech, maple, walnut	1 inch and up	4,000	.40	.80	1.20	1.60	2.00	2.40	2.80	3.20	3.60	4.00
Oak (quarter sawed)	¾ inch	3,200	.32	.64	.96	1.28	1.60	1.92	2.24	2.56	2.88	3.20
Oak (quarter sawed)	⅝ inch	2,700	.27	.54	.81	1.08	1.35	1.62	1.89	2.16	2.43	2.70
Oak (quarter sawed)	½ inch	2,200	.22	.44	.66	.88	1.10	1.32	1.54	1.76	1.98	2.20
Oak (quarter sawed)	⅜ inch	2,000	.20	.40	.60	.80	1.00	1.20	1.40	1.60	1.80	2.00
Ash and rock elm	1 inch and up	3,800	.38	.76	1.14	1.52	1.90	2.28	2.66	3.04	3.42	3.80
Soft elm and sycamore	1 inch and up	3,200	.32	.64	.96	1.28	1.60	1.92	2.24	2.56	2.88	3.20
Shortleaf pine	Boards	3,200	.32	.64	.96	1.28	1.60	1.92	2.24	2.56	2.88	3.20
Cypress	Boards	3,000	.30	.60	.90	1.20	1.50	1.80	2.10	2.40	2.70	3.00
Red gum	1 inch and up	3,300	.33	.66	.99	1.32	1.65	1.98	2.31	2.64	2.97	3.30
Red gum	¾ inch	2,500	.25	.50	.75	1.00	1.25	1.50	1.75	2.00	2.25	2.50
Red gum	⅝ inch	2,200	.22	.44	.66	.88	1.10	1.32	1.54	1.76	1.98	2.20
Red gum	½ inch	1,700	.17	.34	.51	.68	.85	1.02	1.19	1.36	1.53	1.70
Red gum	⅜ inch	1,300	.13	.26	.39	.52	.65	.78	.91	1.04	1.17	1.30
Sap gum	1 inch and up	3,100	.31	.62	.93	1.24	1.55	1.86	2.17	2.48	2.79	3.10
Sap gum	¾ inch	2,400	.24	.48	.72	.96	1.20	1.44	1.68	1.92	2.16	2.40
Sap gum	⅝ inch	2,000	.20	.40	.60	.80	1.00	1.20	1.40	1.60	1.80	2.00
Sap gum	½ inch	1,600	.16	.32	.48	.64	.80	.96	1.12	1.28	1.44	1.60
Sap gum	⅜ inch	1,250	.12	.25	.38	.50	.62	.75	.88	1.00	1.12	1.25
Tupelo	1 inch	3,000	.30	.60	.90	1.20	1.50	1.80	2.10	2.40	2.70	3.00
Tupelo	2 inches and up	3,200	.32	.64	.96	1.28	1.60	1.92	2.24	2.56	2.88	3.20
Poplar, chestnut, cherry and cottonwood	1 inch and up	2,800	.28	.56	.84	1.12	1.40	1.68	1.96	2.24	2.52	2.80
Poplar	¾ inch	2,100	.21	.42	.63	.84	1.05	1.26	1.47	1.68	1.89	2.10
Poplar	⅝ inch	1,600	.16	.32	.48	.64	.80	.96	1.12	1.28	1.44	1.60
Basswood	1 inch and up	2,600	.26	.52	.78	1.04	1.30	1.56	1.82	2.08	2.34	2.60
Buckeye	1 inch and up	2,500	.25	.50	.75	1.00	1.25	1.50	1.75	2.00	2.25	2.50

[1]For rates over 10 cents per 100, either use multiples of those given for from 1 to 10 cents, or add two or more of them together.

TABLE 14.—*Cost per 1,000 board feet, Doyle rule, of shipping green logs of different kinds of woods at freight rates given in table.*

Kinds of wood	Size of logs Diameter inside bark at small end Inches	Weight per 1,000 bd. ft. Doyle Scale	Freight rate in cents per 100 pounds[1] 1	2	3	4	5	6	7	8	9	10
			Cost per 1,000 board feet, Doyle scale, at above rates									
Ash	12	11,100	$1.11	$2.22	$3.33	$4.44	$5.55	$6.66	$7.77	$8.88	$9.99	$11.10
	18	7,700	.77	1.54	2.31	3.08	3.85	4.62	5.39	6.16	6.93	7.70
	24	6,600	.66	1.32	1.98	2.64	3.30	3.96	4.62	5.28	5.94	6.60
Basswood	12	9,500	.95	1.90	2.85	3.80	4.75	5.70	6.65	7.60	8.55	9.50
	18	6,600	.66	1.32	1.98	2.64	3.30	3.96	4.62	5.28	5.94	6.60
	24	5,600	.56	1.12	1.68	2.24	2.80	3.36	3.92	4.48	5.04	5.60
Beech	12	12,700	1.27	2.54	3.81	5.08	6.35	7.62	8.89	10.16	11.43	12.70
	18	8,900	.89	1.78	2.67	3.56	4.45	5.34	6.23	7.12	8.01	8.90
	24	7,500	.75	1.50	2.25	3.00	3.75	4.50	5.25	6.00	6.75	7.50
Cherry	12	10,500	1.05	2.10	3.15	4.20	5.25	6.30	7.35	8.40	9.45	10.50
	18	7,300	.73	1.46	2.19	2.92	3.65	4.38	5.11	5.84	6.57	7.30
	24	6,200	.62	1.24	1.86	2.48	3.10	3.72	4.34	4.96	5.58	6.20
Chestnut	12	12,600	1.26	2.52	3.78	5.04	6.30	7.56	8.82	10.08	11.34	12.60
	18	8,800	.88	1.76	2.64	3.52	4.40	5.28	6.16	7.04	7.92	8.80
	24	7,500	.75	1.50	2.25	3.00	3.75	4.50	5.25	6.00	6.75	7.50
Elm, soft	12	11,200	1.12	2.24	3.36	4.48	5.60	6.72	7.84	8.96	10.08	11.20
	18	7,800	.78	1.56	2.34	3.12	3.90	4.68	5.46	6.24	7.02	7.80
	24	6,600	.66	1.32	1.98	2.64	3.30	3.96	4.62	5.28	5.94	6.60
Gum, red	12	10,700	1.07	2.14	3.21	4.28	5.35	6.42	7.49	8.56	9.63	10.70
	18	7,500	.75	1.50	2.25	3.00	3.75	4.50	5.25	6.00	6.75	7.50
	24	6,300	.63	1.26	1.89	2.52	3.15	3.78	4.41	5.04	5.67	6.30

Hickory	12	14,700	1.47	2.94	4.41	5.88	7.35	8.82	10.29	11.76	13.23	14.70
	18	10,300	1.03	2.06	3.09	4.12	5.15	6.18	7.21	8.24	9.27	10.30
	24	8,700	.87	1.74	2.61	3.48	4.35	5.22	6.09	6.96	7.83	8.70
Maple, sugar	12	12,900	1.29	2.58	3.87	5.16	6.45	7.74	9.03	10.32	11.61	12.90
	18	9,000	.90	1.80	2.70	3.60	4.50	5.40	6.30	7.20	8.10	9.00
	24	7,600	.76	1.52	2.28	3.04	3.80	4.56	5.32	6.08	6.84	7.60
Maple, red	12	11,900	1.19	2.38	3.57	4.76	5.95	7.14	8.33	9.52	10.71	11.90
	18	8,300	.83	1.66	2.49	3.32	4.15	4.98	5.81	6.64	7.47	8.30
	24	7,100	.71	1.42	2.13	2.84	3.55	4.26	4.97	5.68	6.39	7.10
Oak, red	12	14,800	1.48	2.96	4.44	5.92	7.40	8.88	10.36	11.84	13.32	14.80
	18	10,300	1.03	2.06	3.09	4.12	5.15	6.18	7.21	8.24	9.27	10.30
	24	8,800	.88	1.76	2.64	3.52	4.40	5.28	6.16	7.04	7.92	8.80
Oak, white	12	14,400	1.44	2.88	4.32	5.76	7.20	8.64	10.08	11.52	12.96	14.40
	18	10,000	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00
	24	8,500	.85	1.70	2.55	3.40	4.25	5.10	5.95	6.80	7.65	8.50
Sycamore	12	12,000	1.20	2.40	3.60	4.80	6.00	7.20	8.40	9.60	10.80	12.00
	18	8,400	.84	1.68	2.52	3.36	4.20	5.04	5.88	6.72	7.56	8.40
	24	7,100	.71	1.42	2.13	2.84	3.55	4.26	4.97	5.68	6.39	7.10
Yellow poplar	12	8,800	.88	1.76	2.64	3.52	4.40	5.28	6.16	7.04	7.92	8.80
	18	6,100	.61	1.22	1.83	2.44	3.05	3.66	4.27	4.88	5.49	6.10
	24	5,200	.52	1.04	1.56	2.08	2.60	3.12	3.64	4.16	4.68	5.20
Walnut	12	11,900	1.19	2.38	3.57	4.76	5.95	7.14	8.33	9.52	10.71	11.90
	18	8,300	.83	1.66	2.49	3.32	4.15	4.98	5.81	6.64	7.47	8.30
	24	7,100	.71	1.42	2.13	2.84	3.55	4.26	4.97	5.68	6.39	7.10

[1]For rates over 10 cents per 100, either use multiples of those from 1 to 10 cents, or add two or more of them together.

TABLE 15.—*Shipping weights per stack of bolts, green and dry, of different lengths and diameters and different kinds of wood.*

		LENGTH OF BOLT—FEET								
	Diameter Inches	2½ (⅝ cd.)[1]	3 (¾ cd.)[1]	3½ (⅞ cd.)[1]	4 (1 cd.)[1]	4½ (1⅛ cd.)[1]	5 (1¼ cd.)[1]	5½ (1⅜ cd.)[1]	6 1½ cd.)[1]	Weight per cu. ft.
		WEIGHT PER STACK—POUNDS								
Ash, white										
Green	6	2,600	3,200	3,700	4,200	4,800	5,300	5,800	6,300	48.1
	9	2,800	3,300	3,900	4,400	5,000	5,500	6,100	6,600	
	12	2,900	3,400	4,000	4,600	5,100	5,700	6,300	6,900	
Air dry	6	2,300	2,800	3,200	3,700	4,200	4,600	5,100	5,600	42.1
	9	2,400	2,900	3,400	3,900	4,400	4,800	5,300	5,800	
	12	2,500	3,000	3,500	4,000	4,500	5,000	5,500	6,000	
Basswood										
Green	6	2,300	2,700	3,200	3,600	4,100	4,500	5,000	5,500	41.3
	9	2,400	2,800	3,300	3,800	4,300	4,700	5,200	5,700	
	12	2,500	2,900	3,400	3,900	4,400	4,900	5,400	5,900	
Air dry	6	1,400	1,700	2,000	2,300	2,600	2,800	3,100	3,400	25.8
	9	1,500	1,800	2,100	2,400	2,700	3,000	3,300	3,600	
	12	1,500	1,800	2,100	2,500	2,800	3,100	3,400	3,700	
Cottonwood										
Green	6	2,600	3,100	3,600	4,100	4,600	5,100	5,600	6,100	46.5
	9	2,700	3,200	3,700	4,300	4,800	5,300	5,900	6,400	
	12	2,800	3,300	3,900	4,400	5,000	5,500	6,100	6,600	
Air dry	6	1,500	1,800	2,100	2,400	2,700	3,000	3,300	3,600	27.3
	9	1,600	1,900	2,200	2,500	2,800	3,100	3,500	3,800	
	12	1,600	1,900	2,300	2,600	2,900	3,200	3,600	3,900	
Elm, rock and wh'te										
Green	6	2,700	3,200	3,700	4,300	4,800	5,300	5,900	6,400	48.6
	9	2,800	3,400	3,900	4,500	5,000	5,600	6,100	6,700	
	12	2,900	3,500	4,000	4,600	5,200	5,800	6,300	6,900	
Air dry	6	1,900	2,300	2,700	3,000	3,400	3,800	4,200	4,600	34.6
	9	2,000	2,400	2,800	3,200	3,600	4,000	4,400	4,800	
	12	2,100	2,500	2,900	3,300	3,700	4,100	4,500	4,900	

Hickory, shagbark										
Green	6	3,500	4,200	4,900	5,600	6,300	7,000	7,700	8,400	63.8
	9	3,700	4,400	5,100	5,900	6,600	7,300	8,100	8,800	
	12	3,800	4,500	5,300	6,100	6,800	7,600	8,500	9,100	
Air dry	6	2,800	3,400	4,000	4,500	5,100	5,700	6,200	6,800	51.5
	9	3,000	3,600	4,100	4,700	5,300	5,900	6,500	7,100	
	12	3,100	3,700	4,300	4,900	5,500	6,100	6,700	7,300	

[1]Stacks are 4 feet in height by 8 feet long, made up of bolts of different sizes. Bolts 4 feet long make a standard cord, while shorter lengths make "short cords', and longer lengths a cord and over.

TABLE 16.—*Weights of piling and poles of different sizes, green and dry, for different kinds of wood; also weight per cubic foot of each.*

Length	White oak		Black oak		Sugar maple		Chestnut		White elm		Black gum		Increase with top diameter of 8 inches
Feet	Green	Air dry	Green	Air dry	Green	Air dry	Green	Air dry	Green	Air dry	Green	Air dry	Per cent
	WEIGHT—POUNDS												
20	610	470	610	440	550	430	540	300	480	340	440	350	15.3
25	770	590	770	550	690	530	670	370	600	430	550	450	15.4
30	920	700	920	660	820	640	810	440	710	510	660	530	15.6
35	1,080	820	1,080	770	960	750	940	520	840	600	770	620	15.7
40	1,580	1,200	1,590	1,140	1,410	1,100	1,390	760	1,230	880	1,130	920	12.3
45	1,780	1,360	1,790	1,280	1,590	1,240	1,560	860	1,390	990	1,270	1,030	11.9
50	1,980	1,500	1,980	1,420	1,770	1,370	1,730	950	1,540	1,090	1,410	1,140	12.3
	Weights per cubic foot used above—Pounds												
	67.2	45.0	62.5	47.6	55.9	43.4	54.8	30.2	48.6	34.6	44.7	36.2	

Top diameter 6 inches. Butt diameter 12 inches for piling 20 to 35 feet inclusive
14 inches for piling 40 to 50 feet inclusive.

Freight

Tables 13, 14, 15 and 16 should prove useful in calculating the costs of shipping different kinds of wood and classes of material.

6. Contracts and Supervision

In disposing of timber it is always best to have written contracts with purchasers or with the jobbers who are to deliver the material to purchasers. It is best, of course, to eliminate the jobber, if possible, and to deliver the material directly to the purchaser.

The following are the important items to be included in a contract with a purchaser where the products are to be cut and delivered by the farmer:

1. Kinds of woods and classes of materials, such as logs, bolts, poles, lumber, etc., and specifications in regard to forms, sizes, quality or grade, and quantity of different materials.
2. Price per unit of measurement, such as per 1,000 feet log scale or per cord, for each specified class of material, and time when payment is to be made. Payment should be made on delivery unless seller is protected by a bond on the purchaser.
3. Method of sale or delivery of the material.
4. Times, places, and methods of measurements of the material, including log rules, methods of allowing for defects, grading rules, etc., to be used.
5. Bond or other guarantee for faithful performance of contract.
6. Method of arbitration in case of disputes.

In case sale is to be made of standing timber the following additional stipulations should be provided for in the contract (From Bulletin 9 of the State of New York Conservation Commission). Many of these same stipulations can be used with jobbers in case contracts are made with them to cut and deliver products to purchaser:

1. Timber to be cut.

    Quantity and location of cutting.
    Sizes of trees to be cut or saved.
    Kinds of trees to be cut or saved.

    Provisions should be made for exceptions to the above clauses through marking of special trees to be saved or cut. If possible it is best to allow only those trees to be cut which are marked.

