VOLUME VIII NUMBER 1

THE RESOURCES OF TENNESSEE

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

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NASHVILLE, TENN.

JANUARY, 1918

CONTENTS

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CONTENTS

Corrections to article on Barite Deposits of the Sweetwater District, East Tennessee, by C. H. Gordon, in *Resources of Tennessee.* Vol. VIII, No. 1, 1918.

Page 50, eighth line from the bottom: Strike out "The Sweetwater deposits also contain a small amount of strontium as shown by the accompanying analyses".

Page 62, fifth line from the bottom, read "which have been worked".

Page 66, sixth line from the bottom, for "contain" read "contains".

Page 68, thirteenth line from the top, read "has a dip of 17 degrees, south 30 degrees east".

Page 74, last paragraph should follow second paragraph, page 75.

Page 75, first paragraph should follow first paragraph, page 74.

Schools in West Plains, Missouri, in 1887-8, and Assistant Superintendent in the U. S. Indian School at Albuquerque, New Mexico, in 1889-91. In 1892-3 he was an assistant geologist on the Arkansas Geological Survey.

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In addition to his duties as a professor in the University of Arkansas, he found a steadily increasing amount of committee and other responsible executive work falling upon his shoulders, and about the time of his leaving there was prominently spoken of in

Dr. A. H. Purdue

BY L. C. GLENN

Dr. A. H. Purdue died on December 12th, 1917, as a result of an operation that he underwent on December 5th, in the hope of obtaining relief from the ill health from which he had suffered during the greater part of the past year. He leaves a wife and two sons.

The following brief sketch of his life and work is here presented to the people of the State in whose service he so faithfully labored up to the very hour of the operation that ended his career.

Albert Homer Purdue was born in Warrick County, Indiana, March 29th, 1861. He graduated from the Indiana State Normal School in 1886, received his A. B. degree from Leland Stanford University in 1893, remaining there another year for advanced study, and in 1895-6 pursued graduate work and was Fellow in Geology in the University of Chicago. In 1912, the University of Arkansas conferred upon him the degree of LL.D. He was Superintendent of Schools in West Plains, Missouri, in 1887-8, and Assistant Superintendent in the U. S. Indian School at Albuquerque, New Mexico, in 1889-91. In 1892-3 he was an assistant geologist on the Arkansas Geological Survey.

On leaving the University of Chicago in 1896, he became Professor of Geology in the University of Arkansas, at Fayetteville, and in 1902 had the subject of mining added to his chair, which he continued to hold until 1912, when he resigned to become State Geologist of Tennessee. Meantime, he became a member of the U. S. Geological Survey in 1895 and for some years during his vacations did detailed areal mapping and other field work in Arkansas for that organization. During the exposition in St. Louis in 1904, he was in charge of the department of mines and metallurgy for Arkansas, and from 1907 to 1912, was ex officio State Geologist of Arkansas.

In addition to his duties as a professor in the University of Arkansas, he found a steadily increasing amount of committee and other responsible executive work falling upon his shoulders, and about the time of his leaving there was prominently spoken of in connection with the presidency of that institution. He preferred, however, to continue his scientific investigations and the outlook for this work in Arkansas not being then particularly bright, because of disturbed political conditions that had cut off the support of the State Survey, he was induced to come to Tennessee, where he succeeded Dr. G. H. Ashley as State Geologist in March, 1912.

His interests were always broader than his immediate specific work and his participation in general community activities was one of his marked characteristics. In Fayetteville, Arkansas, he was a member of the Board of Education and was very actively interested in its work. He made numerous addresses before schools and educational gatherings over the State and represented the faculty of the University on various public occasions.

On coming to Nashville, he soon identified himself with the public-spirited activities of the community and State, and on his death was a member of the Commercial, Rotary and Freolac clubs, of the Tennessee Historical Society, the Engineering Association of Nashville, the State Highway Commission, and had recently been elected president of the Tennessee Academy of Science. He was a delegate from the State to meetings of the Southern Commercial Congress, the Rivers and Harbors Congress, the Exhibition of Chemical Industries, and to good roads and forestry and numerous other such meetings. These serve to give some indication of the breadth of his interests in organizations for general public welfare.

Among more technical scientific organizations, he was a member of the American Institute of Mining Engineers, of the Indiana and the Tennessee Academies of Science, the National Geographic Society, the Association of State Geologists, and the Geological Society of London. In addition, he was a fellow of the American Association for the Advancement of Science, and of the Geological Society of America.

Upon assuming his duties here in March, 1912, Dr. Purdue found the work of the Survey well organized and continued the various lines of investigation that had been initiated by his predecessor. During his administration, however, there has been a great development of the resources of the State, and in furthering this growth it has been necessary from time to time to add new departments to the Survey. A permanent chemist, for example, has been employed and a division of Forestry established and placed in charge of a forester.

Recently, the work of the Survey has been planned to meet any possible demands that might be made because of the war.

Brief reports of work accomplished by the Survey during Dr. Purdue's administration have appeared regularly in the *Resources* and longer ones have been published from time to time as bulletins, while the manuscript reports for still other bulletins are some on hand ready for publication and others in an advanced stage of preparation. Dr. Purdue planned and directed these activities, attended to a large volume of office work, gave freely of his time and energy to general public service, and in addition found time for numerous field investigations, the results of a number of which have appeared in the *Resources*. In this issue appears an article on manganese—a subject made important by our war needs—that was dictated by him in the hospital, while awaiting the hour for the operation. While thus waiting, he also discussed plans for carrying forward the work of the Survey in case he should not recover and continue as its director. He was thus actively at work up to the very last.

Dr. Purdue was especially fortunate in his training, both as a young field geologist in Arkansas and as a student in Stanford University, in having the guidance of Dr. J. C. Branner. His interests and acquirements in geology covered a wide range through his experience as a university professor, an original investigator and State Geologist in Arkansas and Tennessee. He was especially familiar with the stratigraphy and structure of the Paleozoic area of Arkansas and with the natural gas, coal, zinc, slate and underground water resources of that State, as well as the detailed areal geology of quite a number of quadrangles there, which he mapped for the U. S. Geological Survey. In Tennessee, he soon became familiar with the general geology and economic resources of the State, and in planning the work of the Survey kept in mind the practical needs of the State and shaped the activities of the Survey to these ends. His own especial field or subject was the geology of lead and zinc. His publications are quite numerous, cover a wide range of subjects and have appeared as special reports published by the Arkansas, the Tennessee or the U. S. Geological Surveys, or have been contributed to the various scientific journals of the country.

As a man he thought things out carefully and in his viewpoint was sane, level-headed and practical. He would take counsel with others and yet his decisions were his own, and in carrying them out there was a quiet forcefulness that indicated the strength of the man. He was pleasant in manner, but of quiet and dignified bearing,—well-poised, frank and direct. His friendships were many and unusually firm and lasting.

His death at the early age of fifty-six would seem untimely, and yet he had led a busy life and accomplished much, and the summons from labor unto rest was so brief that any of us might envy him. These thoughts, however, do not lessen the great loss thus suffered by his friends, by the science of geology, or by the State that he had served so well.

The Climate of Tennessee

By Roscoe Nunn, Meteorologist, U. S. Weather Bureau.

INTRODUCTION.

Climatic records were made in Tennessee as far back as the year 1834. Prior to 1870, however, the observations were few and the records fragmentary, and not until about 1883 was there anything like a comprehensive method of studying the climate of the State. In 1883, under the supervision of the United States Signal Service, a State Weather Service was established, with a number of well distributed observation stations, and the publication of a monthly summary of the records thus obtained was begun.

In July, 1891, the meteorological work of the Signal Service was transferred to the Weather Bureau of the U. S. Department of Agriculture, and under the Weather Bureau the importance of the climatological service was more fully recognized. Improvements were made, (1) by more careful supervision of the observations; (2) increasing the number of stations; (3) furnishing better equipment, and (4) systematizing the observations and the publications of data. From 1895 to the present time the Weather Bureau climatic records throughout the United States have been fairly homogeneous in character; that is, there has been uniformity in respect to instruments used, exposure of instruments, and data obtained and published.

It is therefore possible now to give a more accurate description of the climate of Tennessee than ever before, and it is also possible, on account of the uniform system of making climatic records throughout the country during the last twenty to twenty-five years, to make comparisons of the climatic features of Tennessee with those of other sections of the United States.

The physiography of Tennessee has an appreciable effect in causing local climatic variations, and a description of the natural divisions of the State, accompanied by a physiographic map, is therefore given. It also seems appropriate to mention briefly the soils and crops of the State. The principal climatic features are then described and compared with those of some other sections. The local variations of climate in the State are shown by the charts and the tabulated matter. The tables also contain data for a number of stations outside of the State, for sake of comparison. The charts and tables are fully explained in the text.

In the preparation of this article, the author has made use of the publications of the United States Weather Bureau, particularly of Bulletin Q, "Climatology of the United States", by Alfred J. Henry, Professor of Meteorology, and of "Climatological Data for the United States by Sections", consisting of 106 parts, and issued under the supervision of the Climatological Division of the Weather Bureau. Some special data were kindly furnished by the Chief of the Weather Bureau and the officials in charge of the Weather Bureau stations at Atlanta, Ga., Bismarck, N. D., Columbia, Mo., Dodge City, Kans., Fort Worth, Texas, Indianapolis, Ind., New Orleans, La., and Parkersburg, W. Va.

So complete a climatic survey of the State as is here presented would have been impossible except for the aid given by the faithful volunteer observers in the various parts of the State, some of whom have kept reliable weather records daily for more than 25 years.

These records are on file at the Nashville office of the Weather Bureau.

PHYSIOGRAPHY.

Tennessee lies between parallels 34° 58′ and 36° 39′ north latitude. It is in a latitudinal belt that includes northern New Mexico and a part of California lying just south of the center of the State. It is in the same latitude as central Japan and is not very different in lati-

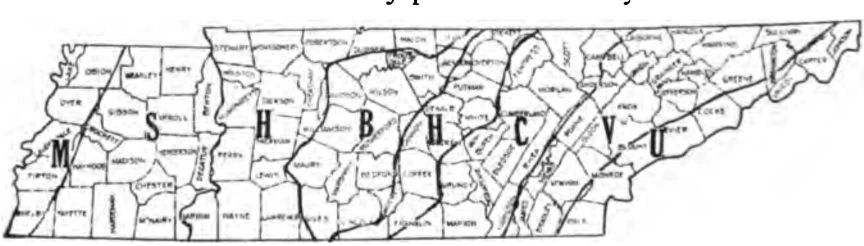

Fig. 1.—Map showing the physiographic divisions of Tennessee.
U.—Unaka Chain, or Smoky Mountains.
V.—Valley of East Tennessee.
C.—Cumberland Plateau.
HH.—Highland Rim.
B.—Central Basin.
S.—Slope of West Tennessee.
M.—Mississippi Bottoms.

tude from the most southern parts of Greece, Italy, and Spain. However, the climates of the foreign districts just mentioned, being modified by their insular positions, are much milder than that of Tennessee. The climate of the California coast is also comparatively equable and mild, on account of the presence of the Pacific ocean to the westward and the prevailing winds that come from the ocean.

Probably there is hardly any other area of equal extent in the United States that presents a more diversified and interesting physiography than Tennessee. In a general way, the surface of the State slopes from the east to the west; from the Smoky Mountains with elevations of 4,000 to 6,000 feet, to the Mississippi bottoms with elevations of 300 to 400 feet above sea-level. This general trend is frequently interrupted, and as a result there are no less than seven natural divisions* of the State, each having its characteristic features. The seven divisions are outlined on the accompanying map, Fig. 1.

The Great Smoky Mountains.—These mountains (in some portions called the Unaka Mountains) mark the dividing line between North Carolina and Tennessee. They are a part of the Appalachian Mountain system. The Smoky Mountain section of Tennessee comprises a belt from two to twenty miles wide along the eastern border of the State. Peaks in this section reach elevations of 4,000 to 6,000 feet, while the general elevation ranges from 2,000 to 3,000 feet, and occasional depressions are as low as 1,000 feet. This is the roughest and most mountainous part of the State. But little of this section is cultivated except the wider valleys or coves, but the lands are used as grazing grounds for cattle in summer. This section has furnished much timber, and parts of the territory are being purchased by the Federal Government for forest reserves.*

The Valley of East Tennessee.—Lying westward from the Smoky Mountain section is the Great Valley of East Tennessee, which is about 30 to 60 miles wide, and runs obliquely across the State from

*The well-known civil divisions of the State—East Tennessee, Middle Tennessee, and West Tennessee—do not follow the lines of natural divisions, except in part. East Tennessee comprises the Smoky Mountain region, the Great Valley of East Tennessee, and the eastern part of the Cumberland Plateau. Middle Tennessee comprises the western part of the Cumberland Plateau, the Highland Rim, and the Central Basin. West Tennessee comprises all the region west of the Tennessee River in its northward course across the State.

*"The Soils of Tennessee", by C. A. Mooers, Vol. V, No. 4 of this magazine.

northeast to southwest. It is broken by a series of ridges parallel with the trend of the valley. The average elevation of the valley is about 1,000 feet, and its area is about 9,000 square miles. It is well watered by the Tennessee River and its tributaries. This division is distinctly marked, being bordered on the east by the steep sides of the Smoky Mountains and on the west by the Cumberland Plateau, which rises rather abruptly to an elevation nearly 1,000 feet above the general level of the valley.

The Cumberland Plateau.—The Cumberland Plateau is 30 to 50 miles wide and extends across the State in a somewhat northeast-southwest direction. Its area is about 5,000 square miles. It has an average elevation of about 2,000 feet and a maximum elevation of over 3,500 feet. About five-sixths of the surface of the Plateau is flat to gently rolling, while the remainder, in the northeastern portion of the district, is a maze of sharp-topped ridges and spurs.*

The Highland Rim.—The Highland Plain (or, Highland Rim as it is now called) was in ages past a plain extending from the Cumberland Plateau westward to the Tennessee River in its northward course across the State. But, on account of the formation, by erosion, of the Central Basin with its very distinguishing features in the heart of the plain, this large section is now recognized as two divisions, and is generally spoken of as the "Central Basin with its surrounding wide highland rim". The Highland Rim is quite different in physiographic features from the Central Basin. The Highland Rim completely surrounds the Central Basin, forming one of the largest divisions of the State, with an area of approximately 9300 square miles. Its general elevation on its eastern border is about 1000 feet, (or nearly 1000 feet lower than the Cumberland Plateau adjacent on the east), while on its western border the elevations range from 600 to 800 feet. Its surface is usually a rolling plain, but here and there it is broken by narrow and deeply cut stream valleys.†

Central Basin.—This division, as stated in connection with the description of the Highland Rim, or Plain, was evidently formed by erosion in the center of the Highland Plain. It has an area of about 5400 square miles, being about 50 to 60 miles wide (east-west)

*"Physiographic Influences in the Development of Tennessee", by L. C. Glenn, Vol. V, No. 2, of this magazine.

†Glenn, op. cit.

and about 100 miles in length. The surface of the Central Basin is about 300 to 400 feet lower than the surrounding Highland Rim, its general elevation being about 600 feet above sea-level The general surface is that of a gently rolling plain. Hills rise here and there 200 to 300 feet above the surrounding surface. Murfreesboro is near the center of the Central Basin and Nashville is situated near its northwestern margin. The Cumberland River flows through the northern part. The Harpeth, Duck, and Elk rivers are important streams of this division. The first is a tributary of the Cumberland, while the second and third flow into the Tennessee.

Slope of West Tennessee.—The Tennessee River, in its northward course through the State, flows just west of the Highland Rim, in a valley 300 to 500 feet deep and a few miles in width. West of this valley begins the upland plain of the Slope of West Tennessee. From elevations of 500 to 700 feet on its eastern margin this slope falls gently to elevations of 300 to 400 feet near the Mississippi River, and ends in the Mississippi Bottoms. There are hills of considerable height in the Slope of West Tennessee, especially in its eastern edge and also on its western margin overlooking the flood plain of the Mississippi. The streams of this division all flow into the Mississippi River.

Mississippi Bottoms.—This division comprises about 900 square miles of lands along the Mississippi River. Near the banks of the river the flood plain is high enough to remain above water in all but the highest floods. Farther back from the river the elevation is less and the surface is frequently flooded, and is swampy. With good drainage and protection from floods, this land would be very valuable for agriculture.

SOILS AND CROPS.

The plant life and crops of a region are of course related to its climate, and a description of the soils may be pertinent; but these subjects are treated in various other publications,* and we shall only refer to them very briefly. The prevailing soils are silt loams and loams. True clay soils and true sandy soils are rare. The alluvial soils cover a relatively small area and vary greatly in character; they occur of course along the many streams.

*See "The Soils of Tennessee", by C. A. Mooers, Vol. V, No. 4, of this magazine.

In the Great Valley of East Tennessee the soils are mostly loams and are well suited to such crops as corn, wheat, clover, grass, and forage crops in general. Stock raising, dairying, fruit raising, and market gardening are successfully engaged in.

The Cumberland Plateau has fine sandy soil, and both climate and soil are well adapted to the growth of a fine quality of vegetables, fruit, and small fruit, while parts of this region are capable of producing large yields of the finest quality of white potatoes.

The Highland Rim has large areas of limestone soils and also considerable areas of silt loams. A variety of crops are grown in this region, principally corn, tobacco, clover, alfalfa, peanuts and vegetables, and the conditions are favorable for orchards and for stock raising.

The Central Basin soils are of limestone origin and are the most durable and productive of any large area in the State, and a great variety of farm and garden crops is grown, the principal ones being corn, wheat, oats, clover, timothy, fruits and vegetables. Stock raising and dairying are also important industries in the Central Basin.

Over the slope of West Tennessee the soils are mostly silt loams containing no gravel, and in no other division of the State are the soils considered so well adapted to a large range of crops. Corn, wheat, and cotton are the principal farm crops, cotton being a leading crop in the southern counties, while corn, wheat, and tobacco are foremost in the northern counties. Stock raising and truck gardening are important in this region.

In all the great divisions of the State there are extensive areas of woodland, and the timber industry is a large and important one. The principal forest growths are of oak, poplar, hickory, cedar, chestnut, sweet gum, and yellow pine.*

CLIMATIC FEATURES.

General remarks.—The climate of any region is determined, (1) by its distance from the equator, or latitude; (2) by its situation with regard to land and water surfaces; (3) by its elevation above the

*"Marketing Woodlot Products in Tennessee", by W. D. Sterrett, Vol. VII, No. 3, of this magazine.

level of the sea, and (4) by its situation relative to the paths of cyclones and anti-cyclones.†

Judging the climate of Tennessee from the latitude alone, we would expect it to be mild. If we take into consideration the first two of the factors above named, we would say our climate is fairly mild, but, owing to its inland position, is characterized by considerable range in temperature and by moderate rainfall. If we consider the first three factors, we would say our climate is fairly mild for the most part, but, owing to our inland position and the considerable elevation of some large areas, there are sections of the State where the climate is less mild than the latitude would indicate, being moderately rigorous in the winter months and free from extreme heat in summer, and with abundant but not excessive rainfall. Finally, considering all the factors, and remembering particularly the fourth factor above named, we would say that the climate of Tennessee ranges from mild to temperate; that the section is comparatively free from great extremes of temperature, sudden weather changes, and severe storms; that the rainfall is abundant but not excessive, the humidity moderate, and the distribution of sunshine and cloudiness through the year desirable. We would add that the ground is rarely covered with snow for more than a few days at a time, and that the crop growing season is long as compared with that of the northern and western sections of the United States.

The data in the accompanying tables will bear out the statements just made.

Tennessee is in an advantageous position relative to the influence of the fourth one of the climatic factors mentioned, viz., cyclonic and anti-cyclonic movements. This section does not lie within any of the principal storm tracks that cross the country, and therefore the weather changes experienced here are only of moderate frequency. Sudden and decided changes in temperature are rare here, as compared, for example, with their frequency in the Great Lake region, where from thirty to forty such changes occur to ten in Tennessee.

Again, it will be found that, while the total rainfall received in Tennessee is considerably greater than in, say, northern Illinois, the

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†The ordinary weather movements that are attended by cloudiness and precipitation over large areas, with or without strong winds, are called "cyclones". By "anti-cyclone" is meant the opposite of cyclone, that is, fair weather conditions.

number of days with measurable precipitation is somewhat greater there than here. Compare, for example, the records for Chicago and Nashville. Chicago has on an average 126 days in the year with precipitation; Nashville has 121. At Boston, Mass., the annual precipitation is slightly less than at Nashville, but Boston has 130 days in the year with measurable precipitation to Nashville's 121. These facts are cited to show that the weather is more variable in these northern districts than in Tennessee. This is due to the fact that Tennessee lies outside the most frequented paths of storm movements.

Climate has often been defined as "an average of the general weather conditions". As climatic studies have advanced and more details have been collected, the faultiness of the definition just quoted has been recognized — it is necessary to know a good deal more than the "average" conditions. It is very important to know not only the *averages* of the principal climatic elements,—such as temperature, rainfall, humidity, sunshine, and winds — but also the ranges and extremes of these elements, and their annual and seasonal distribution.

Tables have been prepared, therefore, as far as practicable, to show both the averages and the extremes of temperature and precipitation and also their distribution through the year. The Tennessee stations in the various tables were selected with a view to giving a fair representation to the different sections of the State and exhibiting their respective climatic features. While there are no very great contrasts of local climate in the State, there are some noteworthy differences. The following table shows the stations used, with their locations and altitudes:

CLIMATOLOGICAL STATIONS USED.

Station	County	Division	Elevation above sea-level, feet
Carthage	Smith	Middle	500
Chattanooga	Hamilton	Eastern	693
Clarksville	Montgomery	Middle	550
Decatur	Meigs	Eastern	850
Florence	Rutherford	Middle	560
Greeneville	Greene	Eastern	1581
Jackson	Madison	Western	450
Johnsonville	Humphreys	Middle	364
Knoxville	Knox	Eastern	932
Lynnville	Giles	Middle	770
Memphis	Shelby	Western	274
Mountain City	Johnson	Eastern	2486
Nashville	Davidson	Middle	497
Rugby	Morgan	Eastern	1410
Savannah	Hardin	Western	442
Springdale	Claiborne	Eastern	1058
Trenton	Gibson	Western	345
Tullahoma	Coffee	Middle	1075

One may be familiar with the climate of a place or section in a general way without being familiar with the numerical data, in which case he would gain but little knowledge as to the differences in the climate of, say, his home section, and that of some other section by reading the numerical data for the distant section only. He should have data for both, and then he can make satisfactory comparisons. Data for a number of well known Weather Bureau stations in other states are therefore appended to each table, for convenient comparison.

TEMPERATURE.

The temperature element is usually considered of greatest importance in the climatic data for a place or district. First, the mean temperature is considered by months. The mean for any single month is obtained as follows: Record is made in one column of the highest temperature for each day and in another column of the lowest for each day. At the end of the month averages of the two columns are taken. These averages are the "mean maximum" and the "mean minimum". Then, by taking an average of the mean maximum and mean minimum (adding them together and dividing by 2), the *monthly mean* is obtained.* If a long series of records is used, an average of all the monthly means for any month gives a normal, or general mean for that month, and in publishing climatic data it is customary to say simply "mean" temperature when referring to the general average, or normal. It will be noted that practically all the stations used in the tables have records for twenty years or longer.

Monthly and Annual Mean Temperatures.—The mean temperatures for the State as a whole are as follows; in degrees, Fahrenheit: January, 38.5; February, 40.1; March, 49.1; April 58.5; May, 66.9; June, 74.5; July, 77.2; August, 76.2; September, 70.9; October, 59.0; November, 48.3; December, 40.2; for the year 58.3.

Table 1 gives the mean temperature for individual stations by months and the year. There are decided differences in the means for the various stations. The highest annual mean is 61.4°, at Memphis, and the lowest, 52.3° at Mountain City. The variations in mean temperature over the State are graphically shown in Charts I and II. Chart I shows the mean temperature for the coldest month of the

*It has been found by trial that a mean derived from the two extremes is practically correct, or nearly the same as the mean of hourly readings.

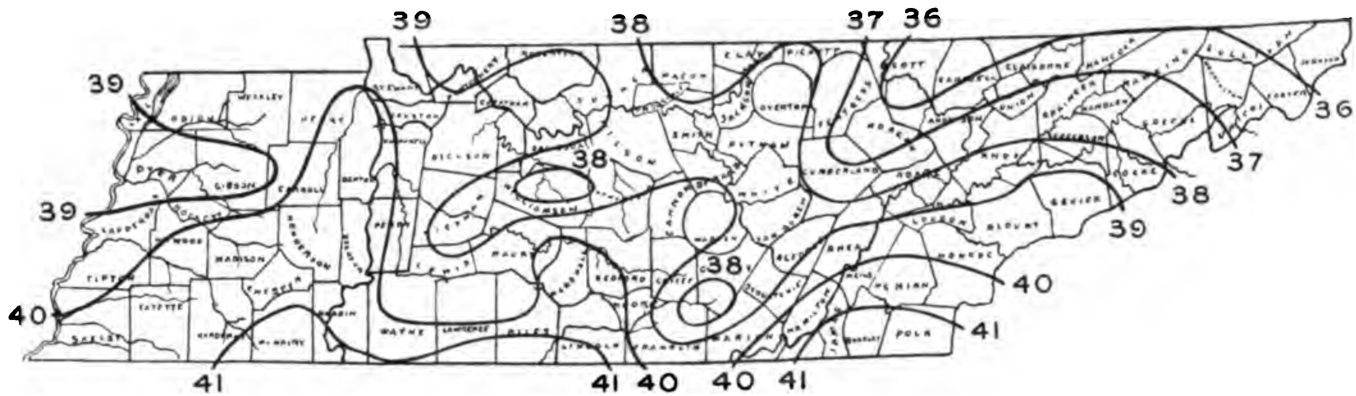

Chart I—Normal Mean Temperature for January—Degrees Fahr.

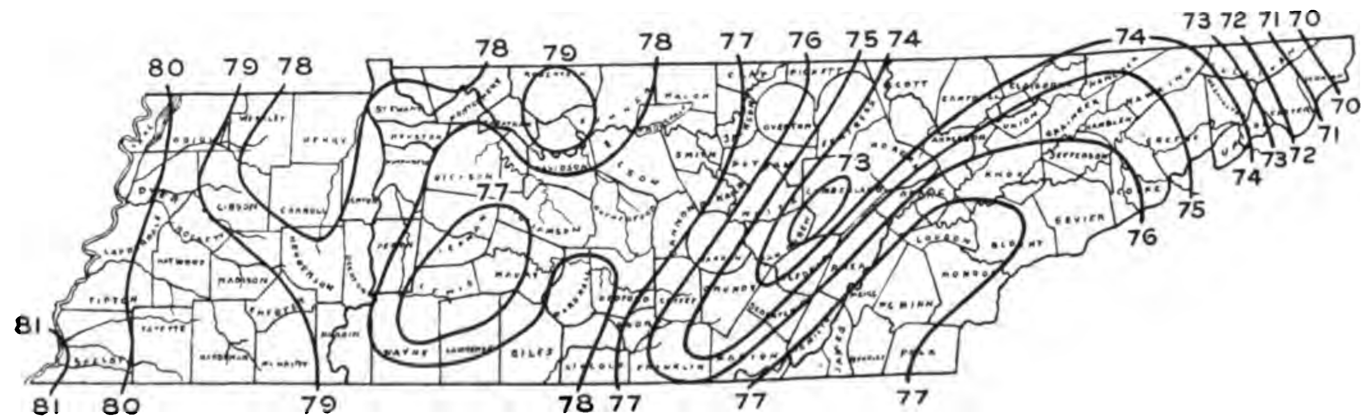

Chart II—Normal Mean Temperature for July—Degrees Fahr.

year, January, and Chart II makes a similar exhibit of the warmest month, July.

The charts show a considerable range of temperature from the southern border to the northeastern border. The decrease in temperature northeastward is due partly to the effects of higher latitude, but mostly to the increased elevation above the level of the sea. Mountain City, the coldest place, has an elevation of 2,486 feet, while Memphis, the warmest place, is 274 feet above sea-level. July is the warmest month in the year on an average. The temperature variations for different parts of the State are decidedly greater in July than in January. It averages 11 degrees warmer at Memphis than at Mountain City in July, but in January only about 5 degrees warmer at Memphis. It is well known that the effect of elevation in reducing temperature is greater in summer than in winter. It is seen from the chart that there is a small area in the extreme northeastern part of the State where the mean temperature for July ranges from 70 to 72 degrees, which corresponds with the mean temperature for the same month at Denver, Col., (72°) Milwaukee, Wis., (70°), Chicago (72°), Detroit (72°), Ithaca, N. Y. (71°), Albany, N. Y. (72°), and Boston (71°). There are large areas in the Cumberland Mountains, not far from the center of the State, where the July mean temperature is between 73 and 74 degrees.

Extremes of monthly mean temperature.—The mean temperature for any particular month may show a wide departure from the normal. It is important to note how much difference there may be, for example, between January of one year and January of another year. For the State as a whole, the coldest January on record was that of 1884, with a mean of 29.4°; while the warmest was that of 1890, with a mean of 50.0°. One January, therefore, may be as much as 20.6° colder than another. In the first case the mean was 9.1° below the normal and in the second 11.5° above the normal, the normal for January being 38.5°.

In July, for the State as a whole, the lowest mean was that of 1891, when it was 74.0°, and the highest was that of 1901, when it was 81.1°; showing that the variations from normal in the warm months are comparatively slight, the normal for July being 77.2°. Similar variations occur, of course, at individual stations.

Absolute extremes of temperature—highest and lowest on record. Table 2 shows the highest temperatures ever recorded for each month of the year and Table 3 the lowest ever recorded. These data are important, as they indicate the limits of the range that may be expected. Maximum temperatures of 100°, or slightly above, are occasionally reached in all parts of Tennessee except the more elevated portions.

At Nashville temperatures as high as 100° have been registered in only ten summers out of forty-seven. On an average, the temperature reaches 95° or above in the warmer parts of the State on about 10 to 15 days a year, during the period June to September, inclusive. On the Cumberland Plateau and in the Smoky Mountain section the temperature rarely reaches 95°. The low temperature, pure atmosphere, and picturesque scenery of the mountain districts render them very inviting as places of resort in summer. The Highland Rim also enjoys the advantage of its elevation in perceptibly reduced summer temperatures and the freshness of the air, as compared with the places of low elevation.