2. Provisions against waste.

   Height of stumps. This height should be specified, and ordinarily it should not exceed the stump's diameter.

   Utilization of tops. The smallest diameter to which material must be utilized should be stated. Material to be taken. It should be specified that all merchantable material be taken,—and the specific amount of defects which products may have and still be considered merchantable should be stated.

Fig. 19.—Woodlot almost ruined by fire in East Tennessee.

   Form in which timber is to be worked up. This should be specified if possible (thus, that certain sizes be converted to logs, others to poles, etc.)

   Materials to be used for roads, skidways, and other lumbering operations. It should be specified that only dead trees or certain inferior kinds be used.

3. Protection against damage.

   Care against injuring trees to be left.

   Provisions for protection from fire, and responsibility for fires occurring while on the work. Any fences removed, etc., to be replaced by substantial new fences.

4. Location of camps, mill site, etc.
   If these are used, provisions concerning them should be made.
5. Payments.
   Time—generally at least half should be paid as soon as trees are cut; and the rest before removal from land.
   Price per unit of measurement for each grade of material specified.
6. Faithful performance.
   Bond or other guarantee of at least one-quarter of the value of products included should be required. Penalties for violations of different clauses should be stipulated; in case the operator cuts trees that should be left or fails to remove trees marked for cutting, at double the ordinary price agreed on; for carelessly injuring trees to be left or other violations, a definite sum for each offense.
7. Duration of contract.
   The contract should stipulate when work is to begin and end, and that a certain amount is to be done within given limits of time. Repeated violations of any terms of the contract shall terminate it, with forfeiture of bond for faithful performance.

Supervision of cutting, logging, and scaling operations is very important; and a definite and clear contract, in writing, greatly simplifies this work. Measurements of material purchased should always be checked as provided for in the contract.

7. Co-operation with Neighboring Woodlot Owners

The chances of increasing profits from the sale of woodlot products can be greatly improved by intelligent coöperation with neighbors. The Forest Service, U. S. Department of Agriculture, in conjunction with various State organizations, plans to assist materially in developing this feature. Its agent will work coöperatively with the county agent and farmers in a given county to decide upon ways and means for profitable woodlot utilization in the county.

There are many different ways in which coöperation may be effected, only a few of which are suggested here:

1. Where favorable contracts for the sale of woodlot material can be made only in carload lots and the individual farmer has not

enough material to fill such contracts by himself, it will be wise for him to coöperate with his neighbors in supplying the necessary amounts.

2. Coöperation will be useful in securing information on favorable markets and prices for different classes of material.

3. Coöperative logging and manufacture of different classes of material, including the collective ownership and operation of logging outfits, sawmills, etc., may yield higher returns to the farmers than the present methods of sale.

Only by intelligent coöperation along some such lines will the woodlot owners, as a class, be able to get better values for the different classes of material grown in their woodlots.

Summary of Points to be Observed in Marketing

What the farmer should do in order to get the best returns from his woodlot sales may be summed up as follows:

1. Estimate the timber in the woodlot in terms of the most profitable classes of material.

2. Get as complete a knowledge as possible of local and outside markets for the different kinds of wood and classes of material contained in the woodlot. This should include the current prices and the specifications in regard to quality, size, and form. Write freely to wood-using firms for prices and specifications, using the directory of firms given in this report.

3. Estimate the cost of getting out the different kinds of trees and classes of material for the different possible markets; determine which markets will yield the highest net profits, and sell accordingly.

4. Never sell by the boundary or lump sum unless the timber has been carefully estimated.

5. Where there is uncertainty in regard to the amount of standing timber of a given kind in the woodlot, sell by log scale, cord, rick, or piece.

6. Always have a written contract with the purchaser, preferably supported by bond, stipulating in detail the form, size and quality or grade of material to be purchased by him, and the method of scaling, payments, etc.

7. Be thoroughly familiar with any deficiencies in the log rule to be used, especially in regard to underscaling of small logs, and figure on the price accordingly.

8. Coöperate freely with other woodlot owners in securing advantageous markets, and, if practicable, in logging and manufacture.

9. Be careful to use as much of every tree cut as can possibly be taken out at a profit.

10. Do not cut small, thrifty trees less than a foot or so in diameter on land to be held in woodlot, unless they are crowding more desirable individuals that are to be left.

HOW TO PREVENT THE DETERIORATION OF CUT WOODLOT PRODUCTS

It is often necessary or desirable to put off the delivery of logs, bolts, poles, etc., until some months after cutting, either in order to allow them to season or because a good sale can not be arranged at once. A great deal of the weight of fresh-cut products is due to the water they contain, and a few months' seasoning will often reduce this to a marked degree, the amount of reduction depending, of course, on the climate, the weather, and the exposure to sun and air. At the same time, unless preventive measures be taken, the products are sure to deteriorate through decay, insect attack, checking, or some other agency. A certain amount of deterioration is apt to take place in any case if the delivery is put off for some time; but the amount can be greatly reduced, and the saving in weight and increase in strength due to seasoning are more than enough to counterbalance any small deterioration which may occur in spite of the preventive measures.

Logs should never be allowed to remain long in the woods after cutting. As soon as possible they should be taken to a dry, well-aired, and unshaded area, and placed on skids well off the ground. The bark may be left on the logs and the ends should be coated with paint, creosote, or tar. This will not only assist in preventing decay but will also retard seasoning to some extent and thus keep the logs from checking badly.

Poles should be peeled and hauled or dragged to a place free from débris or rank vegetation and freely exposed to sun and wind. There they should be rolled upon skidways not less than 18 inches high, so that no part of them will rest on the ground. There should be only one layer of poles on each skidway. When ties are cut it is usually cheapest and most desirable to haul them, unseasoned, directly to the railroad and there pile them according to the specifications furnished by the tie buyer.

Cordwood should be stacked in loose piles in a sunny, well-aired and well-drained place free from rank vegetation. Two sticks on the ground running the length of the pile will keep it from contact with the soil and thus prevent decay in the lower layers.

DIRECTORY OF WOOD-USING FIRMS*

1. Sawmills in Tennessee Using Saw Logs

(Which cut for the most part over 1,000,000 board feet a year)

County	*Town*	*Firm name*
Benton	Camden	J. B. Reed
Blount	Cades Cave	Sam Spak
Blount	Razar	John C. Lambert
Blount	Maryville	Lee Grindstaff
Blount	Maryville	Maryville Lumber Company
Blount	Townsend	Little River Lumber Company
Bradley	McDonald	James Cooper
Bradley	Cleveland	Cleveland L. & M. Co.
Carter	Roan Mountain	T. H. Whitehead
Carter	Hampton	Pittsburg Lumber Company
Cheatham	Ashland City	Burkholder Bros.
Claiborne	Clairfield	Valley Creek & Co.
Coffee	Tullahoma	M. R. Campbell
Cumberland	Westel	Troller Lumber Co.
Davidson	Nashville	John B. Ransom & Co.
Davidson	Nashville	Cherokee Lumber Company
Davidson	Nashville	Lieberman, Loveman & O'Brien
Davidson	Nashville	Davidson, Hicks & Greene Co.
Dickson	Dickson	W. P. Branson & Sons Lumber Co.
Dickson	McEwen	S. W. Taylor & Co.
Dickson	Pardue	Albert E. Pardue
Dickson	Dickson	M. R. Campbell
Dickson	Decherd	C. E. Murry
Dyer	Trimble	Trimble Lumber Company
Dyer	Dyersburg	North Vernon Lumber Company
Dyer	Tiger Tail	Tiger Tail Mill & Land Co.
Dyer	Mengelwood	Mengel Box Co.
Fentress	Harriman	J. H. Watts
Fentress	Allardt	E. C. Ross & Sons
Fentress	Lake	Logan Finch
Fentress	Allardt	Otto Fritzoche
Fentress	Allardt	H. Whealton & Son
Fentress	Wilder	Davidson, Hicks & Greene Co.
Franklin & others	Nashville	Southern Lumber Co.
Gibson	Rutherford	A. A. Tray
Gibson	Humboldt	B. C. Jarrell & Co.
Giles	Pulaski	Pulaski Rim & Spoke Co.
Greene	Greeneville	F. J. Brown

*It is not claimed that this directory is complete. It represents only those firms whose names the Forest Service has in its files, some of which may now be out of business.

County	*Town*	*Firm name*
Greene	Greeneville	John Heilman Lumber Co.
Greene	Greene County	Patterson Lumber Co.
Grundy	Tracy City	Sam Wener
Hamilton	Chattanooga	Cedar Products Co.
Hamilton	Chattanooga	The Loomis & Hart M. Co.
Hamilton	Chattanooga	McLean Lumber Co.
Hamilton	Chattanooga	Williams & Sons Lumber Co.
Hamilton	Chattanooga	Berry Lumber & Stove Co.
Hardeman	Toone	Wanerkent Co.
Hawkins	Rogersville	Chas. D. Jarvis
Henry	Paris	W. Soger
Hickman	Hickman County	S. H. Hinson
Hickman	Only	J. C. Burchard
Hickman	Hampshire	G. W. Stanley & Sons
Houston	Stewart	Mitchell & Dunagan
Humphreys	Hurricane Mills	Jas. J. Anderson
Humphreys	Hurricane Mills	H. D. Estes
Jackson	Difficult	Cassetty Bros.
James	Georgetown	L. A. Caster
James	Apison	J. H. Reed
Johnson	Butler	Geo. W. Kite
Johnson	Butler	W. F. Burton
Johnson	Pottsville	Tennessee Lumber Manufacturing Co.
Knox	Straw Plains	C. H. Duignan
Knox	Knoxville	D. M. Rose & Co.
Knox	Knoxville	Vestal Lumber & Manufacturing Co.
Knox	Knoxville	Knoxville Sawmill Co.
Lake	Phillippy	Chas. D. Phillippy Merc. & Lumber Co.
Lake	Ridgely	Hannington Bros. Lumber Co.
Lawrence	Lewis	U. S. Slak Lumber Co.
Lawrence	Ethridge	W. W. Lumber Co.
Lawrence	Ethridge	J. C. Keplinger
Lawrence	Henryville	J. E. Stone & Co.
Lawrence	Iron City	Forsyth Bros. Lumber Co.
Lewis	Hampshire	W. M. Taggin
Lewis	Hohenwald	S. H. Hinson
Lincoln	Fayetteville	Williams Lumber Co.
Loudon	Lenoir City	R. M. Callaway
McMinn	Riceville	W. P. Pellis
McNairy	Guys	A. C. Wilson
Macon	Red Springs	W. D. Parkhurst
Madison	Jackson	Young and Cutsinger
Marion	South Pittsburg	Eagle Pencil Co., or Hudson Lumber Co., Jan. 1, 1912
Maury	Mt. Pleasant	C. A. Long
Monroe	Tellico Plains	Tellico River Lumber Co.

County	*Town*	*Firm name*
Monroe	Mt. Vernon	W. J. Norris (?)
Morgan	Harriman	J. G. Cooper
Morgan	Harriman	Tennessee Stave & Lumber Co.
Obion	Polk	Hale Bros.
Obion	Fulton	Swain-Karmile Lumber Co.
Perry	Lobelville	W. J. Bates
Perry	Linden	Jones & Woolfolk Co.
Polk	Jennya	J. B. Taylor
Polk	Cincinnati	Marion Timbering Co.
Polk	Bonnie	Albert Crumly
Polk	Conasauga	Alaculsy Lumber Co.
Putnam	Monterey	Johnson Bros.
Putnam	Monterey	Woodcliffe Lumber Co.
Putnam	Cookeville	Cookeville Veneer Co.
Putnam	Baxter	J. A. Isbell
Rhea	Spring City	Penn. Coal & Lumber Co.
Roane	Oakdale	James Newhouse
Roane	Rockwood	John Molyneaux
Robertson	Cedar Hill	Cedar Hill Lumber Co.
Rutherford	Walterhill	Gulf Red Cedar Works
Rutherford	Murfreesboro	R. P. Wilson
Scott	Norma	New River Lumber Co.
Scott	Lexington	E. B. Spotswood & Son
Scott	Elk Valley	Douglass & Walkey Co.
Sevier	Trundles X R'ds.	George Brown
Sevier	Trundles X R'ds.	W. J. Sauk
Sevier	Sevierville	Twin River Lumber Co.
Sevier	Sevierville	A. J. Hupp
Shelby	Memphis	Mossman Lumber Co.
Shelby	Memphis	I. M. Darnell Son Co.
Shelby	Memphis	Anderson-Tully Co.
Shelby	Memphis	Bennett Hardwood Lumber Co.
Shelby	Memphis	Anchor Sawmill Co.
Shelby	Memphis	Russe & Burgess, Inc.
Shelby	Memphis	R. J. Darnell, Inc.
Shelby	Memphis	O. S. Gladden
Shelby	Memphis	Green River Lumber Co.
Shelby	Memphis	Nickey & Sons Co.
Shelby	Memphis	Nickey Bros. Hardwood Lumber Co.
Shelby	Memphis	McLean Hardwood Lumber Co.
Shelby	Memphis	Mahannah Lumber Co.
Shelby	Memphis	Memphis Veneer Lumber Co.
Shelby	Mf's, 10	Mfg. Sawmill Co.
Shelby	Memphis	Florence Pump and Lumber Co.
Shelby	Memphis	Moore & McFerren
Shelby	Memphis	J. V. Stimson Hardwood Co.

County	Town	Firm name
Shelby	Memphis	May Bros.
Shelby	Onabaska	Philip A. Ryan Lumber Co.
Shelby	Memphis	McCollum Bros.
Shelby	Memphis	Tschew Lumber Co.
Shelby	Memphis	Hartzell Handle Co.
Shelby	Millington	Woods Lumber Co.
Sullivan	Abindgdon, Va.	Burkman, Wright & Mock Co.
Sullivan	Blountville, Tenn.	E. R. & J. T. Fey
Sullivan	Blountville, Tenn.	R. E. Houser
Sullivan	Johnson City	Dickey Lumber Co.
Sullivan	Bristol	Peter McCain Lumber Co.
Sullivan	Bluff City	Black Mountain Land Co.
Tipton	Covington	W. S. Nayes (Nayes Lumber Co.)
Unicoi	Unicoi	Clear Fork Lumber Co.
Unicoi	Flag Pond	T. G. Salts
Unicoi	Unicoi	W. C. N. Goodman
Union	Speedwell	Morris Williams
Union	Carryton	W. T. Gibbs
Warren	McMinnville	Burroughs-Ross-Colville Co.
Warren	McMinnville	McMinnville Spoke & Lumber Co.
Washington	Johnson City	American Cigar Box Lumber Co.
Washington	Johnson City	Harris Manufacturing Co.
Washington	Johnson City	Tenn. Lumber & Veneer Corp'n
Washington	Telford	Sam Light
Washington	Garbers	F. D. Hill
Wayne	Allens Creek	Clendenin Bros.
Wayne	Clifton	J. J. Halder
Wayne	Waynesboro	R. L. Morrow
Weakly	Dresden	Dresden Spoke Co.
Wilson	Lebanon	Gulf Red Cedar Works

2. Vehicle Stock Plants and Dealers

(Which purchase hickory logs, bolts, and billets, some white oak, and a little red oak)

Town	Firm name
Algood	Pennock-Walter Manufacturing Co. (spokes)
Bristol	Beveridge & Taylor (spokes)
Brownsville	Byrn Bros. (spokes)
Centerville	Buckeye Spoke Co.
Chattanooga	Hickory Spoke Works (spokes)
Dickson	M. R. Campbell (spokes)
Dresden	Dresden Spoke Works (spokes)
Dyersburg	W. N. Clayton (spokes)
Dyersburg	Imperial Wheel Co.
Halls	W. N. Clayton (spokes)

Town	*Firm name*
Halls	Halls Spoke Co. (spokes) (also at Spring City)
Harrison	N. C. Blanchard (spokes)
Hohenwald	The Mitchell Wheel Co.
Humboldt	Foltz Manufacturing Co. (handles and spokes)
Jackson	Weis & Lesh Mfg. Co. (spokes, skewers, and butcher's blocks)
Livingston	J. C. Bilbrey Spoke Co. (spokes)
McMinnville	Burroughs, Ross, Colville Co. (handles & spokes)
Manchester	Manchester Manufacturing Co. (wagon stock)
Memphis	Kelsey Wheel Co.
Memphis	Gillette Bros.
Memphis	Memphis Carriage & Wagon Supply Co. (stock)
Memphis	Memphis Pioneer Pole & Shaft Co. (stock)
Memphis	Weis & Lesh Manufacturing Co.
Millington	D. C. Jennings (spokes)
Monterey	Standing Stone Manufacturing Co. (spokes)
Monterey	A. L. Saylor (spokes)
Morrison	Philpot Lumber Co. (vehicle stock)
Nashville	Hermitage Spoke Co.
Nashville	Rock City Spoke Co.
Newbern	Inman Bros. (vehicle stock)
Polk (Obion County)	Henry Blevins (spokes and handles)
Pulaski	Pulaski Rim & Spoke Co.
Smithville	E. J. Evans & Son (spokes)
Sparta	Sparta Spoke Factory
Tullahoma	M. R. Campbell (hubs and spokes)
Tullahoma	Campbell & Dann Mfg. Co. (wagon stock)
McKinney, Ky.	Columbia Singletree Co. (also spokes and neck-yokes)
Owensboro, Ky.	Owensboro Wheel Co.
Owensboro, Ky.	Carriage Woodstock Co.
Paducah, Ky.	Lack Singletree Co.
Paducah, Ky.	J. W. Little (spokes)
Scottsville, Ky.	J. W. Allen (spokes)

3. Tie, Pole, and Pile Producers and Buyers

Town	*County*	*Firm name*
Athens		Tennessee Tie & Lumber Co.
Bluff Point	Hickman	J. A. Ray & Son
Camden	Benton	J. C. Durden & Sons
Crab Orchard	Cumberland	Wilson & Wheeler
Crab Orchard	Cumberland	C. F. Willoughby
Chattanooga	Hamilton	Chattanooga Pole Co.
Chattanooga	Hamilton	Doran & Co.
Crossville	Cumberland	Cumberland Tie Co.

Town	*County*	*Firm name*
Dickson	Dickson	F. W. Crow
Jackson	Madison	Mississippi Valley Tie Co.
Johnson City	Washington	Valley Tie & Lumber Co.
Johnson City	Washington	Clinchfield Tie & Lumber Co.
Knoxville	Knox	Blue Ridge Tie Co.
Knoxville	Knox	Standard Tie Co.
Livingston	Overton	Valley Tie & Lumber Co.
Memphis	Shelby	Ayer & Lord Tie Co.
Nashville	Davidson	Davidson & McBride (poles)
Nashville	Davidson	Joyce-Watkins Co.
Nashville	Davidson	Nashville Tie Co.
Saltillo	Hardin	J. M. Gibbs
Stewart	Houston	Mitchell & Dunagan
Bowling Green, Ky.		Ayer & Lord Tie Co.
Louisville, Ky.		American Creosoting Co.
Louisville, Ky.		W. J. Hughes & Sons Co.
Louisville, Ky.		Ohio Valley Tie Co.
Paducah, Ky.		Ayer & Lord Tie Co.
Paducah, Ky.		Bartee Tie Co.
Paducah, Ky		Paducah Pole & Timber Co.
Paducah, Ky.		A. B. Smith Lumber Co. (piling and poles)
Chicago, Ill.		Chicago Mill & Lumber Co. (black locust poles, posts, and piling)
Chicago, Ill.		Lake Superior Piling Co.
St. Louis, Mo.		Berthold & Jennings Lumber Co. (piling, poles, and ties)
St. Louis, Mo.		Geo. M. Griffin (piling and poles)
St. Louis, Mo.		Hearne Timber Co.

In addition to the above, apply to local and outside railroads and electric roads, to telegraph and telephone companies, and to dock construction companies in large cities, for prices and specifications on ties, poles, and piling.

4. Veneer Mills

(Using logs and bolts)

Town	*Firm name*
Chattanooga	Consignees Favorite Box Co. (gum, pine, maple)
Cookeville	Cookeville Veneer Co. (gum, poplar, and maple)
Dandridge	G. B. and J. C. Williams (pine, poplar)
Dyer	Dyer Fruit Box Mfg. Co. (gum, poplar, elm, and sycamore)
Graysville	Graysville Fruit Package Co.
Greenfield	Ward-Kent Co. (gum)
Johnson City	American Cigar Box Lumber Co. (poplar)

Town	*Firm name*
Johnson City	Tennessee Veneer Co.
Knoxville	Knoxville Basket & Crate Co. (gum, maple, poplar)
Knoxville	Knoxville Veneer Co.
Memphis	Anderson-Tully Co. (gum, maple, poplar, cottonwood)
Memphis	Memphis Veneer & Lumber Co (white and red oak)
Sharon	J. E. Edwards (gum)
Trezevant	Ware & Goodwin (gum)
Trimble	Sharon Veneer Co. (gum)
Burnside, Ky.	Chicago Veneer Co. (oak, poplar)
Hickman, Ky.	Mengel Box Co. (gum)
Louisville, Ky.	Louisville Veneer Mills (oak and poplar)
Louisville, Ky.	Kentucky Veneer Works (gum and poplar)
Louisville, Ky.	Southern Veneer Manufacturing Co. (white oak)
Paducah, Ky.	Paducah Box & Crate Co. (gum)
Cincinnati, Ohio	Maley, Thompson & Moffet Co. (oak)
Cincinnati, Ohio	Talbert-Zoller Lumber Co. (oak)
Evansville, Ind.	Evansville Dimension Co. (gum, oak, elm)
Indianapolis, Ind.	Indiana Veneer & Lumber Co. (oak)
Indianapolis, Ind.	Indianapolis Sawed Veneer Co. (oak)
Indianapolis, Ind.	National Veneer & Lumber Co. (oak)
Indianapolis, Ind.	Gemmer Veneer & Lumber Co. (oak)
New Albany, Ind.	Wood Mosaic Co. (oak)
New Albany, Ind.	Roberts & Conner (oak, walnut, cherry, etc.)
Cairo, Ill.	Singer Manufacturing Co. (walnut, oak, gum)
Mound City, Ill	Portsmouth Veneer & Panel Co. (oak,poplar,gum)
St. Louis, Mo	St. Louis Box & Basket Co.(oak,gum,cottonwood)
Sheffield, Mo.	Penrod Walnut & Veneer Co. (walnut and oak)

5. Slack Cooperage Plants

(Using Logs and Bolts)

County	*Town*	*Firm name*
Tennessee		
Bedford	Nashville	Welch Stave & Heading Co. (oak, etc.)
Davidson	Shelbyville	Caldwell Stave Co. (elm, beech, oak)
Dickson	White Bluffs	Hunter & Ashton (oak)
Dickson	White Bluffs	Graham Stave Co. (oak)
Dickson	White Bluffs	Turnbull Stave Co. (oak)
Dickson	Spencers Mill	Luther Bros. (oak)
Dickson	Cumb. Furnace	J. T. Peeler (oak)
Dickson	Burns	M. J. Lampley (oak)
Dickson	Vanleer	Frank H. Stone (oak)
Dyer	Dyersburg	Dyersburg Hoop Co. (elm hooks)

County	*Town*	*Firm name*
Tennessee		
Dyer	Dyersburg	Fields-Rupe Stave Co. (gum, elm, maple, ash, cottonwood, sycamore)
Dyer	Mengelwood	Mengel Box Co. (gum, cottonwood)
Fayette	Moscow	Moscow Cooperage & Lbr. Co. (gum)
Franklin	Sherwood	Gayer Lime & Mfg. Co. (all kinds)
Hickman	Bon Aqua	W. M. Dudley & Son
Henry	Paris	Paris Lumber Co. (gum, poplar, sycamore)
Houston	Erin	V. R. Harris (oak)
Houston	Erin	E. W. Raucher (oak, gum, etc.)
Houston	Stewart	Mitchell & Dunagan (oak)
Lake	Tiptonville	Park-Davis Stave Co. (gum, elm, ash, cottonwood, sycamore)
Lawrence	Napier	J. J. Jensen & Co. (oak, etc.)
Lawrence	Loretta	Green Bros. (oak, hickory, hoops)
Lincoln	Elora	C. E. Murry (oak)
Maury	Mt. Pleasant	Tennessee Cooperage Co. (oak, chestnut, poplar)
Montgomery	Palmyra	J. W. Wickam (oak hoops)
Montgomery	Louise	E. D. Lewis & Son (oak, etc.)
Obion	Rives	Obion Cooperage Co. (oak, maple, beech, poplar gum)
Obion	Obion	H. Forcum & Co. (all kinds)
Rutherford	La Vergne	J. S. Griggs (elm and chestnut hoops)
Shelby	Memphis	Memphis Stave Mfg. Co. (gum, cottonwood, etc.) (Anderson-Tulley Co.)
Shelby	Memphis	Tennessee Hoop Co. (elm hoops) (Anderson-Tully Co.)
Shelby	Memphis	W. P. Hall Stave Co. (cottonwood)
Smith	Rome	J. T. Green & Highers (hoops, elm, etc.)
Stewart	Indian Mount	W. E. McGregor (oak)
Williamson	Jingo	Advance Stave & Lumber Co. (oak)
Williamson	McMinnville	Welling Bros. (elm hoops)
Wilson	Watertown	S. H. Flippen & Co. (elm hoops)
Kentucky		
Allen	Scottsville	J. D. Read & Co.
Allen	Hopkinsville	Forbes Manufacturing Co.
Allen	Paducah	Sherrill-King Mill & Lumber Co.
Fulton	Hickman	A. P. Mills
Illinois		
	Metropolis	H. Rampendahl, Jr., & Co. (gum, etc.)
	Mound City	Reed Manufacturing & Box Co.

County	Town	Firm name
Missouri		
	New Madrid	New Madrid Hoop & Lumber Co.
	New Madrid	Modern Cooperage Co.
	Caruthersville	Caruthersville Cooperage Co.
	Cape Girardeau	George McBride

6. Pulp and Excelsior Plants

(Using bolts)

Town	Firm name
Bristol, Tenn.	Columbian Paper Co.
Buena Vista, Va	Columbian Paper Co.
Burnside, Ky.	Burnside Excelsior Co.
Cleveland, Tenn.	Cleveland Excelsior Co.
Jackson, Tenn.	Patton-Black Mfg. Co. (willow, poplar, cottonwood)
Knoxville, Tenn.	Knoxville Coffin Co. (basswood and buckeye)
Knoxville, Tenn.	Knoxville Excelsior Mattress Co. (poplar, pine)

7. Tanbark and Extractwood Plants and Users

County	Town	Firm name
Blount	Maryville Tenn.	Sprinkle & Son
Blount	Walland	The Schlosser Leather Co.
Campbell	Jellico	Elk Valley Tannery
Carter	Watauga	Beggs & Coff
Cocke	Newport	Unaka Tanning Co.
Coffee	Tullahoma	J. N. Tipps
Davidson	Nashville	Marsh Collar & Harness Co.
Green	Greenville	The Greenville Tannery
Hamblen	Morristown	Morristown Oak Leather Co.
Hamilton	Chattanooga	Robert Schloze Tannery
Hamilton	Chattanooga	Union Tanning Co.
Knox	Knoxville	Southern Extract Co.
Lincoln	Fayetteville	W. J. Landers & Co.
Roane	Harriman	American Oak Leather Co.
Sumner	Gallatin	A. L. Fry
Union	Maynardsville	L. M. Wallace
Washington	Johnson City	Union Tanning Co.
Washington	Johnson City	Watauga Tannery
	New Decatur, Ala.	American Oak Leather Co.
	Middlesboro, Ky.,	Union Tanning Co.

8. Handle Factories

(Using logs and bolts—mostly hickory and some ash, white oak, and dogwood)

Town	*County*	*Firm name*
Baxter	Putnam	J. A. Isbell (hickory)
Caney Springs	Marshall	Turner-Day-Woolworth Handle Co.
Cookeville	Putnam	E. J. Greggory Handle Works (hickory)
Chattanooga	Hamilton	Dixie Logging Tool Co. (hickory)
Crockett	Obion	Turner-Day-Woolworth Co. (hickory)
Dickson	Dickson	A. H. Leathers Handle Co. (hickory)
Fowlkes	Dyer	Fowlkes Handle Co. (hickory)
	Hickman	S. H. Hinson (hickory)
Jackson	Madison	The Anchor Block Mills (hickory)
Lynnville	Giles	Turner-Day-Woolworth Handle Co.
Memphis	Shelby	The Hartsell Handle Co. (hickory)
Memphis	Shelby	Turner-Day-Woolworth Handle Co.
Nashville	Davidson	Reuther Scranton Handle Co.
Nashville	Davidson	Nashville Spoke & Handle Co. (hickory)
Nashville	Davidson	Turner-Day-Woolworth Handle Co.
Sequatchie	Marion	Sequatchie Handle Works (hickory)
South Berlin	Marshall	Turner-Day-Woolworth Handle Co. (hickory)
Kentucky		
Bowling Green	Warren	Turner-Day-Woolworth Handle Co.
Princeton	Caldwell	Turner-Day-Woolworth Handle Co.
Scottsville	Alden	Turner-Day-Woolworth Handle Co.
Missouri		
Caruthersville		Geo. C. Peattie
Dexter		I X L Handle Manufacturing Co.
Poplar Bluff		Hanna & Young Handle Co.
Illinois		
Cairo		Clark-Danforth Handle Co.
Cairo		Wm. Haas & Sons

9. Miscellaneous

(Using logs)

Town	*Firm name*
Algood, Tenn.	Algood Column Co. (small poplar logs)
Brownsville	E. B. Chester (hickory and ash)
Elizabethton	Empire Chair Co. (logs)
Jackson	Weis & Lesh Mfg. Co. (hickory and beech logs—butcher blocks and skewers)
Johnson City	Harris Mfg. Co. (oak logs)
Knoxville	Nickerson Mfg. Co. (small poplar logs)

Town	*Firm name*
Memphis	Anchor Boat Oar Co. (select ash & hickory logs)
Memphis	Oil Well Supply Co. (ash and hickory logs)
Memphis	E. G. Willingham (hickory)
Sparta	Sparta Colonial Column Co. (small poplar logs)

10. Shuttle Block Mills

(Using dogwood and persimmon)

Town	*County*	*Firm name*
Algood, Tenn.	Putnam	Speyer Lumber Co.
Brownsville	Haywood	E. B. Chester
Cookeville	Putnam	Dorman & High
Dickson	Dickson	J. Murchison
Harriman	Madison	Harriman Shuttle Block Co.
Hohenwald	Lewis	Hohenwald Block Mills
Jackson	Madison	Anchor Block Mills Co.
Maryville	Madison	Randolph Shuttle Block Mill
Memphis	Shelby	Anchor Boat Oar Co.
Decatur, Ala.		J. W. Reese

11. Users of Cedar

Town	*Firm name*
Chapel Hill	Cumberland Cedar Mills
Chattanooga (Alton Park)	Cedar Products Co.
Chattanooga	Hudson Lumber Co. (pencil stock), South Pittsburg, Tenn.
Christiana	Wm. Foerster & Co.
College Grove	Cox & Maney (also at Murfreesboro)
Johnson City	American Cigar Box Lumber Co.
Lebanon	Gulf Red Cedar Works (also at Waterhill)
Lebanon	Thos. J. Dye & Son (cedar posts)
Lewisburg	American Lead Pencil Co.
Lewisburg	Houston & Liggett
Murfreesboro	R. P. Wilson Red Cedar Works
Murfreesboro	W. T. Bruer & Son (cedar products) (also at Nashville)
Nashville	F. & O. Cedar Works
Nashville	Myers Manufacturing Co.
Nashville	J. B. Ransom & Co.
Nashville	J. P. Meredith Cedar Co. (also at Lebanon)
Shelbyville	Cumberland Cedar Mills (pencils)
Shelbyville	Cumberland Cedar Works
Shelbyville	Landers & Co. (cedar posts, poles, pencils)
Shelbyville	Ransom & Frierson (cedar posts, poles, pencils)
Smyrna	W. T. Bruer & Son (cedar products)
Smyrna	W. B. Coleman (cedar posts)
Smyrna	Pruitt & Hibbett (cedar posts)

12. Buyers of Black Walnut Logs

State	*Town*	*Firm name*
Alabama	Mobile	N. W. Dunlap (exporter)
Illinois	Belvidere	National Sewing Machine Co.
	Cairo	Singer Manufacturing Co.
	Chicago	R. S. Bacon Veneer Co.
	Kankakee	Foley & Williams
	Rockford	Illinois Sewing Machine
	Chicago	C. L. Willey
	East St. Louis	East Saint Louis Walnut Co.
Indiana	Fort Wayne	Hoffman Bros. Co.
	Indianapolis	Indiana Veneer & Lumber Co.
	Indianapolis	The Talge Mahogany Co.
	Lawrenceburg	Batesville Lumber & Veneer Co.
Kentucky	Lexington	Headley Lumber Co. (exporters)
Maryland	Baltimore	Williamson Veneer Co.
Louisiana	New Orleans	Schut & Kiehn (exporters)
Missouri	East St. Louis	East Saint Louis Walnut Co.
	Kansas City	Pickerel Walnut Co.
	St. Louis	Penrod Walnut & Veneer Co.
North Carolina	Lenoir	Lenoir Veneer Co.
Ohio	Cincinnati	The Ohio Veneer Co., 2624 Colrain Ave.
	Dayton	H. C. Hossafores
	Piqua	George W. Hartzell
Pennsylvania	Philadelphia	A. H. Fox Gun Co.
Tennessee	Concord	P. W. Bevins
	Knoxville	Vestal Lumber & Mfg. Co.
	Knoxville	R. J. Denton
	Memphis	Penrod-Jurden & McCowan
	Memphis	May Brothers
	Memphis	A. C. Franck
	Nashville	J. B. Ransom & Co.