Comparing extremes of temperature in Tennessee with those of stations in other parts of the United States, we find that Bismarck, N. Dak., has a record of 107°, which exceeds the record of most stations in Tennessee. Indianapolis, Ind., and Omaha, Neb., have records of 106°, which exceed the record at Nashville, while Columbia, Mo., has a record of 111° and Dodge City, Kans., 112°.

Table 3 gives the lowest temperature on record for each month at the various places named. The minus sign (—) is used to indicate temperatures below zero. It is seen that zero temperatures have occurred in Tennessee in each of the winter months. Zero weather, however, is rare for the State generally, but usually occurs at the mountain stations a few times during almost every winter. Records of 5° to 10° above zero, occur pretty generally over the State on about four or five days during the winter, and zero or below on an average of about once in two or three years.

Mean maximum and mean minimum temperatures.—Table 4 shows the average height the temperature reaches at the warmest part of the day, for each month and for the year, and Table 5 shows the average of the lowest point reached during the day. The tables indicate the average extent of the daily range of temperature. For example, the mean maximum for January at Nashville is 47.0° and the mean minimum 31.0°, showing that the daily range, on an average, is about 16° in January. Of course the range is much

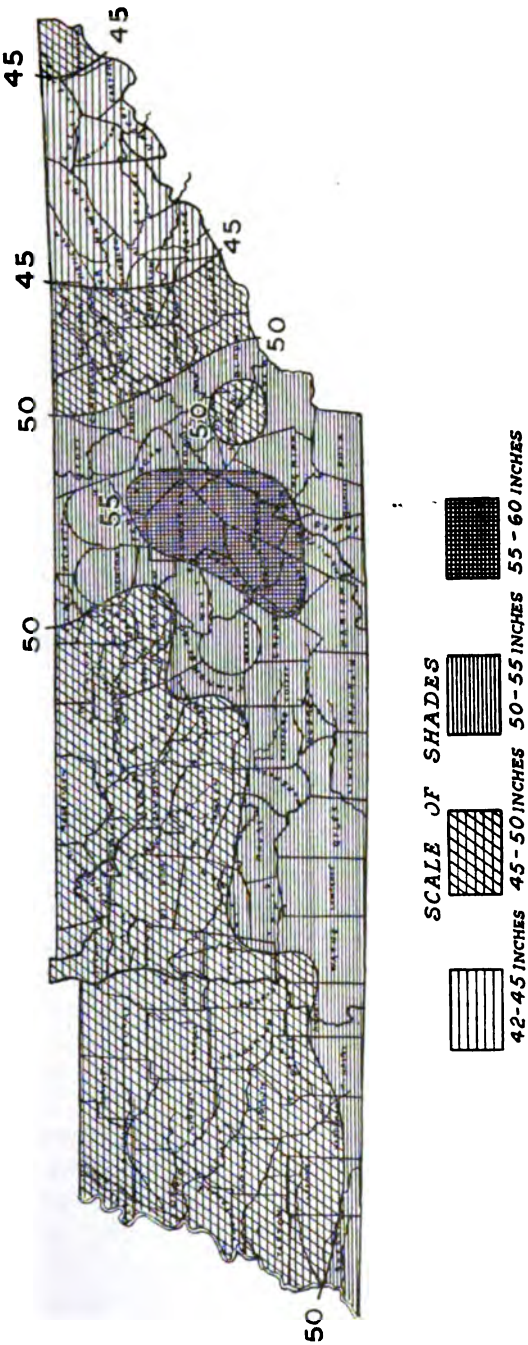

Chart III—Normal Annual Precipitation

greater on some days and much less on others. Cold or warm waves sometimes cause a range of 35 to 40 degrees in one day. Tennessee, however, is comparatively free from great fluctuations, as was stated in "General Remarks".

PRECIPITATION.

Taking the general average for the State, the normal monthly rainfall is as follows, in inches: January, 4.55; February, 4.61; March, 5.21; April, 4.39; May, 4.01; June, 4.26; July, 4.45; August, 3.87; September, 3.08; October, 2.54; November, 3.59; December, 4.49; for the year, 49.05. While the general average for the State is 49.05 inches a year, some localities have considerably more than that and some several inches less. The station with the greatest annual rainfall is Erasmus, Cumberland County, with 59.77 inches; the station with the least annual amount is Bluff City, Sullivan County, with 42.06 inches.

Chart III shows how the annual rainfall is distributed over the State. It is readily seen that the Cumberland Plateau receives the greatest amount, while the least occurs in Sullivan, Greene, and Washington counties in upper East Tennessee. Over the western half of the State the distribution is rather uniform.

Variability of rainfall.—It is observed that the rainfall is rather evenly distributed through the year, on an average. This is shown by the monthly averages above quoted, also by Charts IV, V, and VI, which indicate that the differences in amounts received for the several months are not very great. Chart IV shows the average rainfall for all parts of the State for March, which is the wettest month, and Chart V shows the average for October, which is the driest month. March rainfall averages about double that of October.

Tables 7, 8, 9, and 10, give the total rainfall for each month and year from the beginning of records to the end of the year 1916, for Chattanooga, Knoxville, Memphis, and Nashville. These tables are valuable for their exhibition of all the variations in monthly rainfall that have occurred during a long period of years. These four stations represent well the general conditions in Tennessee with respect to monthly rainfall. It will be readily seen that large variations occur; for example, Chattanooga had as much as 14.74 inches of rainfall in January, 1882, and as little as 1.33 in 1907, while in annual amounts the range is from 67.97 inches, in 1880, to 32.68, in 1904. Somewhat similar extremes are found in the records for Knoxville,

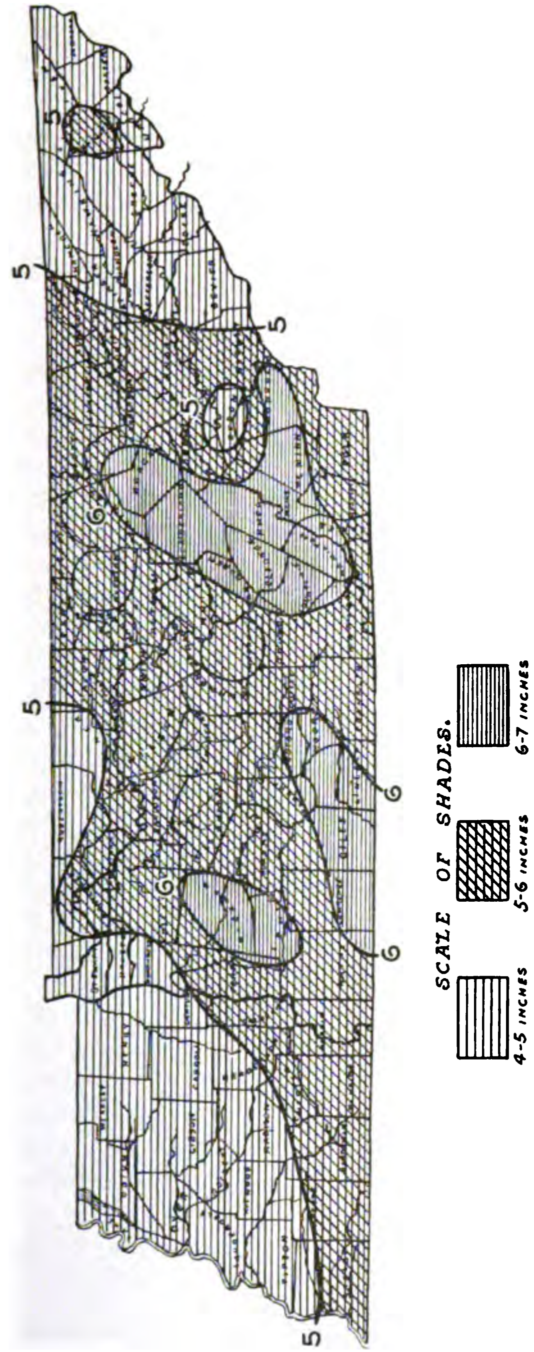

Chart IV—Normal Precipitation for March

Memphis, and Nashville, and also for stations generally in the State.

July rainfall.—Attention is directed to the July rainfall on account of its importance to the corn crop. Copious rains during the period about July 1 to August 10 are essential to the best development of corn in this State. Chart VI shows that on an average the rainfall is ample in July. The normal average for the State is 4.45 inches. In August the rainfall averages about 87 per cent of the July amount, or 3.87 inches.

Frequency of rainfall.—Rain of measurable amount (0.01 inch or more) occurs on an average about 120 days a year in Tennessee. Table 11 shows the average number of days for each month and the year at various stations. The annual number of days varies from 88 to 137. On account of the lack of automatically recording rain gages at the co-operative stations and the absence of strict rule for obtaining the number of days with 0.01 inch or more, the number of days credited with rain at these stations is generally smaller than at regular Weather Bureau stations, where the record for each 24 hours is accurately kept. While the monthly totals at co-operative stations are just as reliable as a rule as those for the regular stations, the strict division of rainy periods into days of 24 hours each (midnight to midnight, as at regular stations) is not possible. If we consider the four regular Weather Bureau stations, Chattanooga, Knoxville, Memphis, and Nashville, we find that Knoxville has the greatest number of days with 0.01 inch or more, viz., 135, while the smallest number, 114, occurs at Memphis.

Rain occurs more frequently in the mountain sections than over the plains of the middle and western parts of the State. The month with the greatest number of days with rain is March, which has 11 days for the State as a whole. The least number occurs in October, which has only 6.

It should be understood that a day with rain does not mean a "rainy" day in the sense that rain falls during most of the day. Many days with 0.01 inch may be clear and fine practically all day. Nor are the days with rain at all regularly distributed through the month but they come most often in periods of 1 to 3 days, with intervals of fair weather lasting from 2 to 10 days. Occasionally rainy spells last 5 to 10 days.

Periods of drought.—By far the greater number of long dry spells occur from the middle of August to the end of November, the period

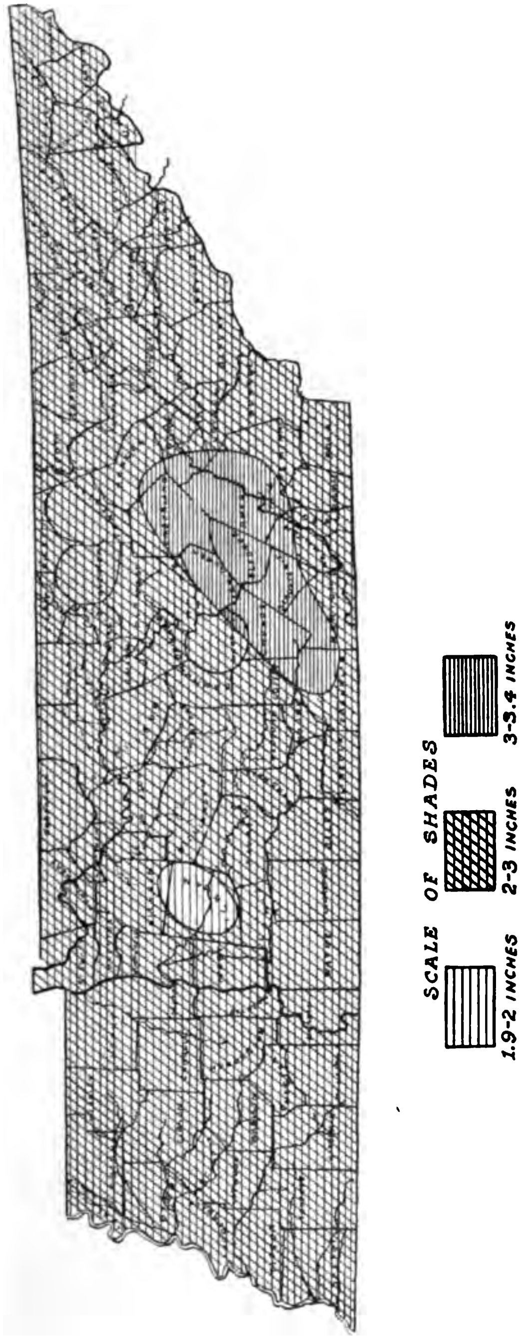

Chart V—Normal Precipitation for October of maximum occurrence being in October. In a study of this subject from Nashville records we found that in 43 years there were 53 periods of 21 days or longer with less than 0.25 inch of precipitation; but only 10 occurred in the period May 1 to July 31, and in July only 2 in the 43 years.

Special features of precipitation.—Table 12 shows some special features of precipitation. First, it gives the annual number of days that rainfall of given amounts occurs, and shows the relative frequency of these amounts at various stations. Only regular Weather Bureau stations are used, as they are the only stations having the necessary equipment for registering these special features. Secondly, the table shows the relative intensity of rainfall at the stations named. Thirdly, the average date of beginning of the snowfall season in autumn and its ending in spring; also the average annual duration, in days, of measurable snow on the ground.

Snowfall.—The average annual number of days with snowfall of importance—say, one-half inch or more—at Nashville, is 4. The Nashville record no doubt represents the average for the State approximately, but as a rule the snowfall is considerably heavier in the northern tier of counties than in the southern half of the State. The average number of days per season with a fall of 2.0 inches or more at Nashville is 1.4; indicating that, on an average, a snowfall of importance occurs only once or twice a year. In Tennessee a depth of 10 inches or more is seldom seen on the ground, but there have been occasional heavy falls, amounting to as much as 10 to 20 inches, and accumulated depths of 25 inches have occurred.

Tables 12 and 13 give an exhibit of snowfall data for Tennessee and a number of outside points. Taking an average of the records for Chattanooga, Knoxville, Memphis, and Nashville (Table 12), we find that the number of days in a year with the ground covered to a measurable depth (0.1 inch or more) is 6. Chattanooga has an average of 5 days; Knoxville, 7; Memphis, 4; and Nashville, 9. Parts of the mountain sections of course have a great many more days with snow-covered ground than the stations just mentioned.

Special compilations from the records for Nashville show that for the twenty-three years, 1893 to 1916, inclusive, there were four seasons with more than 20 days, all told, when the ground remained covered to a depth of 0.1 inch or more. The greatest total number of such days in any season was 34, in 1894-5. The longest period of

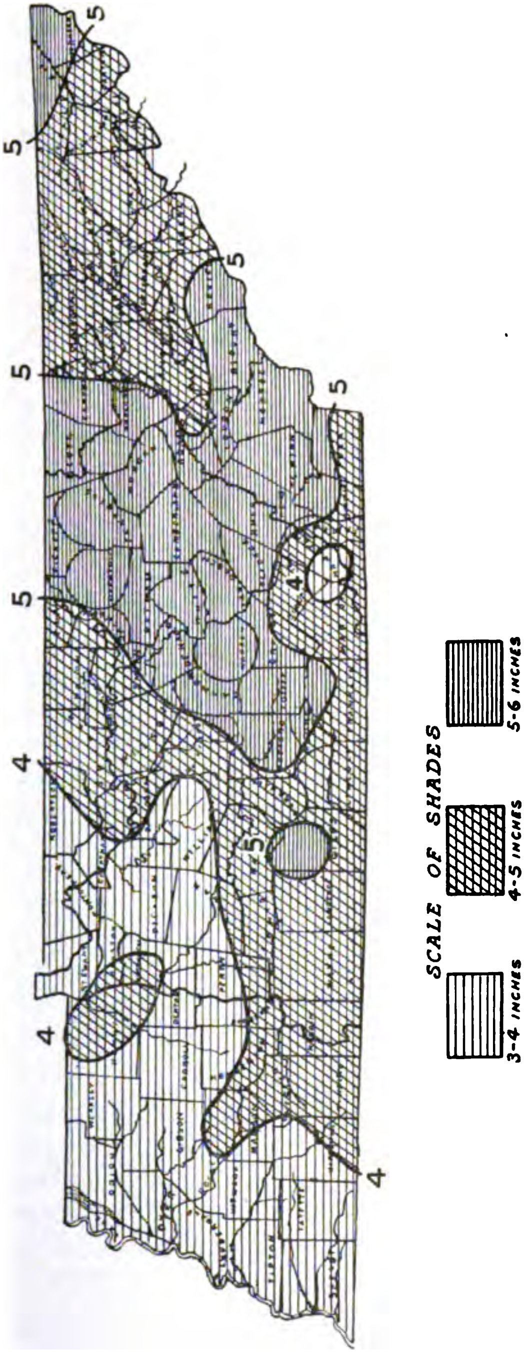

Chart VI—Normal Precipitation for July

consecutive days with snow-covered ground was 21 days, from January 28, to February 17, 1895; the next longest, 19 days, from January 29, to February 16, 1905. There were two winters (1899-1900 and 1907-8) when the ground was not covered at any time with snow.

Humidity.—Table 14 gives the mean relative humidity for each month and the year. These means are obtained from observations made at 7 a.m. and 7 p.m. While the records of humidity are rather incomplete, they are similar in character for all stations, and have value for comparison. By "relative" humidity is meant the percentage of the possible amount of moisture present in the air, or the amount necessary to saturate. If the air be perfectly dry the relative humidity would be 0; if the air be full of moisture, the relative humidity would be 100 per cent. Humidity is an important phase of climate in its relation to bodily comfort and health. The records show that in Tennessee the average relative humidity is moderate, as compared with the general conditions east of the Mississippi River. It is considerably lower than along the Atlantic and Gulf coasts but decidedy higher than in the arid regions of the far southwest.

Sunshine and cloudiness.—Tennessee occupies a medium position in the amount of sunshine received. Table 15 shows the percentage received of the possible amount. The average annual amount for the State is 58 per cent; that is, bright sunshine prevails 58 per cent of the time that the sun is above the horizon. The highest percentage of sunshine occurs in the extreme southwestern part of the United States, where it is at least 70 per cent. The region of least sunshine is in the north Pacific coast States and some distance inland. There are other sections with a very low percentage of sunshine, viz., the lower Lake region, the upper Ohio Valley, and northern New England, where the percentage ranges from 20 to 30 per cent. The average for the United States as a whole is between 50 and 60 per cent.

Frost; length of growing season.—Table 16 gives the average date of the first killing frost in autumn and the last in spring; also the earliest and latest dates on record for a number of stations, and the average length of the crop growing season. For the State as a whole the average date of the first killing frost in autumn is October 22 and of the last in spring, April 9. The average growing season is 196 days. For individual localities there is a considerable range. Frost comes, on an average, about two weeks earlier in the colder parts of the State than in the warmer portions, and in the spring the last frost occurs about four weeks later at the coldest station (Mountain City) than at the warmest (Memphis). The crop growing season, of course, has a similar range.

TABLE I—MEAN TEMPERATURE

Stations	Length of Record, yrs.	Jan.	Feb.	Mch.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	An'l
Carthage	32	38.3	40.2	49.4	58.9	67.4	75.1	77.6	76.8	71.8	59.8	48.6	40.0	58.7
Chattanooga	35	41.8	43.6	51.9	59.6	68.7	75.6	78.4	77.5	72.1	61.3	50.8	42.9	60.4
Clarksville	52	38.0	39.1	48.1	58.0	65.3	74.0	77.6	76.1	70.4	58.1	47.3	39.5	57.7
Decatur	18	40.0	40.0	51.7	58.0	67.9	74.6	77.7	77.3	71.6	59.8	48.3	39.9	58.9
Florence	34	39.0	40.7	49.5	59.0	67.5	75.2	77.5	76.6	71.6	59.7	48.8	40.7	58.8
Greeneville	23	35.4	39.1	47.2	55.1	64.7	72.0	74.6	73.4	69.0	56.9	46.5	39.0	56.2
Jackson	23	40.8	41.3	51.8	60.6	68.9	76.8	79.4	78.8	73.4	60.7	50.7	41.3	60.4
Johnsonville	20	40.0	39.5	51.2	59.2	68.5	75.6	78.9	78.3	72.7	60.4	49.4	39.8	59.5
Knoxville	43	38.5	41.2	49.1	57.9	65.9	74.0	77.0	75.9	70.5	58.8	47.5	39.8	58.1
Lynnville	28	39.3	40.4	49.5	58.2	66.8	74.9	77.4	77.2	71.2	59.6	48.7	41.1	58.7
Memphis	45	40.4	42.5	52.4	61.9	70.4	77.9	80.7	79.4	73.5	62.7	51.6	43.3	61.4
Mountain City	17	35.5	33.7	45.6	50.6	61.3	67.1	70.2	68.9	63.9	53.3	42.4	34.9	52.3
Nashville	45	38.9	40.9	49.5	59.2	68.3	76.1	79.2	78.0	71.9	60.5	48.9	40.9	59.4
Rugby	26	35.0	36.5	46.8	54.5	64.0	71.3	74.1	73.1	67.7	54.9	44.7	37.3	55.1
Savannah	30	41.0	42.2	51.8	60.5	68.8	75.9	79.0	78.3	72.3	60.4	50.2	42.0	60.2
Springdale	20	37.6	39.2	49.1	56.6	65.2	74.0	76.4	76.0	70.0	56.7	45.9	36.8	57.0
Trenton	33	38.6	40.0	49.5	59.6	67.6	75.0	78.0	77.3	71.4	59.3	48.2	39.7	58.7
Tullahoma	27	38.4	39.3	49.3	57.7	66.1	73.1	76.3	75.6	70.3	58.3	47.3	39.9	57.6
In Other States														
Atlanta, Ga.	25	42.9	43.3	53.0	60.4	70.0	76.2	78.1	77.6	73.3	62.4	52.1	43.7	61.1
Bismarck, N. Dak.	42	6.7	9.9	23.5	43.2	54.1	63.6	69.4	67.4	57.6	45.0	27.7	15.2	40.3
Columbia, Mo.	27	30.2	30.3	42.6	54.9	64.5	73.1	76.9	76.0	68.9	57.2	44.2	33.4	54.4
Dodge City, Kans.	31	27.3	31.1	41.7	54.4	63.5	73.1	77.7	76.5	68.2	54.7	40.5	31.5	53.3
Fort Worth, Texas	19	47.0	46.8	57.8	64.1	71.8	80.3	83.1	83.5	77.4	66.7	56.8	46.3	65.2
Indianapolis, Ind.	45	28.7	30.2	40.0	52.5	63.1	72.0	76.1	73.9	67.0	55.3	41.9	32.1	52.8
New Orleans, La.	46	54.3	56.7	62.8	68.8	75.2	80.7	82.3	82.2	79.0	70.5	61.7	55.4	69.1
Parkersburg, W. Va.	29	33.4	32.3	42.8	53.1	63.4	71.4	75.2	73.6	67.8	55.4	44.1	35.1	54.0

TABLE II—HIGHEST TEMPERATURE

Stations	Length of Record, yrs.	Jan.	Feb.	Mch.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	An'l
Carthage	32	76	82	90	92	98	104	103	101	102	96	85	74	104
Chattanooga	35	75	78	89	90	95	100	101	101	98	92	81	73	101
Clarksville	26	75	79	87	92	98	107	108	107	105	93	85	73	108
Decatur	18	76	75	91	89	96	100	104	101	100	96	79	72	104
Florence	32	74	75	86	88	94	100	100	100	98	93	79	71	100
Greeneville	23	73	78	82	88	91	95	97	97	96	90	78	69	97
Jackson	13	79	83	82	90	102	104	103	104	103	98	85	72	104
Johnsonville	22	78	80	90	92	100	105	107	103	103	96	88	73	107
Knoxville	43	74	79	87	90	95	99	100	100	99	94	80	75	100
Lynnville	19	73	75	85	91	93	100	102	99	97	94	79	73	102
Memphis	43	79	79	87	90	97	100	104	102	99	92	82	76	104
Mountain City	17	74	71	82	85	89	91	92	93	88	87	78	72	93
Nashville	45	76	77	89	90	95	100	102	104	99	92	81	75	104
Rugby	26	73	76	88	88	95	99	100	98	98	89	80	70	100
Savannah	30	76	77	87	90	95	104	105	104	103	94	84	78	105
Springdale	15	75	77	88	92	95	99	100	100	104	88	79	73	104
Trenton	30	76	80	86	90	100	106	103	100	103	95	85	75	105
Tullahoma	27	74	73	86	90	94	99	100	100	97	91	79	70	100
In Other States														
Atlanta, Ga.	37	75	78	87	89	97	100	100	98	97	94	82	73	100
Bismarck, N. Dak.	42	60	64	81	90	96	103	107	105	102	91	73	64	107
Columbia, Mo.	27	77	81	92	91	96	104	111	105	104	95	84	75	111
Dodge City, Kans.	42	76	83	98	95	101	107	108	105	101	92	85	79	108
Fort Worth, Texas	19	93	96	100	97	103	105	109	112	104	99	87	83	112
Indianapolis, Ind.	45	70	72	84	87	96	100	106	101	98	89	76	68	106
New Orleans, La.	46	82	82	85	90	96	102	102	100	98	94	89	83	102
Parkersburg, W. Va.	29	74	76	86	93	96	99	102	98	99	90	78	72	102

TABLE III—LOWEST TEMPERATURE

Stations	Length of Record, yrs.	Jan.	Feb.	Mch.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	An'l
Carthage	32	—17	—18	— 4	20	33	41	51	47	36	24	10	— 4	—18
Chattanooga	35	— 7	—10	2	25	37	39	56	54	38	27	16	3	—10
Clarksville	26	— 9	—14	4	26	32	43	51	47	35	26	7	— 5	—14
Decatur	18	— 9	—20	2	22	30	40	51	52	34	19	12	1	—20
Florence	32	— 7	—16	3	25	34	42	53	53	35	24	9	— 3	—16
Greeneville	26	—20	—14	3	21	31	35	51	49	28	24	10	— 8	—20
Jackson	18	—10	—13	10	27	31	41	52	49	34	21	8	— 1	—13
Johnsonville	22	—11	—23	4	22	31	41	48	49	30	21	8	— 8	—23
Knoxville	43	—16	—10	5	24	34	42	52	50	35	24	12	— 5	—16
Lynnville	19	— 4	—13	4	25	33	41	53	52	37	24	10	— 2	—13
Memphis	43	— 8	— 9	15	27	40	50	58	58	39	28	16	2	— 9
Mountain City	17	— 8	—16	— 8	15	25	35	40	38	29	14	4	— 9	—16
Nashville	45	—10	—13	3	26	37	42	56	51	38	27	10	— 2	—13
Rugby	26	—17	—19	— 2	16	26	32	42	44	28	16	4	—18	—19
Savannah	30	—12	—10	6	25	32	45	50	51	33	25	10	0	—12
Springdale	16	—15	—24	3	17	29	39	51	51	29	19	7	—11	—24
Trenton	30	—12	—29	8	26	32	42	50	48	30	21	14	— 4	—29
Tullahoma	27	—14	—22	0	22	29	40	41	48	27	22	5	— 5	—22
In Other States														
Atlanta, Ga.	37	— 2	— 8	8	25	38	39	58	55	43	30	16	1	— 8
Bismarck, N. Dak.	42	—45	—43	—36	— 3	13	31	32	32	10	— 2	—28	—42	—45
Columbia, Mo.	27	—20	—26	— 6	18	28	42	45	40	26	19	5	—23	—26
Dodge City, Kans.	42	—20	—26	— 9	13	19	40	46	43	30	10	—13	—15	—26
Fort Worth, Texas	19	1	— 8	22	30	34	48	56	55	40	24	20	9	— 8
Indianapolis, Ind.	45	—25	—18	0	19	31	39	48	44	30	22	— 5	—15	—25
New Orleans, La.	46	15	7	30	38	52	58	66	63	55	40	29	20	7
Parkersburg, W. Va.	29	—12	—27	4	20	31	41	48	45	33	20	15	— 5	—27

TABLE IV—MEAN MAXIMUM TEMPERATURE

Stations	Length of Record, yrs.	Jan.	Feb.	Mch.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	An'l
Carthage	18	50.7	50.2	62.8	71.0	81.2	87.8	90.4	90.2	86.1	75.2	61.9	49.5	71.4
Chattanooga	35	49.7	52.4	61.3	70.1	79.3	85.5	87.7	86.7	82.0	71.8	60.0	51.2	69.8
Clarksville	18	48.1	46.9	60.6	68.2	78.6	86.2	89.3	88.7	83.7	72.1	60.0	47.5	69.2
Decatur	18	50.5	51.1	63.6	71.0	81.6	87.1	89.6	89.5	84.7	74.0	61.3	50.1	71.2
Florence	19	49.1	48.5	60.3	68.0	78.2	84.8	87.1	85.3	82.5	70.1	59.9	48.6	68.5
Greeneville	10	45.6	46.8	60.1	65.9	77.6	83.3	85.9	85.1	81.1	70.9	57.1	42.5	66.9
Jackson	13	50.3	50.8	61.9	70.4	81.4	88.9	91.5	90.5	87.0	74.8	63.0	50.1	71.7
Johnsonville	19	50.8	50.5	63.4	71.7	81.4	88.2	91.3	90.6	86.2	74.6	62.5	49.8	71.8
Knoxville	39	47.2	50.0	59.2	68.4	77.7	84.2	86.9	85.8	81.2	70.2	57.8	47.6	68.1
Lynnville	19	48.8	48.2	60.6	68.0	78.6	85.9	87.8	86.9	82.8	72.0	59.8	48.2	69.0
Memphis	45	48.7	51.3	60.7	70.6	79.0	85.4	89.0	87.9	82.3	71.7	59.9	50.9	69.9
Mountain City	16	45.6	44.2	57.1	63.0	73.8	78.6	80.8	79.5	74.9	65.1	54.1	44.5	63.4
Nashville	42	47.0	49.6	58.7	67.5	78.3	85.6	88.5	87.5	81.9	71.1	58.1	48.8	68.6
Rugby	17	47.0	47.0	60.5	66.4	77.6	83.7	85.9	86.4	82.0	71.1	57.9	46.8	67.8
Savannah	19	51.4	51.8	63.9	71.3	80.8	88.3	90.8	90.8	85.8	74.8	63.0	50.9	72.0
Springdale	14	48.7	49.2	62.9	69.1	81.4	86.5	89.1	88.6	84.1	72.3	59.5	47.6	69.9
Trenton	18	50.3	48.9	62.0	69.2	79.9	87.5	90.2	90.4	86.4	74.8	61.8	48.8	70.8
Tullahoma	18	49.9	49.8	62.6	69.1	78.8	85.3	87.7	87.5	83.4	72.4	60.0	49.0	69.6
In Other States														
Atlanta, Ga.	34	50.2	53.4	62.0	70.0	78.8	84.8	86.8	85.3	81.0	71.0	60.6	52.1	69.7
Bismarck, N. Dak.	42	17.2	20.3	34.0	54.7	66.0	74.9	81.7	80.3	70.6	57.1	38.2	25.1	51.7
Columbia, Mo.	27	39.9	40.1	53.1	66.1	75.6	84.2	87.9	87.8	80.9	69.5	55.2	42.0	65.2
Dodge City, Kans.	36	40.6	44.7	56.4	67.5	75.5	85.0	89.9	88.9	81.6	69.5	54.8	44.9	66.6
Fort Worth, Texas	19	57.6	57.9	69.1	74.6	81.1	90.3	93.1	93.6	87.7	77.6	67.3	55.9	75.5
Indianapolis, Ind.	45	36.0	38.0	48.2	59.8	72.4	81.3	85.5	83.4	76.6	64.5	49.5	38.9	61.2
New Orleans, La.	43	62.0	64.2	70.9	76.4	82.9	87.8	89.1	88.9	85.7	77.7	69.6	62.8	76.5
Parkersburg, W. Va.	29	41.8	40.8	52.0	63.4	74.2	81.8	85.5	84.0	78.7	66.3	53.1	42.9	63.7