13. Tennessee Tight Cooperage Plants and Dealers

(Using logs, bolts, and billets of white and red oak)

CAMPBELL COUNTY

Town	*Firm name*	*Main office*
Cupp	Wilkerson & Early	
Morley	Valley Creek Lumber Co.	Rochester, N. Y.
Westbourn	A. R. Humble	Somerset, Ky.
	C. G. Steele	London, Ky.

CARROLL COUNTY

Huntingdon	F. Priest & Son	
Westport	J. H. McCall (idle)	

Town	Firm name	Main office
	CUMBERLAND COUNTY	
Crossville	Jos. Deters & Son	
	DAVIDSON COUNTY	
Nashville	I. F. McLean	McLean Mfg. Co.
Nashville	Chess & Wymond Co	Louisville, Ky.
	DICKSON COUNTY	
Dickson	R. K. Nicks	
Dickson	Interstate Cooperage Co	719 Hickox Bldg. Cleveland, Ohio
Tenn. City R. D. 2.	W. A. Franklin	
Vanleer	F. H. Stone	
	DYER COUNTY	
Dyersburg	N. W. Calcutt Co	
	GIBSON COUNTY	
Eaton	Harlan-Morris Co.	Trenton, Tenn.
Rutherford	Barton Bros. & Co	Harlan-Morris
Trenton	Harlan-Morris Co.	
Trenton	Gibson County Gin Co	
	GRUNDY COUNTY	
Coalmont	Christian Kopp	Altamont, Tenn.
Altamont	I. F. McLean	
	HAMILTON COUNTY	
Chattanooga	Interstate Cooperage Co.	
Chattanooga	Chattanooga Stave & Cooperage Co.	Consol. Cooperage Co., Inc.
	HAYWOOD COUNTY	
Brownsville	F. H. Valterman	
Shepp	F. H. Valterman	
Stanton	F. H. Valterman	
	HENDERSON COUNTY	
Juno	J. H. Holmes	
	HENRY COUNTY	
	L. W. McGehee (idle)	Hazel, Ky.

HICKMAN COUNTY

Town	*Firm name*	*Main office*
(Near Centerville)	A. L. Hayes & Co.	Centerville
	I. F. McLean (?)	
Goodrich	J. W. Simpson (idle)	Waverly
Littlelot	T. B. Tatum	
Lyles	W. I. Tatum (idle)	

HOUSTON COUNTY

Stewart	J. R. Jones & Co.	
Erin, R. D. 1	W. J. Clark	

HUMPHREYS COUNTY

McEwen	Patterson & Cowen	
Tennessee City (Dickson County)	S. W. Taylor & Co.	
Waverly	E. E. Wollam	
Waverly	Ridings & Turner	

LAKE COUNTY

Ridgeley	N. W. Calcutt	Dyersburg

MCNAIRY COUNTY

Ramer	Harlan-Morris Co.	Trenton

MADISON COUNTY

Jackson	W. H. Coleman Co.	

MAURY COUNTY

Mt. Pleasant	Tennessee Cooperage Co. (idle)	

MORGAN COUNTY

Deer Lodge	Rugby Stave & Lumber Co.	

OVERTON COUNTY

Hanging Limb	Welch Stave & Heading Co.	
Livingston	J. C. Brilbrey Spoke Co.	
Livingston	I. F. McLean	
Livingston	J. R. Hogue	
Rickman, R. D.	Smith & Marlow	
Livingston	J. G. Eastland	
	Laurel Creek Stave & Lumber Co.	
Wirmingham	William Parks	

PUTNAM COUNTY

Town	*Firm name*	*Main office*
Cookeville	J. W. Scott	
Monterey, R. D.	Johnson Bros.	

SCOTT COUNTY

Town	*Firm name*	*Main office*
Huntsville	W. H. Potter	
Oneida	Crescent Stave Co.	

SEQUATCHIE COUNTY

Town	*Firm name*	*Main office*
	Frazier & Hunt	Tatesville

SHELBY COUNTY

Town	*Firm name*	*Main office*
Memphis	Chickasaw Cooperage Co.	
Memphis	Interstate Cooperage Co.	719 Hickox Bldg. Cleveland, Ohio
Memphis	Kennedy Heading Co.	

STEWART COUNTY

Town	*Firm name*	*Main office*
Big Rock	Harris & Cherry	

WEAKLEY COUNTY

Town	*Firm name*	*Main office*
Dresden	Shannon & Loyd	
Greenfield	Stout Bros.	
Sharon	Coats, Malone & Co.	

WILLIAMSON COUNTY

Town	*Firm name*	*Main office*
Franklin, R. D.	I. F. McLean	

14. Wood-using Firms in Tennessee Using Sawed Lumber

(Chiefly of firms consuming over one-half million feet a year)

Town	*Firm name*
Alton Park (near Chattanooga)	Chattanooga Bottle & Glass Mfg. Co. (boxes)
Athens	Athens Planing Mill
Athens	Athens Table Mfg. Co.
Athens	J. A. Royle
Bristol	Bristol Coffin Co.
Bristol	Bristol Door & Lumber Co.
Bristol	Paxton Lumber Co.
Bristol	Peter-McCain Lumber Co.
Bristol	Stone-Huling Lumber Co.
Camden	Hudson & Durdin
Centreville	T. S. Colley's Sons

Town	*Firm name*
Chattanooga	Chattanooga Box & Lumber Co.
Chattanooga	Acme Box Co.
Chattanooga	Chattanooga Wagon Co.
Chattanooga	Chattanooga Lumber Co.
Chattanooga	Consignees Favorite Box Co.
Chattanooga	Chattanooga Coffin & Casket Co.
Chattanooga	Chattanooga Furniture Co.
Chattanooga	King-Baxter Lumber Co.
Chattanooga	Hunt Spring Bed Co.
Chattanooga	The Odorless Refrigerator Co.
Chattanooga	Tennessee Coffin & Casket Co.
Chattanooga	Union Lumber Co.
Chattanooga	Lookout Planing Mill.
Clarksville	Sewanee Lumber Co.
Cleveland	Barnes Manufacturing Co.
Cleveland	Cleveland Coffin & Casket Co.
Cleveland	W. S. Mulne (furniture)
Cleveland	Marshall Planing Mill
Clinton	The T. H. Leinart Co.
Columbia	Vaughn Manufacturing Co.
Cookeville	Crawford, Lowe & Qualls
Decherd	S. P. Bruner & Son
Dickson	Dickson Planing Mill Co.
Dyer	Hearn Lumber Co.
East Chattanooga	H. J. Judd & Co. (curtain poles)
Elizabethton	Empire Chair Co.
Elizabethton	Star Planing Mill
Franklin	W. J. Beasley
Franklin	Craig Lumber Co.
Franklin	Southern Bros.
Gallatin	S. D. Simpson & Son
Greeneville	Greeneville Chair Co.
Greeneville	Greeneville Furniture Co.
Harriman	Stowers Lumber & Mfg. Co.
Harriman	Harriman Mfg. Co. (agricultural implements)
Harriman	Dame Mantel Co.
Hohenwald	Hohenwald Planing Mill & Brick Mfg. Co.
Huntington	Wilder & Leach
Jackson	Budde-Lindsay Mfg. Co. (fixtures)
Jackson	Southern Seating & Cabinet Co.
Johnson City	Sella Lumber & Mfg. Co.
Johnson City	Exum Furniture Co.
Johnson City	Harris Mfg. Co. (also agric. implements)
Johnson City	Tenn. Box. Co. (low-grade pop. logs and lumber)
Knoxville	American Mantel Mfg. Co.
Knoxville	C. B. Atkins Co. (furniture)

Town	*Firm name*
Knoxville	Broadway Mfg. Co.
Knoxville	Chavannes Lumber Co.
Knoxville	F. B. Cooley & Son
Knoxville	Holston Box & Lumber Co.
Knoxville	Hall & Donahue Coffin & Casket Co.
Knoxville	H. L. Ingles Mantel Co.
Knoxville	Knoxville Coffin Co.
Knoxville	Knoxville Basket & Crate Co.
Knoxville	Knoxville Lumber Co.
Knoxville	The Proctor Furniture Co.
Knoxville	D. M. Rose Lumber Co.
Knoxville	Ross Lumber Co.
Knoxville	Tennessee Mantel Manufacturing Co.
Knoxville	Whittle Trunk & Bag Co.
Lafayette	Brown-Hunt Co.
Lafayette	Freeman Mill Co.
Lebanon	Wilson County Planing Mill Co.
Lenoir City	Electric Lumber Co.
Lewisburg	Sanders Bros. & Co.
Lexington	T. Edwards
Loretto	Meiers, Augustin & Co.
Lynnville	Lynnville Lumber Co.
McMinnville	McMinnville Spoke & Lumber Co.
Madisonville	J. R. Burllason
Madisonville	Madisonville Chair Co.
Martin	City Lumber Co.
Maryville	Bittle & Hufstetler Co.
Maryville	Cherokee Manufacturing Co.
Maryville	Southern Coffin & Casket Co.
Maryville	G. N. Mize
Memphis	Anderson Tully Co. (boxes)
Memphis	Cole Manufacturing Co.
Memphis	Dugger & Goshorn Co. (agric. implements)
Memphis	Darnell-Taenzer Lumber Co.
Memphis	Florence Pump & Lumber Co.
Memphis	George O. Friedel Lumber & Manufacturing Co.
Memphis	James & Graham Wagon Co.
Memphis	Jorgsen Bennett Manufacturing Co.
Memphis	Lee Lumber Co.
Memphis (south)	Larkin Co. of America (chairs)
Memphis	Memphis Coffin Co.
Memphis	Memphis Hardwood Flooring Co.
Memphis	Moore & McFerren
Memphis	Wabash Screen Door Co.
Memphis	Walden Braxton Manufacturing Co.
Memphis	York Manufacturing Co.

Town	*Firm name*
Monterey	Monterey Planing Mill Co.
Morristown	I. P. Fort Co.
Morristown	Johnson-Baker-Donaldson Chair Co.
Murfreesboro	Perkins-Crichlow Co.
Murfreesboro	Williams Bros.
Nashville	The Davidson, Hicks & Greene Co.
Nashville	Home Building & Manufacturing Co.
Nashville	George Moore & Sons
Nashville	G. O. Kirkpatrick & Sons
Nashville	Lieberman, Loveman & O'Brien (boxes)
Nashville	Merchants Wire-bound Box Co.
Nashville	Nashville Hardwood Flooring Co.
Nashville	Southern Lumber & Manufacturing Co.
Nashville	Standard Furniture Co.
Nashville	Tennessee Oak Flooring Co.
Nashville	White Trunk & Bag Co.
Newcomb	Newcomb Manufacturing Co.
Newport	McCabe Lumber Co.
Portland	Portland Planing Mill Co.
Pulaski	J. M. Patterson & Son
Pulaski	T. W. Pittman & Co.
Sevierville	Sevierville Planing Mill Co.
Sparta	Carter & Potter
Sparta	East Sparta Planing Mill Co.
Springfield	Springfield Planing Mill Co.
Tellico Plains	Tellico River Lumber Co.
Tracy	Samuel Weaner
Tullahoma	The Anderson-Stegall Manufacturing Co.
Tullahoma	Greenfield-Talbot Furniture Co.
Viola	Mansfield-Bonner Co.
Waynesboro	Buchanan & Gower

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VOLUME VII NUMBER 4

THE RESOURCES OF TENNESSEE

A MAGAZINE DEVOTED TO THE DESCRIPTION, CONSERVATION AND DEVELOPMENT OF THE RESOURCES OF TENNESSEE

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THE RESOURCES OF TENNESSEE

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OCTOBER, 1917

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Looking down on the Eastern Highland Rim from the Cumberland Plateau

Structure of the Waynesboro Quadrangle with Special Reference to Oil and Gas*

TN 24 .T2 44

By Hugh D. Miser

INTRODUCTION

In the early nineties and in 1915 gas in small quantities was struck at shallow depths in two wells at Iron City, in the southeast corner of the Waynesboro quadrangle. This discovery, together with reported surface showings of oil and gas and with the search for new oil and gas fields, has raised the question in the minds of many people as to the possibility of the presence of commercial quantities of these substances in this quadrangle. A detailed study of the geology of the quadrangle, conducted in 1913 and 1914 by the writer with the assistance in 1913 of Dr. N. F. Drake, Dr. Bruce Wade, and Mr. Olaf P. Jenkins, revealed the presence of several domelike or anticlinal folds, a type of structure that is one of the conditions favorable for the accumulation of oil and gas. A description of these folds and a discussion of the possibilities of finding oil and gas in paying quantities are given in this report.

TOPOGRAPHY

The Waynesboro quadrangle is a little west of south-central Tennessee and includes nearly all of Wayne County and narrow strips of the adjoining counties of Hardin, Perry, Lewis, and Lawrence. It also includes a narrow strip of Lauderdale County, Alabama. It embraces a part of the Highland Rim, which is a dissected plateau. The part so embraced in the quadrangle varies in different places

*The field work in this area was done under a coöperative agreement between the State Geological Survey and the U. S. Geological Survey, the latter bureau being represented by Mr. Miser. This paper is published by permission of the Director of the U. S. Geological Survey. A preliminary report by Dr. N. F. Drake was published in 1914 in vol. 4, no. 3 of the Resources of Tennessee. The detailed report is now in course of preparation by the present writer.

from 750 to 1,050 feet above sea level and is extensively dissected by stream valleys which are usually 100 to 300 feet deep below the plateau surface. The principal streams as well as many of the smaller ones are shown on the accompanying map.

The area is sparsely populated. The chief occupations are iron mining, lumbering, and agriculture.

The Florence & Sheffield Branch of the Louisville & Nashville Railroad traverses the southeast corner of the quadrangle passing through St. Joseph and Iron City. Another branch of this railroad runs from Iron City through Wayland Springs and West Point to Pinkney. The Tennessee Western Railroad runs from Iron City to Collinwood. The Centerville Branch of the Nashville, Chattanooga & St. Louis Railway enters the northeast corner of the area and extends as far as Allens Creek. Tennessee River, which crosses the northwest corner of the area, is navigated by river steamers.

GEOLOGY

STRATIGRAPHY

The exposed rocks of the Waynesboro quadrangle are all of sedimentary origin and consist predominantly of limestone, though beds of shale, chert, sandstone, gravel, and sand are found. They are of Ordovician, Silurian, Devonian, Carboniferous, Cretaceous, and Quaternary age. Their sequence and general character and distribution are given in the following generalized section:

Generalized section of rocks in the Waynesboro quadrangle

QUATERNARY SYSTEM

Alluvium, 35+ feet thick; gravel and loam in narrow strips along most streams.

Terrace deposits, 35+ feet thick; gravels overlain by loam; occurs in patches along Tennessee and Buffalo rivers.

CRETACEOUS SYSTEM

UPPER CRETACEOUS SERIES

Eutaw formation, 50 feet thick; red fossil-wood-bearing sand on ridges in southwest quarter of quadrangle.

Tuscaloosa formation, few feet to 150 feet thick; gravel on ridges in all parts of quadrangle but in greatest quantity in southwest quarter.

CARBONIFEROUS SYSTEM

MISSISSIPPIAN SERIES

St. Louis limestone, 50 to 200 feet thick; cherty, gray limestone overlain almost everywhere by thick, residual mantle of clay and chert; has larger surface distribution than any other formation.

Fort Payne chert, 100 to 200 feet; composed of dense, black chert and platy, gray shale but mainly of dark, calcareous chert that changes on slopes to soft, yellow, platy, porous chert; contains some crinoidal limestone in southeast part of quadrangle; exposed on hill slopes in all parts of area.

Ridgetop shale, 0 to 90+ feet thick; composed of dark, platy shale in northern and western parts of quadrangle; beds of apparently the same age in the southeast part are green siliceous shale and thin and thick beds of cherty gray crinoidal limestone. Maury glauconic member, which in places is platy shale and in others sandstone, is at base; dark, phosphatic nodules common; 0 to 2 feet thick.

DEVONIAN SYSTEM

UPPER DEVONIAN SERIES

Chattanooga shale, 0 to 37 feet thick; black shale from a feather edge to 22 feet thick; widely distributed but less so than the basal member, the Hardin sandstone, which is composed of rather fine-grained, gray, massive sandstone and which is from 0 to 15 feet thick.

MIDDLE DEVONIAN SERIES

Pegram limestone, 0 to 5⅝ feet thick; granular, gray, crinoidal limestone in small area on Mill Creek near Forty-eight post office.

LOWER DEVONIAN SERIES

Linden formation, 0 to 55 feet thick; gray, granular limestone in places; in others cherty, sandy limestone; present only in northwest part of quadrangle.

SILURIAN SYSTEM

Decatur limestone, 0 to 60 feet thick; massive, light-gray to bluish-gray, granular to dense limestone; present only on west side of quadrangle.

Brownsport formation

Lobelville shaly limestone member, 0 to 62 feet thick; shaly limestone containing large coral fauna; present only on west side of quadrangle.

Bob crystalline limestone member, 0 to 35 feet thick; massive, crystalline, gray limestone; present only in northern and western parts of quadrangle.

Beech River shaly limestone member, 0 to 84 feet thick; shaly, fossiliferous, cherty limestone; present only in northern and western parts of quadrangle.

Wayne formation

Dixon early limestone member, 0 to 45 feet thick; earthy limestone; red near Clifton but greenish gray to the east and southeast; exposed in all except southwest parts of quadrangle.

Lego limestone member, 0 to 36 feet thick; compact pinkish and bluish-gray limestone; exposed in all except southwest parts of quadrangle.

Waldron clay member, 0 to 5 feet thick; fossiliferous, indurated, gray though less often pink clay, near middle of which is thin, persistent limestone layer; exposed in all except southwest parts of quadrangle.

Laurel limestone member, 0 to 32 feet thick; sompact, pinkish and bluish-gray limestone; exposed in all except southwest parts of quadrangle.

Osgood earthy limestone member, 0 to 17 feet thick; thin-bedded, earthy limestone; red at and near Clifton and Iron City but gray elsewhere; exposed in all except southwest parts of quadrangle.

Brassfield limestone, 1 to 25 feet thick; even-bedded, finely crystalline, gray limestone containing glauconite; exposed in northern and southeastern parts of quadrangle.

ORDOVICIAN SYSTEM

UPPER ORDOVICIAN SERIES

Fernvale formation, 20 to 40 feet thick; the lower half is phosphatic gray limestone; the upper, green shale. Exposed in northern and southeastern parts of quadrangle.

Arnheim limestone, 0 to 3 feet thick; cherty, gray limestone; exposed only at Clifton.

Leipers limestone, 0 to 75+ feet thick; dark-bluish, fossiliferous limestone and a less amount of brown shale; exposed on Shoal Creek northeast of Wayland Springs.

MIDDLE ORDOVICIAN SERIES

(Cathey's limestone not known to be present.)

Bigby limestone, 0 to 45 (?) feet thick; light-gray and dark-gray, fossiliferous limestone; not exposed but found in wells at Iron City.

Hermitage formation, 80+ feet thick; even-bedded, dark-bluish limestone in thin layers alternating with about same amount of dark, fissile shale; exposed only in northwest part of quadrangle.

STRUCTURE

General features.—The rocks of the Waynesboro quadrangle have been deformed but little since their deposition in a nearly horizontal position. Although they lie upon the southwest flank of the Nashville dome they have no marked dip to the southwest. They have been bent into numerous gentle but irregular anticlinal and synclinal folds. The general structure of the quadrangle is a dome whose highest part, as a whole, is in the center. The principal anticline which crosses the center of the quadrangle, has a northeastward trend parallel with that of the folds in the Appalachian region in East Tennessee and other states.

The rocks of the quadrangle are comparatively free from faults; only three have been observed.

Mode of representation.—The structure of the rocks is represented on the accompanying map, which shows contour lines on the deformed upper surface of the Chattanooga shale as determined by the outcrops of that shale and overlying formations. The Chattanooga, although thin, is one of the most widely exposed formations in the quadrangle and is one of the most easily recognized. The map does not necessarily represent exactly the structure of the other formations because most of them are not present everywhere and because even where they are present their thicknesses are not uniform. The relief of the deformed surface in any portion of the quadrangle is shown by the contour lines on the map, which represent intervals of 50 feet, the numbers showing elevations above the sea.

Anticlines and domes.—The Collinwood anticline, named from Collinwood which is near its axis, is by far the most pronounced fold in the Waynesboro quadrangle. It extends from near Powells Mill in the southwestern part of the area, northeastward across the center of the quadrangle, terminating in the northeast corner of Wayne County and the northwest corner of Lawrence County. It is irregular in shape, and the more prominent irregularities are here mentioned. One prong near Ovilla trends eastward, another prong that is southwest of Allens Creek trends northward, and another, though lower, prong which is later described as the Wayland Springs anticline runs southeastward to the southeast corner of the quadrangle. The highest part is southwest of Allens Creek; there the elevation of the Chattanooga shale exceeds 800 feet above sea level. This part also contains the oldest exposed rocks. These rocks belong to the Fernvale formation and are exposed along Blowing Spring Branch, a tributary of Forty-eight Creek. The dip away from the axis is in most places between 25 and 40 feet to the mile, but the northwest and southwest slopes of the anticline merge into minor anticlinal folds.

The Wayland Springs anticline which might be called a prong of Collinwood anticline is in the southeast part of the quadrangle. It trends in a southeast direction, merging to the northwest with the Collinwood anticline and terminating to the southeast near St. Joseph. Its highest part is a low nearly circular domelike area on Shoal Creek and the lower course of Factory Creek just northeast of Wayland Springs. This part is steepest on the northeast side where the dip is 100 feet in half a mile. The oldest rocks revealed by erosion on its crest belong to the Leipers limestone. Another but smaller dome occupies the crest of the anticline 3 miles south of west of West Point. The oldest rocks exposed on it belong to the Wayne formation. Two wells drilled at Iron City on the southwest slope of the anticline obtained a small flow of gas from the Bigby and Hermitage formations. Descriptions of these wells are given on pages 207-212.

The Waynesboro anticline is L-shaped and culminates in two small domes, one of which is about a mile north of Waynesboro and the other about 1½ miles west of that place. Both domes are about the same height. Erosion has, however, cut deeper into the one than the other. The Osgood earthy limestone and higher members of the Wayne formation are the oldest exposed rocks on the crest of the dome north of Waynesboro, and the Chattanooga shale is the oldest exposed formation on the crest of the one west of that place.

A small dome, attaining an elevation of over 650 feet above sea level, is on the divide between Hardin and Flat Gap creeks, on the west side of the quadrangle. The oldest strata exposed on its crest belong to the Dixon earthy limestone member of the Wayne formation.

The Eagle Creek anticlines are south-southeast of Clifton and are between that town and Eagle Creek. Both are small but the one to the south is the higher. It trends in a northeast direction parallel with the course of Eagle Creek, which flows in a narrow syncline along the southeast side of the anticline. The other anticline trends

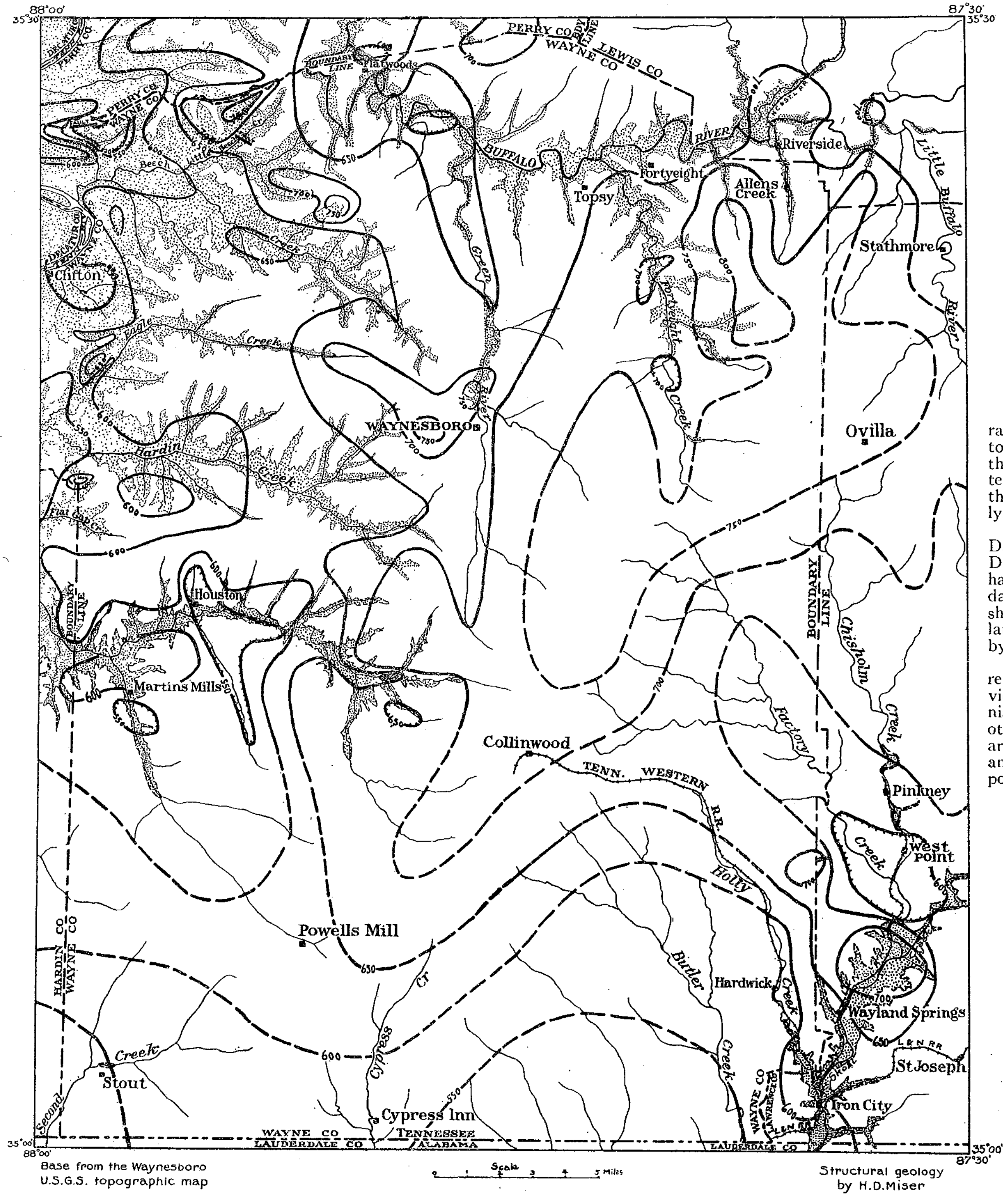

PLATE 1.

Map of Waynesboro quadrangle showing structure contours on the upper surface of the Chattanooga shale as determined by the outcrops of the Chattanooga and overlying formations.

Contour interval 50 feet. Datum is mean sea level. Depression contours are hachured. Contours are dashed where Chattanooga shale is deeply buried beneath later rocks. Faults are shown by heavy lines.

Dotted portions of map represent areas in which Ordovician, Silurian, and Devonian rocks are exposed; the other portions represent areas in which Carboniferous and Cretaceous rocks are exposed.

westward and is separated from the one to the south by a syncline. The oldest formation exposed on the crest of the higher anticline is the Hermitage while the oldest on the crest of the lower one is the Fernvale.

The crest of a dome or anticline, as indicated by excellent rock exposures along the right bank of Tennessee River, is located at the old cement furnace at the west edge of Clifton. This furnace is just west of the area shown on the accompanying map. A normal fault with a downthrow of about 75 feet on the west side apparently runs in a nearly northward direction across the crest a short distance west of the cement plant. East of the fault the Hermitage is the oldest exposed formation, while to the west of it the Brassfield limestone is the oldest. Owing to a lack of exposures north and south of this locality the extent of the dome or anticline in these directions is not known.

Three anticlinal folds are near Beech Creek in the northwest part of the quadrangle. One of these is on the west edge of the quadrangle north of the mouth of Beech Creek; it trends almost east and west. The second is just north of Little Beech Creek. It trends in a northeastward direction; is triangular in outline and reveals the Hermitage formation on its crest, which is occupied by the valley of a small tributary of Little Beech Creek. The third, of irregular shape, is on the divide between Beech Creek and Buffalo River, 4 miles west of south of Flatwoods. The highest part, which is at the east end, has been cut into by a small tributary of Beech Creek. The Hermitage is the oldest exposed formation on this tributary.

A number of other anticlines which are lower than the ones described above occur in the northern and western parts of the quadrangle. Among them are one just north of Martins Mill, one 3 miles north-northwest of Houston, one 2½ miles northeast of Clifton, one 6 miles nearly due east of Clifton, and one 3 miles east-northeast of Riverside. These are all shown on the accompanying map.

Basins.—Several basin-like or synclinal folds in the upper surface of the Chattanooga shale occur in different parts of the quadrangle, but most of them are along the larger streams. The relation of the structure to the drainage is more fully discussed under the next heading.

Relation of structure to drainage.—A striking relation between the drainage and the folds in the rocks is apparent from the accompanying map, but would probably be more so from a structure map with a much smaller contour interval than 50 feet. The drainage, which is radial from the central part of the quadrangle, is away from the axis of the Collinwood anticline, the principal anticline which, as above indicated, extends from near Powells Mill in a northeastward direction to the vicinity of Allens Creek and Strathmore. The divide between the drainings on the two sides of the anticline therefore coincides very closely with the axis of the anticline.