TABLE V—MEAN MINIMUM TEMPERATURE

Stations	Length of Record, yrs.	Jan.	Feb.	Mch.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	An'l
Carthage	17	30.5	28.8	39.9	46.3	55.9	63.6	65.6	66.0	60.6	48.6	37.8	30.3	47.9
Chattanooga	35	33.4	34.8	42.5	50.3	58.0	65.8	69.1	68.3	62.7	51.0	41.0	34.6	51.0
Clarksville	18	30.2	28.4	40.4	47.1	57.0	65.0	68.7	67.4	61.5	48.6	38.2	30.6	48.6
Decatur	18	29.6	28.8	39.7	44.8	54.2	62.0	65.8	65.1	58.6	45.6	35.1	29.7	46.6
Florence	19	31.3	30.1	40.9	47.4	57.1	65.1	68.2	67.3	61.4	48.9	38.4	31.6	49.0
Greeneville	10	26.7	26.2	38.5	41.9	52.6	60.5	63.4	62.8	56.4	45.2	35.3	28.6	44.8
Jackson	17	31.8	31.2	41.9	48.6	57.0	60.3	67.5	66.8	61.3	48.3	38.8	32.0	48.8
Johnsonville	19	29.2	28.2	39.5	46.1	55.2	62.8	66.4	65.8	59.4	46.4	36.2	29.4	47.0
Knoxville	39	30.5	32.2	39.5	47.5	56.1	64.2	67.6	66.4	60.6	48.1	38.0	31.9	48.6
Lynnville	19	31.5	30.0	40.7	46.7	56.6	64.5	67.8	66.9	61.3	48.9	38.4	32.0	48.8
Memphis	45	33.7	35.7	44.2	53.4	61.8	69.7	72.8	71.2	64.9	53.8	43.2	36.1	53.4
Mountain City	16	25.0	23.4	33.9	38.2	48.2	55.6	59.6	58.7	53.0	41.0	30.4	24.8	41.0
Nashville	42	31.0	32.4	40.4	49.7	58.6	66.9	70.2	68.7	61.9	50.2	39.8	33.2	50.2
Rugby	17	26.1	24.3	36.1	40.2	49.9	57.6	61.8	60.8	54.3	41.3	31.9	25.9	42.5
Savannah	19	32.6	31.6	42.3	48.3	57.1	64.7	68.4	67.6	61.1	48.3	39.2	32.9	49.5
Springdale	14	26.9	26.1	36.7	40.5	51.7	59.7	63.6	63.9	56.0	41.8	31.5	26.0	43.7
Trenton	18	30.2	28.8	41.1	48.2	57.3	63.8	66.9	66.6	59.8	47.0	37.3	30.4	48.1
Tullahoma	18	30.2	29.0	40.4	45.5	54.0	62.0	65.4	64.9	58.8	46.1	35.7	30.3	46.9
In Other States														
Atlanta, Ga.	34	35.1	36.7	44.0	51.5	60.1	67.0	69.7	68.9	64.2	53.5	43.5	36.5	52.6
Bismarck, N. Dak.	42	—3.7	—0.5	13.2	31.6	42.3	52.3	57.0	54.6	44.7	33.0	17.1	5.3	28.9
Columbia, Mo.	27	20.6	20.6	32.0	43.9	53.4	62.4	65.6	64.0	57.5	45.2	33.4	24.0	43.6
Dodge City, Kans.	36	17.1	19.7	29.4	40.9	51.0	60.6	65.4	64.5	55.8	43.0	29.1	21.2	41.5
Fort Worth, Texas	19	36.4	35.7	46.8	53.7	62.1	70.2	73.2	73.4	67.0	55.6	45.4	36.7	54.8
Indianapolis, Ind.	45	21.4	22.5	31.9	43.4	53.8	62.7	66.6	64.4	57.4	46.1	34.3	24.9	44.1
New Orleans, La.	43	46.9	48.8	55.2	61.2	67.7	73.7	75.5	75.4	72.6	63.5	54.3	47.9	61.8
Parkersburg, W. Va.	29	25.5	24.0	33.5	42.8	52.6	61.0	64.8	63.2	56.9	44.5	35.1	27.5	44.3

TABLE VI—AVERAGE PRECIPITATION

Stations	Length of Record, yrs.	Jan.	Feb.	Mch.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	An'l
Carthage	22	4.34	4.54	5.30	4.23	3.85	4.64	4.47	4.16	3.02	2.54	3.76	4.18	49.03
Chattanooga	38	5.17	4.97	5.63	4.64	3.82	4.16	4.23	3.85	3.37	2.82	3.25	4.83	50.74
Clarksville	56	4.29	4.21	5.01	4.72	4.06	3.99	3.88	3.32	2.83	2.40	4.10	4.62	47.43
Decatur	18	4.51	5.48	6.76	5.33	4.29	5.02	5.18	4.46	3.56	2.93	3.16	5.57	56.25
Florence	34	4.51	4.63	5.34	4.20	4.02	3.91	4.22	3.69	3.34	2.41	3.52	4.17	47.96
Greeneville	27	3.21	4.01	4.87	3.41	3.79	4.66	4.22	4.57	2.22	2.39	2.47	2.98	42.80
Jackson	25	4.14	3.52	4.59	5.47	4.07	4.36	4.38	3.51	2.67	2.57	3.92	5.11	48.31
Johnsonville	32	4.47	4.28	4.56	4.72	4.04	3.84	4.26	3.83	3.39	2.45	4.23	4.46	48.53
Knoxville	48	4.70	4.67	5.10	4.44	3.80	4.29	4.26	3.94	2.92	2.52	3.31	4.22	48.17
Lynnville	26	4.70	5.30	5.79	4.83	4.33	4.42	5.54	4.20	3.84	2.65	3.33	4.90	53.83
Memphis	53	5.00	4.59	5.25	4.93	4.28	4.03	3.18	3.54	2.84	2.64	4.36	4.39	49.03
Mountain City	17	3.57	3.63	4.84	3.85	4.25	5.28	5.89	5.28	3.17	2.83	2.30	3.61	48.50
Nashville	53	4.70	4.34	4.96	4.41	3.83	4.23	4.15	3.54	3.70	2.45	3.61	3.88	47.80
Rugby	26	5.12	5.20	6.17	5.02	4.32	4.61	5.29	4.29	3.53	2.29	3.46	4.50	53.80
Savannah	33	4.74	4.89	5.57	4.51	4.10	4.47	4.37	3.59	3.30	3.27	3.73	5.22	50.76
Springdale	23	4.00	4.93	4.86	4.08	3.76	4.15	5.42	4.53	2.78	2.46	3.37	3.97	48.31
Trenton	36	5.03	4.31	4.86	4.76	3.73	3.86	3.19	3.43	2.91	2.80	4.54	4.44	47.86
Tullahoma	27	5.26	4.62	5.91	4.70	3.62	4.15	5.00	3.95	3.36	2.79	3.44	5.59	52.39
In Other States														
Atlanta, Ga.	37	4.69	4.73	5.48	3.54	3.31	3.99	4.85	4.36	3.26	2.58	2.99	4.45	48.40
Bismarck, N. Dak.	42	0.53	0.49	1.03	1.64	2.48	3.60	2.26	2.04	1.28	1.00	0.64	0.58	17.57
Columbia, Mo.	19	2.46	2.18	2.91	3.88	4.83	4.86	4.08	3.58	3.84	2.16	2.15	1.70	38.46
Dodge City, Kans.	42	0.45	0.68	0.74	1.77	3.08	3.17	2.89	2.45	1.86	1.35	0.59	0.57	19.60
Fort Worth, Texas	23	1.79	2.11	2.53	3.68	4.79	3.31	3.23	2.04	2.58	2.90	2.63	1.77	33.36
Indianapolis, Ind.	46	3.11	2.97	3.86	3.35	3.89	4.05	4.16	3.26	3.01	2.68	3.36	2.90	40.84
New Orleans, La.	70	4.50	4.21	4.60	4.61	4.24	5.45	6.60	5.73	4.70	3.37	3.71	4.65	56.26
Parkersburg, W. Va.	24	3.37	3.29	3.69	3.06	3.40	4.38	4.53	3.39	2.70	2.25	2.67	2.66	39.39

TABLE I—MEAN TEMPERATURE

Stations	Length of Record, yrs.	Jan.	Feb.	Mch.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	An'l
Carthage	32	38.3	40.2	49.4	58.9	67.4	75.1	77.6	76.8	71.8	59.8	48.6	40.0	58.7
Chattanooga	35	41.8	43.6	51.9	59.6	68.7	75.6	78.4	77.5	72.1	61.3	50.8	42.9	60.4
Clarksville	52	38.0	39.1	48.1	58.0	65.3	74.0	77.6	76.1	70.4	58.1	47.3	39.5	57.7
Decatur	18	40.0	40.0	51.7	58.0	67.9	74.6	77.7	77.3	71.6	59.8	48.3	39.9	58.9
Florence	34	39.0	40.7	49.5	59.0	67.5	75.2	77.5	76.6	71.6	59.7	48.8	40.7	58.8
Greeneville	23	35.4	39.1	47.2	55.1	64.7	72.0	74.6	73.4	69.0	56.9	46.5	39.0	56.2
Jackson	23	40.8	41.3	51.8	60.6	68.9	76.8	79.4	78.8	73.4	60.7	50.7	41.3	60.4
Johnsonville	20	40.0	39.5	51.2	59.2	68.5	75.6	78.9	78.3	72.7	60.4	49.4	39.8	59.5
Knoxville	43	38.5	41.2	49.1	57.9	65.9	74.0	77.0	75.9	70.5	58.8	47.5	39.8	58.1
Lynnville	28	39.3	40.4	49.5	58.2	66.8	74.9	77.4	77.2	71.2	59.6	48.7	41.1	58.7
Memphis	45	40.4	42.5	52.4	61.9	70.4	77.9	80.7	79.4	73.5	62.7	51.6	43.3	61.4
Mountain City	17	35.5	33.7	45.6	50.6	61.3	67.1	70.2	68.9	63.9	53.3	42.4	34.9	52.3
Nashville	45	38.9	40.9	49.5	59.2	68.3	76.1	79.2	78.0	71.9	60.5	48.9	40.9	59.4
Rugby	26	35.0	36.5	46.8	54.5	64.0	71.3	74.1	73.1	67.7	54.9	44.7	37.3	55.1
Savannah	30	41.0	42.2	51.8	60.5	68.8	75.9	79.0	78.3	72.3	60.4	50.2	42.0	60.2
Springdale	20	37.6	39.2	49.1	56.6	65.2	74.0	76.4	76.0	70.0	56.7	45.9	36.8	57.0
Trenton	33	38.6	40.0	49.5	59.6	67.6	75.0	78.0	77.3	71.4	59.3	48.2	39.7	58.7
Tullahoma	27	38.4	39.3	49.3	57.7	66.1	73.1	76.3	75.6	70.3	58.3	47.3	39.9	57.6
In Other States														
Atlanta, Ga.	25	42.9	43.3	53.0	60.4	70.0	76.2	78.1	77.6	73.3	62.4	52.1	43.7	61.1
Bismarck, N. Dak.	42	6.7	9.9	23.5	43.2	54.1	63.6	69.4	67.4	57.6	45.0	27.7	15.2	40.3
Columbia, Mo.	27	30.2	30.3	42.6	54.9	64.5	73.1	76.9	76.0	68.9	57.2	44.2	33.4	54.4
Dodge City, Kans.	31	27.3	31.1	41.7	54.4	63.5	73.1	77.7	76.5	68.2	54.7	40.5	31.6	53.3
Fort Worth, Texas	19	47.0	46.8	57.8	64.1	71.8	80.3	83.1	83.5	77.4	66.7	56.8	46.3	65.2
Indianapolis, Ind.	45	28.7	30.2	40.0	52.5	63.1	72.0	76.1	73.9	67.0	55.3	41.9	32.1	52.8
New Orleans, La.	46	54.3	56.7	62.8	68.8	75.2	80.7	82.3	82.2	79.0	70.5	61.7	55.4	69.1
Parkersburg, W. Va.	29	33.4	32.3	42.8	53.1	63.4	71.4	75.2	73.6	67.8	55.4	44.1	35.1	54.0

TABLE II—HIGHEST TEMPERATURE

Stations	Length of Record, yrs.	Jan.	Feb.	Mch.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	An'l
Carthage	32	76	82	90	92	98	104	103	101	102	96	85	74	104
Chattanooga	35	75	78	89	90	95	100	101	101	98	92	81	73	101
Clarksville	26	75	79	87	92	98	107	108	107	105	93	85	73	108
Decatur	18	76	75	91	89	96	100	104	101	100	96	79	72	104
Florence	32	74	75	86	88	94	100	100	100	98	93	79	71	100
Greeneville	23	73	78	82	88	91	95	97	97	96	90	78	69	97
Jackson	13	79	83	82	90	102	104	103	104	103	98	85	72	104
Johnsonville	22	78	80	90	92	100	105	107	103	103	96	88	73	107
Knoxville	43	74	79	87	90	95	99	100	100	99	94	80	75	100
Lynnville	19	73	75	85	91	93	100	102	99	97	94	79	73	102
Memphis	43	79	79	87	90	97	100	104	102	99	92	82	76	104
Mountain City	17	74	71	82	85	89	91	92	93	88	87	78	72	93
Nashville	45	76	77	89	90	95	100	102	104	99	92	81	75	104
Rugby	26	73	76	88	88	95	99	100	98	98	89	80	70	100
Savannah	30	76	77	87	90	95	104	105	104	103	94	84	78	105
Springdale	15	75	77	88	92	95	99	100	100	104	88	79	73	104
Trenton	30	76	80	86	90	100	106	103	100	103	95	85	75	105
Tullahoma	27	74	73	86	90	94	99	100	100	97	91	79	70	100
In Other States														
Atlanta, Ga.	37	75	78	87	89	97	100	100	98	97	94	82	73	100
Bismarck, N. Dak.	42	60	64	81	90	96	103	107	105	102	91	73	64	107
Columbia, Mo.	27	77	81	92	91	96	104	111	105	104	95	84	75	111
Dodge City, Kans.	42	76	83	98	95	101	107	108	105	101	92	85	79	108
Fort Worth, Texas	19	93	96	100	97	103	105	109	112	104	99	87	83	112
Indianapolis, Ind.	45	70	72	84	87	96	100	106	101	98	89	76	68	106
New Orleans, La.	46	82	82	86	90	96	102	102	100	98	94	89	83	102
Parkersburg, W. Va.	29	74	76	86	93	96	99	102	98	99	90	78	72	102

TABLE V—MEAN MINIMUM TEMPERATURE

Stations	Length of Record, yrs.	Jan.	Feb.	Mch.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	An'l
Carthage	17	30.5	28.8	39.9	46.3	55.9	63.6	65.6	66.0	60.6	48.6	37.8	30.3	47.9
Chattanooga	35	33.4	34.8	42.5	50.3	58.0	65.8	69.1	68.3	62.7	51.0	41.0	34.6	51.0
Clarksville	18	30.2	28.4	40.4	47.1	57.0	65.0	68.7	67.4	61.5	48.6	38.2	30.6	48.6
Decatur	18	29.6	28.8	39.7	44.8	54.2	62.0	65.8	65.1	58.6	45.6	35.1	29.7	46.6
Florence	19	31.3	30.1	40.9	47.4	57.1	65.1	68.2	67.3	61.4	48.9	38.4	31.6	49.0
Greeneville	10	26.7	26.2	38.5	41.9	52.6	60.5	63.4	62.8	56.4	45.2	35.3	28.6	44.8
Jackson	17	31.8	31.2	41.9	48.6	57.0	60.3	67.5	66.8	61.3	48.3	38.8	32.0	48.8
Johnsonville	19	29.2	28.2	39.5	46.1	55.2	62.8	66.4	65.8	59.4	46.4	36.2	29.4	47.0
Knoxville	39	30.5	32.2	39.5	47.5	56.1	64.2	67.6	66.4	60.6	48.1	38.0	31.9	48.6
Lynnville	19	31.5	30.0	40.7	46.7	56.6	64.5	67.8	66.9	61.3	48.9	38.4	32.0	48.8
Memphis	45	33.7	35.7	44.2	53.4	61.8	69.7	72.8	71.2	64.9	53.8	43.2	36.1	53.4
Mountain City	16	25.0	23.4	33.9	38.2	48.2	55.6	59.6	58.7	53.0	41.0	30.4	24.8	41.0
Nashville	42	31.0	32.4	40.4	49.7	58.6	66.9	70.2	68.7	61.9	50.2	39.8	33.2	50.2
Rugby	17	26.1	24.3	36.1	40.2	49.9	57.6	61.8	60.8	54.3	41.3	31.9	25.9	42.5
Savannah	19	32.6	31.6	42.3	48.3	57.1	64.7	68.4	67.6	61.1	48.3	39.2	32.9	49.5
Springdale	14	26.9	26.1	35.7	40.5	51.7	59.7	63.6	63.9	56.0	41.8	31.5	26.0	43.7
Trenton	18	30.2	28.8	41.1	48.2	57.3	63.8	66.9	66.6	59.8	47.0	37.3	30.4	48.1
Tullahoma	18	30.2	29.0	40.4	45.5	54.0	62.0	65.4	64.9	58.8	46.1	35.7	30.3	46.9
In Other States														
Atlanta, Ga.	34	35.1	36.7	44.0	51.5	60.1	67.0	69.7	68.9	64.2	53.5	43.5	36.5	52.6
Bismarck, N. Dak.	42	—3.7	—0.5	13.2	31.6	42.3	52.3	57.0	54.6	44.7	33.0	17.1	5.3	28.9
Columbia, Mo.	27	20.6	20.6	32.0	43.9	53.4	62.4	65.6	64.0	57.5	45.2	33.4	24.0	43.6
Dodge City, Kans.	36	17.1	19.7	29.4	40.9	51.0	60.6	65.4	64.5	55.8	43.0	29.1	21.2	41.5
Fort Worth, Texas	19	36.4	35.7	46.8	53.7	62.1	70.2	73.2	73.4	67.0	55.6	45.4	36.7	54.8
Indianapolis, Ind.	45	21.4	22.5	31.9	43.4	53.8	62.7	66.6	64.4	57.4	46.1	34.3	24.9	44.1
New Orleans, La.	43	46.9	48.8	55.2	61.2	67.7	73.7	75.5	75.4	72.6	63.5	54.3	47.9	61.8
Parkersburg, W. Va.	29	25.5	24.0	33.5	42.8	52.6	61.0	64.8	63.2	56.9	44.5	35.1	27.5	44.3

TABLE VI—AVERAGE PRECIPITATION

Stations	Length of Record, yrs.	Jan.	Feb.	Mch.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	An'l
Carthage	22	4.34	4.54	5.30	4.23	3.85	4.64	4.47	4.16	3.02	2.54	3.76	4.18	49.03
Chattanooga	38	5.17	4.97	5.63	4.64	3.82	4.16	4.23	3.85	3.37	2.82	3.25	4.83	50.74
Clarksville	56	4.29	4.21	5.01	4.72	4.06	3.99	3.88	3.32	2.83	2.40	4.10	4.62	47.43
Decatur	18	4.51	5.48	6.76	5.33	4.29	5.02	5.18	4.46	3.56	2.93	3.16	5.57	56.25
Florence	34	4.51	4.63	5.34	4.20	4.02	3.91	4.22	3.69	3.34	2.41	3.52	4.17	47.96
Greeneville	27	3.21	4.01	4.87	3.41	3.79	4.66	4.22	4.57	2.22	2.39	2.47	2.98	42.80
Jackson	25	4.14	3.52	4.59	5.47	4.07	4.36	4.38	3.51	2.67	2.57	3.92	5.11	48.31
Johnsonville	32	4.47	4.28	4.56	4.72	4.04	3.84	4.26	3.83	3.39	2.45	4.23	4.46	48.53
Knoxville	48	4.70	4.67	5.10	4.44	3.80	4.29	4.26	3.94	2.92	2.52	3.31	4.22	48.17
Lynnville	26	4.70	5.30	5.79	4.83	4.33	4.42	5.54	4.20	3.84	2.65	3.33	4.90	53.83
Memphis	53	5.00	4.59	5.25	4.93	4.28	4.03	3.18	3.54	2.84	2.64	4.36	4.39	49.03
Mountain City	17	3.57	3.63	4.84	3.85	4.25	5.28	5.89	5.28	3.17	2.83	2.30	3.61	48.50
Nashville	53	4.70	4.34	4.96	4.41	3.83	4.23	4.15	3.54	3.70	2.45	3.61	3.88	47.80
Rugby	26	5.12	5.20	6.17	5.02	4.32	4.61	5.29	4.29	3.53	2.29	3.46	4.50	53.80
Savannah	33	4.74	4.89	5.57	4.51	4.10	4.47	4.37	3.59	3.30	3.27	3.73	5.22	50.76
Springdale	23	4.00	4.93	4.86	4.08	3.76	4.15	5.42	4.53	2.78	2.46	3.37	3.97	48.31
Trenton	36	5.03	4.31	4.86	4.76	3.73	3.86	3.19	3.43	2.91	2.80	4.54	4.44	47.86
Tullahoma	27	5.26	4.62	5.91	4.70	3.62	4.15	5.00	3.95	3.36	2.79	3.44	5.59	52.39
In Other States														
Atlanta, Ga.	37	4.69	4.73	5.48	3.54	3.31	3.99	4.85	4.36	3.26	2.58	2.99	4.45	48.40
Bismarck, N. Dak.	42	0.53	0.49	1.03	1.64	2.48	3.60	2.26	2.04	1.28	1.00	0.64	0.58	17.57
Columbia, Mo.	19	2.46	2.18	2.91	3.88	4.83	4.86	4.08	3.58	3.84	2.16	2.15	1.70	38.46
Dodge City, Kans.	42	0.45	0.68	0.74	1.77	3.08	3.17	2.89	2.45	1.86	1.35	0.59	0.57	19.60
Fort Worth, Texas	23	1.79	2.11	2.53	3.68	4.79	3.31	3.23	2.04	2.58	2.90	2.63	1.77	33.36
Indianapolis, Ind.	46	3.11	2.97	3.86	3.35	3.89	4.05	4.16	3.26	3.01	2.68	3.36	2.90	40.84
New Orleans, La.	70	4.50	4.21	4.60	4.61	4.24	5.45	6.60	5.73	4.70	3.37	3.71	4.65	56.26
Parkersburg, W. Va.	24	3.37	3.29	3.69	3.06	3.40	4.38	4.53	3.39	2.70	2.25	2.67	2.66	39.39

TABLE IX—MEMPHIS, TENN., MONTHLY AND ANNUAL PRECIPITATION

Year	Jan.	Feb.	Mch.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	An'l
1850	....	....	7.80	5.74	5.31	6.60	3.18	1.47	0.03	1.07	1.65	6.07	.....
1851	1.39	8.77	....	....	....	....	....	....	....	....	....	....	.....
....	....	....	....	....	....	....	....	....	....	....	....	....	.....
1857	....	2.54	0.91	8.73	4.78	2.96	....	....	2.50	1.47	4.82	4.91	.....
1858	4.91	3.25	4.75	3.15	7.56	5.00	9.64	3.37	1.40	1.92	3.14	5.46	53.55
1859	4.05	7.10	6.41	6.40	....	....	1.75	4.48	4.76	1.48	3.77	3.47	.....
1860	7.20	5.46	0.88	3.62	0.50	5.60	2.57	1.09	2.95	3.52	4.15	....	.....
1861	1.30	3.05	3.65	....	....	....	....	....	....	....	....	....	.....
....	....	....	....	....	....	....	....	....	....	....	....	....	.....
1867	....	....	....	....	....	....	....	....	2.23	1.87	3.59	1.81	.....
1868	5.30	1.28	4.17	7.96	3.44	1.53	2.74	6.35	9.31	1.97	2.13	4.27	50.45
1869	2.24	3.97	6.37	8.79	1.74	3.60	2.36	3.26	1.30	3.99	4.84	4.68	47.14
1870	4.96	4.69	5.65	....	....	....	....	....	....	....	....	....	.....
1871	....	....	9.84	5.03	6.02	5.12	2.53	2.69	3.38	4.04	2.23	1.70	.....
1872	2.17	4.24	5.19	6.99	4.16	4.44	4.23	0.54	3.62	3.23	1.67	3.47	43.95
1873	5.85	8.98	3.44	4.87	4.82	6.36	0.82	4.53	3.53	5.95	3.87	3.18	56.20
1874	2.88	4.10	6.61	10.16	0.63	2.22	0.47	4.60	5.99	1.07	3.86	3.12	45.71
1875	7.45	3.34	8.60	3.48	4.21	2.72	4.34	2.39	2.94	2.38	9.63	5.54	57.02
1876	7.65	1.33	11.03	4.51	8.49	2.70	4.38	5.37	3.04	3.95	0.90	2.14	55.49
1877	4.31	1.54	4.24	13.90	1.81	18.16	6.22	6.05	3.11	3.75	5.97	4.44	73.50
1878	4.11	5.08	3.80	11.93	3.66	5.47	2.40	1.72	2.59	2.91	2.45	3.21	49.33
1879	7.71	3.25	2.98	5.54	5.53	3.17	3.01	4.57	0.62	1.39	6.01	8.51	52.29
1880	6.87	9.44	8.82	3.91	3.82	4.96	2.14	3.03	2.47	5.20	8.39	2.62	61.67
1881	4.38	6.41	3.23	5.74	2.80	2.83	0.89	1.97	3.84	3.22	5.14	2.39	42.84
1882	12.87	9.92	9.10	3.56	9.14	4.15	4.13	3.49	2.18	4.08	6.65	1.78	71.05
1883	4.83	8.09	4.43	4.66	6.55	4.92	1.78	1.85	1.05	8.56	4.56	5.86	57.14
1884	5.66	9.64	5.08	8.60	6.46	7.26	2.38	1.27	4.29	2.83	2.08	9.14	64.69
1885	6.61	1.88	3.07	3.00	3.05	1.52	4.80	1.70	4.42	1.18	3.26	2.92	37.41
1886	4.55	6.43	3.00	2.88	2.11	8.06	5.52	6.49	6.20	0.59	8.89	3.00	57.72
1887	5.00	8.37	4.18	2.34	2.83	1.04	3.30	1.21	2.15	2.24	4.06	5.80	42.52
1888	4.04	2.49	5.40	1.15	2.35	4.32	2.12	10.44	1.06	3.51	6.53	3.41	46.82
1889	5.28	1.90	5.33	3.47	1.48	7.39	4.77	5.62	3.01	0.75	5.21	0.46	44.67
1890	8.43	8.13	7.93	5.10	4.42	3.55	2.82	7.56	9.07	2.75	4.88	3.64	68.28

1892	6.16	3.35	3.68	7.58	2.81	3.50	4.11	3.10	0.63	0.47	5.91	3.32	44.62
1893	1.56	7.96	2.49	5.46	6.71	4.92	5.25	2.08	1.45	1.73	1.32	2.49	43.42
1894	3.80	7.37	2.37	2.81	3.85	1.43	2.24	4.79	0.47	1.50	0.55	6.26	37.44
1895	6.72	1.95	4.65	3.36	5.63	3.39	4.50	1.89	0.59	1.24	1.90	2.93	38.75
1896	1.49	5.51	5.30	4.24	5.31	5.61	7.36	1.25	2.02	1.59	4.32	0.95	44.95
1897	2.91	4.66	9.59	6.26	6.11	3.18	3.83	5.23	1.92	1.97	1.87	5.42	52.95
1898	7.68	0.56	3.97	3.34	1.60	3.47	2.97	4.86	7.44	3.13	2.10	1.67	42.79
1899	3.70	6.21	11.28	2.68	3.58	3.71	3.93	1.52	1.68	2.53	0.89	2.70	44.41
1900	3.35	5.52	3.64	1.92	1.72	6.42	3.90	3.64	3.41	2.21	5.63	2.75	44.11
1901	4.31	0.79	4.32	5.35	4.03	6.44	0.69	10.48	4.13	1.57	1.30	12.34	55.75
1902	3.71	3.53	6.37	1.79	2.09	5.45	3.73	2.39	8.04	0.99	4.03	3.46	45.58
1903	2.10	8.35	6.96	7.21	3.09	3.39	2.26	3.86	0.62	1.88	4.19	1.98	45.89
1904	2.02	4.42	6.35	1.90	2.34	1.66	2.50	3.92	1.10	0.07	3.43	5.37	35.09
1905	3.24	5.68	3.86	4.36	3.80	3.55	3.23	7.35	0.55	4.55	1.27	5.16	46.60
1906	3.60	1.24	3.83	2.64	4.69	5.73	6.53	1.35	3.82	2.38	3.78	3.57	43.16
1907	1.29	3.19	5.17	3.79	3.54	4.28	3.04	2.16	6.89	0.93	5.80	3.72	43.80
1908	4.04	2.87	3.25	3.02	2.15	2.07	3.90	3.95	1.78	2.57	3.13	5.65	38.38
1909	3.17	7.05	5.98	5.70	4.14	9.68	7.01	3.17	2.91	1.61	0.91	2.49	53.82
1910	3.66	4.19	0.72	4.12	7.28	3.13	5.09	3.86	3.68	1.68	0.97	4.94	43.32
1911	4.79	4.83	3.99	7.66	1.23	2.72	4.31	2.99	1.89	3.78	4.37	4.84	47.40
1912	3.00	2.96	7.04	7.98	5.94	2.44	4.32	2.66	5.08	1.30	1.47	6.42	50.61
1913	8.93	4.51	6.43	2.00	4.86	1.56	3.77	1.44	3.34	2.45	1.11	3.59	43.99
1914	1.64	3.47	3.97	4.50	1.25	3.91	7.11	5.69	1.04	3.57	1.29	7.86	45.30
1915	4.18	3.37	2.57	1.45	3.59	6.24	3.72	3.95	4.04	2.68	5.48	7.77	49.04
1916	5.23	3.33	2.25	2.03	4.71	5.29	6.48	4.24	2.84	1.97	2.55	3.63	44.55
Means	4.70	4.67	5.10	4.44	3.80	4.29	4.26	3.94	2.92	2.52	3.31	4.22	48.17

TABLE X—NASHVILLE, TENN., MONTHLY AND ANNUAL PRECIPITATION

Year	Jan.	Feb.	Mch.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	An'l
1839	....	....	....	....	....	1.50	1.00	0.50	4.00	0.10	3.64	2.76	.....
1840	3.05	4.87	4.05	11.82	6.55	5.72	5.05	4.90	3.04	6.83	2.19	1.07	59.14
1841	9.09	2.25	4.89	4.38	4.50	4.42	5.47	8.58	5.70	5.45	2.95	4.02	61.70
1842	5.56	7.30	5.63	4.15	6.48	4.81	2.73	4.50	5.09	1.29	3.01	3.04	53.59
1843	3.79	2.93	4.29	4.65	4.04	4.87	4.23	5.94	8.61	5.09	6.16	3.71	58.31
1844	3.54	2.57	5.66	1.00	3.15	5.16	4.57	1.39	3.23	3.30	5.54	3.16	42.27
1845	5.01	3.98	4.90	5.20	4.94	5.00	4.41	5.06	5.13	4.39	3.97	3.00	54.99
....	....	....	....	....	....	....	....	....	....	....	....	....	.....
1850	5.49	5.92	5.42	1.07	....	4.98	5.00	3.55	1.15	....	....	....	.....
....	....	....	....	....	....	....	....	....	....	....	....	....	.....
1871	2.76	4.58	5.01	4.13	3.30	2.98	1.58	2.36	0.95	1.31	2.13	1.65	32.74
1872	2.32	2.11	3.14	5.91	3.09	5.17	6.10	1.65	4.50	1.58	2.25	2.38	40.20
1873	2.96	7.14	4.11	3.59	6.31	4.20	4.63	2.36	1.81	4.28	4.36	5.94	51.69
1874	5.22	9.23	5.36	11.84	1.49	2.87	2.65	3.52	3.12	2.63	6.12	4.19	58.24
1875	6.15	3.06	8.14	4.25	1.73	5.63	8.12	1.60	3.79	1.25	5.46	4.30	53.48
1876	6.41	2.22	5.28	3.62	3.40	5.65	7.15	5.77	2.52	2.68	1.26	0.95	46.91
1877	4.05	1.06	4.95	9.47	1.25	6.02	3.25	4.16	5.40	2.61	4.93	2.49	49.64
1878	3.34	2.11	3.48	6.88	2.33	3.28	9.43	5.02	1.28	2.17	3.20	6.04	48.56
1879	6.32	3.13	3.81	2.88	2.88	2.50	8.47	4.62	5.18	2.90	5.85	9.15	57.69
1880	3.74	12.37	8.16	5.26	4.13	3.95	5.69	2.22	5.39	7.24	5.77	3.32	67.24
1881	3.54	5.48	2.79	5.12	3.67	3.70	0.86	1.81	6.57	4.80	4.89	4.85	48.08
1882	14.51	8.61	9.38	3.59	7.38	2.54	4.06	5.54	1.61	1.11	3.60	1.52	63.45
1883	3.76	7.90	3.98	9.12	4.82	3.82	4.88	4.47	2.23	5.27	3.11	4.97	58.33
1884	7.20	8.18	8.89	3.51	3.58	6.53	3.18	2.81	2.36	2.43	1.57	3.78	54.02
1885	6.29	2.00	2.33	3.75	4.36	3.72	5.26	1.02	5.60	2.99	2.73	2.90	42.95
1886	5.18	3.82	4.76	2.36	2.10	7.69	1.90	5.50	3.68	0.51	5.76	1.48	44.74
1887	5.13	8.47	3.36	2.67	3.43	2.31	3.77	2.89	6.85	1.92	2.29	5.31	48.40
1888	6.29	3.78	6.46	4.18	2.97	4.68	2.36	7.03	3.82	2.82	4.33	1.77	50.49
1889	3.83	1.84	2.47	2.83	5.00	5.33	2.74	1.57	6.81	1.54	6.88	1.17	42.01
1890	8.10	10.95	8.64	3.84	4.16	2.23	0.46	6.59	5.86	3.01	2.01	4.12	59.97
1891	6.15	6.96	10.31	2.24	2.39	6.50	1.49	3.72	1.25	0.84	6.71	4.26	52.82
1892	2.81	2.73	4.10	7.45	4.03	5.01	5.13	3.39	4.78	0.25	3.91	6.43	50.02
1893	1.27	4.88	3.37	4.11	7.31	4.74	2.12	1.92	6.43	3.68	2.97	3.50	46.30

1894	4.28	8.65	2.69	4.05	2.53	3.55	5.45	2.43	3.07	0.53	1.92	2.81	41.96
1895	5.71	0.98	5.09	3.07	2.05	2.90	7.14	1.40	6.69	1.57	2.14	4.09	42.83
1896	1.37	3.65	6.45	2.92	4.05	1.82	7.33	1.40	2.74	0.98	5.71	1.79	40.21
1897	3.13	3.84	8.49	5.79	1.22	1.82	8.53	2.34	0.19	0.92	2.83	4.93	44.03
1898	9.46	0.63	5.36	3.16	1.80	4.97	4.50	6.56	4.87	3.21	3.09	2.41	50.02
1899	5.59	5.19	7.81	3.25	3.36	0.75	6.44	2.53	1.50	1.83	1.55	4.64	44.44
1900	2.61	3.80	2.20	4.04	1.86	10.35	2.87	1.24	4.55	3.93	8.87	2.22	48.54
1901	3.45	1.60	2.39	4.99	4.11	0.48	2.59	8.24	4.27	0.63	0.85	4.51	38.11
1902	4.68	2.20	6.96	3.08	4.36	2.77	1.89	2.69	2.82	1.83	4.04	6.58	43.90
1903	1.80	4.81	5.17	4.00	5.64	7.58	3.04	1.42	0.13	2.06	3.47	3.91	43.03
1904	3.93	1.24	5.20	2.35	2.97	6.38	4.62	2.80	0.81	0.29	1.66	5.01	37.26
1905	3.17	2.66	5.10	1.50	6.00	7.31	3.23	2.97	6.12	3.56	1.35	4.15	47.12
1906	3.26	0.79	6.49	1.75	3.80	2.62	3.61	2.94	10.95	2.28	5.88	5.11	49.48
1907	2.60	3.53	3.58	4.66	6.01	2.67	0.80	2.53	1.95	2.01	4.39	2.69	37.42
1908	3.02	4.15	4.16	4.43	2.80	2.73	3.32	1.69	1.89	0.44	3.31	2.10	34.04
1909	2.34	7.08	4.94	4.12	4.57	5.56	4.93	2.73	4.23	1.01	2.58	2.90	46.99
1910	3.45	4.87	0.85	6.10	5.81	6.61	4.45	1.73	0.74	3.20	1.17	3.92	42.90
1911	2.00	4.68	2.22	5.11	1.67	4.58	3.34	5.17	1.89	2.21	4.38	11.01	48.26
1912	2.92	4.21	6.00	11.73	4.02	5.66	5.37	3.05	2.46	2.45	0.65	5.14	53.67
1913	12.30	4.71	5.54	1.65	2.66	0.90	4.09	0.85	1.79	2.93	1.84	2.45	40.71
1914	1.56	2.03	4.33	3.83	3.01	2.95	2.58	8.64	1.46	2.80	2.13	5.06	40.38
1915	5.89	1.01	2.14	0.72	4.94	1.42	2.03	6.03	4.63	0.42	6.75	6.44	42.42
1916	7.62	1.19	3.60	2.49	5.37	4.62	4.17	4.27	1.92	2.67	1.00	4.29	43.21
Means	4.70	4.34	4.96	4.41	3.83	4.23	4.15	3.54	3.70	2.45	3.61	3.88	47.80

TABLE XI—AVERAGE NUMBER OF DAYS WITH 0.01 INCH OR MORE OF PRECIPITATION

Stations	Length of Record, yrs.	Jan.	Feb.	Mch.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	An'l
Carthage	33	11	11	12	11	10	12	11	9	7	7	8	11	120
Chattanooga	35	13	12	13	11	10	13	13	12	9	7	9	12	134
Clarksville	24	10	10	12	11	10	8	8	8	6	6	7	10	106
Decatur	18	12	11	13	11	10	13	14	11	8	7	9	13	132
Florence	32	10	9	10	10	9	10	10	8	7	6	7	9	105
Greeneville	23	12	11	12	10	12	11	13	11	7	7	7	10	123
Jackson	15	9	11	11	11	9	9	8	9	7	7	7	9	107
Johnsonville	21	11	10	11	10	10	10	10	9	6	6	8	10	111
Knoxville	43	13	11	13	12	12	13	12	12	8	7	9	13	135
Lynnville	26	8	8	9	9	8	9	10	8	6	4	6	8	93
Memphis	45	11	10	12	10	10	10	10	8	7	6	9	11	114
Mountain City	16	12	11	12	12	13	14	14	13	9	7	8	12	137
Nashville	45	12	11	12	11	10	11	11	9	8	6	9	11	121
Rugby	24	10	9	10	10	10	10	10	8	6	5	6	9	103
Savannah	15	9	7	11	9	9	8	8	7	6	5	6	8	93
Springdale	15	11	10	11	11	9	9	11	9	6	5	7	11	110
Trenton	29	8	8	9	8	8	8	7	6	6	5	7	8	88
Tullahoma	25	10	9	11	9	9	10	10	9	7	6	7	11	108
In Other States														
Atlanta, Ga.	34	12	11	11	10	9	11	12	13	8	7	9	11	124
Bismarck, N. Dak.	42	6	5	7	7	10	12	9	8	7	5	4	6	86
Columbia, Mo.	27	8	9	10	12	13	12	9	9	9	8	7	8	114
Dodge City, Kans.	36	4	5	6	7	10	9	9	7	5	5	4	4	75
Fort Worth, Texas	19	5	5	7	8	9	6	6	5	5	5	6	6	75
Indianapolis, Ind.	45	15	5	11	12	18	14	8	8	8	9	6	12	126
New Orleans, La.	46	10	9	9	7	9	13	15	14	11	6	7	11	121
Parkersburg, W. Va.	29	15	13	15	13	12	14	12	10	9	9	10	13	145

TABLE XII—PRECIPITATION, SPECIAL FEATURES OF

Stations	Average annual No. days: .01 to .25 inch.	.26 to 1.0 inch.	More than 2.0 inches	With more than 1.0 inch an hour.	Absolute maximum in 24 hours, inches.	Absolute maximum in one hour, inches.	Average date of first snow in autumn.	Average date of last snow in spring.	Av. annual duration of measurable snow, days.
Chattanooga, Tenn.	80	40	2	2	6.60	2.57	Nov. 21	March 18	5
Knoxville, Tenn.	74	43	2	1	5.68	2.01	Nov 22	March 29	7
Memphis, Tenn.	59	37	3	1	9.67	2.34	Dec. 8	March 3	4
Nashville, Tenn.	66	38	2	3	6.05	2.25	Nov. 22	March 27	9
Atlanta, Ga.	79	39	3	2	7.36	2.40	Dec. 2	March 10	2
Bismarck, N. Dak. ..	67	17	0	1	3.76	2.96	Oct. 15	April 28	98
Columbia, Mo.	70	33	2	3	6.13	2.80	Nov. 7	April 5	34
Dodge City, Kans. ..	56	17	1	1	6.03	4.81	Nov. 1	March 22	20
Fort Worth, Texas .	35	21	2	3	7.44	3.07	Dec. 13	Feb. 24	3
Indianapolis, Ind. ...	77	39	1	2	6.80	2.59	Nov. 5	April 11	37
Minneapolis, Minn.	73	33	2	1	4.96	2.62	Oct. 25	April 22	87
New Orleans, La. ...	64	36	4	7	8.76	3.01	....	....	0
Parkersburg, W. Va..	91	42	1	1	3.76	2.12	Nov. 10	April 12	32

TABLE XVI—FIRST AND LAST KILLING FROST.

Stations	Length of record, years	Average date of first killing frost in autumn	Average date of last killing frost in spring	Earliest date of killing frost in autumn	Latest date of killing frost in spring	Average growing season (days)
Carthage	16	Oct. 28	April 7	Oct. 11	April 25	204
Chattanooga	35	Oct. 26	April 2	Sept. 30	May 14	207
Clarksville	23	Oct. 24	April 5	Oct. 1	May 1	202
Decatur	17	Oct. 23	April 18	Oct. 11	May 10	188
Florence	23	Oct. 23	April 4	Oct. 1	April 21	202
Greeneville	14	Oct. 19	April 19	Sept. 30	May 15	183
Jackson	22	Oct. 23	April 2	Oct. 2	May 2	204
Johnsonville	20	Oct. 21	April 8	Sept. 22	May 2	196
Knoxville	43	Oct. 28	April 2	Oct. 1	April 24	209
Lynnville	23	Oct. 21	April 7	Sept. 27	April 27	197
Memphis	44	Nov. 2	Mar. 22	Oct. 2	April 25	225
Mountain City ...	15	Oct. 13	April 30	Sept. 27	May 22	166
Nashville	45	Oct. 27	April 1	Oct. 8	April 24	209
Rugby	20	Oct. 13	April 26	Sept. 18	May 15	170
Savannah	22	Oct. 25	April 3	Sept. 30	May 2	205
Springdale	18	Oct. 15	April 24	Sept. 30	May 21	174
Trenton	22	Oct. 19	April 3	Sept. 30	May 2	199
Tullahoma	22	Oct. 19	April 11	Sept. 27	May 10	191
In Other States						
Atlanta, Ga.	27	Nov. 5	Mar. 24	Oct. 11	April 17	226
Bismarck, N. Dak.	43	Sept. 21	May 11	Aug. 23	June 7	133
Columbia, Mo. ...	27	Oct. 14	April 12	Sept. 18	May 9	185
Dodge City, Kans.	41	Oct. 16	April 17	Sept. 23	May 27	182
Fort Worth, Tex..	25	Nov. 18	Mar. 14	Oct. 22	April 3	249
Indianapolis, Ind.	39	Oct. 19	April 16	Sept. 21	May 14	186
New Orleans, La.	44	Dec. 16	Jan. 25	Nov. 11	Mar. 27	325
Park'sburg, W. Va.	30	Oct. 14	April 16	Sept. 29	May 22	181

TABLE XIII—SNOWFALL, AVERAGE MONTHLY IN INCHES

Stations	Length of Record, yrs.	Jan.	Feb.	Mch.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	An'l
Carthage	32	2.5	3.3	1.8	0.3	0	0	0	0	0	T	0.1	1.1	9.1
Chattanooga	35	2.1	2.6	0.4	0.2	0	0	0	0	0	T	0.3	1.2	6.9
Clarksville	24	4.4	4.0	2.5	0.5	T	0	0	0	0	0.1	0.4	2.7	14.6
Decatur	18	1.7	3.1	0.6	T	0	0	0	0	0	T	0.6	1.1	7.1
Florence	29	2.7	3.0	1.9	0.2	0	0	0	0	0	T	0.2	1.3	9.3
Greeneville	23	4.5	4.2	1.8	1.9	T	0	0	0	0	T	1.5	4.4	18.3
Jackson	15	1.8	2.0	0.3	T	0	0	0	0	0	T	0.2	2.0	6.3
Johnsonville	18	3.0	2.7	0.5	T	0	0	0	0	0	T	0.3	1.4	7.9
Knoxville	28	3.0	3.0	0.8	0.3	T	0	0	0	0	T	0.4	1.9	9.4
Lynnville	26	2.1	2.7	1.2	T	0	0	0	0	0	T	0.4	0.9	7.3
Memphis	31	2.1	1.8	0.9	0	0	0	0	0	0	0	T	1.4	6.2
Mountain City	16	6.6	5.0	3.0	1.4	T	0	0	0	0	0.2	1.8	4.7	22.7
Nashville	31	2.5	3.1	1.7	0.1	T	0	0	0	0	T	0.2	1.1	8.7
Rugby	24	5.1	5.9	2.6	0.8	T	0	0	0	0	T	1.5	3.3	19.2
Savannah	16	1.3	1.5	0.4	T	0	0	0	0	0	T	T	1.5	4.7
Springdale	18	4.6	4.0	1.2	0.5	T	0	0	0	0	T	1.0	2.7	14.0
Trenton	25	3.2	3.2	0.8	T	0	0	0	0	0	0.1	0.4	1.4	9.1
Tullahoma	25	2.7	2.9	1.7	0.2	0	0	0	0	0	T	0.5	1.8	9.8
In Other States														
Atlanta, Ga.	27	1.2	1.3	0.1	0.1	0	0	0	0	0	T	0.1	0.5	3.3
Bismarck, N. Dak.	25	5.4	4.5	8.7	2.9	0.8	0	0	0	0.1	1.0	5.5	5.7	34.5
Columbia, Mo.	27	5.4	7.3	4.2	0.5	T	0	0	0	0	0.1	0.7	4.4	22.6
Dodge City, Kans.	26	4.8	7.3	4.5	1.1	T	0	0	0	0	0.3	1.4	4.2	23.6
Fort Worth, Texas	19	0.8	0.6	0.2	0	0	0	0	0	0	0	T	0.6	2.4
Indianapolis, Ind.	32	6.4	6.0	4.1	0.9	0.1	0	0	0	0	T	1.2	5.2	23.9
New Orleans, La.	46	0.2	0.2	0	0	0	0	0	0	0	0	0	T	0.4
Parkersburg, W. Va.	29	7.9	7.9	5.3	1.0	T	0	0	0	0	T	1.4	5.3	28.8

T—Trace, amount too small to measure.

TABLE XIV—MEAN RELATIVE HUMIDITY (PERCENTAGES)

Stations	Length of Record, yrs.	Jan.	Feb.	Mch.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	An'l
Chattanooga, Tenn.	25	76	71	69	66	71	75	76	78	78	76	72	75	74
Knoxville, Tenn.	26	77	72	72	65	69	74	76	79	77	75	74	77	74
Memphis, Tenn.	28	73	70	70	66	71	73	75	76	74	71	70	74	72
Nashville, Tenn.	28	75	73	70	64	68	70	71	74	72	70	70	75	71
Atlanta, Ga.	33	76	72	70	66	68	72	76	79	75	72	71	75	72
Bismarck, N. Dak.	23	74	74	72	66	64	70	66	65	66	70	74	74	70
Dodge City, Kans.	23	72	71	63	61	61	64	64	64	64	65	68	70	67
Fort Worth, Texas	7	66	61	59	64	64	58	57	62	65	63	63	68	63
Indianapolis, Ind.	38	80	77	72	66	67	67	66	68	70	70	72	78	71
New Orleans, La.	46	79	77	77	76	76	77	79	80	79	77	78	79	78
Parkersburg, W. Va.	27	80	80	74	68	70	74	73	76	78	76	76	80	75

TABLE XV—SUNSHINE (PERCENTAGE OF POSSIBLE)

Stations	Length of Record, yrs.	Jan.	Feb.	Mch.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	An'l
Chattanooga, Tenn.	17	41	45	46	54	62	62	60	60	62	65	54	42	55
Knoxville, Tenn.	16	41	49	51	55	68	63	62	59	62	71	60	44	56
Memphis, Tenn.	15	46	53	57	63	72	72	73	70	72	69	62	43	63
Nashville, Tenn.	19	43	48	52	61	68	69	70	69	70	66	56	40	59
Atlanta, Ga.	22	48	53	54	62	69	69	61	60	65	66	62	47	60
Bismarck, N. Dak.	18	54	59	53	59	59	61	70	66	62	60	50	47	58
Columbia, Mo.	19	54	56	57	62	67	71	73	73	66	67	61	53	63
Dodge City, Kans.	17	64	66	65	68	66	73	76	78	72	74	68	68	70
Indianapolis, Ind.	19	39	48	46	53	58	65	68	65	65	62	53	40	59
New Orleans, La.	26	49	49	57	59	67	61	53	55	61	64	55	45	57
Parkersburg, W. Va.	18	27	23	38	49	55	58	61	58	58	49	35	25	44

Manganese Deposits of Bradley County*

By A. H. Purdue.

The deposit of manganese on White Oak Mountain, Bradley County, has previously been described by Mr. W. A. Nelson.† This deposit occurs in the Fort Payne chert of Lower Carboniferous age.

In October, 1916, a new deposit was opened up a little more than a mile east of Marble Switch on the Southern Railroad, and something like nine miles south of Cleveland. In September, 1917, a second opening was made two miles north of the first one on a farm belonging to Mr. A. B. Hambright.

The manganese is in an area mapped by the late Dr. C. W. Hayes as Tellico sandstone,‡ of Ordovician age. It occurs in a limestone which was not mapped by Dr. Hayes but which lies immediately below the Tellico sandstone and probably is the Holston marble. This limestone is gray, crystalline, fossiliferous, and contains a large per cent of iron. The iron is hematite, and occurs in thin, paper-like sheets most of which are parallel with the laminae, but some are wrapped almost around the fossils and others are in veins that stand at a high angle to the lamination. Also, it is this limestone and the residual soil above it that carry the manganese. The sandstone, limestone, and other rocks beneath them, dip at a high angle south of east. Excellent structure sections are shown by Dr. Hayes.|| This ore was deposited in solution caverns in the limestone, which, so far as the writer could observe, were along the bedding planes of the limestone. This gives the manganese the appearance of a bedded deposit of the same age as the limestone, and is so considered by those working the deposits. As the writer observed them, the manganese layers vary from a few inches in thickness to as much as fourteen inches. The ore, which is reported to be of very high grade, is found

*This article was dictated by Dr. Purdue on the morning of the operation which resulted in his death, and he therefore had no opportunity to look over the manuscript.

†Res. of Tenn., Vol. I, No. 6, pp. 220-228.

‡U. S. Geol. Surv., Cleveland folio, No. 20.

||Loc. cit.

both in the caverns above mentioned and in the residual clay, from which bowlders have been taken out that weigh 800 pounds.

Associated with the manganese is iron ore whose color indicates that it is manganiferous; but this and the manganese are never so closely associated as to prevent hand picking.

It seems without question that the immediate source of both the iron and the manganese is the Tellico sandstone, which is described by Dr. Hayes* and others in the East Tennessee folios. This sandstone, which is responsible for the ridge whereon the manganese occurs, breaks down into a deep chocolate-colored to red soil.

A fault, which is mapped by Dr. Hayes, occurs a short distance east of the deposits, but there is no genetic relation between this and the ores.

To the present time, the work has all been done by hand, but at the southernmost area, steam shovels are being installed. It appears that the operators expect to secure about one ton of manganese to each hundred tons of residual material; but this cost of recovery will be reduced by the cavern deposits yet remaining in the limestone.

The belt in which ore may reasonably be expected is perhaps 100 yards wide. In this area it is seven miles long and extends southward into Georgia.

There are other prospects in the vicinity of Hiwassee River, east of Charleston, but unfortunately the writer has not been able to see these. The area in which these deposits occur is mapped by Hayes as the Tellico sandstone, underlain by the Athens shale. Should there be no limestone beneath the Tellico sandstone, as in the area south of Cleveland, the manganese would be expected in largest quantity at the base of the sandstone, and resting on the shale. This area extends northward to a point five miles northeast of Athens and has a total length of more than twenty-five miles, with an average width of the Tellico sandstone area of more than a half mile; but as in the southern area, the belt in which manganese can be expected would be narrow.

There are many other belts of outcropping Tellico sandstone in East Tennessee that are shown in the several folios of that area by the U. S. Geological Survey. In view of the great war demand for manganese at this time, all these areas should be looked into as possible sources of that mineral.

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*Loc. cit.

Barite Deposits of the Sweetwater District, East Tennessee

By C. H. Gordon, University of Tennessee, Knoxville.

INTRODUCTION.

Prior to 1914, the barium industry in the United States was on a precarious footing owing to the fact that European barite could be sold to the eastern manufacturers cheaper than the domestic ore. While large deposits of barite exist in Missouri, Georgia, Tennessee, Kentucky, and Virginia, the high freight rates to the chief markets which are east of the Allegheny Mountains combined with the low market price of the ore as determined by the cheap ores from Europe was a serious handicap to the production of crude barite in this country. The government statistics* for 1916 show almost a complete cessation of imports of crude barite and 42 per cent decrease in the manufactured products over the imports of 1914. The increase in prices which naturally followed removal of foreign competition has given a great impetus to American production, and many mines, idle for years, have taken on renewed activity and new properties have been opened. The year 1915 showed a marked advance in the production of crude barite over that of 1914, but the year 1916 broke all previous records with a total production of 221,952 short tons valued at $1,011,232, an increase of 104 per cent in quantity and 165 per cent in value over the output of 1915. While there was a large increase in output in all the states heretofore producing, the outstanding feature of the report for 1916 is the displacing of Missouri as the leading producer by Georgia and the entry of Colorado and Nevada into the list of producing states. The revival of the industry has been especially marked in Tennessee, where the output for 1916 was 32,416 short tons valued at $123,968, an increase of 220 per cent in quantity and 625 per cent in value over the output of 1914.

To meet the demand for information concerning the Sweetwater deposits in East Tennessee, the writer spent some time in the field

*Mineral Resources of the United States for 1916, Pt. II, pp. 243-254.

during June, 1917, and presents herein the results of the investigation then made.

The following papers comprise most of the important writings pertaining to the Sweetwater district:

Fay, A. H., Barytes in Tennessee, Eng. and Mining Jour., vol. 87, p. 137, 1909.

Grasty, J. S., The Barite Deposits in Tennessee, The Tradesman, May 1, 1917, pp. 34-38.

Hayes, C. W., U. S. Geological Survey, Cleveland Folio, (No. 20), 1895; Kingston Folio (No. 4), 1894.*

Keith, Arthur, U. S. Geological Survey, Loudon Folio (No. 25), 1895.*

Henegar, H. B., Barite Deposits in the Sweetwater District, The Resources of Tennessee, vol. 2, pp. 424-429, Tennessee Geological Survey, 1912.

Herzey, C. S., Tennessee Barytes, Mineral Industry, vol. 10, p. 58, 1901.

Judd, E. K., The Barytes Industry of the South, Eng. and Min. Jour., vol. 83, pp. 751-752, 1907.

Watson, T. L., Fluorite and Barite in Tennessee, Trans. Am. Inst. Min. Eng., vol. 37, p. 890, 1907

Watson, T. L., and Grasty, J. S., Barite of the Appalachian States, Amer. Inst. Min. Eng., Bull. 98, pp. 369-374, Feb. 1915.

Weller, C. A., Barytes Mines of the Commercial Mining and Milling Co., Eng. and Min. Jour., vol. 83, p. 851, 1907.

For information concerning the deposits of barite in the Appalachian region outside of Tennessee, the following, many of which contain references to the Tennessee deposits, may be consulted with profit.

Grasty, J. S., Barite Deposits of Alabama, The Tradesman, July 17, 1913, pp. 35, 36.

Hayes, C. W., and Phalen, W. C., Barite Near Cartersville, Georgia, U. S. Geol. Surv., Bull. 340, pp. 458-462, 1908.

Hill, James M., Mineral Resources of the United States for 1915, Pt. 2, pp. 161-187. 1916.

Fohs, F. J., Barite Deposits of Kentucky, Kentucky Geological Survey, 4th. ser., vol. 1, Pt. 1, pp. 441-588, 1913.

The author takes pleasure in acknowledging the cordial co-operation and assistance received from Mr. H. B. Gilman, Vice President and General Manager of the Duplex Chemical Corporation whose wide acquaintance with the field and unfailing courtesy greatly facilitated the investigation. Among others who contributed services or information, special mention is due Mr. H. J. Moore and Mr. G. R. McMahan and to these we extend our cordial thanks.

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*The government folios describe the geology of the region but make no mention of the barite deposits.

NATURE AND OCCURRENCE OF BARITE.

Physical character—Barite* is a white, opaque to translucent crystalline mineral having a hardness of 2.5 to 3.5, or very nearly that of calcite. Its specific gravity is relatively high, 4.3 to 4.6, and this together with the fact that it does not effervesce when treated with hydrochloric (muriatic) acid readily distinguishes it from calcite, whose specific gravity is 2.71. Barite crystallizes in the rhombic (orthorhombic) system, the crystals being usually the combination of the unit prism and the basal pinacoid, but well formed crystals are rarely found in the Sweetwater area. The mineral occurs usually as aggregates of straight, or slightly curved, cleavable plates, or in granular, fibrous, earthy, stalactitic or nodular masses. The plates, which are commonly united by their broad sides in crested, divergent groups, separate readily when struck with a hammer. The mineral is brittle, breaking with an uneven, or conchoidal fracture and when unaltered has a vitreous pearly luster but it becomes a dull, earthy white as a result of weathering. The color is typically white, varying to light shades of yellow, brown, red or blue. The Sweetwater barite is commonly white or gray, sometimes shading to light brown or pink as a result of iron stain. Before the blowpipe, barite decrepitates readily, fusing at about 3 and coloring the flame yellowish green.

Chemical character.—Barite is the sulphate of barium ($BaSO_4$), and contains when pure 65.7 per cent of baryta, or barium oxide (BaO), and 34.3 per cent sulphur trioxide (SO_3). In nature it practically always includes other elements of which the most common are silica (SiO_2), lime (CaO), magnesia (MgO), and the oxides of aluminium, iron, and manganese. Sometimes strontium is present, the Kentucky deposits† showing from a trace to 11 per cent of this substance. The Sweetwater deposits also contain a small amount of strontium as shown by the accompanying analyses. The strontium is present usually in the form of sulphate and for the most uses the presence of a small amount of this substance is not considered objectionable. Hence determinations of strontium are not commonly made.

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*Known also as Baryte or Barytes, and Heavy Spar, from *barus* meaning "heavy".

†Fohs, F. J., Kentucky Geological Survey, 4th. ser., vol. I, pt. 1, pp. 450, 451.

Associated minerals.—The most common associated minerals are calcite, fluor spar, zinc blends, galena and, less frequently but locally of importance, quartz, strontianite, pyrite, limonite, chalcopyrite, smithsonite, and manganese oxide. The first four minerals mentioned are present in varying amounts in the Sweetwater deposits. Limonite and quartz in the form of chert are the most common minerals associated with the barite. There is a small amount of manganese oxide but strontianite, chalcopyrite, pyrite and smithsonite are of rare occurrence.