Many of the larger streams, including Factory, Indian, Hardin, Eagle, Beech, and Forty-eight creeks and Green and Buffalo rivers, flow partly or wholly in synclinal folds that occur on either side of the Collinwood anticline. On the other hand, Shoal Creek takes an unexpected course across a comparatively large dome, and Chisholm and Holly creeks do not bear any relation to the minor anticlinal or synclinal folds. As many of the larger streams occupy synclinal folds, most of their tributaries flow toward the axes of the synclines and thus with the dip of the rocks. The grade of the streams in many places is the same or nearly the same as the downstream dip of the rocks.

From the above it is obvious that the structure has in great measure controlled the courses of the streams.

OCCURRENCE OF OIL AND GAS

The Chattanooga and Ridgetop shales contain a small quantity of oil which may be detected by the odor of fresh pieces of the shale but they probably do not contain over a few gallons to the ton. The oil could be recovered only by mining the shale and distilling the oil from it, but its recovery would probably not be economical under present conditions unless the yield were well over 20 gals. to the ton of shale. Samples of the Chattanooga shale obtained at Bakers and Newsom, Tenn., near Nashville, contained from none to 9.1 gallons of oil and from 835 to 1,916 cubic feet of gas per short ton.[1] This shale near Hamburg, Tenn., about 15 miles west of the Waynesboro quadrangle, contains so much bituminous matter, including oil, that a large

[1]Ashley, G. H., Oil resources of black shales of the eastern United States: U. S. Geol. Survey Bull. 641, pp. 316-319, 1917.

pile of the fresh shale dumped at the edge of Tennessee River near that place caught on fire from spontaneous combustion and burned for about two months.*

Showings of oil and gas on the surface and in shallow wells are reported at a number of places in the northwest part of the quadrangle but the most noteworthy occurrences thus far discovered are in two wells at Iron City.

In 1892 or 1893 a well was drilled at that place to a depth of 315 feet where gas was struck. The flow of gas was so strong that it blew the drill out of the well, but it decreased enough in 2 or 3 days for the well to be capped without difficulty. The gas was burned at times for 2 or 3 months; but, as its utilization was not undertaken on account of the financial panic at the time, a poplar plug was driven deep into the well to prevent the escape of gas.† At the time of the writer's visit in 1914 the strong sulphur water that was encountered at a depth of 200 feet was being used for drinking. The sulphur water probably comes from near the base of the Bigby limestone and the gas probably came from the Hermitage formation.

A second well, known as the Seavy-Lull well, was begun in December, 1914, 300 feet west of the above-described well, but owing to a crooked hole it was abandoned March 1, 1915, after it had been drilled to a depth of 261 feet. Mr. E. L. Lull, a mining engineer, who had charge of the drilling, reports that an estimated flow of 5,000 cubic feet of gas per 24 hours with a rock pressure of about 20 pounds per square inch was obtained from the Bigby limestone at a depth of 182 to 205 feet. He also reports a trace of gas and oil from the Hermitage formation at and near the bottom of the well. A practically complete set of cuttings from the well was carefully saved by Mr. Lull and sent to the writer for examination. A few fragmentary fossils found in the cuttings were examined and reported upon by Mr. E. O. Ulrich. The record of the well follows:

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*Bowers, Paul C., An interesting case of spontaneous combustion: The Resources of Tennessee, vol. 6, pp. 37-40, 1916.

†This information was furnished the writer by the late Captain H. P. Seavy who was a prominent citizen of Iron City.

RECORD OF SEAVY-LULL WELL, IRON CITY, TENN.

[Engineer in charge, E. L. Lull; drillers, J. R. Wilson and F. P. Miller. Drilling begun December 11, 1914; well discontinued March 1, 1915. F[illegible]tion of top of well 565 feet above sea level.]

Age	Formation	Member	Sample No.	Depth (in feet) at which sample was obtained	Author's description of samples	Des[illegible] of rocks and remarks by engineer in charge
Quarternary	Alluvium					0-8 feet, alluvium
SILURIAN	Wayne formation	Laurel limestone member	1	8-10	Finely crystalline, gray limestone with pink spots, making limestone pinkish gray	Very hard limestone
			2	10-12	Same as sample No. 1	
		Osgood earthy limestone member	3	12-14	Red and greenish, compact, somewhat earthy limestone	
			4	14-18	Red, compact, somewhat earthy limestone	Very hard, shaly, red limestone
			5	18-20		
			6	20-23	Same as sample No. 4	Very hard red limestone; cherty layers
			7	23-26		Very hard brownish limestone; so called spathite
	Brassfield Limestone		8	26-29.5	Compact, light-gray limestone with glauconite grains	Very hard, siliceous limestone; little or no iron
SILURIAN or ORDOVICIAN	Brassfield Limestone or Fernvale Formation		9	29.5-33	Red limestone	Soft, red shale
ORDOVICIAN	Fernvale formation		10	33-35	Buff, calcareous, argillaceous material, probably shale	Green shale, probably phosphatic
			11	35-37.5	Greenish-gray, slightly phosphatic, sandy, argillaceous, highly calcareous material, probably impure limestone	Green shale
			12	37.5-39	Soft, calcareous, gray shale	
			13	39-44	Dark-gray, very impure limestone, containing much fine quartz sand	Green shale, probably arenaceous

Age and formation		Sample No.	Depth (in feet) at which sample was obtained	Author's description of samples	Description of rocks and remarks by engineer in charge
ORDOVICIAN	Fernvale formation	14	44-48	Slightly phosphatic, rusty, earthy limestone	Hard, brownish-yellow limestone
		15	48-51.5	Yellowish clayey, calcareous rock; probably shale with limestone streaks	
		16	51.5-55	Compact, light-gray, fossiliferous, slightly phosphatic limestone	Hard, gray limestone
		17	55-57	Light-gray, compact, phosphatic limestone	
	Leipers limestone	18	57-62	Gray calcareous shale	Soft, blue limestone and clay
		19	62-65	Gray earthy, calcareous material, probably shale	Blue limestone
		20	65-70	Gray earthy, calcareous material. It is calcareous shale or very earthy limestone	Very hard blue limestone
		21	70-72	Gray fossiliferous, slightly phosphatic limestone and gray shale	
		22	72-75	No sample	Fairly hard, blue limestone; shaly layers
		23	75-90	Dark-gray shale and finely crystalline, slightly phosphatic, fossiliferous gray limestone	Fairly hard, blue limestone
		24	90-100	Slightly phosphatic, dark-gray compact, fossiliferous limestone	
		25	100-105	Drab-colored, calcareous shale, containing some gypsum	Very hard, blue limestone
		26	105-110	Dark-gray, slightly phosphatic, fossiliferous limestone, containing some clayey matter	
		27	110-115	Same as sample No. 26	

Age and formation		Sample No.	Depth (in feet) at which sample was obtained	Author's description of samples	Description of rocks and remarks by engineer in charge
ORDOVICIAN	Bigby limestone (?)	28	115-120	Light-gray, slightly phosphatic limestone and dark-gray arenaceous shale	Soft blue shaly limestone
		29	120-125	Same as sample No. 28; fossils examined by E. O. Ulrich, who reports them as "probably older than Catheys"[a]	Fairly hard, impure, blue crystalline limestone
		30	125-130	Fine-grained, dark-gray, slightly phosphatic, fossiliferous limestone containing some argillaceous matter	
		31	130-135	Brown, slightly phosphatic, fossiliferous, somewhat earthy limestone; grain of medium size	Fairly hard, yellowish fine-grained, fossiliferous, crystalline limestone
		32	135-139	Brown, slightly phosphatic, earthy material, may be earthy ferruginous limestone	Hard, yellowish, fine-grained, fossiliferous, crystalline limestone
		33	139-143	Gray, slightly phosphatic, fossiliferous limestone of medium grain; some material contains considerable clayey matter	Very hard, coarse, fossiliferous, crystalline, grayish limestone
		34	143-145.5	Like sample No. 35, except no fossils were seen	Very hard, fine-grained, crystalline, grayish limestone
		35	145.5-150	Light-gray, moderately crystalline, slightly phosphatic, fossiliferous limestone	
		36	150-154	Light-gray and dark-gray, moderately crystalline, slightly phosphatic, fossiliferous limestone	Very hard, coarse, crystalline, grayish limestone
		37	154-160	Dark-gray, finely crystalline, slightly phosphatic, fossiliferous limestone and some shale	Very hard, bluish limestone

[a]The Catheys limestone where present in Tennessee is between the Bigby and Leipers limestones.

Age and formation	Sample No.	Depth (in feet) at which sample was obtained	Author's description of samples	Description of rocks and remarks by engineer in charge
ORDOVICIAN — Bigby limestone	38	160-165	Dark-gray, slightly phosphatic, calcareous, fossiliferous shale. Fossils examined by Ulrich	Very hard, bluish limestone
	39	165-170	Dark-gray, finely crystalline, phosphatic, fossiliferous limestone and black shale. Fossils examined by Ulrich	Very hard, bluish limestone; probably arenaceous
	40	170-173	Dark-gray, finely crystalline, slightly phosphatic limestone and slightly calcareous black shale. Fossils examined by Ulrich	Very hard, probably arenaceous bluish limestone; trace of gas
	41	173-179	Limestone like that in sample No. 40. Fossils examined by Ulrich	Very hard, fine-grained crystalline, bluish limestone; trace of gas
	42	179-182	Dark-gray, finely crystalline, slightly phosphatic limestone and slightly calcareous, black shale. Contains some pyrite	Verv hard, fine-grained, crystalline, bluish-gray limestone; trace of gas
	43	182-184	No sample	Very hard, fine-grained, crystalline, bluish-gray limestone containing pyrite. A strong flow of water highly charged with various salts, hydrogen sulphide, and probably natural gas. Estimated flow of water 500 gallons per hour rising 150 feet in well. Estimated flow of gas 5,000 cubic feet per 24 hours with rock pressure of about 20 pounds per square inch. Gas burns with bluish flame and gives off sulphur. From the well that was drilled 300 feet to the east I obtained several gallons of drillings that were washed in from the new well. This indicates that the flow of the water is to the east and opposite to the dip of the rocks
	44	184-189	Gray, slightly phosphatic, sandy pyritiferous limestone	
	45	189-191	Slightly phosphatic, gray, sandy, pyritiferous limestone	
	46	191-193	Slightly phosphatic, gray, sandy limestone	
	47	193-198	Gray, slightly phosphatic limestone	
	48	198-205	Gray, slightly phosphatic limestone	

Age and formation	Sample No.	Depth (in feet) at which sample was obtained	Author's description of samples	Description of rocks and remarks by engineer in charge
ORDOVICIAN Hermitage formation	49	205-205.7	Gray, calcareous shale	Soft, bluish-gray, shaly limestone[b]
	50	205.7-208.3	Gray, fossiliferous, fine-grained, slightly phosphatic limestone and gray shale	Hard, bluish-gray limestone
	51	208.3-210	Gray, sandy, pyritiferous, slightly phosphatic limestone	Hard, bluish-gray crystalline limestone
	52	210-215	Black, calcareous shale	Hard, bluish-gray, crystalline limestone
	53	215-219	Finely crystalline, dark-gray, slightly phosphatic, argillaceous, fossiliferous limestone	Very hard, bluish-gray limestone
	54	219-224	Same as sample No. 53 except no fossils were seen	Very hard, bluish-gray limestone; trace of gas
	55	224-228		
	56	228-230	Finely crystalline, light-gray and dark-gray, argillaceous, slightly phosphatic limestone	
	57	230-234	Same as sample No. 56 but shows fossils	Very hard, bluish-gray limestone; trace of gas and black oil
	58	234-240	Same as samples Nos. 60 and 64, but shows fossils	
	59	240-242	Fine-grained, slightly phosphatic, argillaceous limestone	
	60	242-248	Same as sample No. 64	
	61	248-250	Calcareous, argillaceous material, probably all shale	
	62	250-255	Calcareous, gray shale	
	63	255-259	No sample	
	64	259-261	Fine-grained, dark-gray, slightly phosphatic, limestone and slightly calcareous, gray shale	

bDrilling operations from the sulphur water down indicate a series of hard blue limestone beds of fairly uniform thickness separated by several inches of softer material.

ACCUMULATION OF OIL AND GAS

CONDITIONS OF ACCUMULATION

The conditions for the accumulation of oil and gas have been briefly but clearly stated by Dr. A. H. Purdue, the State Geologist, after whom the following is quoted.*

"The general conditions under which oil and gas occur are well known among geologists, and may be stated as follows:

1. There must be a source for the oil and gas.
2. There must be a reservoir to contain them.

"*The source of oil and gas.*—Concerning the origin of oil and gas, there are those who think they are formed by chemical reactions that take place within the earth, between different minerals; and those who think they are formed by reactions that take place as the result of organic matter in the rocks. Most geologists, perhaps all, use the latter as a working basis. That is to say, one of the first things they consider when a prospective new field is brought to their attention is whether or not any of the rocks beneath the surface ever contained a good supply of organic matter. If so, this fact, in so far as it goes, is encouraging. The organic matter was put down with the rock beds in which it occurs.

"There are those who believe that oil and gas were formed from the remains of animals that lived in the sea at the time the beds were put down; and others who think that they were formed from the remains of plants that grew in the water where the beds were formed, and still others who think the plants were washed in by streams. Plant remains in beds now being formed beneath water have both sources, and doubtless have had ever since there were plants on the earth. The reasonable supposition is that both have contributed to the formation of oil and gas. Likewise, any given reservoir of oil and gas might have had an animal origin or a plant origin, or it might have come partly from the one source and partly from the other.

"*The reservor.*—It is plain that oil and gas can not accumulate, either in large or small amounts unless the rocks are capable of receiving and holding them. To receive them, there must be cavities of some kind. These may be open spaces in coarse-grained rocks, or joints in fine-grained ones. The coarse-grained, porous rocks are usually sandstones or conglomerates, the former being composed of coarse grains of sand, and the latter at least largely, of gravel, cemented together. Rocks of this kind form the best reservoirs. As gas will move more freely than oil, a reservoir for gas may be in finer-grained rock than for oil. In the same way, a reservoir for very thin oil may be in finer-grained rocks than for thick oil. Sandstones and conglomerates are the com-

*Purdue, A. H., Oil and gas conditions in the Central Basin of Tennessee: The Resources of Tenn.; vol. 6, no. 1, pp. 4-8, 1916.

mon porous rocks, and so frequently are they the rocks from which oil and gas are delivered to the surface, that drillers in quest of these products are on the constant lookout for 'oil sands'; but they call any rock that yields oil a 'sand'.

"The fine-grained, or rather the close textured rocks that contain oil and gas, are limestones and shales. Water, like oil and gas, will flow through the coarse-grained sandstones and conglomerates, and many of these are the source of water supply. But if water in quantity is found in close textured limestone or in shale, it must come from joints. The same is true of oil and gas. Such rocks are not considered so desirable as sandstones, for reservoirs.

"Oil and gas nearly always occur in stratified rocks, by which is meant those that are in layers or beds. Igneous rocks are not in well defined layers and but few are known to contain oil and gas. The best conditions in rocks saturated with water, occur where the rock beds are bowed upward, forming anticlines. Where the rocks are dry, the oil tends to move down any possible slope and accumulate in the troughs or synclines. Hence in regions of saturated rocks, the anticlines are sought by experienced oil men, while in regions of dry rocks, synclines are sought. Since it is more common to find the rocks saturated than dry, attention is mainly directed to the anticlines.

"Another essential for a reservoir is that the open rock be covered with a 'tight' or close textured one, so as to seal the oil and gas in. Without such a covering, these elusive products will escape upward and be scattered through the overlying rocks in inappreciable amounts, or what is more probable in the case of gas, will be given off into the air above.

"It seems not improbable that nearly all stratified rocks originally contained organic matter that has produced more or less gas or oil, but if so, most of these have given up their products by dispersion to other rocks and to the atmosphere, from want of adequate sealing-in conditions. In the case of oil under such conditions, much of the gaseous matter has escaped from it, leaving asphalt and its kindred products, such as albertite, ozokerite, grahamite, and gilsonite.