Similar species.—Other heavy, light-colored minerals with which barite may be confused are witherite ($BaCO_3$), strontianite ($SrCO_3$), and cerrussite ($PbCO_3$), all of which, however, effervesce with acids. From quartz it is distinguished by its greater weight and lesser hardness; also by its platy or cleavable structure, quartz being without cleavage.

The only other barium mineral of importance is witherite ($BaCO_3$), which carries when pure 77.7 per cent of baryta (BaO), and 22.3 per cent of carbon dioxide. It occurs commonly in globular and botryoidal forms whose structure may be columnar or granular. When crystallized it is usually in hexagonal prisms whose faces are rough and longitudinally striated. Like calcite it is readily soluble in hydrochloric acid with effervescence but is easily distinguished from that mineral by its greater weight and hardness, and from barite by its solubility. Its chief occurrence is as a gangue mineral in metaliferous deposits. The only known commercial deposit of *witherite* in the world is located at Fourstones, Northumberland County, England. The mineral is not known to occur in Tennessee. If present here observers should be able to detect it by means of the above description.

Occurrence.—Barite is a common mineral and has a wide range in geologic age and in geographic distribution. It may be found in many kinds of rocks, igneous, sedimentary and metamorphic. It is a common gangue mineral in metallic ore veins but as such is not of commercial value. According to Ries* it has in nearly all cases been formed by deposition from aqueous solutions and is not found as an original constituent of igneous rocks, nor in contact metamorphic zones or pegmatite veins. Commercially economic deposits of barite may comprise the following:

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*Ries,Heinrich, Economic Geology (1916), p. 309.

I. Veins.

1. Fissure or fault breccia veins of which those of Kentucky are good examples. In these the mineral occurs in brecciated fault zones chiefly as a vein filling from solutions, but replacement deposits and simple veins are known.

2. Bed veins or shattered zones in limestone in which the barite occurs as a replacement, or cement filling the interstices in the breccia.

II. Irregular bodies formed by:

1. The replacement of beds of limestone or pyrite, or

2. The filling of solution caves or breccias.

III. Residual deposits formed by the weathering of any of the above.

In such deposits the barite occurs in lumps and masses in the residual clays derived from the weathering of the limestones containing barite ore bodies.

The Tennessee deposits fall under I.2, and III in the above classification.

BARITE DEPOSITS OF THE SWEETWATER DISTRICT.

Physiography—The Sweetwater area lies near the middle of that part of the Great or Appalachian Valley included within the limits of the State of Tennessee. Sweetwater, a station of the Southern Railroad 42 miles southwest of Knoxville is near the center of the district. Topographically the area presents the ridge and valley type characteristic of the Great Valley in this region. The ridges formed by the more resistant strata alternate with valleys dissolved or worn out of the intervening softer strata, and all trend from northeast to southwest in conformity with the main structural features of the valley. With the exception of a small area in the southwest corner, the drainage of the district is effected by a parallel system of northeast-ward-flowing streams including the Fork, Sweetwater, Pond and Stockton creeks all of which empty into the Tennessee River except the Fork, which empties into the Little Tennessee several miles above its mouth. The valley of the Sweetwater is one of the most important and charming valleys in the State. The streams flow throughout the year, being supplied by springs which are abundant and many of them large. The water supply of Sweetwater comes from two large springs at the south edge of the town.

STRATIGRAPHY

With the exception of a small area in the northwestern part of the district, the rocks belong to the Cambrian and Ordovician systems, the outcropping formations occurring in belts extending from northeast to southwest. The Cambrian is represented by eight narrow bands of shales and sandstones. East of Sweetwater, the shales there called the Nolichucky shales predominate in the belts. West and northwest the shales, there called the Conasauga, are overlaid by siliceous beds called the Rome sandstones. Alternating with the belts of Cambrian formations are wider bands of limestones and dolomite most of which belong to the Ordovician, the next later system to the Cambrian. Chief among these is the great Knox dolomite formation which underlies the larger part of the district and in which the deposits of barite occur. The Knox is a massively bedded dolomitic limestone containing in places a large amount of chert, locally called "flint". The chert occurs in nodules and masses in the strata sometimes in such amount as to almost constitute beds. By reason of its greater resistance to weathering influences the beds containing the chert yield more slowly to wasting agencies and these stand out in more or less prominent ridges. In such areas the soils are stony and poor owing to the large amount of chert left by the decay of the overlying beds, often in such amounts as to make cultivation almost impossible.

Accompanying the Knox are higher formations of shales (Athens), limestones (Stones River), and ferruginous sandstones (Tellico) of the same (Ordovician) age. The red sandy Tellico formation occurs in two narrow bands one on the east side of Fork Creek and the other extending northeast from Sweetwater. This formation thins rapidly from east to west in the valley, its western limit being originally not far west of the town of Sweetwater. Owing to its greater resistance to wasting agencies the Tellico forms ridges marked by rounded knobs, the so-called "red knobs" of Eastern Tennessee. The cementing constituent of the Tellico beds is lime carbonate by the leaching of which the iron contained in the formation is concentrated, forming in places workable deposits of iron ore. Such deposits have been worked to some extent about two miles northeast of Sweetwater.

In the northwestern part of the district is a small area* covered by formations of later age than the Ordovician. These comprise the Rockwood (Clinton) iron ore formation (Silurian), the Chattanooga shale (Devonian) and the Fort Payne chert (Mississippian). In this area are located the Chamberlain iron ore mines which work deposits of the Rockwood ores.

GEOLOGICAL STRUCTURE

A conspicuous feature of the geology of the valley region is the occurrence of the formations in parallel belts extending from northeast to southwest. As a rule the strata dip rather steeply to the southeast but in some belts the dip is to the northwest. The widths of the outcrops of the sandstone, shale and limestone formations are from one to six miles. The repetition of similar formations is due to folding and faulting on a large scale as a result of compressive forces which bent the strata into folds which by the continuance of the thrust broke in some instances along their northwest side permitting an overthrust of the strata toward the northwest. The upper parts of the earth blocks thus formed were then planed off by erosion leaving the different formations exposed in parallel belts. These movements appear to have reached their culmination soon after the close of the Carboniferous period. Seven great faults occur within the boundaries of the district as mapped, in addition to which there are many minor breaks and slips. Beginning at the southeast side the first fault is the Bays Mountain Fault† which follows the south side of the ridge of "red knobs" about half a mile west of Hiwassee College. Next bounding the Fork Creek dolomite belt on the west is the Knoxville Fault† which is about half a mile southeast of Sweetwater. Next following the northwest side of Black Oak ridge is the Clinch Mountain Fault which extends entirely across the State and has a known length of approximately four hundred miles. This fault is paralleled on the northwest by the Beaver Valley Fault† which is succeeded by the Maynardville Fault† seen at Pattie Gap. Next in order is the Wallen Valley Fault† and lastly the Kingston

*The area mapped includes portions of the Loudon and Kingston quadrangles, the geology of which is given in folios published by the United States Geological Survey.

†Name given by the author in Bulletin No. —, Marbles of East Tennessee, Tennessee Geological Survey, (in Ms.).

Fault* in the extreme northwest corner of the area mapped. The dip of the beds in general is from 10 to 40 degrees to the southeast, more commonly 20 to 30 degrees. In some cases, especially in the immediate vicinity of a fault, the dip may approach the vertical.

CHARACTER OF THE ORE DEPOSITS

Geological occurrence.—The barite of the Sweetwater district occurs in two forms of deposits, viz., as bedded veins or shattered zones in the Knox dolomite (type No. 2 of Class I), and as lumps and masses in the overlying residual clays derived from the decay of the dolomite (Class III). The last named deposits only are of commercial importance.

Three separate veins or belts are recognized though these may be one and the same repeated by faulting; they are the Howard vein, the Garrison vein and the Culveyhouse vein so-named from the well known mines located upon them:

The Howard vein is in the Fork Creek valley about three miles southeast of Sweetwater. It parallels that stream along the northwest side throughout most of its known extent. The Garrison vein lies about four miles northwest of Sweetwater following Pond Creek Valley, and the Culveyhouse is about six miles northwest of the town, a part of it lying within Stockton Valley.

The location of these veins is shown on the accompanying map. All three occur in the Knox dolomite areas and appear to occur at very nearly the same horizon in the formation, viz., at about one-third its thickness below the top of the formation, or about the horizon designated by Ulrich as the top of the Copper Ridge Chert. If, as this author asserts†, there is a stratigraphic break at this horizon this fact may have a bearing on the origin of the ore accumulations. While no conclusive evidence establishing this position was obtained by the writer, the impression gained was in favor of the conclusion advanced by Mr. Ulrich.

A few small deposits appear to lie outside the limits of the veins mentioned, but they are apparently local and do not include any of importance.

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*Name given by the author in Bulletin No. —, Marbles of East Tennessee, Tennessee Geological Survey, (in Ms.).

†Ulrich, E. O., Revision of the Paleozoic Systems, Bull. Geol. Soc. of America, vol. 22, 1911, p. 638.

Original source of the barium.—As stated by Dr. Ries*, barite "is in nearly all cases formed by deposition from aqueous solutions". Descending waters carrying barium sulphate in solution following the easy channels provided by the cavernous, brecciated zone having deposited the sulphate upon the walls more or less completely filling the spaces, and cementing the mass together. The source of the barium was evidently in the dolomite and associated limestones, great thicknesses of which have in the course of time been removed by solution. To ascertain if the asso[illegible] may have furnished the barium, analyses were made with [illegible] following results:

Analyses of the Knox dolomite

	SiO_2	Al-Fe	CaO	MgO	$BaSO_4$	BaO	S	So_3
1.	4.00	1.02	29.48	19.47	...	.04	tr.	...
2.	8.64	1.22	28.96	17.61	.03	.09	.04	.12
3.	11.34	.84	45.00	2.59	.08	.05	.13	.10

Paul C. Bowers, Analyst.

1. From ledge of dolomite just below the barite deposit in the Clyne mine.
2. Outcrop of dolomite one-half mile southeast of the Clyne mine.
3. Pinnacle or "horse" in the Kyker mine.

These analyses indicate the presence of barium in appreciable quantities both as sulphate and oxide and confirm the view that these beds have by their dissolution furnished the material for the filling of the veins. Number 3 is a limestone intercalated in the dolomite series. A sprinkling of small grains of quartz in this rock accounts for the high content of silica shown in the analysis.

Nature of the deposits.—In their original form the ores were deposited by solutions circulating within a zone of brecciation in the Knox dolomite, thus cementing the broken rock into a solid mass. Indications of deposition in irregular spaces is seen in the banded and crested structure of the ore while in some cases deposition appears to have ceased before the cavity was completely filled, leaving vacant spaces or "vugs" lined with projecting cystals of barite. In a few mines, notably the Howard, Johnson, Ballard and Minton, the underlying dolomite has been exposed showing the unaltered vein breccia composed of fragments of dolomite cemented together by barite and in places fluorite. Above the solid rock the barite is often found in large cavernous masses the spaces filled with clay repre-

*Op. Cit.

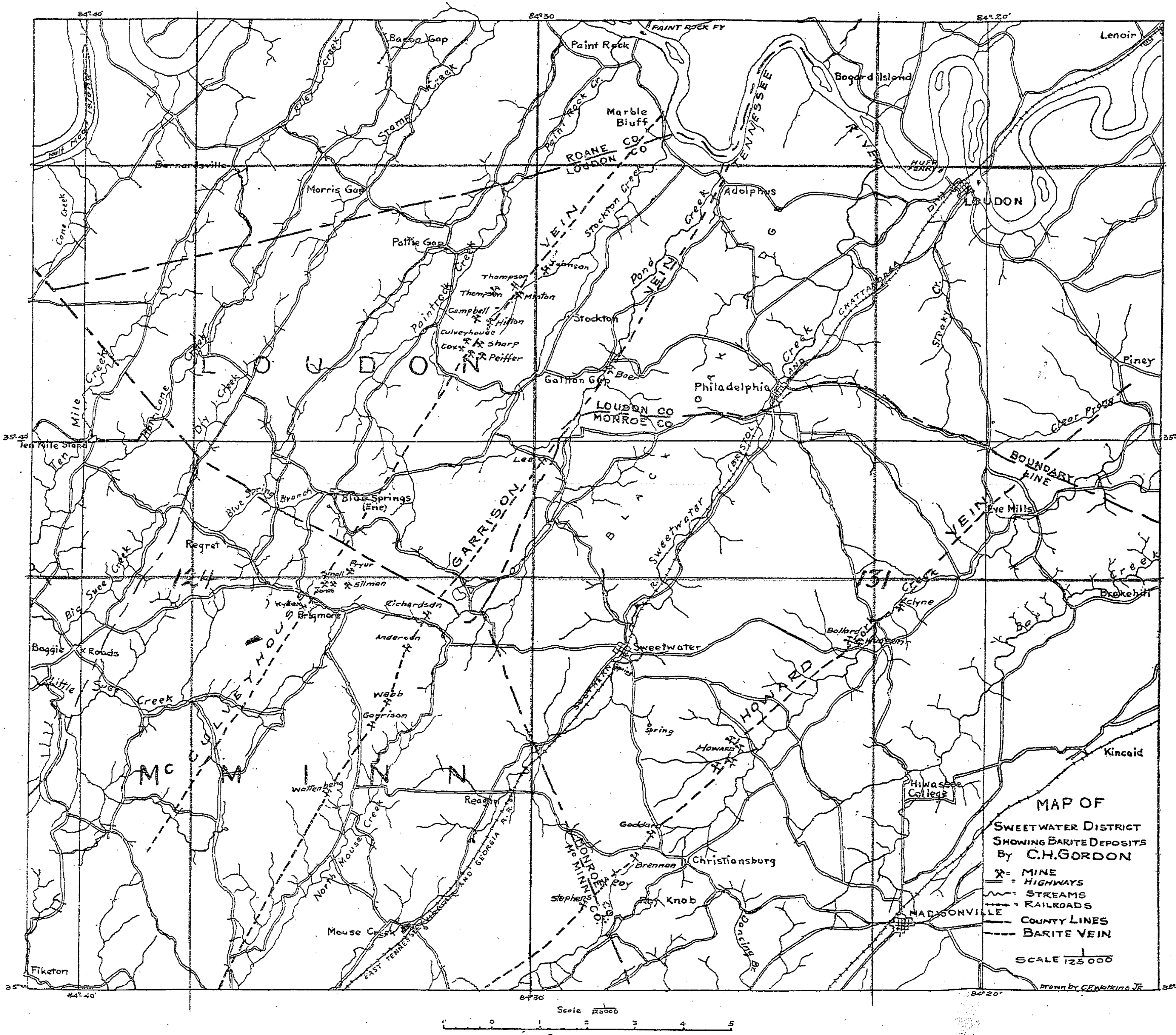

Fig. 1. Map of Sweetwater District.

senting the residuum from the limestones which originally filled the space. In some instances the limestone fragments had not undergone complete decay. (Fig. 5).

The unaltered ore is crystalline massive, gray or grayish white sometimes stained pink or brown by iron oxide, and with vitreous luster. Under the influence of the weather the mineral assumes a

Fig. 2—a. Cavernous barite. When taken from the mine the spaces are filled with clay resulting from the decay of the dolomite fragments which originally occupied them.

b. Original vein material. The white is barite, the gray is dolomite.

c. Cavernous fluorite. The spaces are due to the decay of the fragments of dolomite that originally occupied them, as in the case of a.

dull lustreless white appearance and ultimately crumbles to a white powder. Hence the surficial portions of the residual deposits are likely to be reduced to a fragmental condition known as "gravel" ore. No effort has been made to work the unaltered vein nor is it likely that efforts to do so will prove successful owing to the greater cost of mining and the difficulty of separating the ore from the limestone.

All of the output of barite from the Sweetwater district, as stated above, comes from the residual clay deposits resulting from the weathering of the inclosing dolomite. The barite being less soluble than the dolomite resists longer the action of the weather and remains distributed as lumps and masses in the clays.

Workable deposits appear only at intervals along the outcrop of the vein, barite showing only in traces perhaps, in the intervening areas. In places the surface appears to have been covered by a deposit of alluvial clay and hence more exhaustive prospecting may reveal the presence of barite in vein localities where no ore now shows at the surface. However, the conditions for ore accumulation (brecciation, etc.) are likely to be the same throughout the extent of the vein and hence localization of deposits is likely to be the rule rather than the exception. The ore will naturally be most abundant in areas where brecciation of the dolomite, and consequent vein filling, was most pronounced and it is these areas that contain workable bodies of ore.

Chert in varying amounts is present in all the deposits, but it occurs in greater amount in the western or Garrison and Culveyhouse veins. The chert was originally inclosed in the dolomite and being highly resistant to weathering it remains commingled with the barite in the residual clays. It may occur inclosed in barite or in separate masses in the clay.

The ore belt at the surface is usually from 100 to 300 feet wide. The width of the shattered zone or vein proper is probably less, but as no workings have fully exposed the vein its width and dip can not be authoritatively given. Available data seem to corroborate the view held by operators that the vein dips to the southeast in conformity with the dip of the rocks. With disintegration of the beds there followed naturally not only a concentration of ore at lower levels but a spreading of the ore as it was lowered and hence the greater width of the surface outcrop of the deposits as compared with the original vein. (Fig. 3).

Overlying the barite deposits in many places is a variable thickness up to six or eight feet of alluvial red clays of later origin than the residual clays beneath. The removal of this by erosion deposit has exposed the barite where it now appears at the surface. At the Ballard mine these alluvial clays containing rounded pebbles indicative of their origin appear resting upon the uneven eroded surface of the residual baritiferous clays.

The ore is not uniformly distributed but occurs in pockets separated by barren areas. In some of the mines, notably the Ballard, the deposit is intersected longitudinally by a cherty reef or ledge called the "midrib", which owing to its greater resistance to solution has not suffered so much from decay as the less cherty beds by which it is flanked on either side.

The effect of weathering on the ore is to cause it to break up into small pieces, the so-called "pebble" or "gravel" ore. In places the surficial portion of the deposit is made up in large part of this "gravel" ore. Under former methods of mining most of this was cast aside but with the introduction of log washers much of it can be saved.

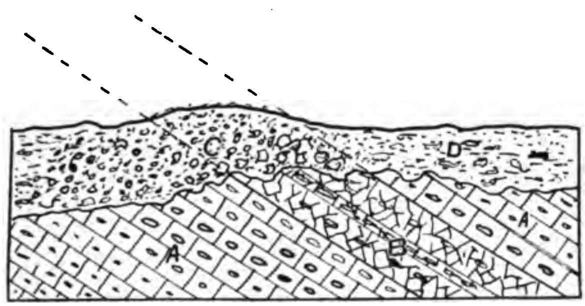

Fig. 3. Ideal section showing relations of residual deposits to the original vein. a. Knox dolomite. b. Brecciated zone with a more resistant middle stratum, the socalled "midrib". c. Residual clays with barite and chert resulting from the decay of the vein breccia. d. Residual clay and chert.

Associated minerals.—Fluorspar is a frequent occurrence in the mines. It is especially abundant at the Howard, Ballard and Minton mines. Usually it is confined to certain parts of the vein while other parts are entirely free from it. The mineral occurs both as a filling on the limestone breccia similar to the barite, and in crystals in cavities. Cavernous masses (Fig. 2c) left on the decay of the included limestone fragments are common in all the fluorspar areas. Sometimes the fluorspar occurs alone but usually barite and fluorspar are more or less intimately intermingled. Where they occur together the barite is inclosed in the fluorite indicating it to be of earlier formation.

While it appears that a considerable amount of fluorspar occurs in some of the deposits, no reliable estimate can be given as to the quantity, since it is the practice of the miners to abandon areas in which fluorspar makes its appearance. It is believed that some of the deposits of fluorspar may be workable but the most serious difficulty to be surmounted will be the separation of the mineral from the barite, though this may be effected by jigging as its specific gravity (3.1) is less than that of barite (4.5).

Chert or impure flint is present in greater or less amount in all the deposits. It increases westward, being especially prominent in the western veins. The unaltered chert is of a dark, almost black color but on weathering it becomes gray or white. Much of the chert is porous from the leaching out of calcium carbonate. This mineral is highly resistant to weathering but after long exposure it crumbles to a white powder. Deposits of it are sometimes worked for much the same uses as tripoli, viz., polishing powders, soap filling and boiler and steampipe covering. A deposit of this kind near Cleveland, Tennessee produces what is known commercially as "silex". At first glance the white chert may be mistaken for barite; it is readily distinguished from that mineral by its lighter weight and greater hardness.

Iron oxide in the form of brown iron ore or limonite occurs in varying amount. In some deposits it is present in considerable quantity. It often forms a thin layer, one-sixteenth to one-eighth inch thick around the barite, but may occur also inclosed within it. It is confined to the weathered deposits and appears to have been deposited by solutions following openings caused by the initial decay of the limestones. It is more abundant in some mines, and in different parts of the same mine, than it is in others. It is especially prominent in the Howard vein due possibly to the presence in this area of the Tellico beds whose decay may have furnished the iron to the waters circulating through the beds below.

Sphalerite or zinc sulphide occurs in small amount in places, as does also galena, the sulphide of lead. Anglesite, the sulphate of lead, occurs in the Culveyhouse mine in which instance it results from the alteration of galena.

Calcite, or lime carbonate, in masses showing the characteristic rhombic cleavage is occasionally found.

Manganese oxide is present in small amount but celestite ($Sr.SO_4$) and chalcopyrite, minerals often found associated with barite have not been observed. Analyses of the barite, however, indicate the presence of strontium in small amount as shown below in Kentucky samples:

Analyses of the Sweetwater barite

	SiO_2	Al-Fe	CaO	MgO	$BaSO_4$	Sr.	SrO
Average sample from Durex works......	.32	.38	.24	.04	97.88	...	...

PAUL C. BOWERS, Analyst.

For comparison the following analyses of the Kentucky barite is given:

*Analyses of barite from Kentucky**

Substances	3530	3532	3533	3534	3536	3538
Barium sulphate	77.44	91.76	98.54	91.06	83.67	98.40
Strontium sulphate	16.31	6.90	tr.	4.38	12.25	0.37
Calcium sulphate	2.47	0.53	0.00	0.00	0.00	0.00
Calcium fluoride	5.03	1.06	0.00	2.91	0.28	0.00
Calcium carbonate	0.00	0.00	0.00	1.07	0.10	0.00
Zinc carbonate	tr.	0.00	0.00	0.00	1.89	0.00
Spec. gravity	4.228	4.456	4.444	4.291	4.428	4.523

Galena and the other metallic sulphides, sphalerite, Chalcopyrite and pyrite, are harmful, as they discolor the ground product. Unless present in large amount the quartz, calcite and fluorite may be eliminated by proper treatment. In some places, however, the fluorite occurs in such amount as to make necessary the abandonment of these areas. Small amounts of iron oxide may be removed by treating the ground product with sulphuric acid. In some of the mines where iron oxide is present in considerable quantity, most of it is removed by cobbing. Manganese is difficult to remove, but this substance is not present in very large amount in the Sweetwater district.

DESCRIPTION OF THE DEPOSITS.

Introduction.—As previously stated (page 55) the Sweetwater deposits occur in three veins which may be designated as the Howard vein, the Garrison vein and the Culveyhouse vein. They are all located in the Knox dolomite and occupy an horizon about one-third of its thickness below the top of that formation corresponding approximately with the top of the Copper Ridge chert division as defined by Ulrich.

HOWARD VEIN

This vein is located about 4 miles southeast of Sweetwater and upon it deposits of barite have been located at intervals from a point 6 miles northeast of Sweetwater to Athens a distance of 17 miles. This vein was the first to be worked, the Howard mine supplying the first ore shipped from this district. It is estimated that nearly 100,000 tons of barite have been taken from this mine.

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*Fohs, F. J., Kentucky Geological Survey, Ser. IV, vol. 2, pt. 1, pp: 450-451, 1913.

Clyne mine.—This is the most northerly opening made on the Howard vein. It is located on the east bank of Fork Creek about six miles northeast of Sweetwater. The ore occurs in residual clay resting upon the uneven surface of the Knox dolomite, pinnacles of which rise above the floor of the mine. The decay of the dolomite or limestone has proceeded very unevenly as shown by a test hole located within a few feet of one of the pinnacles which penetrated 45 feet of barite-bearing clay without reaching the bottom. The pinnacles showing through the clay in the mine consist of shattered dolomite cemented together with barite. At this place the strata appear to be nearly horizontal but one-fourth of a mile east the dip is about 12 degrees south 45 degrees east. The thickness of the ore-bearing clay here ranges from one to over 45 feet. This mine was worked to a limited extent at one time but has been idle for a number of years. Work has been resumed recently by a company headed by Mr. J. F. Doherty and Mr. G. R. McMahan of Sweetwater. At the time of our visit development work was in progress.

Three hundred yards northeast of the present workings on the opposite side of the creek the surface is strewn with pieces of barite, but no work has been done at this point.

Ballard-Hudson mines.—About one and one-fourth miles southwest of the Clyne, on the west side of the creek and north of the road leading to Sweetwater are the Ballard and Hudson mines. The Hudson which lies next to the creek has produced about 2,000 tons of ore but it is now idle.

The Ballard adjoins the Hudson on the west. The opening is near the top of the slope about sixty feet above the creek bottom. The workings cover a space about 300 feet wide and 1000 feet long. Extending longitudinally through the middle of the mine is a reef or ledge of undecomposed or partially decomposed vein rock which the miners call the "midrib". This reef is about 75 feet wide and consists of brecciated cherty limestone containing barite, fluorspar and iron oxide. This "midrib" is flanked on both sides by ore-bearing clays which have worked to a depth of 50 to 60 feet and testing shows them to extend 10 to 20 feet deeper. At one place the "midrib" has been decomposed nearly to the bottom of the mine opening a passageway from one pit to the other. Fluorspar is prominent in the "midrib" but there is none present in the areas on either side.

Alluvial deposits of variable thickness rest upon the eroded surface of the residual ore-bearing clays.

A washer has been installed here and is operated with water pumped from the creek. The ore is extracted with pick and shovel and transported by wheelbarrow to the washer. The quantity of ore in sight here is large but there is a large amount of waste owing to the presence of iron oxide. The mine is operated under lease by Moore and Evans with a daily output of about 100 tons. To date this mine is reported to have yielded about 20,000 tons of ore.

Howard mine.—This mine is located about three and one-half miles southwest of the Ballard mine in a small valley tributary to

Fig. 4. The Howard mine. Worked by pick and shovel.

Fork Creek on the north side. The Howard was the first mine to be operated in this district. The old workings, now mostly filled in, are located on the south side of the branch. A large amount of ore was taken from this pit which is said to have reached the limestone below. The present workings are on the north side of the branch following the strike of the vein. Two pits are now being worked, one about 200 yards northeast of the other. The width of the vein as shown by outcroppings of ore in the bed of the dry weather branch which forms nearly a right angle with the vein is about 600 feet. The two openings now working cover an area of about 4500 square feet and extend to a depth of 30 to 40 feet. A shaft 18 feet deep in the more northerly pit with good ore to the bottom fails to reach the limestone. Some ore has been removed from some shallow workings still farther northeast. The ore occurs in pockets alternating with lean and barren areas.

A large mass of fluorspar was struck in the pit nearest the branch, but this mineral has not been observed in the other workings.

Mining is done by pick and shovel the ore being handpicked and hauled to Sweetwater by wagon. The mine is operated by lease by the Durex Chemical Corporation of Sweetwater and Baltimore, Md. It is said to have produced about 50,000 tons of ore to date.

About 400 yards south 70 degrees west and a like distance north of the Howard mine are other small pits which have been located apparently on a parallel vein. These deposits seem to be limited and are not being worked at the present time.

Goddard mines.—Two to two and one-half miles southwest of the Howard mine openings have been made on the Goddard property, one on the east, the other on the west of the Sweetwater-Madisonville road. No work is being done on this property at the present time.

Brennan mine.—Three-fourths of a mile southwest of the Goddard mines on the Brennan property is another idle mine. An opening 100 by 300 feet and fifteen feet deep has been made from which about 2000 tons of ore have been extracted. The ore shows up well in the sides of the pit but it is mostly "gravel" ore which will require washing for which no water is available. It is probable that coarser ore will be found at depth. The outcroppings cover an area of about 300 feet by 1000 feet.

Roy mine.—Adjoining the Brennan on the southwest is the Roy property owned by the two Roy brothers. The mine comprises several openings on the south half of the estate. This mine illustrates well the common method of mining in this district known as "hogging", that is, working only the richer leads and shifting in a haphazard way from place to place to often leaving the dumps on ground that may be more productive than that which is being worked. The first and largest pit which is located at the northeast side of the property is about 100 feet wide by 300 long and 70 feet deep. It is now filled with water to a depth of 30 feet, a supply sufficient to operate a log washer if properly conserved. A small gasoline engine has been installed to haul the clay out of the mine. This mine is said to have produced about 10,000 tons of ore. It is operated on lease by J. F. Doherty and often goes by the name of the Doherty mine.

Stephens prospect.—Deposits are reported to occur on this vein as far southwest as Athens. There is said to be a good showing of ore on the Stephens farm one-half mile southwest of the Roy mine. Barite also appears in the bed of a small branch at Athens.

THE GARRISON VEIN.

This vein lies about 4 miles northwest of Sweetwater in a belt of the Knox dolomite which is bounded on the southeast by the Clinch Mountain fault and on the northwest by the Beaver Valley fault, each of which brings to view a narrow band of Cambrian sandstones and shales. Seven ore bodies have been opened on this vein within a distance of about ten miles. Of these the Barr prospect nearly due west of Philadelphia, the next station on the Southern Railroad north of Sweetwater, is the most northerly outcropping of ore. No work of importance has been done on this prospect.

In all about 25,000 tons of ore have been taken from the Garrison vein.

Lee-Forkner mine.—The Lee-Forkner is the most northerly mine on this vein. It is about 5 miles northwest of Sweetwater. The Forkner property lies on the north side of the road and the Lee on the south side. Operations have been confined to the Lee property where a small opening has been made in the side of the hill from which about 2,000 tons of ore have been removed. The ore in sight begins at the grass roots and consists chiefly of bright crystalline gravel ore. There is apparently a good body of ore remaining in this mine, though no work is being done here at present. This mine belongs to the Durex Chemical Corporation. A washer used in cleaning ores from this and the Culveyhouse and Pfiffer mines was operated here by the W. D. Gilman Company, the predecessors of the Durex Chemical Corporation. An ample supply of water is available from the creek which adjoins the property on the west.