"Yet another condition usually given as an essential for a reservoir, is that the open rock be underlain by a tight layer, like the overlying one, for the reason that oil or gas may be dissipated downward as well as upward.

"*Size of the reservoir.*—The size of the reservoirs in which oil and gas are stored may not be larger than a pea, or it may cover many square miles. Examples of the small ones may be found in many limestones, in which occur cavities filled or partly filled with petroleum. Such limestones are seductive, for they excite prospecting, but seldom yield oil in paying quantity. The cavities may be numerous and all may contain some oil, but they are not connected, and consequently there is no possibility of the oil flowing from one to another and finally into the drill hole, from which it can be pumped to the surface.

"Most of the large reservoirs are in sandstone, the storage space being composed of the infinite number of pores between the sand grains composing the rock. In fact each one of these small pores is a reservoir in itself, but they are all connected, and because of this the oil or gas will flow through the rock a limited distance to a drill hole. The actual distance through which it will flow varies, being short for small pores and low rock pressure, and comparatively great for large pores and high pressure.

"*Shape of the reservoir.*—Where folding is a factor in forming the reservoir, its shape depends upon that of the structural features. If in an anticline, and the anticline be dome shaped the outline of the reservoir will be circular; but if the anticline should be of the common, elongated kind, the reservoir will be more or less linear in outline. For this reason, geologists and experienced well drillers work out the structure and follow it, not only in trying out an undeveloped field, but if the rocks prove to be saturated with water, in extending it after a successful well has been drilled.

"But here the layman must be warned against making the common mistake of supposing that the bending of the rock layers conforms to the surface irregularities. The rock layers can not be supposed to bow upward where there are hills and downward where there are valleys. If they are not level, they perhaps more commonly bow downward in the hills as synclines and upward beneath the valleys as anticlines; or more commonly yet, they dip in one direction as monoclines. In the latter case, the hard rock layers occur in the ridges, and the soft ones in the valleys.

"*Angle of the rock beds.*—Folded rock beds may stand at any angle from near the horizontal to the perpendicular. The most desirable position for oil and gas is the one near the horizontal. This, for the reason that the lower the dip the wider the anticline and consequently the larger the field; and for the further reason that it is easier for the driller to put down a straight hole in rocks of low than of high dip. If the rocks dip as much as 20 degrees, it is difficult to drill a straight hole, especially if they consist of alternating beds of shale and sandstone or other hard rock. When the drill passes through a soft bed and strikes a high-dipping hard one, the tendency is for the bit to slip downward over the hard surface, and turn the hole away from the perpendicular. Yet, with care, an experienced driller can put down a straight hole in alternating beds of sandstone and shale that dip 20 degrees, or even more.

"*Horizontal reservoirs.*—There are reservoirs that consist of lenses of sandstone lying horizontal or nearly so, sealed up in beds of shale. In such cases, neither the geologist nor the driller can locate the reservoir, without drilling. It follows that the striking of such reservoirs with the drill is a matter of chance; and after such a reservoir is struck, its size can be determined only by the driller."

ACCUMULATION IN THE WAYNESBORO QUADRANGLE

As stated above the rocks of the Waynesboro quadrangle consist predominantly of limestone. Not only the limestone but some of the shale and chert are made up in large part of fossils. These fossils are the remains of animals that were buried in the sea while the sediments that later hardened into the rocks of this area were being laid down, and they may have been the source of much oil and gas. In addition the Chattanooga and Ridgetop shales contain carbonaceous matter that may have been a source of these substances. Although these sources may have furnished much oil and gas and although the domes and anticlines that are described above are a favorable type of structure for the accumulation of oil and gas, there appears to be, if we may judge from our present knowledge of the region, no porous reservoir that contains commercial quantities of these substances. There, however, is a possibility that oil and gas may be found in commercial but not relatively large quantities in cracks and crevices.

The rocks of Carboniferous and Cretaceous age are exposed over most of the surface of the quadrangle, and while those of Silurian and Devonian age are exposed over only a small part of the quadrangle they are exposed in most parts of it. Any large quantities of oil and gas that the rocks of Silurian, Devonian, Carboniferous and Cretaceous age may have once contained have therefore reached the surface and there escaped.

In Allen County, Kentucky, adjoining Tennessee, oil is found in porous dolomitic limestones of Silurian and Devonian age, which underlie the Chattanooga shale, the source of the oil. In the Waynesboro quadrangle the Chattanooga shale is usually so thin that it probably could not have been the source of very much oil. On the other hand, the rocks overlying and immediately underlying the Chattanooga are, as stated above, so widely exposed that if they were porous enough to retain oil they would not be likely to retain large quantities of it. The only bed that appears to be sufficiently porous is the Hardin sandstone member at the base of the Chattanooga shale.

Oil and gas if present in large quantities are thus more likely to have been retained in the Ordovician than in the younger rocks. As shown in the generalized section on pp. 208-212 the exposed rocks of this age are the Fernvale, Arnheim, Leipers, and Hermitage formations, named in order of their age with the youngest first.

The Fernvale formation is composed of shale in its upper part and of hard dense limestone in its lower part, and is exposed in the northwest, northeast, and southeast parts of the quadrangle. It is therefore not likely to contain much oil and gas even in the central, west-central, and southwest parts of the quadrangle where it is not exposed. In some parts of the area it might however be a seal to keep them from excaping upward from formations beneath. The shale in its upper part is thin and probably at no place exceeds 20 feet in thickness. The only known occurrence of the Arnheim limestone in the quadrangle is at an exposure on the right bank of Tennessee River at Clifton. The Leipers limestone contains some shale that might act as a seal for oil and gas but the interbedded limestone layers are not porous and hence could not hold much oil and gas even where the limestone is favorably situated for their accumulation and retention. The limestone is exposed in the southeast part of the quadrangle and would not now yield any oil and gas there if it ever contained them. It may underlie the northeast, central, and southwest parts of the quadrangle but it is absent in the northwest part. The Bigby limestone has been penetrated in the two wells at Iron City as above stated. A flow of gas estimated at 5,000 cubic feet per 24 hours with a rock pressure of 20 pounds per square inch is reported to have been obtained from the base of the Bigby in the last well drilled at that place. The gas may occupy fissures in the limestone but further drilling in the region seems necessary to prove this.

The Hermitage formation being composed of interbedded shale and limestone in about equal proportions, is probably the most impervious cap for oil and gas in the rocks of Ordovician age. If it should at any place be porous enough, it might yield paying quantities of oil and gas in the east half and southwest quarter of the quadrangle, but it could not be expected to yield these substances in those domes in the northwest part of the quadrangle that reveal the Hermitage on their crests. The exposed limestone layers in this formation are fine-grained and are not porous. They thus could not be the reservoir for any considerable quantity of oil and gas. Relatively small quantities of them may however be found in fissures. The flow of gas from the earlier-drilled well at Iron City and the trace of gas and oil from the later-drilled well at that place are from the Hermitage formation.

The Hermitage formation and Bigby limestone are of Trenton age. Rocks of this age are still looked upon with favor by many drillers because they are the rocks that supplied the northeastern Indiana and northwestern Ohio (Lima-Indiana) field which was in prominence 10 to 20 years ago. Such a view regarding the rocks of Trenton age in Tennessee is a mistake because they differ from those in the oil-producing parts of Indiana and Ohio. There the oil-producing limestones have been made porous by the process of the changing of the limestone to dolomite* whereas the limestones of Trenton age in Tennessee have undergone no such change.

Rocks of Ordovician age older than the Hermitage are not exposed in the Waynesboro quadrangle nor have they been penetrated in wells there. Their exact character is not known but they probably comprise the following formations named from the upper to the lower ones: Carters, Lebanon, Ridley, Pierce, and Murfreesboro limestone of Lower Ordovician age and the Knox dolomite, of Lower Ordovician and Upper Cambrian age. The Knox is a massive dense dolomite and is exposed in the Wells Creek basin in the southwestern part of Stewart County and in a large part of the Valley of East Tennessee. It is probably at least several hundred feet thick in the Waynesboro quadrangle and other parts of Central Tennessee. The Ordovician rocks above the Knox outcrop in the Central and Wells Creek basins and aggregate a thickness of approximately 800 feet. Those between the Knox and the Hermitage are close textured and contain no pores in which oil and gas may collect. They however contain joints in which oil may have accumulated.

The Ordovician rocks in the Central Basin have been penetrated in both deep and shallow wells at a number of places. Concerning the presence of oil and gas in them there Dr. A. H. Purdue says:†

> "There are numerous localities over the Central Basin where a small amount of gas and some oil have been sealed in, and these are not infrequently struck in drilling for water. But the oil is insignificant in amount where it occurs at all, and the gas usually exhausts after a

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*Orton, Edward, The Trenton limestone as a source of petroleum and natural gas in Ohio and Indiana: U. S. Geol. Survey, Eighth Ann. Rept., pt. 2, pp. 582-587, 1889.

†Purdue, A. H., Oil and gas conditions in the Central Basin of Tennessee: The Resources of Tennessee, vol. 6, p. 12, 1916.

few days' flow. The greatest supply of gas they could be expected to furnish would be for private use, such as heating a residence, or a kitchen range. In most cases, the supply would be too small to justify the necessary piping even for one of these purposes."

CONCLUSION

From the foregoing there appears to be no great possibility of finding oil and gas in paying quantities in the Waynesboro quadrangle unless they be found in fissures in the rocks. If they occur in fissures their yield would probably be relatively small and their occurrence sporadic. The prospecting that is to be carried on should be done on or near the crests of the domes and anticlines described above. The possibility of finding oil and gas in the rocks above the Knox dolomite is probably greater than in the Knox. Therefore no well should be drilled which would penetrate more than 800 feet of Ordovician rocks. This amount, as stated above, is the estimated thickness of the Ordovician rocks overlying the Knox dolomite in Middle Tennessee.

General Oil and Gas Conditions of the Highland Rim Area in Tennessee

By A. H. Purdue

INTRODUCTION

It should be stated at the beginning of this paper that a careful investigation of the oil and gas conditions over the Highland Rim of Tennessee has not been practicable except for that part covered by the Waynesboro quadrangle, the results of which are contained in the preceding paper by Mr. Miser. The justification of the statements herein, though only of a general nature, is in the large number of inquiries that come to this Survey about the oil and gas possibilities in the State, and also in the desirability of public knowledge of all those areas where the conditions indicate a possibility of oil, even though they may not be very encouraging.

LOCATION OF THE HIGHLAND RIM

The name, Highland Rim, seems first to have been applied to that surface division of Tennessee herein considered, by the late Dr. James M. Safford.* It completely surrounds another important surface feature of the State, which Dr. Safford called the Central Basin†.

That part of the Highland Rim on the east of the Central Basin lies between the latter and the western escarpment of the Cumberland Plateau, which in places rises above the Rim upwards of 1000 feet, and which is indented by many stream valleys, large and small. On the north, the Highland Rim passes into the rather level region of middle Kentucky, and on the west it comprises the highlands between the Central Basin and Tennessee River, which in southern Tennessee and northern Alabama, merge into those of the eastern Rim.

*Geol. of Tenn., p. 81, 1869.

†Ibid., p. 97.

The eastern Rim includes parts of the counties of Franklin, Coffee, Grundy, Warren, Cannon, Van Buren, DeKalb, White, Putnam, Overton, and Pickett; the northern Rim, the northern parts of Clay, Macon, and Sumner counties, and all of Robertson County; the western Rim, Montgomery, Stewart, Houston, Humphreys, Dickson, Cheatham, Hickman, Perry, Lewis, Wayne, and Lawrence counties, a little of the western part of Maury County, of the western part of Williamson County, and the northwestern part of Davidson County. A small part of the southern parts of Lincoln and Giles counties constitute that part of the southern Rim in Tennessee.

The geological map of Tennessee, recently issued by the State Geological Survey, distinctly shows the area of the Central Basin (in red) and that of Highland Rim (in purple and gray).

SURFACE

The Highland Rim stands from 300 to 500 feet above the Central Basin, a like distance above the general surface of West Tennessee, and from 800 to 1050 feet above sea level. It is therefore a plateau of moderate height, but the surface is generally uneven and in parts rugged, made so from the numerous stream valleys of the area.

ROCKS

The rocks of the western Highland Rim are represented in the Waynesboro quadrangle and have been described by Mr. Miser in the preceding paper (pp. 207-212). Those of the eastern Rim are in general the same as those of the western one, with the exception of the Silurian and Devonian rocks, which are there wanting.* It follows that the Chattanooga shale which is used by Mr. Miser as the datum for determining the structure of the Waynesboro quadrangle, rests, in the eastern Rim, on rocks of Ordovician age, instead of on those of Silurian and Devonian age, as it does in most of the western Rim, and in the western part of the northern Rim.

STRUCTURE

The type of structure in the Waynesboro quadrangle as shown by Mr. Miser's map accompanying the preceding paper, is prevalent

*Whether the Chattanooga shale is of Devonian or Mississippian age is undecided.

over those parts of the Highland Rim that have come to the writer's attention, and it probably is common to all of it, as well as to all of Middle Tennessee, for such detailed geological work as has been done in the Central Basin* shows it to obtain there also.

As is generally known, the structure should have careful attention in all regions that are being prospected for oil, provided the conditions are such that it can be made out. These conditions prevail in the Highland Rim, though they are easier of interpretation in some parts than in others.

The Chattanooga shale is easier to recognize than any of the other formations of the area, because of its black color, its oily nature, its softness, and the (Hardin) sandstone, which in most places underlies it. For this reason, the Chattanooga shale is, where exposed, a convenient reference for locating the anticlines and synclines, which in this area are usually of so uncertain extent that they perhaps more properly could be spoken of as domes and basins.

This shale is exposed all around the inner edge of the Highland Rim, but is not to be seen in many places away from the edge, except in the southern part of the western Rim—the part covered by Perry, Lewis, Hickman, Lawrence and Wayne counties, where it outcrops along the sides of the valleys. With this as a datum, the structure is not difficult to determine, in the counties named. Because this easily recognizable formation is generally under cover of other rocks in other parts of the Highland Rim, the geologist will there have to depend upon the less definite Ridgetop shale and Fort Payne chert, in working out the structure.

The reader of Mr. Miser's paper should carefully note that he says the streams as a rule flow in synclines. This is plainly shown in his map. It follows that most of the anticlines of the area lie between the streams, and that as a rule the most likely places for successful drilling are on the divides and not in the valleys where most of the test wells of the western Rim seem to have been located.† Let

*Hayes, C. W., and Ulrich, E. O., U. S. Geol. Survey, folio No. 95; and Galloway, J. J., and Coryell, C. N., unpublished map and manuscript of Rutherford County.

†For an account of these see Munn, M. J., Tenn. Geol. Surv. Bull. 2-E, pp. 34 and 35, 1911. A well recently drilled three-quarters of a mile south and west of the railroad station at White Bluff has a strong flow of artesian sulphur water. The depth from which this comes was not ascertained. No oil is reported. It was put down in a valley.

it be understood that this statement applies to this region but should not be blindly followed elsewhere, for in many others it does not hold.

The careful reader will at once infer that a locality on the Highland Rim about which streams head, and from which they flow in opposite directions, is one of dome or anticlinal structure. This is a pretty safe inference, but before money is spent in drilling it should be confirmed by a capable geologist, for there probably are such areas in which the rock beds are horizontal, and some of them may even be synclinal. Again, there are parts of valleys in which the structure is anticlinal.

POSSIBLE OIL HORIZONS

A complete account of the wells that were drilled in the Highland Rim up to 1911 has been published by this Survey,* but the well records obtainable were so indefinite that the exact horizons from which oil was secured can not be determined.

The St. Louis limestone produces oil in the Cumberland Plateau† but it could not be expected to do so in the Highland Rim, for the reason that it there is not covered by other rocks. The oil-producing formation in the Spring Creek district of Overton County is thought by Munn to be the Fort Payne formation‡, but most of the oil of the Highland Rim has come from various depths below the Chattanooga shale, which underlies the Fort Payne.