Richardson mine.—The Richardson mine, also owned by the Durex Chemical Corporation, lies about 4 miles southwest of the Lee-Forkner property on the north side of the Sweetwater-Ten Mile road. The "gravel ore" shows well at the hill slope and in the workings which have been extended into the hillside. The ore is imbedded in a red clay interspersed with patches of mottled gray and white clays. Chert is not especially abundant.

An opening covering 2,000 square yards and 20 feet deep has been made in the side of the hill from which approximately 3000 tons of ore have been extracted. The surface outcroppings indicate the presence of a large body of ore on this property. As it is predominantly of the "gravel" type its recovery necessitates the use of more advanced methods of mining than formerly prevailed in this district. A log washer has been installed, water for which is available in the small creek at the side of the road, and mining is done with a steam shovel.

Fig. 5. The Richardson mine. Worked by steam shovel. The white spots in the bank at the left of the shovel are in part barite and in part chert.

Anderson mine.—This mine, now idle, is located in a field about three-fourths of a mile southwest of the Richardson mine. About 1000 tons of barite have been taken from a small opening now partly filled with water. The ore, which is mostly of the pebbly variety, contain a rather large proportion of iron, judging from the heap of rejected ore.

Webb mine.—The Webb mine, also idle, is located in the woods about one and one-half miles southwest of the Anderson mine. The workings cover an area 75 by 100 feet and are fifteen feet deep. From this opening about 2000 tons of ore have been removed. Indications point to the existence of a considerable body of ore on this property, but as it contains much iron and chert a separation plant will be needed for successful operation and water is wanting.

Ore outcrops in a low flat area midway between the Anderson and Webb mines in what is known as the McManus prospect. This locality was not visited by the writer. No development of importance has been made on this property according to report.

Garrison mine.—On the crest of a low hill three-fourths of a mile southwest of the Webb mine is the Garrison mine. The openings here cover an area of about 1000 square yards. The width of the

Fig. 6. The Garrison mine. Worked by pick and shovel. Log washers are in use at this mine for separating the barite from the attached clay.

ore belt is approximately 600 feet separated longitudinally, as at the Ballard, by a "midrib" of hard barren, cherty material. At present mining is confined to the strip along the east side of the "midrib" or reef. The ore is of good quality and fairly free from iron. A small amount of fluorspar is met with in this mine.

Two log washers have been installed, water for which is pumped from a small spring creek 200 yards away. To conserve the limited supply the waste water is caught in a sump and used over again. The ore is mined with pick and shovel and wheeled to the washers in wheelbarrows.

This mine is operated under a lease by Moore and Evans. It has yielded to date about 15,000 tons of ore.

Wattenbarger mine.—About one and one-half miles southwest of the Garrison is the Wattenbarger mine. The principal opening is on the north slope of the hill from which about 2,000 tons of ore have been removed. The mine has been idle for several years but it was recently acquired by the Krebbs Pigment and Chemical Company of Newport, Delaware. Work is now in progress in removing the overburden preparatory to ore extraction. The top of the hill has been dug over more or less but the chief work done was on the northern hill slope. Pinnacles of limestone (dolomite) seamed with barite and calcite appear in an excavation on the east side. The limestone has a dip of 17 degrees south, 30 degrees east. This mine was formerly known as the Thompson mine. It was operated for some time by John T. Williams, the ore being hauled by wagon to Reagan station on the Southern Railroad for shipment.

CULVEYHOUSE VEIN

The third or Culveyhouse vein occurs in the stratigraphic block lying next west of that in which the Garrison is found. This block is bounded on the east by the Beaver Valley fault and on the west by the Maynardville fault. This vein occupies approximately the same horizon in the Knox dolomite as the other veins. An abundance of chert characterizes some of the beds of the dolomite in this area and these, owing to their resistance to erosion, form a rather prominent ridge which northward is known as Copper Ridge.

Johnson mine.—The most northerly deposit noted on this vein is on the Johnson property five and one-half miles northeast of Philadelphia. This mine is located on a mild slope on the west side of Stockton Creek valley. The ore occurs in residual clay in two troughs separated by a reef of more resistant cherty limestone which is notched and pinnacled as a result of differential weathering. The workings cover an area measuring about 75 feet by 150 feet and are fifteen feet deep. A shaft put down alongside the "midrib" to a depth of 45 feet is said to have been all in clay containing good ore. The limestone pinnacles showing in the mine represent the shattered portion of the formation recemented by barite. (b Fig. 2).

The ore is highly crystalline and contains but little iron. Sphalerite, or the sulphide of zinc, occurs in places along with the barite in the original vein matter.

The limestone outcrops at the surface 50 yards northeast of the working showing the ore body to be limited in that direction. Two hundred feet west of the present pits ore crops at the surface but little indications of ore appear in the intervening area.

This mine was recently opened by J. F. Doherty and associates, the ore being hauled to Philadelphia for shipment.

Minton-Thompson mines.—These mines are located on the same vein and about a mile southwest of the Johnson property. They are located on opposite slopes of a narrow valley, the Minton on the east and the Thompson on the west. Several pits have been opened on the Minton property from which about 1000 tons of ore have been taken. The openings on the Thompson are less extensive, 500 tons of ore being credited to this mine. A considerable amount of ore is now on the ground at the Thompson mine awaiting shipment. There is a good showing of ore at the surface and in the faces of the pits in both of these properties. Ledges of limestone and cavernous vein rock show in the lower part of the slopes on both sides. Large cavernous masses of fluorspar and barite appear in the old working on the Minton and a large amount of this material and the original vein breccia appears in the dump. Where weathering has been effective the limestone has been reduced to clay while the more resistant barite or fluorspar remains as a cavernous mass or honeycomb of ore.

Fluorspar is prominent in this mine but the exposures are not such as to justify a definite statement as to its commercial value.

From a longitudinal cut at the top of the hill at the Thompson mine good ore is now being mined, but its shipment must await the convenience of the farmers who furnish teams for hauling the ore to market. Shipment is retarded frequently also by bad roads.

The size of the deposit in this locality is approximately 300 feet wide by 1000 feet long. Both of these properties have been acquired by the Durex Chemical Corporation who also control the only others on this vein toward the southwest now in operation, viz., the Culveyhouse and the Jones-Small mines. Mining has been entirely with pick and shovel. Conditions here would seem to warrant the installation of a log washer, water for which is available from the spring-fed creek adjoining.

Culveyhouse mine.—The Culveyhouse mine is located about one and a half miles southwest of the Minton-Thompson mines. Ore outcrops in a number of places in the intervening area, the prospects being known as the Thompson (No. 2), Hilton, Bettis and Campbell. A small amount of ore has been taken from some of these, but no extensive work has been done on them.

One of the leading mines on this vein is the Culveyhouse from which about 20,000 tons of ore have been extracted. It occupies a low flat hill top covering an area 200 feet wide by 1000 feet long, the pits being about fifteen feet in depth. No limestone shows in the mine. Operations have been conducted with pick and shovel in a desultory way for about thirteen years. A large amount of ore now lies piled up awaiting favorable road and labor conditions for shipment.

Adjoining the Culveyhouse on the south is the Cox property on which as yet little work has been done.

Pfiffer mine.—About a mile southwest of the Culveyhouse is the Pfiffer mine extensively worked at one time but now idle. The excavation is about sixty feet deep and from it there have been removed 20,000 tons of ore. No limestone shows in the workings but the dolomite outcrops in a branch at a slightly lower horizon one-fourth of a mile west of the mine. At this point the strata dip 20 degrees south, 45 degrees east.

The Brown and Sharp properties adjoin the Pfiffer but no work is being done there at the present time. We are informed that about 5,000 tons of ore have been taken from each of these mines.

Jones-Small mines.—About 5½ miles southwest of the Pfiffer mine are the Jones-Small mines. Ore outcrops in places in the intervening area but the only openings of importance are the Pryor and Gilman mines adjoining the Jones-Small all of which belong to the Durex Chemical Corporation.

The Jones-Small mines are about seven miles west of Sweetwater and about one-half mile north of the Sweetwater-Ten Mile road. The two openings lie on the opposite sides of a shallow ravine, the chief workings being on the Jones property. A log washer has been installed and the ore is extracted from the pit by a steam shovel. Water for the washer is pumped from Big Suee Creek one-half mile away. The excavations cover approximately 200 square yards and in places reach a depth of twenty feet, all in clay. About 25,000 tons of ore have been recovered from these mines.

Kyker mine.—On the south side of the Ten Mile road, one-half mile southwest of the Jones-Small mines is the Kyker mine. The excavations here cover an area approximately 200 feet wide by 600 feet long and vary in depth from fifteen to twenty-five feet. Chert is relatively abundant and pinnacles of limestone are exposed in the deeper workings. The limestone outcrops near the road but little below the level of the bottom of the mine. One of the ledges outcropping in the mine is a dove-colored limestone containing small grains of quartz and little magnesia. This mine has produced about 5000 tons of ore but has not been worked for some years.

Shelton mine.—The Shelton mine is located on the Culveyhouse vein on the north side of the Hiwassee River four miles west of Charleston. A small opening in the southward facing slope has yielded a considerable amount of ore which lies on the dump, no shipments having been made from this mine recently. The ore body lies close to the fault which bounds the stratigraphic block on the southeast, bringing to sight the Cambrian sandstones and shales about 100 yards east of the mine. Barite in abundance appears at the surface above the mine and in the adjoining field owned by T. Bradford. This mine is controlled by lease by the Gilman Paint and Varnish Company of Chattanooga, Tennessee.

From the Kyker to the Shelton, a distance of twenty-five miles, the Culveyhouse vein has not been fully explored. Deposits of barite are reported to occur near the south end of this area and it is probable that investigation will reveal the presence of a number of deposits of importance in this part of the vein.

MINING OPERATIONS IN THE SWEETWATER DISTRICT

Historical statement.—While prospecting for lead in McMinn County in 1840 Colonel R. C. Morris is said* to have discovered an extensive bed of barite "on the west side of a ridge running down between Hiwassee River and Mouse Creek". The bed which he penetrated for twenty feet is said to be "rich and heavy". This is evidently the Shelton deposit described above. By 1874 considerable progress had been made in the mining of barite according to the authors quoted who state that in that year 1,040,177 pounds of barite ore was shipped from several stations of the East Tennessee and Georgia, now the Southern Railroad.

*Killebrew, J. B., and Safford, J. M., Resources of Tennessee, p. 270, 1874.

The first mill was established at Sweetwater during the Franco-Prussian war when the imports of barite from Germany had been cut off. On the establishment of peace the markets were flooded with cheap German ore with which domestic ores were unable to compete on account of excessive freight rates and the industry languished.

In 1899, W. D. Gilman the senior member of the Durex Chemical Corporation who, prior to this had been interested in the barite industry in Baltimore, Maryland, took over a number of leases in the Sweetwater district and began operations under the name of the W. D. Gilman Company. A mill was built in 1903 which has been in almost continuous operation ever since. In 1914 the company was reorganized under the name of the Durex Chemical Corporation with headquarters in Baltimore. The mill was partly burned in March, 1917, but this is being restored and a unit built which will greatly increase its capacity.

About 1903 John T. Williams took over a number of leases and prospected the district extensively. He is said to have worked as many as forty prospects and mines at one time. The low price of ore combined with the high cost of mining and shipping the ore depressed the industry and he abandoned the field in 1908 or 1909.

For the period preceding the present war the production of barite in Tennessee reached its high water mark in 1907, in which year there were mined 20,863 short tons of barite. Of this all but 400 short tons came from the Sweetwater district. The operators of barite mines in Tennessee in that year were as follows:

John T. Williams and Sons, Bristol Virginia.
Mines located near Cleveland, Niota, Reagan, Sweetwater, Philadelphia, Del Rio and Greeneville.

William D. Gilman Company, Sweetwater, Tennessee.
Mines located in Loudon (Dist. No. 5), and near Sweetwater.

Commercial Mining and Milling Company, Knoxville, Tenn.
Mines located near Sweetwater and Del Rio.

J. F. Doherty, Sweetwater, Tennessee.
Mines located near Sweetwater.

C. L. Hudson, Niota, Tennessee.
Mines located near Sweetwater.

From 1907 to 1914 the production of barite in Tennessee declined, the low price of ore making operations unprofitable With the nearly complete cessation of imports in 1914 caused by the war, domestic ores have found a ready market at good prices and there has naturally followed a marked increase in mining activity. Prior to 1907, Greene and Cocke counties were in the list of producers but since that time the entire output of barite in Tennessee has come from the Sweetwater district.

MINING AND PREPARATION FOR THE MARKET

Mining.—The workable deposits being all of the residual type the mining of barite in this district is a relatively simple matter, and has heretofore been carried on by pick and shovel, the ore and clay being removed from the pit in wheelbarrows. There are no pits deeper than 60 feet nor has aditing nor tunneling been practiced. In only a few cases has excavation extended to the limestone below, and no effort has been made to work the original vein by sinking shafts and drifting and stoping. The method that has prevailed mostly in the past is to break the ground by picks, shovel the material into wheelbarrows or dump carts and haul it out for further treatment. The ore separated from the clay by hand is scattered on the ground or on platforms exposed to the heat of the sun, and the rain which will remove most of the adhering clay. The ore is then loaded into wagons with a fork, the smaller pieces going to waste. It is estimated that thirty per cent or more of the ore is lost by this process of handling.

Steam shovels and log washers have been installed in some of the mines with fairly satisfactory results, though in some cases poor results have been obtained owing to poor management. A factor that has to be dealt with, however, is the pockety character of the deposits. All of the deposits are pockety with considerable masses of barren clays. In mining by hand these can be left untouched, but the steam shovel requires their removal; it is doubtful if this method will prove economical in all of the mines. Some recommend* the practice of washing with a 16-foot log washer, crushing and rewashing with a 12-foot washer. Where water is available, by washing at the mines there is a saving of 25 per cent or more in the cost of milling.

The hydraulic method would undoubtedly prove most advantageous in handling these residual clays, but water under sufficient head is not available in the Sweetwater district.

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*Fohs, F. J., Kentucky Geological Survey, Ser. IV, Vol. I, pt. 1, p. 537, 1913.

Preparation for the market.—The preliminary treatment in the preparation of the ore for market comprises handpicking before placing on the dump, screening, handcobbing, grading, washing, crushing, and concentrating. Much of the crude material undergoes only the first three of these processes, viz., picking, screening and handcobbing. This method, however, is adapted only to the coarse material and the large quantities of fine stuff resulting from breakage, and the pebble ore, are lost.

Where log washers are employed, the ore is graded and the finer ores along with the clay inclosing them are sent direct to the washers. Where the product consists of both coarse and fine material in rather large proportions it is usually screened through an inch mesh screen and the lumps removed for handcobbing and the screenings for washing if a log washer is available. The proportion of fine or "gravel" ore is much greater in some mines than in others and hence the installation of the log washer makes possible the operation of mines which otherwise can not be worked with profit.

Only one grade of barite is marketed in tne Sweetwater district, viz. the No. 1, or pure white variety. The ore is practically free from calcium carbonate, and manganese oxide and runs 98 to 99 per cent barium sulphate. The silica runs from .30 to 1 per cent and the alumina and iron from .40 to 1.50 per cent. Ore that does not comply with these requirements is rejected. Doubtless much of this might find a market as second and third grade following the classification of the Kentucky report*, according to which the second grade may contain as high as 20 per cent of impurities, such as calcite, limestone, fluorspar, etc., while the third grade includes material that is off-color, usually deeply reddish from iron oxides and running as high as 40 per cent in fluorspar, limestone, calcite, etc. Material of this character of the second and third grades is not regarded as commercial barite in the Sweetwater district. Should a demand for such low grade ore develop, a considerable amount of material now rejected or left untouched would find its way to market.

Most of the mines controlled by the Durex Chemical Corporation are owned by the company. The others are operated in the main under lease. Where worked on royalty the royalty varies from 25 to 75 cents per ton.

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*Fohs, F. J., Kentucky Geological Survey, Ser. IV, Vol. I, pt. 1, p. 536, 1913.

The cobbing may be done by the use of a small hatchet, hack hammer, or pneumatic pick. By this means the larger masses containing iron oxide, zinc blende, galena, or clay, may be freed from most of their impurities and raised to the highest grade.

Transportation.—Haulage is done by wagon and as the roads are only in part macadamized this constitutes an important item in the cost of marketing the ore. During rainy seasons it often becomes necessary to suspend work altogether. The injury to roads and teams would be considerably lessened by the use of wagons with wide tires. The cost for hauling is $4.00 to $5.00 per day for man and team. On the average two mules will haul from 4000 to 5000 pounds per load. Where haulage is by the ton instead of by the day the rate is fixed according to distance in such manner as to make the amount equivalent to the prices paid per day. The cost of labor has increased considerably since the government report for 1915 was prepared.

THE MANUFACTURE OF BARIUM PRODUCTS

The following description of the manufacture and uses of barium products is taken from an article by James M. Hill in Mineral Resources of the United States for 1915, Part II, pp. 181-185, 1916. A footnote to this report states that the sections dealing with manufacture of barium products had been read and criticised by Mr. Hugh Rollin, of the Rollin Chemical Company and Mr. Maximilian Toch, of the Durex Chemical Company:

> *Ground Barite.*—The treatment of crude barite to make ground barite varies in different plants. The general practice, however, seems to be to crush to about 1 inch and log-wash and jig to remove clay, calcite, fluorite, silica, and part of the iron oxide. This cleaned material is next crushed to one-fourth to one-eighth inch at some plants, and at others ground and subjected to a bleaching process. The bleaching, largely to remove iron oxide, is accomplished by treating the material with sulphuric acid from 8 to 12 hours in lead-lined wooden tanks. The bleached product is washed several times and ground in burr mills or pulverizers to pass 200 to 300 mesh, and in some plants is water floated to insure a uniformly fine product, and is then dried, pulverized, and packed. Much care is required not only in the bleaching, but also in the drying operation to insure a uniformly perfect color. Details of the manipulation during bleaching and of the drying machinery are not made public.
>
> The softer grades of barytes are preferred by the grinders, as there is less wear on the machines in treating this class of material. However, in some plants, hard crystalline barite is ground successfully. Several grades of barite

are on the market, varying from unbleached, coarsely-ground material to the finest grade of white-bleached and water-floated pigment.

Lithopone.—Lithopone is a mixture of approximately 70 per cent barium sulphate, 25 to 29 per cent zinc sulphide, and 1 to 5 per cent zinc oxide, which is made by mixing hot solutions of barium sulphide and zinc sulphate. In the preparation of high grade lithopone the solutions of barium and zinc compounds must be essentially pure. The precipitate from the tanks is filter-pressed, dried, subjected to considerable heat, quenched in water, ground to pulp, filter-pressed, dried, and packed for shipment. A recent paper by O'Brien* brings out the important points in the preparation of lithopone and indicates some of the features necessary to produce a light-proof product. Lithopone is sold under a great variety of trade names, such as Beckton White, Green Seal, Blue Seal, Sterling White, Fulton White, Phonolith.

Barium chemicals.—The principal chemicals made in the United States are the binoxide, carbonate, chloride, hydroxide, nitrate, and sulphate or blanc-fixe. Some crude barium sulphide ("Black Ash") is sold to makers of lithopone and manufacturers of chemicals who are not equipped to roast sufficient barite to meet their needs.

As all the barium compounds are poisonous, care must be exercised in their manufacture. Naturally the salts which are only slightly soluble in water are not so dangerous as those which are more soluble. The sulphide is soluble in hot water. The carbonate is sparingly soluble in pure water and is slightly soluble in water containing carbonic acid. The chloride is soluble in water, particularly hot water, but is insoluble in strong hydrochloric acid and alcohol. Barium nitrate is slightly soluble in water, but is insoluble in concentrated nitric acid and alcohol. Barium sulphate is insoluble in water, but is slightly soluble in dilute acids and more so in strong acids.

As there are no published accounts of the actual methods used in manufacturing barium chemicals, and as it is not ordinarily possible to inspect chemical plants, it is not known what methods are actually used in the preparation of the barium salts at various plants. Applied chemistry is, of course, essential to the success of this industry, yet a detailed knowledge of markets, not only for crude materials but also of first products, by-products and labor is of prime importance.

The following notes abstracted in part from Thorp's "Dictionary of Applied Chemistry" and Roscoe and Schorlemmer's "Treatise on Chemistry" are not given as a method of procedure to be followed by those desiring to make barium chemicals, but for general information to those interested but specializing in the subject.

The manufacturers of barium chemicals prefer to use washed, high-grade barite of the soft variety; nevertheless they can, and some do, use barite which could not be used for the highest grades of ground floated barite. The first step in the barium chemical plants is the reduction of the barium sul-

*O'Brien, W. S., A study of lithopone, Jour. Phys. Chem. vol. 19, pp. 113-144, 1915.

phate to the sulphide, which is soluble in water. The barite is finely crushed and mixed with a certain proportion of coal and common salt. The mix varies in different plants, but is generally stated to be about one-fourth coal by volume. This material is fed to rotating furnaces, where it is roasted from three to four hours. The charge is next leached in most plants, first, with a boiling, weak solution of barium sulphide, which is obtained by washing the leached material with hot water. The ash after the leaching and washing is waste, though it may contain some undissolved barium compounds. The extraction of barium sulphide is ordinarily stated to be 70 per cent, though it is known that a higher extraction can be made. The liquid from the barium sulphide leach is stored in large heated tanks, from which it is drawn into the different vats for the preparation of the various salts. Barium sulphide can be precipitated by allowing the solution to cool below 150 degrees F.

The processes of the manufacture of the varius chemicals are intricate and require special study and application of chemical and physical knowledge when done on a commercial scale. The manufacturing chemists do not make public the special methods which they have evolved for the preparation of pure salts. It is known in general that the carbonate and the sulphate can be precipitated from the hot sulphide liquor by the use of appropriate salts of sodium and that a salable sodium sulphide by-product will be formed. It is also known that barium chloride can be made by treatment of the sulphide liquor with hydrochloric acid and by roasting a mixture of barytes, charcoal, limestone, and calcium chloride, but the first precipitate requires purification. Barium nitrate can be made by treating the sulphide solution with nitric acid or by mixing hot saturated solutions of barium chloride and sodium nitrate. The preparation of the binoxide or peroxide (BaO_2) and hydroxide ($Ba(OH)_2$) are said to require a particularly high degree of technical skill, as very high and very low temperatures are required during the course of process and the materials require careful manipulation to insure uniformity. Barium monoxide or baryta (BaO) can be made by heating the nitrate till the evolution of red nitrous oxide fumes ceases, but the heated mass is liable to froth, though this can be prevented by using equal amounts of nitrate and sulphate, which reduces the yield. It can also be prepared from the carbonate by bringing that salt to a white heat when most of the carbon monoxide is driven off. The hydroxide ($Ba(OH)_2$) can be formed by the combination of baryta and water, but as a great amount of heat is evolved, its manufacture in this manner requires considerable care. It can also be produced by passing moist carbon dioxide gas over heated barium sulphide forming the carbonate, after whch superheated steam passed over the carbonate forms barium hydroxide with the evolution of carbon dioxide. The hydroxide can also be made by the electrolysis of barium hydrosulphide. Barium peroxide can be prepared by passing air freed from carbonic acid over baryta (BaO) heated to a dull red, or by treating heated baryta with powdered potassium chlorate, but this peroxide requires purifying.

USES OF BARIUM PRODUCTS

Ground barite of the lower unbleached grades is sold to manufacturing chemists and to paint manufacturers for incorporation in colored mixed paints; it can also be used in the preparation of rubber and in other industries where a colored product is made. The bleached and floated barite of the finer grades is used as a white pigment in preparation of ready mixed white paints and as a filler for the chemical pigments. In the paper industry it is largely used in the manufacture of heavy, stiff material, such as playing cards, bristol boards, and the like.

Lithopone is sold and used as a white pigment for ready mixed paints, being particularly used for the preparation of what are called the "sanitary flat wall paints" which are used to a large extent. It is also used in some enamels and calsomines, and in the rubber, paper, and cloth industries, where it is replacing barite and some of the metallic pigments.*

The barium chemicals have a wide variety of uses and may enter into the manufacture of other products. In the study of the industry the products have not been followed beyond the plants at which the chemicals are made from crude barite. Barium binoxide, or peroxide (BaO_2) apparently finds its principal market with the manufacturers of hydrogen peroxide, though some is believed to be used in the preparation of oxygen. This salt has the property of giving up part of its oxygen under certain conditions and of recombining with more oxygen under reverse conditions. This property is not, however, everlasting, and fresh supplies of the peroxide are frequently required.

Barium carbonate is used in the preparation of other barium chemicals—in rat poisons, as a water softener, in the manufacture of flat wall paints, and in the ceramic industry. Probably the last is its largest use at present. It is said that this material will fill the requirements of case-carbonizing steel, which was formerly filled by ground bone. Ground bone, which formerly commanded a price of $60 per ton, has risen in price and the makers of case-carbonized steel have been in search of a substitute. The barium carbonate for this purpose must contain no sulphur, but may carry calcium and small amounts of other impurities. It is said the demand should be several thousand tons a year.

Barium chloride is used in the preparation of other barium salts, as a water softener, a chemical reagent, particularly for the purification of table salt, to some extent in the ceramic arts, and in the preparation of rat poisons.

Barium hydroxide is used as a chemical reagent. It can be used in the refining of sugar, but on account of its poisonous nature is not often employed; another reason why it is not used is the difficulty of its regeneration from the carbonate which is formed by the reactions.

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*From Rogers' Manual of Chemistry we learn also that lithopone "does not oxidize progressively, and this single feature has made it invaluable to the table oilcloth and floor oilcloth industry throughout the world. Its indiscriminate use, however, is not to be recommended, and the paint chemist should be permitted to decide when its value is the greatest. As a marine paint, either as a first coat or for making neutral paints where other whites would be necessary, it is found to outlast both zinc oxide and lead carbonate."

Barium monoxide has its principal use in the preparation of the binoxide and hydroxide. It is used to some extent in the manufacture of special glasses.

Barium nitrate is used as a chemical reagent in the preparation of "green fire" and green signal lights and in the manufacture of an explosive known as saxifragin.

Barium sulphate, usually sold under the name of blanc-fixe or permanent white, is a pigment extensively used in the paint industry, in the manufacture of highly glazed papers and of putty, and in the fabrication of rubber and of lake colors.

*Producers**

Companies	Ground Barite	Lithopone	Barium Chemicals
Barbour Chemical Works, West Coast Life Building, San Francisco, Cal.	+	..	+
Baryta Manufacturing Company, 205 Pearl St., New York City	..	..	+
Beckton Chemical Company, Cleveland, Ohio	..	+	..
Carolina Baryta Company, Stackhouse, N. C.	+	..	..
Chemical Products Company, 616 Majestic Building, Denver, Colo.	..	..	+
Cherokee Chemical Company, 109 Hollingsworth Street, Baltimore, Md.	+	..	..
Chicago Copper and Chemical Company, 111 West Jackson Boulevard, Chicago, Ill.	..	..	+
Clinchfield Products Company, 120 Broadway, New York City	..	..	+
Durex Chemical Corporation, 320 Fifth Ave., New York City, and Sweetwater, Tenn.	+	..	+
Elkhorn Chemical Company, Elsinore and Gilbert Avenues, Cincinnati, Ohio	+	..	+
J. C. Fink Mineral and Manufacturing Co., 101 Barton Street, St. Louis, Mo.	+	..	..
Globe Chemical Company, 1205 Regent Avenue, Cincinnati, Ohio	..	..	+
Graselli Chemical Company, Cleveland Ohio	..	+	..
N. Z. Graves Corporation, 22 to 24 South Third Street, Philadelphia, Pa.	..	+	..
Krebs Pigment and Chemical Company, Newport, Delaware	..	+	..
Lamar Chemical Works, 44 to 56 Lewis Avenue, Jersey City, N. J.	..	..	+
Mantua Chemical Company, 350 Grays Ferry Road, Philadelphia, Pa.	..	+	..
Midland Chemical Company, 80 East Jackson			

*Mineral Resources, U. S. Geological Survey, 1915.

Companies	Ground Barite	Lithopone	Barium Chemicals
Boulevard, Chicago, Ill.	..	+	..
New Jersey Zinc Company, 55 Wall Street, New York City	..	+	..
Nulsen, Klein and Klausse Manufacturing Co., Levee and Sidney Sts., St. Louis, Mo.	+	..	..
Point Milling and Manufacturing Company, Mineral Point Mo.	+	..	..
Port Morris Chemical Works, 141 Locust Ave., New York City	..	..	+
Product Sales Company, 423 to 425 Equitable Building, Baltimore, Md.	+	..	..
Rollin Chemical Company, Charleston, West Va.	..	..	+
Thompson, Weinman and Company, 100 Williams Street, New York City	+	..	..

PRODUCTION AND PRICES

The amount of crude barite marketed in the United States in 1915* was 108,547 short tons valued at $381,032 or an average of $3.51 per ton. This is an increase over the production of 1914 of 52,747 short tons valued at $155,647, or an average increase of .56 per ton. Of this amount Tennessee furnished 25,074 short tons valued at $71,390, or $2.85 per ton. In total output, Tennessee stands third, being exceeded by Missouri with 39,113 short tons, and Georgia with 31,027 short tons.

The prices paid for crude barite in 1915 varied considerably. They were highest in Missouri where $6.27 was paid and lowest in Alabama at $3.56.

Crude barite marketed in Tennessee, 1903 *to* 1916.

	Short tons	Value	Average price per sh. ton
1903a	14,185	$49,618	$3.49
1904a	10,565	37,172	3.51
1905a	7,400	25,545	3.45
1906a	1,754	6,439	3.67
1907a	20,863	45,863	2.20
1908a	7,649	17,075	1.97
1909a	4,631	6,946	1.50
1910a	1,800	2,000	1.11

*Hill, J. M., Mineral Resources of the United States for 1915, p. 162, 1916.

	Short tons	Value	Average price per sh. ton
1911a	4,106	5,079	1.24
1912b	3,718	8,682	2.34
1913b	2,098	3,568	1.70
1914b	10,113	16,273	1.61
1915b	25,074	71,390	2.85
1916b	32,416	123,986	3.85

a. Reports of the Tennessee State Mining Department.
b. Mineral Resources of the United States.

Marketed production of barium products in 1915a

	Short tons	Value	Average price short ton
Ground barite	51,557	$ 635,318	$12.32
Lithopone	46,494	3,760,472	80.88
Barium chemicals	8,823	b	b

a Mineral Resources of the United States for 1915.
b. Not reported.

With the exception of ground and floated barite nearly all the barium products used in the United States prior to 1915 were imported either from Germany, England or France, the industry being best developed in the two first named countries. Ground barite has been produced at various plants in the United States for many years and a small quantity of barium chemicals, but there is no published information of the industry for these years. Following is the production of crude barite in the United States since 1902:

Production and prices of crude barite in the United States, 1903 *to* 1915a

	Short tons	Valuation	Average price per short ton
1903	50,397	$152,150	$3.02
1904	65,725	174,958	2.66
1905	48,235	148,803	3.08
1906	50,231	160,367	3.19
1907	89,621	291,777	3.26
1908	38,527	120,442	3.13

a. Mineral Resources of the United States. The price given is that paid to the miner for the crude ore, hand cobbed, sorted and ready for shipment to the mill. It is not supposed to include the cost of haulage by wagon, boat or railway.

	Short tons	Valuation	Average price per short ton
1909	61,945	209,737	3.39
1910	42,975	121,746	2.83
1911	38,445	122,792	3.19
1912	37,478	153,313	4.09
1913	45,298	156,275	3.45
1914	52,747	155,647	2.95
1915	108,547	381,032	3.51
1916	221,952	1,011,232	4.56

NOTE ON FLUORSPAR

The occurrence of fluorspar in some of the mines of the Sweetwater district has been noted in the foregoing descriptions. Its chief occurrence is in the Howard, Ballard and Minton mines. It appears at certain spots in the ore body associated with barite in varying portions. As its presence lowers the grade of the barite, these places are shunned by the miners. The exposed areas are relatively small and the extent of the deposit of fluorspar is largely a matter of conjecture. A considerable amount of limestone and chert occurs along with the fluorspar and barite and the utilization of the spar is questionable. In view of the demand for this mineral, however, these deposits merit investigation.

Since the fluorspar and barite both withstand weathering better than the limestone or dolomite, the surficial part of the vein containing them remains as a cavernous reef-like mass in the clays, grading below into unaltered vein material. Where the two minerals are easily separated they may be sorted into two products, the one consisting mostly of barite, the other of fluorspar. When ground for mixed paints, or for cold water paints the presence of a small percentage of fluorspar is not harmful since the fluorspar (except with strong sulphuric acid) like the barite remains inert, will grind white, and its triangular-shaped particles will assist in making a more compact film.*

The specific gravity of fluorspar is only a little less than that of barite. According to the author quoted above, fluorspar is helpful as a color extender and is now used to some extent in off-color paints.

*Fohs, F. J., Kentucky Geological Survey, Ser. IV, vol. I, pt. 1, p. 551, 1913.

VOLUME VIII NUMBER 2

THE RESOURCES OF TENNESSEE

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

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ANNOUNCEMENT

Election of New State Geologist

BY L. C. GLENN.

After the death of Doctor Purdue on December 12, 1917, Dr. L. C. Glenn of Vanderbilt University proferred his services for attending informally to the correspondence and personal inquiries of the Survey's office until more definite arrangement could be made. On January 10, 1918, the Geological Commission met and elected Doctor Glenn Acting State Geologist to serve until a permanent successor to Doctor Purdue could be secured.

The committee appointed to look up candidates reported to the Commission at a meeting on April 9th and Mr. Wilbur A. Nelson was elected State Geologist.

Mr. Nelson graduated as bachelor of science from Vanderbilt University in 1910 and soon after became assistant geologist on this Survey, which position he held for three years. His investigations during this time covered a wide range of subjects, among which may be mentioned especially, building sand, caves, coal, clays, iron ore, lead, lignite and manganese.

Mr. Nelson then spent a year's leave of absence in graduate study at Leland Stanford University, where he took the degree of Master of Science in 1914. He was elected to membership while there in the honorary scientific society Sigma Xi. Following this he returned to the Survey, but later resigned to become geologist for the N., C. & St. L. railway. After nearly two years he gave up this work to accept a responsible position with the Paga Barite Mining Company at Cartersville, Georgia, and was connected with this corporation when elected State Geologist. He has also done special work for the Southern Manganese Corporation and other mining concerns. His mining and other affairs will prevent his assuming active charge of the Survey before May 1st.

Mr. Nelson comes to the Survey already familiar with its organization and operation and with a knowledge of the State's mineral resources and the possibilities of their further development that will stand him in good stead in continuing the State Survey on the high plane on which Doctor Ashley originally pitched it and Doctor Purdue subsequently maintained it.

Report on the Caves of the Eastern Highland Rim and Cumberland Mountains

By Thomas L. Bailey

During the two months from July 15 to September 15, 1917, the writer explored 109 caves and rock shelters in the eastern part of Middle Tennessee. All except eight of these were caves, these eight being what are known as rock shelters or rock houses. This work was done to determine the value of these caves as possible sources of niter. A sample of the earth was collected from different parts of the floors of all the caves and rock shelters where there were sufficient accumulations of earth to work in case it should contain a fair percentage of niter. From large caves two samples were sometimes collected. These samples were numbered and labeled in accordance with the numbers given to the caves and rock shelters in this report. The descriptions of the individual caves and shelters contained in this paper are generally arranged in the following manner: (1) the location, both geographic and geologic; (2) the topography of the mouth and its surroundings; (3) the dimensions of the cave as nearly as can be approximately estimated; (4) a description of the interior, including the important point of whether there is a running stream in it or not; (5) the average depth of any loose earth on the floor; (6) a description of the stalagmites, stalactites, rock-rimmed pools, terraces, and other water-deposited limestone formations; (7) the use of the cave or rock shelter as a burial ground by Indians, if such were possible to determine, together with other facts of historic interest. This order is frequently modified or changed, but it is followed in the majority of cases. These samples of earth were sent to the Survey's Chemist for analysis soon after being collected. In this investigation there was not sufficient time to go to all caves in the counties visited, but the attempt was made to investigate those which would probably be of most value for deposits of niter. Information concerning the location of these caves was largely gathered from the inhabitants of the region, and very likely some important caves were left unexplored. Those which were explored, however, are believed to be typical representatives of the caves in the region. With the limited amount of time, naturally much of the information here given is only approximate.

The descriptions are given by counties arranged alphabetically. The results of the chemical analyses follow in a brief article by Dr. L. C. Glenn.

CLAY COUNTY.

No. 18. Bailey Cave.

Location.—On the farm of Ben Bailey, 5 miles south of Celina; one-fourth of a mile north of Bailey's house, near the foot of the mountain, on the east side and near the head of a small hollow. It is in the Ordovician limestone about 65 feet below the Chattanooga black shale. It is 300 yards from the Celina road and two miles from the Cumberland River.

The entrance is in thin woods just above an open pasture, and is a vertical hole extending downward for a distance of 20 feet or more and then turning eastward and northeastward. There is a small stream flowing through the cave except near the mouth where it passes beneath the floor. This is not a very large or spacious cave but it is quite long and sinuous, being about a half mile in length. It averages about 6 feet in width and 8 feet in height. There are three rooms of considerable size located at intervals along the cave. At a distance of 300 yards from the mouth and extending back for 100 yards is a bed of loose earth 6 feet thick that contains sparkling crystals of gypsum. There are some other banks of loose earth farther back in the cave. Stalagmites and stalactites are scarce. About one-fourth mile or more from the mouth are some stones with grains of blue corn lying on them that were thought to have been left by the Indians.

No. 19. Saltpeter Cave (Rock Shelter).

Location.—On the farm of Irving Abner, 5 miles southeast of Celina, one-half mile north of Abner's house, 200 yards from a log house at the head of the west fork of the hollow. It is 100 feet below the top of the mountain and a half mile from the public road. It is in Mississippian limestone, 20 feet above the Chattanooga black shale.

This is really more of a rock shelter than a cave, although there are openings in the limestone at the back of the shelter that extend into the bluff about 100 feet in some cases. However, these openings are only 4 feet high and 3 feet wide. The rock shelter is 20 feet high and 100 feet wide and extends back about 100 feet, making an enormous hole in the side of the mountain. The earth on the floor is not over one foot thick on the average and contains a thin, white crust of niter.

No. 20. Daly Cave.

Location.—On the farm of Thomas Daly, 4½ miles northeast of Butler's Landing on the Hilham road. It is a very large cave according to reports and during the Civil War saltpeter was obtained from it. Hoppers where it was leached from the cave earth are still in existence. This cave was not visited but several people gave similar reports of it. It probably still contains a fairly large quantity of niter.

No. 21. Sheals Cave.

Location.—On the farm of Ed. Fowler and his partners, a half mile northeast of Celina near the base of a hill above a large spring in pasture land about 100 yards from the public road. It is in Ordovician limestone. The mouth is on the edge of an open pasture beneath a projecting ledge of rock, which forms the roof farther in. The mouth is closed by a wooden gate and potatoes and other produce are stored in it in the winter. A stream runs throughout almost the entire length of the cave. It is quite large at the mouth and the large chamber extends back about 100 feet. Then it becomes low and narrower. The roof is almost flat. The mouth is 8 feet high and 12 feet wide while the main chamber is 15 feet high and 40 feet wide. There is little loose earth but no stalactites.

No. 22. Rich's Cave.

Location.—Five miles northeast of Celina on the land of Grover Rich, a fourth of a mile west of Rich's house, and two-thirds of the distance to the top of the mountain, at the base of a limestone bluff 30 feet high. It is a quarter of a mile from the Pea Ridge road and a half mile from Obey River. It is in Mississippian limestone, 30 feet above the Chattanooga black shale.

The mouth of the cave is very large and the roof is an overhanging ledge of arenaceous limestone. It is in thick timber and is 10 feet high and 25 feet wide. A small stream flows through the cave, which extends back over 200 yards, but gets too low at the end of 100 yards to penetrate any farther. The average height is 5 feet and the width 8 feet. On both sides of the stream there is loose earth about 3 feet in thickness. This earth is sandy, and there is much sand in the bed of the stream. There are very few stalagmites or stalactites.

No. 23. Williams Cave.

Location—This is a small dry cave on the land of Mrs. M. Williams 4 miles northeast of Celina at the base of a limestone bluff 25 feet high, in thick woods. This cave is so small that it is hard to penetrate and does not seem to contain much loose earth. Its height is 5 feet and its width 4 feet or less. There are a few stalactites.

No. 24. Roundmouth Cave.

Location.—On the land of Ance Key, 5 miles northeast of Celina, about 1½ miles south of Key's house, and three-fourths of a mile northeast of Grover Rich's house in thick woodland near the top of the ridge. It is about a quarter of a mile from the Celina-Lillydale ridge road. It is in Mississippian limestone, 20 feet below the Lee sandstone.

The mouth is a round hole about 4 feet in diameter, that extends downward almost vertically for 25 feet. The cave extends in a northerly direction. There is no stream, but water drips from the roof in many places, and the interior is very cold. This cave is straight and light from the mouth, can be seen back for 150 yards, beyond which point it can not be penetrated easily. It averages 10 feet in height and 6 feet in width.

The loose earth on the floor is rather sandy and averages 3 or 4 feet deep, though in some places it is much deeper while in others the floor is of limestone. The cave formations are very abundant and beautiful and the faint greenish light that enters through the mouth gives the numerous white stalactites, stalagmites and natural columns a very ghostly but attractive appearance. The stalactites and stalagmites arranged regularly along the walls together with the maze of natural columns and slender stalagmites and stalactites at the back of the cave give that part the appearance of a church with its altar at the back.

No. 25. Webb Cave.

Location.—On the farm of W. C. Webb, 4½ miles east of Celina, 100 yards northeast of Webb's house. It is in Ordovician limestone at the foot of the ridge, 30 feet below the Chattanooga black shale. The limestone is rather sandy.

The mouth is roughly triangular. The cave is 10 feet wide and 5 feet high and extends northeastward for a short distance when it gets too low to penetrate. The walls are very smooth and the curves in the cave are at right angles following the joint planes of the sandy limestone. There is little loose material on the floor and a stream flows along it so that any niter has probably been removed.

DeKALB COUNTY.

No. 72. Saltpeter Cave.

Location.—One fourth mile east of Temperance Hall on the land of Dr. Skiler Robinson. It is in the Ordovician limestone 50 feet below the Chattanooga black shale.

The mouth is a round hole in an old field near the top of a low hill in the edge of thin woods. It extends straight down for a distance of 35 feet and then opens into a rather large room. The cave is damp but no regular stream flows through it. It is 500 yards long, 20 feet wide and 25 feet high and is rather winding. There are several banks of clayey earth that are 15 feet high, while the average depth of earth for the cave is about 6 feet. In places the earth is coated over with calcite. There are two very large and beautiful columns fully 30 feet high where the stalagmites and stalactites have only recently met. They are parallel and joined together at the top and base. At the base their thickness in one direction is 20 feet and they are situated on top of a rounded mound-like stalagmite that covers the floor for 50 square feet or more and is about 7 feet high. The whiteness of these columns adds much to their beauty. There are several other thick, inverted-cone-shaped stalagmites at various places, some of which are very pretty. There are also some fringes of stalactites at several points that add to the attractiveness of the cave. The back of the cave seems to be blocked by formations of this kind. There are evidences of former work in the cave. Marks of shovels may be seen in the banks of earth, and there are pieces of old troughs. It is said that gunpowder was once made in this cave.

No. 73. Snow Hill (Saltpeter) Cave.

Location.—Two miles southeast of Dowelltown on the land of Mrs. W. P. Banks, 200 yards south of her house near the foot of Snow's Hill on the edge of a thin woodland about 100 yards from the Smithville pike. It is in the Ordovician limestone over 200 feet below the Chattanooga black shale. The mouth is at the west end of a pit-like hole about 8 feet deep and 50 feet wide. The mouth is wide and rather low, being about 6½ feet high and 40 feet wide. It is a nearly dry cave, but the earth is damp. The average width of this cave is 20 feet and the height is 10 feet. It is about a half mile long, although there are some narrow places through which it is necessary to crawl. It is said to open on Dry Creek over a mile away from the mouth. There is a large amount of loose earth on the floor that has been excavated to a depth of 8 feet in places, while the average depth is probably 5 or 6 feet. There are marks of tools in this earth and also remains of old metal troughs. Stalactites are numerous but none are very large.

No. 74. Jim Cave.

Location.—Two and a fourth miles south of Dowelltown on the land of B. W. Robinson, 200 yards north of Don Williams' house, 100 feet below the top of the hill facing Dry Creek, and between the Smithville Pike and Dry Creek. It is in Ordovician limestone, 150 feet below the Chattanooga black shale.

The entrance is under a low bluff of limestone in a thick grove of young trees. It is only 4 feet wide and 3 feet high and hence is very hard to find. It slopes downward rather steeply for 30 feet. The earth is rather damp but there is no running or standing water present. The cave is 400 yards long and averages 15 feet in height and 10 feet in width. The earth in the cave is in banks 6 feet or more in thickness. The cave is named for a negro, Jim, who killed a man and hid himself here for some months before being apprehended. In the branches of this cave there are a large number of bones, some of which may be human. There are also some very beautiful calcite and aragonite formations, especially near the back of the cave, and a few of the stalactites are rather large. There is one very high and slender stalagmite.

No. 75. Myers' Cave.

Location.—Two miles southeast of Dowelltown on the land of A. R. Myers, 200 yards east of his house, and 200 yards from the Smithville-Liberty pike. It is in the Ordovician.

The mouth is located about 100 feet from the base of the hill near the edge of a grove of cedars. It is 20 feet long and 6 feet wide and opens vertically downward for 25 feet. There is no running water present but there are pools of standing water and the earth is muddy in places. The mouth opens into the main room which is 200 feet long, 50 feet wide and 20 feet high. Three branches lead off from this room, one being about 25 feet above the floor of the main room. The average width of the branches is 12 feet and their height 6 feet. All three are about 50 or 60 yards long and become low at their ends. The loose earth is mostly in these branches and is about 4 feet deep. In the main room the earth is muddy and mixed with rocks but it is probably 4 or 5 feet deep. There are a few pretty stalagmites and stalactites especially in the upper or northern branch, which is reached by means of a ladder. There are evidences of digging in some of the banks of earth.

No. 76. Gin Bluff Cave.

Location.—One mile north of Dowelltown on the land of J. B. Stone near the foot of Gin Bluff about 100 feet above Smith Ford. It is in Ordovician limestone.

There are two mouths to the cave connected by a curved passage. The north mouth is larger and is called the wet mouth since a large stream of water, which forms a series of rapids in its course to South Fork, flows out of it. The south mouth is dry and arch-shaped and is about 10 feet high and 7 feet wide at the base. The wet mouth is 30 feet wide and 6 feet high. These mouths are located just above the strip of woods and at the base of a bare limestone bluff 150 feet high. There are two forks to the cave, the Dry Fork, which connects the dry and wet mouths, and the Wet Fork, which follows the underground branch. From the wet mouth to where the Dry Fork branches off, the floor of the cave is covered with a series of clear pools of water, some of which are 4 feet deep and separated by thin wavy-edged limestone partitions. The mud in the stream in front of the mouth seems to have been calcified only recently, so that it is now possible to walk on it though it looks as if it were boggy. The rock-rimmed basins in this cave are some of the largest and prettiest examples of this type of deposit that were seen in any cave visited. The stream occupies most of the floor of the Wet Fork so that niter is not present. The earth on the floor of the Dry Fork, however, is probably 5 feet deep and is whitish in color, probably containing niter. This fork is about 300 yards long and averages 15 feet in width and 8 feet in height. The Wet Fork is over a quarter of a mile long and is wider but not so high. In the dry mouth there is a large pile of ashes 6 feet deep, from which an Indian skeleton was dug up.

No. 77. Robinson Cave.

Location.—Four hundred yards southeast of Dowelltown on the land of J. A. Robinson, 200 yards below the top of the hill in an open pasture at the foot of a beech tree. The cave is in Ordovician limestone about 200 feet above the bottom of the hill.

The mouth is 12 feet long and 7 feet high and slopes downward at a steep angle. The cave consists mainly of one large oblong-shaped room 400 feet long, 100 feet wide, and 50 feet high. Toward the back of this room there is a high pile of broken rocks and one small passage leads straight west, but it is too low to penetrate easily. This narrow passage seems to open into another room. There is little loose earth on the floor and it is mostly mixed with bowlders. There is a large group or series of groups of wonderful stalactites, stalagmites, columns, terraces and pools separated by high, thin partitions near the top of the high pile of rocks near the south side of the room, and these calcite deposits have cemented the rocks into a breccia in places. One group of slender stalagmites and columns is arranged like the pipes of an organ, but most of them are short and thick but wonderfully symmetrical. Some have acorn-shaped knobs at their extremities.

No. 78. WILLIAMS CAVE.

Location.—Three-fourths of a mile southeast of Dowelltown on the farm of J. B. Williams, 400 yards northeast of Williams' house, and about the same distance from the Smithville pike, in the Ordovician limestone.

The mouth is 75 feet below the top of the hill and is near the top of of a high bluff east of a broad, cultivated bottom. The mouth is under an overhanging ledge of limestone and is 4½ feet high and 10 feet wide. It is in thin woods that are full of bowlders making it hard to find. The roof of the highest part is only 7 feet high and it gradually becomes lower farther back. It is 25 feet wide and 200 yards long. The loose earth is a little damp and is about 5 feet deep. The cave slants backward slightly and is said to open on the other side of the hill but is too low to penetrate much more than 200 yards. It extends northeast and there are very few curves in it. The roof is practically smooth and seems to be a bed of cherty limestone. This cave is 400 yards from the Smithville pike.

No. 79. WILLIAMS CAVE.

Location.—One and a fourth miles southeast of Dowelltown on the farm of Mrs. Rachel Williams, a fourth of a mile northeast of her house. It is in Ordovician limestone about 300 feet below the Chattanooga black shale. This cave is only a half mile from the Smithville pike and 200 yards from a public road, and is very easily accessible for the land between is quite level. The nearest railroad is the Tennessee Central at Watertown, which is about ten miles distant. The Caney Fork is 8 miles east of the cave.

The mouth is a very inconspicuous hole in a small hollow in open pasture land, covered over with cedar brush to prevent cattle from falling into it. It is about 3 feet in diameter and extends straight down for 20 feet. Some dirt has fallen in from above so that it is possible to enter the cave without a ladder. There are two principal forks to this cave and each extends more than a mile, possibly 2 or 3 miles, though there are a few low places. One fork extends southeast and the other north. They are both large, averaging 25 feet in width and 12 feet in height. There are a few rather large, rock-rimmed pools of clear water which are 3 feet deep in places and about 5 feet in diameter, such as those described for numbers 76, 69 and 37. The water with which they are filled drips from the roof. The earth in the north fork is rather damp but much of that in the southeast fork is practically dry and consists mainly of a stiff yellow clay. About a fourth of a mile back in the southeast fork and continuing for a considerable distance the earth as well as the rock walls and roof of the cave are coated with prismatic, needle-like crystals of gypsum which sparkle like thousands of diamonds. This coat of crystals averages about one-half inch in thickness, although in places it is as much as 4 inches thick and very clear and beautiful. The majority of these crystals are more or less discolored on the outside by mud. Internally they are fibrous and have a silky luster. Small crystals of the same mineral can be seen sparkling in the loose earth. The earth which has been dug considerably during Civil War times is probably 10 feet thick in this part of the cave, though the whole cave will average only about 5 feet. There are remains of some old hoppers where the niter was separated from the earth, though metal troughs seem to have been mainly used. The hoppers are in a poor state of preservation but were similar to those described under No. 53. There are some beautiful stalactites and stalagmites in this cave but none are very large.

No. 80. Johnson Cave.

Location—Six miles southeast of Smithville on the land of W. M. Johnson, on the west bluff of Caney Fork, a half mile northeast of Johnson's house. It is in Ordovician limestone, 25 feet above the river.

The mouth is in thick woods on the bank of the river about 100 yards east of a small ravine that leads from near Johnson's house to the Caney

Fork. The entrance is 30 feet wide and 8 feet high and slopes very slightly downward. It is under an outcropping bed of limestone 5 feet thick. This cave is quite large and extends over a mile in a northwesterly direction. It averages 40 feet in width and 15 feet in height. The loose earth is heaped up in high banks and mounds and probably averages 8 feet, but it looks as if it had been washed over by water. There are few stalagmites and stalactites and the earth is a stiff yellow clay. There are a large number of branches and men have been lost in this cave for some hours. There is no regular stream within the cave for a mile from the mouth.

No. 81. Allen Cave.

Location.—Six miles southeast of Smithville on the land of Lou Allen about a fourth of a mile east of Razzie Redman's house on the bluff of Fall Creek. It is in Ordovician limestone.

This is a small cave with a rock bottom and of no importance economically though it is quite pretty, having a number of stalagmites and some pools of water. Some of these are large and there is one large natural column. It is only 5 yards long, 5 feet wide and 7 feet high.

FRANKLIN COUNTY.

No. 88. Keith Cave.

Location.—On the farm of T. A. Keith, 3 miles southeast of Cowan, one-fourth mile northeast of Keith's house near the head of Keith Cove. It is a fourth of a mile from the road and 3 miles from the Nashville, Chattanooga & St. Louis Railway. It is in St. Louis limestone, 700 feet below the Lee sandstone. It is in woods about 200 yards from the foot of the mountain. The mouth is small and it is necessary to crawl 150 feet to get into the large part of the cave. The cave consists mainly of one large room which contains hundreds of various-sized natural columns. Some are 5 feet in diameter while others are 20 feet long and only 5 inches in diameter, and others are even smaller. There are also stalagmites resembling waterfalls or rapids, cones or inverted bowls, rugged masses of various shapes as well as a few rather tall slender ones. The stalactites hang in groups of all shapes and sizes and vary from a few inches to 30 or 40 feet in length. The floor is covered almost entirely with a thick coat of calcite and there are rock-rimmed pools of clear water in many places as well as many such basins that contain no water. In many places prismatic crystals have formed on the outside of these formations and sparkle like thousands of brilliant gems. There is practically no earth on the floor but the crust of calcite sounds somewhat hollow and probably there is cave earth beneath the crust. This cave is about 400 yards long, 100 yards wide and 50 feet high. There is a light hole in the roof of the main room near the center. The formations have been badly mutilated, the smaller ones having been broken off.

No. 89. LITTLE CAVE.

Location.—Two and a half miles northeast of Cowan on the farm of Ed Garner, near the foot of the mountain a fourth of a mile northeast of Garner's house on the side of Miller Cove. It is in Mississippian limestone, 800 feet below the Lee sandstone.

The mouth is in the woods near the foot of a small mountain between Miller and Hawkins Cove. It extends downward for 30 feet, then southwest and south for 150 yards. It averages 25 feet in width, 15 feet in height and has no stream in it. There is very little loose earth, and what there is is mixed with large slabs, except in the back of the cave, where there is a large room with a level earth floor. There are heaps of rocks near the mouth. The loose earth probably does not average over a foot in depth. There are several stalagmites and a few small stalactites in this cave.

No. 93. TALLY FORK CAVE.

Location.—Three and a half miles south-southwest of Sewanee near the head of Talley's Fork at the head of a branch hollow south of the main hollow, on the old Stewart tract, southwest of Joe Milburn's house. It is about a mile from the nearest road and 3 miles from the railroad. It is in St. Louis limestone, 100 feet below the Lee sandstone.

The mouth is in thick woods under a limestone bluff 25 feet high and is wide and rather low and extends downward at a considerable angle. The cave is about 40 feet wide and 5 feet high. It extends west for 150 yards and consists of one main room that is 300 feet wide and 7 feet high. On the north side of the mouth there is a large mass of stalagmites of considerable size that resembles in places a series of waterfalls. At the back of the main room there is a bank of earth and small rock fragments 4 feet deep that has been worked for niter. There are remains of old hoppers.

No. 94. ST. MARY'S CAVE.

Location.—One and a half miles south-southeast of Sewanee, a fourth of a mile northwest of St. Mary's station on the land of the University of the South. It is situated in Mississippian limestone, 40 feet below the Lee sandstone.

The mouth is in thick woods, 100 yards below the railroad, at the base of a limestone bluff 25 feet high. The cave is small and contains no earth. A small stream runs through it. It is 150 yards long and averages 4 feet in height and 8 feet in width. It is very recent in formation and there are no stalagmites.

Hell Hole (Hawkins Cove) Cave.

Location.—Three miles southeast of Sewanee on the University of the South's land near the head of the west fork of Hawkins Cove, on a point 125 feet high between two ravines below Clara's Point. It is in St. Louis limestone, 150 feet below the Lee sandstone, two-thirds the way up the mountain.

The mouth is a rather large, irregular hole in the mountain opening vertically downward. Near the mouth there is a large bowlder of limestone that is almost balanced, having been undermined by water. The entrance is on a bench on the mountain. The hole extends down for 60 feet and opens up below into a room 100 feet long and 75 feet high. There is only one small passage 150 yards long, 4 feet wide and 7 feet high that extends in a northerly direction from the main room. In the main room there are huge piles of broken rock which slope downward steeply toward the back. The main passage of the cave seems to extend downward farther but it is stopped up by these broken rocks. Below the rocks near the edges of the room are banks of yellow clay 15 feet deep. There is also a little earth in the narrow side passage. There are very few stalactites.

No. 96. Wet Cave.

Location.—Two and a half miles northwest of Sewanee near the head of Rowark Cove on the west side of the cove on the land of Buck Crownover, 50 yards south of Crownover's house. It is 100 yards from the public road and 2½ miles from the railroad. It occurs in Mississippian limestone, 800 feet below the Lee sandstone.

The mouth is in an open pasture at the foot of the mountain and below a bluff 10 feet high. The mouth is 8 feet high and 6 feet wide and a small creek flows out of it. There is an exceptionally strong breeze that comes from the mouth which is quite cold in summer and warm in winter. The cave is at least a mile long and smaller just inside the mouth than farther back. There are many curves and crooks in this cave, especially near the mouth. The cave is 20 feet wide and 10 feet high. About 100 yards from the mouth a ladder leads to a ledge above the stream but the stream is reached a short distance farther back. On it there is a waterfall and just above this fall there is a peculiarly symmetrical and smooth-sided pot hole. At one place it is so low that stooping is necessary. At this point the stream flows beneath the floor. Beyond there the roof is higher and the stream appears again. It is necessary to crawl through a small round hole, called Fat Man's Misery in order to reach a large room called Angel's Chamber, which has many small stalactites and stalagmites in it. There are banks of earth along the stream in most places that are 8 feet or more in height.

No. 97. Dry Cave.

Location.—Two and a half miles southeast of Sewanee about a third of the distance up the mountain, on the University of the South's land, on the east side and near the head, of Rowark Cove about a mile east of cave No. 96. It is in St. Louis limestone about 500 feet below the Lee sandstone.

The mouth is at the south end of a very large sink-hole which is fully 60 feet deep. The entrance is low and wide and slopes down over broken rocks for about 25 feet. The cave consists mainly of one large room that averages 200 yards in length, 100 yards in width, and 25 feet in height. There are a large number of natural columns that are 25 feet high and 6 feet or more in diameter. The stalactites and stalagmites are abundant but have been smoked by fires built in the cave. The cave is damp. Water drips from the roof though no regular stream flows through the cave. The earth is 4 or 5 feet deep, much of which has probably been washed in from the sink-hole.

No. 98. Lost Cove Cave.

Location.—Nine miles southeast of Sewanee, 3 miles northeast of Sherwood, near the head of Lost Creek Cove and near the foot of the mountain. It is in Mississippian limestone, 800 feet below the Lee sandstone.

The mouth is about 15 feet high and 30 feet wide and above it is an imposing limestone bluff fully 175 feet high which overhangs the mouth. The bluff with the mouth below it is the most imposing and wonderful part of this cave. A rather strong breeze comes out of the mouth and Lost Creek flows through the cave. This cave is about 2½ miles long and averages 40 feet in width and 30 feet in height. The interior of the cave is very rough and for nearly its whole length there are great heaps of broken rocks piled up on one side or the other of the cave. In many places there are banks of earth and broken rock 20 to 25 feet high. Lost Creek, which flows through this cave, averages 10 feet in width inside the cave and there are many waterfalls and rapids along it. There are no stalagmites or other formations in the main part of the cave, although in some of the small side branches near the mouth there are a few. In one of these branches there is a very beautiful series of rock-rimmed pools. Far back in the cave there is a bat roost. It is said that niter has been mined in this cave and signs of digging can be seen near the second mouth. Besides the mouth where the stream enters there are two other mouths to the cave which enter it almost vertically.

No. 99. Saltpeter Cave.

Location.—Two hundred yards south of Lost Cove Cave and 150 feet above it. It probably is connected with No. 98 by small passages. It consists mainly of one room 20 feet in width, 100 feet in length and 8 feet in height, which contains a good many stalagmites and stalactites. The mouth is low and slit-like. The walls and stalactites are coated in many places with a crust of white, powdery gypsum or niter. The earth in the cave does not average over 6 inches in depth.