The Chattanooga shale contains enough oil to make it burn easily, and it seems probable that downward moving water has carried oil from this formation into the joints of the limestone beneath, and into sand beds should such anywhere occur, though with the exception of the Hardin sandstone, just beneath the shale, none are known; and the Hardin sandstone is not everywhere present. Much of the oil in the Irvine field, Estill County, Kentucky, is secured just beneath this shale. That from the Scottsville field, Allen County, Kentucky, is reported to be secured at varying depths from a few feet to 100 feet or possibly even more, beneath the shale.

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*Munn, M. J., Preliminary report upon the oil and gas developments in Tenn., Bull. 2-E, 1911.

†Glenn, L. C., Tenn. Geol. Surv., Res. of Tenn., vol. VII, no. 1, p. 42.

‡*Ibid*,, p. 8.

Even if the surmise is true that the oil within a reasonable distance beneath Chattanooga shale has been derived from it, the chances for successful wells from this horizon in the southern part of the western Highland Rim are not considered great, for the reason that the shale there is as a rule not thick and in places is absent. (See page 201). But the evidence is that this shale thickens to the north and this fact stimulates the hope for oil beneath it in the northern counties of the Highland Rim, in the anticlines or domes of that area. The Scottsville oil field which is just across the State line in Kentucky gives encouragement, for the sequence of the rocks and other conditions there are presumably the same in adjoining parts of Tennessee.

Oil has been found on the Highland Rim in Overton and Pickett counties* both above and some distance below the Chattanooga shale.

The record of a "dry hole" at McMinnville, Warren County, shows the Chattanooga shale to be 55 feet thick. This thickness of the shale and the necessary structural conditions, would be good ground for hope of striking fissure oil at some point not far below the shale, on the eastern Highland Rim; but it appears that this thickness of the shale can not be relied upon in that area, for it is reported only 10 to 12 feet thick, one mile northwest of Tullahoma.†

Below the rocks underlying the Chattanooga shale, the best hope for oil is in or beneath the Hermitage limestone, described by Miser (p. 202), for the reason that the shale of that limestone may serve as a cover for an oil reservoir, or may even be a source of oil. The depth of this limestone below the Chattanooga shale varies with the locality. In the Columbia quadrangle, which covers a part of Maury and adjacent counties, the top of this limestone is from 70 to 400 feet below the Chattanooga shale, and the Hermitage itself is from 40 to 70 feet thick.‡

According to the foregoing tables by Miser, the distance from the Chattanooga to the Hermitage in the Waynesboro quadrangle varies from 21 to 570 feet, and the Hermitage there exceeds 80 feet in thickness. In Rutherford County, according to Dr. J. J. Galloway, the distance from the Chattanooga shale to the top of the Hermitage

*Munn, M. J., Tenn. Geol. Surv., Bull. 2-E.

†Munn, M. J., Tenn. Geol. Surv., Bull. 2-E, p. 26.

‡Hayes and Ulrich, *Loc. cit.*

varies from 200 to 430 feet,* and the Hermitage itself is from 70 to 80 feet.

Records for the northern part of the Highland Rim are not available, but the distance from the Chattanooga shale to the Hermitage limestone probably increases northward, for the reason that the Devonian rocks become thicker westward and northward from the Waynesboro quadrangle. Data are not at hand from which the amount of this thickness can be estimated. From Stewart County eastward, the Silurian rocks and those of Devonian age beneath the Chattanooga shale thin, and from investigations to the present, do not occur east of Macon County.

The Camden chert, which is of Devonian age, is well exposed in the eastern parts of Benton and Henry counties. In much of this area, erosion has removed the overlying Chattanooga shale and higher rocks, and in such parts there is no hope of oil from the chert, though it may there occur at some of the horizons beneath, later to be mentioned. This chert thins out eastward, somewhere beneath the western Highland Rim, but its presence within 10 miles east of Tennessee River opposite the counties named, can pretty safely be relied upon. In this area, the Chattanooga shale probably is present, underlying the Ridgetop shale. If suitable structure can be found, it will be worth drilling, for the chert probably is much jointed, and if so, supplies one of the necessary conditions for oil accumulation.

The lowest formation described in Mr. Miser's table is the Hermitage limestone (p. 202). Below this, in descending order, the following rocks are exposed in the Central Basin:

MIDDLE ORDOVICIAN

Carters limestone. 40 to 85 feet. "Heavy-bedded, fine-grained, white or light-colored limestone, often containing chert and silicified fossils."†

LOWER ORDOVICIAN

Lebanon limestone. 70 to 120 feet. The following is the description of this limestone in Rutherford County: "Thin-bedded, dense, brittle, dove, blue or brown limestone with shaly partings; beds 1 to 6 inches thick; massive bed of drab limestone 10 or more feet thick near middle; fossils frequently abundant."‡

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*Unpublished manuscript.

†Hayes and Ulrich, U. S. Geol. Surv. folio 95.

‡Galloway, J. J., unpublished manuscript.

Ridley limestone. 100 feet. "Dense, drab, brittle, massive limestone, weathering gray and granular, fluted or platy; sometimes very cherty; oily smell on breaking.*

Pierce limestone. 23 to 28 feet. "Platy layers of dense, blue or drab, brittle limestone, very fossiliferous (Bryozoa) with shaly partings; heavy beds of bluish-brown coarse, crystalline limestone frequently present.*

Murfreesboro limestone. 70+ feet. "Dense, drab, brittle, massive limestone, oily smell on breaking, much black chert on weathering, fucoidal markings common; other fossils rare except in chert.* Total thickness, 130 to 398 feet.

These formations extend from the Central Basin in all directions under the Hermitage limestone, consequently beneath the Highland Rim.

There is hope that the shale of the Hermitage limestone is sufficiently intact to confine such oil as may possibly have accumulated in the joints of the underlying Carters limestone. Besides, it is possible that the shale of the Hermitage is a source of oil.

It will be noticed that Dr. Galloway describes the Ridley and Murfreesboro limestones as having an oily smell, when broken; and it may be that when these are under the cover of the rocks of the Highland Rim they would produce some oil from fissures. While these limestones are not urged as possible oil reservoirs, they are the more hopeful because of the overlying, compact, rather shaly Lebanon limestone.

DEPTH TO DRILL

The distance to the Chattanooga shale will depend mainly on the altitude of the mouth of the well. As above stated, the divides between the streams are as a rule the best locations for wells because these generally are areas of anticlines. Reference to Mr. Miser's table (p. 201) will show that on the divides the distance to the Chattanooga shale varies from approximately 150 to 500 feet in the Waynesboro quadrangle. One hope for oil in the Highland Rim is in the 50 feet below this shale.

A well once started, should continue to the depth of at least 50 feet below the Hermitage limestone, with the hope of striking oil in a fissure of the underlying Carters limestone, unless it is sooner secured.

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*Ibid.

The Knox dolomite underlies the Murfreesboro limestone. Its thickness in Middle Tennessee is not known, but in East Tennessee it is from 3000 to 4000 feet. It probably is much less in Middle Tennessee. In no case would the writer advise going far into this formation.

MARKERS FOR THE DRILLER

The thickness of the several formations beneath the surface of the Highland Rim, as given in the preceding tables (pp. 208-212) will aid the driller somewhat, but this is unsatisfactory because it is so variable.

The Chattanooga shale will always be recognized from its black color and its softness.

The alternating thin layers of limestone and shale that constitute the Hermitage should make that formation recognizable.

Probably the thin-bedded, blue, somewhat shaly Lebanon limestone could be recognized.

There should be no difficulty in recognizing the Pierce limestone with its brittle, platy layers of lime and its shaly partings, so different from the Ridley above and the Murfreesboro below, provided these characteristics hold beneath the Highland Rim.

Unfortunately, the thickness of the Murfreesboro limestone is not known, for its base is not exposed, and reliable well records are not available. It may be that the driller could notice no change in passing from this into the Knox dolomite.

CONCLUSIONS

The foregoing brings one to the following conclusions regarding oil possibilities in the Highland Rim, where the structure is favorable:

1. There is a small chance for oil in the Ridgetop shale, which overlies the Chattanooga shale.
2. A hope for oil is in the 50 feet below the Chattanooga shale and some distance away from its outcrops on hillsides, in the northern and eastern parts of the Highland Rim. The shale is so thin in the southwestern part that the chances there are reduced.

3. There is a possibility of oil in, or a short distance below the Hermitage limestone, away from the outcrops of that formation.

4. There is some hope for oil in the Ridley and Murfreesboro limestone, beneath the Highland Rim.

5. Oil, if struck anywhere in the Highland Rim, is almost sure to come from fissures, for with the exception of the Hardin sandstone, the rocks so far as known are compact to shaly limestones.

Publications of Geological Survey of Tennessee Issued.

The following publications have been issued by the present Survey, and will be sent on request *when accompanied by the necessary postage.*

BULLETIN No. 1—Geological Work in Tennessee.

A. The establishment, purpose, object and methods of the State Geological Survey; by Geo. H. Ashley, 33 pages, issued July, 1910, postage, 2 cents.

B. Bibliography of Tennessee Geology and Related Subjects; by Elizabeth Cockrill, 119 pages; postage, 3 cents.

BULLETIN No. 2—Preliminary Papers on the Mineral Resources of Tennessee, by Geo. H. Ashley and others.

A. Outline Introduction to the Mineral Resources of Tennessee, by Geo. H. Ashley, issued September 10, 1910; 65 pages; postage, 2 cents.

D. The Marbles of East Tennessee, by C. H. Gordon; issued May, 1911; 33 pages; postage, 2 cents.

E. Oil Development in Tennessee, by M. J. Munn; issued January, 1911; 46 pages; postage, 2 cents.

G. The Zinc Deposits of Tennessee, by S. W. Osgood; issued October, 1910; 16 pages; postage, 1 cent.

BULLETIN No. 3—Drainage Reclamation in Tennessee; 74 pages; issued July, 1910; postage, 3 cents.

A. Drainage Problems in Tennessee, by Geo. H. Ashley; pages 1-15; postage, 1 cent.

B. Drainage of Rivers in Gibson County, Tennessee, by A. E. Morgan and S. H. McCrory; pages 17-43; postage, 1 cent.

C. The Drainage Law of Tennessee; pages 45-74; postage, 1 cent.

BULLETIN No. 4—Administrative Report of the State Geologist, 1910; issued March, 1911; postage, 2 cents.

BULLETIN No. 5—Clays of West Tennessee, by Wilbur A. Nelson; issued April, 1911; postage, 4 cents.

BULLETIN No. 9—Economic Geology of the Dayton-Pikeville Region, by W. C. Phalen; issued May, 1911; postage, 4 cents.

BULLETIN No. 10—Studies of the Forests of Tennessee.

A. An Investigation of the Forest Conditions in Tennessee, by R. Clifford Hall; issued April, 1911; 56 pages; postage 3 cents.

B. Chestnut in Tennessee, by W. W. Ashe, issued December, 1911; postage, 2 cents.

C. Yellow Poplar in Tennessee, by W. W. Ashe, issued January, 1914; 55 pages; postage, 3 cents.

BULLETIN No. 13—A Brief Summary of the Resources of Tennessee, by Geo. H. Ashley; issued May, 1911; 40 pages; postage, 2 cents.

BULLETIN No. 14—The Zinc Deposits of Notheastern Tennessee, by A. H. Purdue; issued September, 1912; 69 pages; 30 illustrations; postage, 3 cents a number.

BULLETIN No. 15—Administrative Report of State Geologist, 1912.

BULLETIN No. 16—The Red Iron Ores of East Tennessee, E. F. Burchard; issued November, 1913; 172 pages; postage, 8 cents.

BULLETIN No. 17—The Water Powers of Tennessee, by J. A. Switzer; issued April, 1914; 137 pages; postage, 8 cents.

BULLETIN No. 18—Administrative Report of the State Geologist, 1914.

BULLETIN No. 19—Elevation in Tennessee, by Elizabeth Cockrill; issued 1917, 80 pages; postage, 3 cents.

MAPS—Map of Lewis County, 1915; postage, 2 cents.
Geological Map of Tennessee, 1915; postage, 15 cents.
Map of Rutherford County, 1916; postage, 2 cents.
Map of McNairy County, 1916; postage, 2 cents.

"THE RESOURCES OF TENNESSEE"—This is a quarterly magazine, devoted to the description, conservation and development of the State's resources. Postage, 2 cents a number. The following are the volumes and numbers issued, with the title of the principal papers in each number:

Vol. I. No. 1—The utilization of the small water powers in Tennessee, by J. A. Switzer and Geo. H. Ashley. (Out of print).

No. 2—The Camden chert—an ideal road material, by Geo. H. Ashley.
The Fernvale iron ore deposit of Davidson County, by Wilbud A. Nelson.
Cement materials in Tennessee, by C. H. Gordon.
(Out of print).

No. 3—The gold field of Coker Creek, by Geo. H. Ashley.

No. 4—Coal resources of Dayton-Pikeville area, by W. C. Phalen.

No. 5—Economic aspects of the smoke nuisance, by J. A. Switzer.
Watauga Power Company's hydro-electric development, by Francis R. Weller.
The coal fields of Tennessee, by Geo. H. Ashley.

No. 6—Bauxite Mining in Tennessee, by Geo. H. Ashley.
A New Manganese Deposit in Tennessee, by Wilbur A. Nelson.
Road Improvement in Tennessee, by Geo. H. Ashley.

Vol. II. No. 1—The Utilization of the Navigable Rivers of Tennessee, by Geo. H. Ashley.
Dust Explosions in Mines, by Geo. H. Ashley.
The Rejuvination of Wornout Soil Without Artificial Fertilizers, by Geo. H. Ashley.
Tennessee to Have Another Great Water Power, by George Byrne.
Manufacture of Sulphuric Acid in Tennessee in 1911, by Wilbur A. Nelson.

No. 2—The Ocoee River Power Development, by J. A. Switzer.
Exploration for Natural Gas and Oil at Memphis, Tenn., by M. J. Munn.

No. 3—The Power Development at Hale's Bar, by J. A. Switzer.
Notes on Lead in Tennessee, by Wilbur A. Nelson.

No. 4—The Tennessee Academy of Science.
The Preliminary Consideration of Water Power Projects, by J. A. Switzer.
Lignite and Lignitic Clay in West Tennessee, by Wilbur A. Nelson.

No. 5—The Growth of Our Knowledge of Tennessee Geology, by L. C. Glenn.

No. 6—On the Impounding of Waters to Prevent Floods, by A. H. Purdue.
Drainage Problems of Wolf, Hatchie, and South Fork of Forked Deer Rivers, in West Tennessee, by L. L. Hidinger and Arthur E. Morgan.
The Waste from Hillside Wash, by A. H. Purdue.

No. 7—Where May Oil and Gas Be Found in Tennessee? By Geo. H. Ashley.
Spring Creek Oil Field, by M. J. Munn.

No. 8—The Monteagle Wonder Cave, by Wilbur A. Nelson.
Cave Marble (Cave Onyx) in Tennessee, by C. H. Gordon.

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No. 10—The Iron Industry of Lawrence and Wayne counties, by A. H. Purdue.
Some Building Sands of Tennessee, by Wilbur A. Nelson.

No. 11—Tests on the Clays of Henry County, by F. A. Kirkpatrick. Introduction by Wilbur A. Nelson.
Barite Deposits in the Sweetwater District, by Herbert B. Heneger.

No. 12—The Soils and Agricultural Resources of Robertson County, by Reese F. Rogers.
The Iron Ore Deposits in the Tuckahoe District, by C. H. Gordon and R. P. Jarvis.

Vol. III. No. 1—The General Features of the Tennessee Coal Field North of the Tennessee Central Railroad, by L. C. Glenn.
The Tennessee Coal Field South of the Tennessee Central Railroad, by Wilbur A. Nelson. (Out of print).

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