GRUNDY COUNTY.

No. 90. Wonder Cave.

Location.—At the foot of the mountain 3 miles north of Monteagle on the land of Mrs. R. M. Payne at the Monteagle pumping station.

There is a good road up the mountain to Monteagle and the Nashville, Chattanooga & St. Louis Railway is about 3 miles distant. Many people visit this cave. It is in Mississippian limestone, 800 feet below the Lee sandstone.

The mouth used by visitors is artificial. The entire width of the natural mouth is occupied by a stream 3 to 5 feet deep, whose surface is within 3 feet of the roof. The cave was discovered by accident by somebody wading in the creek. The artificial mouth was blasted out to allow easy entrance for visitors. This cave is probably the greatest show cave in the State. It is lighted with acetylene gas. The cave is very large and is said to extend for 3 or 4 miles along the stream. It has been explored for 2 miles, though it is necessary to wade in some places in order to enter farther than three-fourths of a mile. The main stalactite and stalagmite room is about a half mile from the mouth and is separated from the main cave in all but two places by an irregular partition of limestone. The cave averages about 40 feet in width and 12 feet in height. The stream that flows through it is a good-sized creek. In many places there are large banks of yellow, clayey earth along the stream. These are 12 feet or more in height and a rod or more in width.

The main stalactite room is about 400 yards long, 100 yards wide and 8 feet high. The floor is very smooth and white and is composed of solid calcite deposited by water. In this room are thousands of stalagmites, stalactites and natural pillars of all shapes and sizes. The natural columns are unusually abundant and some are 4 feet or more in diameter, while there are a few which are 8 feet high but only an inch in diameter. Others are very grotesque and weird in shape, with fancied resemblance to various objects. The stalagmites are especially wonderful and grotesque in shape, those near the walls being unusually beautiful and varied in form. The stalactites are characteristically long and slender and give the effect of white drapery. The whole roof of this room is studded with them. There are a few very large and massive stalactites. Some of them fail to touch the stalagmites below by only a few inches while in a great many other cases the floor below them is smooth and level. Many of these formations are so white that they resemble porcelain ware, while some are made up of many tiny calcite and aragonite crystals brilliantly irridescent and sparkling. Near the center of the room there are also several rock-rimmed pools of clear water. Some of the most picturesque formations in the cave are the many little round grotto-like places separated from the main room by a drapery of long slender white stalagmites. Some of these stalactites and stalagmites give a musical note when struck. In the number of stalactites this cave far surpasses any other cave visited, although Keith Cave, No. 88, would nearly equal it if these formations had not there been largely broken off.

No. 91. Crystal Cave.

Location.—Three and a half miles north-northwest of Monteagle on the land of Mrs. R. M. Payne, 300 yards west of the mouth of Wonder Cave, in St. Louis limestone.

The mouth is situated 20 feet north of the road in a small hole or depression about 15 feet deep. Stone steps lead into the cave. The mouth is 5 feet wide and 6 feet high and is barred by a wooden gate. The cave is about a quarter of a mile long, 15 feet wide and $5\frac{1}{2}$ feet high. There is a small spring just inside the mouth and a little stream flows to the back of the cave. The banks of earth on both sides of the cave average 4 feet in depth. Rocks are mixed with the earth.

There are some beautiful formations in this cave many of which are coated with a white powder, possibly niter. Two human skeletons were dug out of the earth at the mouth. There is an ash heap here about 6 feet deep.

No. 92. Saltpeter Cave.

Location.—Five miles northwest of Monteagle on the farm of Shak Rollins near the head of the cove on the opposite side of the ridge from Wonder Cave, a quarter of a mile south of Rollins' house. It is 500 yards from the public road and 5 miles from the railroad. It is in St. Louis limestone, 600 feet below the Lee sandstone and about 100 feet from the foot of the mountain.

The mouth is a round hole 3 feet in diameter, in thick woods near the base of a limestone bluff 25 yards from a dim road. The cave extends in a southwest direction for 300 yards. It is small, averaging 5 feet in height and 6 feet in width. It contains a loosely cemented breccia which is mixed with much earth and averages 4 feet in depth. In places holes have been dug in this material and the earth removed for making niter. There are no stalactites.

No. 100. Coal Mine Rock Shelter.

Location. — Three and a half miles northeast of Monteagle, near Clouse Hill Junction, a half mile north of Dr. Lillian Johnson's house. This shelter is formed by the rapid weathering of a bed of shale between the top of the Mississippian limestone and the base of the massive Lee sandstone.

This shelter is the site of a former coal mine. The shelter is 300 yards long, 6 feet high, and 7 feet wide on the average. The earth on the floor is about 4 feet deep. In several places this earth is coated with pure alum a half inch thick and there seems to be some niter present also.

No. 102. Peter Rock Cave.

Location.—Three and a half miles southeast of Beersheba Springs on the land of D. H. Savage on the east side of Pound Gulf and near its mouth, 50 yards above the foot of Peak Mountain. It is situated in St. Louis limestone, about 800 feet below the Lee sandstone.

The entrance is at the base of a limestone bluff 25 feet high at the head of a small hollow in the woods near an old field, a short distance south of the junction of Pound and Savage Gulfs. There are two small mouths which are only 6 feet apart and extend in different directions at first but finally converge. The main mouth is only 3 feet in diameter. There is no stream in this cave but the floor is damp and in some places muddy. For about 50 yards inside the mouth the cave in only 3½ feet high and 4 feet wide, but after climbing down a low precipice, a good-sized cave is reached. From this point on, the cave extends about 200 yards farther and averages 15 feet in width and 12 feet in height. Several small passages lead in various directions from the main cave. The earth on the floor averages 5 feet or more in depth. There are many beautiful stalagmites and stalactites and a few large natural columns. Several little side rooms are almost completely shut off from the main cave by natural columns and stalactites. Some of these formations are very attractive.

No. 103. Big Bear Cave.

Location—Seven miles southeast of Beersheba Springs, on the land of Joe Dickens, on the east bluff of Savage Creek, about 4 miles north of the head of Savage Gulf near Jumping Water Branch. It is in St. Louis limestone about 500 feet below the Lee sandstone.

The mouth is on the steep bluff of Savage Creek 100 feet above the creek in the thick, wild woods. 300 yards south of Jumping Water Branch. It is situated at the base of a limestone bluff 15 feet high and is only 3 feet high and 5 feet wide. There are three other small entrances near this one. The cave contains no niter but is quite dry. It is exceedingly intricate and full of intercommunicating passages which form a labyrinth in which it is easy to get lost. There are several small holes in the floor that are 50 feet or more in depth. The earth is fully 10 or 12 feet deep. In some places holes have been dug and the earth removed. The main cave is over a mile long and several lateral passages are as much as a fourth of a mile long. The average height is 8 or 10 feet and the width about 8 feet. There are some very beautiful stalactites, stalagmites, limestone terraces, and natural columns in this cave, some of which ring like bells when struck. This cave is very hard to find. D. H. Savage and Elliott Adams who live near Beersheba Springs are practically the only people that know where it is. It is rather inaccessible and any material mined would have to be hauled to the top of the mountain by a cable, probably. The nearest railroad is about 13 miles away, at Coalmont.

JACKSON COUNTY.

No. 9. Saltpeter Cave.

Location.—In the bluff on the north side of the Cumberland River on the farm of J. T. Draper, a fourth of a mile west of Draper's house 1½ miles south of Gladdico. The cave is in Ordovician limestone, a third of the way up the bluff. It is a fourth of a mile from the public road and a half mile from the Cumberland River.

The mouth of the cave is 5 feet by 5 feet and overlooks a broad bottom which is cultivated. The bluff is thinly wooded below the mouth but there is a perpendicular limestone ledge above it. The cave is small, extending only about 50 yards, and is quite dry inside. It averages 30 feet in height. The loose earth on the floor is 5 or 6 feet deep and contains bones, possibly of Indians.

There are practically no stalactites or stalagmites in it. The end of the cave seems to be filled up with loose earth.

No. 10. Burial Cave.

Location.—A fourth of a mile north of Flynns Lick on the farm of Joshua Haile, Sr., in the low west bluff of Flynns Creek. The mouth is only 200 yards west of the Gainsboro road and about 2 miles from the Cumberland River. It occurs in Ordovician limestone, 300 feet below the Chattanooga black shale.

The mouth is in the west bluff of the Creek about 15 feet above water level at the top of a low limestone ledge. There are several other small caves near by with their mouths along the same ledge. This cave is damp inside but there is little standing or running water in it. It was once used by the Indians as a dwelling place as well as a burial ground. and about a half mile from the mouth is a wide, flat rock that was used by the Indians for a table. Bats frequent this cave and in some places piles of guano have collected.

There are two main forks and each extends for nearly half a mile. There the loose earth is abundant. In some places it is as much as 6 feet thick but averages about 3 feet. The northwest fork averages 8 feet in width and 7 feet in height while the southeast one is somewhat wider and lower. In some places the cave is very narrow and sinuous and the roof is very high and narrows to a mere crack. The stalactites and stalagmites are rather small but very numerous, especially in the northwest fork. In some places the walls are thickly studded with small knob-like projections of limestone about a fourth of an inch long. The southeast fork contains fewer stalactites but more loose earth.

No. 11. HAILE CAVE.

Location.—A fourth of a mile north of Flynns Lick, 40 yards south of No. 10 and at the same level in the Ordovician limestone.

The topography of the mouth of this cave is very similar to that of No. 10, being in a low, wooded limestone ledge with fields surrounding it above and below. The mouth is 10 feet by 6 feet, being a little larger than No. 10, and the floor slopes downward from the mouth at a little steeper angle, but the cave is not so large as No. 10. There is another mouth about 100 yards southwest of the main entrance that opens vertically into the cave from the top of the bluff and was formed probably by the caving of the roof. The front part of the cave is only slightly damp but near the back of it there is a stream of clear water.

The length of this cave is about 500 yards, while the width averages 15 feet and the height 6 feet. There are two low places through which it is necessary to crawl, one being near the vertical mouth and another farther back. There is a bat roost in this cave and considerable deposits of bat guano have been formed. The large numbers of bats flying about make it disagreeable to explore. The loose earth varies in depth at different places but it probably averages 3 feet. Indian remains have been found here, also. The stalactites and stalagmites are scarce and small.

No. 12. FOWLER CAVE.

Location.—Twelve miles southeast of Gainsboro on the farm of Dr. J. B. Fowler on the side of a steep hill or mountain half a mile southeast of Fowler's house, on the west side near the head of Fowler Hollow. It is about a half mile from a public road and 2 miles from the Cumberland River. It occurs near the junction of the St. Louis limestone and the Ft. Payne chert at the base of a limestone bluff 20 feet high.

The mouth is situated about two-thirds of the distance to the top of the hill in thick tangled woods and a large limestone boulder covers the northwest end of the mouth. The entrance proper is 6 feet wide and 5 feet high, but the width of the entire opening is probably 25 feet. The floor slants downward from the mouth and except near the mouth it is extremely dry. There are some spacious chambers in the cave. It extends about 100 yards due south and then opens into a room fully 70 feet wide and 25 feet high, from which arms branch in various directions. The approximate length from the mouth to where the longest branch of the main room gets low is 300 yards, and it is said that one can penetrate farther by crawling a short distance. The average width is 25 feet and the height averages about 12 feet.

The loose earth averages probably 5 feet in the main part of the cave but certain thin strata are calcified so that it appears to be thinner than it is. Stalactites are scarce but the walls are worn away in a peculiarly grotesque manner in many places. It is a very attractive cave in spite of the scarcity of water formations.

No. 13. Van Hoover Cave.

Location.—On the farm of Ed Van Hoover, 4 miles northeast of Gainesboro, a half mile southwest of the Roaring River bridge and a fourth of a mile northwest of Van Hoover's house. It is only a fourth of a mile from a public road and a half mile from the Roaring River. It is located in St. Louis limestone about 10 feet above the Ft. Payne chert.

The mouth is in thick woods on the east side and near the top of a high hill. It slopes almost vertically downward for 25 feet and then the cave continues in a southwesterly direction for about 100 yards. It is rather small, being not quite 100 yards long and averaging 15 feet in width and 6 feet in height. The earth on the floor is damp but there is no water in this cave. The loose earth averages about 3 feet in thickness. There are very few stalactites or stalagmites.

No. 14. Saltpeter Cave.

Location.—At the head of Kirk Hollow 150 yards southeast of the Gainesboro-Celina road on the farm of Ormsby Kirk, 300 yards west of a small house. It is in Mississippian limestone, just above the Chattanooga black shale, at the foot of a dome-shaped overhanging limestone bluff 30 feet thick.

The mouth is situated in thin woods and is very picturesque. A stream flows from the cave, appearing as a spring 20 feet below the mouth. The mouth is funnel-shaped, and where narrowest is about 5 feet in diameter. It was not explored much farther than the mouth for buzzards were using it as a nesting place. It is reported to extend westward for over 300 yards and to be quite large at places. Since water flows through the cave it is not likely to contain much saltpeter. The loose earth inside the mouth is about 1 foot thick.

No. 15. North Spivey Cave.

Location.—On the farm of Rad and Paul Spivey, a half mile northeast of Spivey's ferry, 2 miles southwest of Meagsville, in the north fork of Spivey's Hollow, 400 yards northeast of Tom Langford's house, near the top of the high bluff on the west side of Cumberland River. It is about a half mile from the public road and the same distance from the Cumberland River. It is located in Mississippian limestone about 10 feet above the top of the Chattanooga black shale.

The mouth is small and slit-like and slopes downward gradually for 100 feet. It is under an overhanging limestone bluff. The cave is quite dry and the earth on the floor at a short distance from the mouth is dusty. Its length is about a mile and its width averages 8 feet and height 10 feet. The cave is very sinuous and in places very narrow. There are some old steps about a half mile from the mouth. Lateral branches are numerous and confusing. The cave is said to open on the bluff of the Cumberland River over a mile from the mouth. It is also said that two men were overcome by foul air in this cave and one of them died.

The loose earth averages only 2 or 3 feet in depth, though in some places it is probably over 5 feet deep. The stalactites are quite numerous and beautiful and hang from the roof and cover the walls in places. There are also a few large stalagmites. It is reported that Indian implements have been carried out of this cave.

No. 16. West Spivey Cave.

Location.—On the farm of Rad and Paul Spivey on the west side of the Cumberland River, a half mile northeast of Spivey's Ferry, 2 miles southwest of Meagsville, 300 yards west of Tom Langford's house. It is about a half mile southwest of No. 15 and is in the west fork of Spivey Hollow, 50 feet below the top of the hill. It is a half mile from the Cumberland River and from a public road. It occurs 50 feet below the top of the hill in Mississippian limestone just above the Chattanooga black shale.

The mouth is at the base of an overhanging limestone bluff and is wide and low. Just within the mouth it narrows to 3 by 4 feet. It is only about 150 yards long, but its height averages at least 35 feet and its width 15 feet, while the main chamber is 65 feet high and 25 feet wide. The cave is quite damp but there is no permanent stream in it.

The cave earth averages about 5 feet in thickness and is a sticky yellow clay for the most part. The main roof is festooned on all sides with beautiful clusters of tapering stalactites and resembles in a striking manner the interior of a stately cathedral. The walls are very irregular and many grotesque shadow effects are produced in the dim lantern light. There are only a few small stalagmites.

No. 17. CHERRY CAVE.

Location.—On the farm of Bill Cherry, 3½ miles northeast of Meagsville on the west side of the Cumberland River, 100 yards west of Cherry's house. It is only 100 yards from a wagon road and a mile from the Cumberland River. It occurs in Ordovician limestone, 85 feet below the Chattanooga black shale.

The mouth is located near the base of a bluff in the middle of a clump of cedar trees. A stream flows through the cave for almost its entire length. The mouth is about 8 feet high and 9 feet wide and slopes downward for about 50 yards, where the stream is reached. This stream appears as a spring about 25 feet below the mouth. The cave is about 8 feet high and 6 feet wide, though in a few places it is low and wide. Its length is probably over a mile and it is very crooked. There are banks of loose earth that have been cut into by the stream to a depth of 6 feet in many places. Saltpeter is said to have been found here. The stalactites and stalagmites are very few and small.

MARION COUNTY.

No. 101. SALTPETER CAVE.

Location.—Seven miles southeast of Monteagle on the land of J. H. Shetter at the foot of the mountain on the south side of Cave Cove, 100 yards from a small farmhouse. It is 6 miles from the Tracy City branch of the Nashville, Chattanooga & St. Louis Railway. It is in Mississippian limestone about 800 feet below the Lee sandstone.

There are two mouths about 200 yards apart. It is in the woods above the bed of a dry creek and near the edge of an old field and orchard. The cave is dry. The main part averages 30 or 40 feet in width and 15 or 20 feet in height. There are a number of side passages, some of which are almost as large as the main cave, while others are very narrow. A white coat of gypsum incrusts practically all the walls. The cave is over 2 miles long and winds about very much. The earth averages 5 or 6 feet in thickness, though many banks are 15 feet or more. There are at least 25 or 30 old hoppers that were used in obtaining the niter from the earth. They are a little larger but similar to those in No. 53 and three or four tons of earth are heaped up in each of them. There are many evidences of digging. This earth is exceedingly dry and dusty like that in Big Bone Cave. There are no stalagmites or stalactites, but the walls and roof are very irregular in places. The passages are so numerous and intricate that it is very easy to get lost in them.

OVERTON COUNTY.

No. 39. Garret's Cave and Rock Shelter.

Location.—On the land of J. D. Garrett, 2½ miles west of Wirmingham, a half mile southeast of Garret's house. It is about 200 yards below a small road and a mile from the Livingston road. The nearest railroad is at Livingston, 9 miles away. It is in Mississippian limestone about 100 feet above the Chattanooga black shale. The cave is located at the head of a hollow through which a small stream flows and its mouth is at the back edge of a rock shelter. The middle of this rock shelter has fallen in, leaving the outside part of the roof standing as a small natural bridge. The gap between the roof of the rock shelter and that of the natural bridge is still only about 6 feet wide but is being enlarged by a small stream that flows down through it. The shelter is about 25 feet wide and 20 feet high and extends in an arc around the hollow for 300 yards. Where the stream flows over the edge it forms a pretty waterfall. The cave proper is small and rather low, extending about 100 yards back from the main mouth which is 5 feet high and 4½ feet wide. There are also several smaller mouths. There are two main rooms. The cave earth averages 5 feet or more in depth. Water floods parts of the cave at times. There are a number of short and thick stalactites near the walls that are quite pretty, but stalagmites are rare. It is reported that saltpeter was made in this cave about 1865.

No. 40. Saltpeter Cave.

Location.—On the land of W. R. White, 2 miles northwest of Monroe, a fourth of a mile southeast of White's house on the bluff of a small stream near where it empties into Eagle Creek. It is a fourth of a mile from a wagon road and 6 miles from Livingston, which is a railroad terminus. It is in St. Louis limestone about 50 feet below the top of the bluff and 75 feet above the Ft. Payne chert.

The mouth is 6 feet high and 12 feet wide and is in rather thick woods under an overhanging bluff. There is a stream in the cave about 50 yards from the mouth, which extends to the back of the cave, but does not flow out through the mouth. This cave is 6 feet high and 7 feet wide and about 150 yards long. The earth on the floor averages 2 or 3 feet in depth and is found in banks mixed with rock fragments. Stalagmites and stalactites are few and small. The cave extends in a general southeasterly direction and there are no important branches.

No. 41. Wash Lee Cave.

Location.—Three miles northeast of Livingston on the farm of Wash Lee, 75 yards northeast of Lee's house at the head of Copeland Cove, at the foot of the mountain. It is 100 yards from the public road and 3 miles from the railroad. It is in St. Louis limestone, 300 feet below the Lee sandstone. The mouth is slit-like, being 50 feet wide and 5 feet high, and the cave extends downward at a rather steep angle. It is underneath an outcropping limestone cliff 20 feet high, in open pasture land, on the edge of thin woods. Cattle are housed in the cave in cold weather. Just inside the mouth the cave opens up into a main chamber which is tolerably well lighted from the mouth. This room is fully 75 feet high and 100 feet wide and is nearly circular in outline. Its roof is dome-shaped and the light which enters through the mouth gives it a greenish hue. At the inner edge of the main chamber a small stream falls from a rock 45 feet high and breaks into fine spray on the rocks beneath. The stream reverses its direction after falling over the precipice and flows away from the mouth. The cave branches in several directions and at several levels at the end of the main part, which is 150 yards long, but the roofs of these branches are too low to make exploration easy. The stream also divides like a river in a delta plain. The cave extends in a southeasterly direction and the floor is very uneven so that there are several more noisy waterfalls at intervals. There is a large amount of loose earth on the floor of this cave both in the main chamber and in banks in the back part. It will average probably 5 feet in depth. The average width of the back part of the cave is 35 feet and its height 20 feet. A few Indian arrowheads and some bones are found in the earth of the main chamber.

No. 42. Crawford Cave.

Location.—On the land of Bill Crawford, 3 miles southwest of Livingston, on the south side of the Overton County railroad, 20 feet from the track. It occurs in St. Louis limestone, 350 feet below the Lee sandstone.

The mouth is located in the railroad embankment about 20 feet above a rather large creek and is triangular in shape. It is about 8 feet wide at the base and 5 feet high in the center, and the cave floor slopes downward at a slight angle for a few feet inside the mouth. At a distance of 75 yards from the mouth a stream is reached which turns eastward and does not empty through the mouth on the railroad embankment. The cave averages only 4 feet in height from the mouth to where the stream is first reached, this part having been partly filled with earth. In the center, however, there is a very irregular, narrow cleft extending upward for an uncertain distance and in some places there are other rooms above this. After the stream is reached, the floor is lower so that the altitude is about 6 feet for the 150 yards from there to the other mouth which opens into a sink 30 feet deep. The average width of the whole cave is about 15 feet. The other mouth formed by the caving in of the roof, is larger than the first. The cave continues on the other side of the sink-hole but is quite narrow for a considerable distance. This cave probably connects with a larger cave about a mile away, called Bear Cave. There is much loose earth on the floor but it is flooded by high waters. The earth averages 4 feet in depth, but is much deeper near the first mouth. There are several very large, rounded stalagmites and in two places a group of short, thick natural columns that extend from the cleft in the roof to the floor. There are also a large number of smaller stalactites.

No. 43. Saltpeter Cave.

Location.—One and a half miles northeast of Windle on the land of I. F. Gregg, at the edge of a field a fourth of a mile southeast of Gregg's house. It is a fourth of a mile from a wagon road and 1½ miles from the railroad, and in St. Louis limestone about 50 feet below the top of a low hill.

The mouth is in low ground at the head of a small hollow and the floor slants downward slightly. It is on the edge of thin woods in the midst of a thick clump of bushes. It is 7 feet in diameter and nearly circular. There is a spring that starts 15 feet inside of the mouth and flows toward the back of the cave. It is a half mile long and averages 10 feet in height and 8 feet in width. It is comparatively straight and there are no branches of any size. Near the back of the cave there are several large banks of loose earth 6 feet deep, but much of the earth has been removed. Holes have been dug in the earth and there are remains of what might have been a saltpeter hopper. It is reported that saltpeter was gotten from this cave during the Civil War. There are a few large stalagmites and some small stalactites present.

No. 44. Allen Cave.

Location.—A mile northwest of Windle on the farm of Monroe Allen on the edge of an old field a half mile southeast of Albert Qualls' house. It is in St. Louis limestone.

The mouth is located in the midst of a clump of bushes and brambles in an old field that is comparatively level. The mouth is 4 feet wide and 8 feet high. The earth is abundant and averages 4 or 5 feet in depth, but looks as if it has been recently flooded. It was quite damp inside but no stream was seen. It extends 300 yards to a place where it becomes low enough to make crawling necessary. It is about 6 feet high and 20 feet wide and seems to have been partly filled with earth recently. There are a few cave formations here.

No. 54. Saltpeter Cave.

Location.—Two miles northeast of Obey City, on the land of Billy Collins, in the bluff of East Fork of Obey River, 1½ miles from the Wilder branch of the Tennessee Central Railroad. It is in Mississippian limestone just beneath the Lee sandstone.

The mouth of the cave is 3½ feet high and 5 feet wide and is under a rock shelter which overhangs, and is 15 feet wide. The cave is about 100 yards long but is only 4 feet in height and 15 feet in width. There is a little earth in this cave. It is a hard yellow clay and is quite dry. In some places the earth is dark purplish red. The earth at the back of the cave is about 3 feet deep. The earth at the bottom of the rock shelter is very red and heavy. Bones, probably human, are found in the back of this cave.

No. 55. Quarles Cave.

Location—About a mile northwest of Green Pond on the land of Tilson Quarles in a hollow below, and a quarter of a mile north of, Wade Norrod's house, on the bank of Sourwood Branch, 100 yards west of the waterfall. It is in Mississippian limestone, 100 feet below the Lee sandstone.

The mouth, which is small and low, is under a small rock shelter in rather thick woods. It is necessary to crawl 60 feet before the first room is reached. This room is nearly cylindrical, its height being 40 feet and diameter 15 feet. It was probably formed by a stream down along a fissure or joint. There is another low place and then another comparatively large room. The cave, with the exception of these rooms, averages only 4 feet in height and 5 feet in width. There are gravel and some earth on the floor but it is flooded during rainy seasons, so there is little chance for niter. There are few stalactites and no stalagmites, but the walls of the rooms are gracefully carved by water.

No. 56. Quarles Rock Shelter.

Location.—A mile northwest of Green Pond on the land of Tilson Quarles under the waterfall of Sourwood Branch, 1¼ miles from Wade Norrod's house and three-fourths of a mile from the Wilder branch of the Tennessee Central Railroad. It is in Mississippian limestone, 100 feet below the Lee sandstone. It is 150 feet long, 15 feet wide and about 15 feet high. The earth on the floor is about 4 feet deep.

No. 57. Falling Water Cave.

Location.—One and a fourth miles northwest of Green Pond on the land of Tilson Quarles about 100 feet from the bottom of Big Sunk Cave, three-fourths of a mile north of Wade Norrod's house, and a mile from the Wilder branch of the Tennessee Central Railroad. It is in the St. Louis limestone about 500 feet below the Lee sandstone. The mouth is located in thick woods at the bottom of a rather large sink-hole 6 feet deep and about 200 feet wide. A stream flowing in a due easterly direction flows over the cliff above the mouth of the cave and forms a waterfall 40 feet high and then flows into the mouth of the cave in a due westerly direction. The mouth is 6 feet high and 12 feet wide. Just inside the mouth the cave is very large and the floor which slopes downward at a steep angle, is covered with large blocks of broken rock. The average width of the whole cave is 12 feet while the big room is 30 feet wide. During the recent high water the sink-holes in the bottom of the Big Sunk Cave were unable to accommodate all the water and it rose so high that it flooded the cave and filled it with sediment for a fourth of a mile from the mouth. This cave is said to be over 2 miles long. There are banks of earth in it 6 feet thick that are not of recent deposition, though the average thickness of the earth is only 4 feet and much of this is sediment. The stalactites and stalagmites are rare but the walls and roof of the main room are curiously sculptured by solution.

No. 58. Pine Hill Rock Shelter.

Location.—One and a fourth miles west of Hanging Limb on the land of the Copeland heirs near the top of Pine Hill. It is 200 yards above a wagon road and a mile from the Tennessee Central Railroad. It is located where the Lee sandstone comes in contact with the Mississippian limestone.

It is very conspicuously situated and can be seen from nearly all the neighboring mountains. It is roughly rectangular in shape, being about 200 feet long, 20 feet wide and 25 feet high. It was worked considerably during the Civil War for saltpeter and the earth left is only 2 or 3 feet deep.

No. 59. Wolf Branch Cave and Rock Shelter.

Location.—Two and a half miles southeast of Hanging Limb on the land of the Briar Hill Collieries on the east bluff of Wolf Branch, a mile from the Wilder branch of the Tennessee Central Railroad. The cave is in Mississippian limestone, 50 feet below the Lee sandstone.

The mouth of the cave is at the back of a rock shelter 30 feet high, 20 feet wide and 200 yards long. The earth on the floor of this shelter is a foot deep. The cave is small and low and has a small stream running through it. Its average height is 4 feet and width 6 or 8 feet, and it is about 200 yards long, but becomes lower toward the back. The banks of earth are about 2 feet thick.

No. 60. Briar Hill Cave and Rock Shelter.

Location.—On the opposite side of Wolf Branch from No. 59. It is similar to No. 59 but a much larger stream of water flows out of it and there is a pretty waterfall in the mouth of the cave under the rock shelter. The shelter is not quite so large as that of No. 59.

No. 61. Quarles Cave.

Location.—On the land of Mrs. T. A. Quarles, 300 yards south of Quarles' house near the Three Forks of West Fork of Obey River, 4 miles west of Crawford. It is in St. Louis limestone, 400 feet below the Lee sandstone.

The mouth is 60 feet wide and 15 feet high and is in open woods 50 feet west of the county road in a slight sink at the head of a small ravine. For about 65 feet from the mouth the floor of the cave slants downward slightly but from that place back, there is a gradual upward slope that continues through the cave with the exception of sinks at various places along the floor. At the bottom of some of these sinks a stream can be seen. There is a small spring 60 feet inside the mouth whose water sinks into the ground. The cave earth averages 6 feet, while in places there are banks of loose earth mixed with angular rock fragments 15 or 20 feet high. There is no stream on the floor of this cave but one appears to flow underneath it. There are fragments of old shingles in one bank that may be the remains of old saltpeter hoppers and the earth seems to have been dug into in places. The cave is about 300 yards long, 35 feet wide and 20 feet high. There are a number of stalactites and some stalagmites.

No. 62. Peter Cave.

Location.—A fourth of a mile west of Rushing Springs schoolhouse, on the land of H. C. Kimes in an old field near the bottom of Dry Hollow. It is in St. Louis limestone about 500 feet below the Lee sandstone.

The mouth is in a small cane patch about 20 feet above the bottom of a sink in the valley. It is flooded by high waters and any niter present has probably been washed away. The mud on the floor is about 3 feet deep. The cave is 300 yards long and averages 12 feet in height and 8 feet in width. Its mouth is divided into two by a narrow natural bridge. It contains a few pretty stalagmites and stalactites.

PICKETT COUNTY.

No. 26. Phillips Cave.

Location.—Three miles southeast of Lillydale, 200 yards southeast of the signboard, "Byrdstown 10 miles". It is on the land of Jesse Phillips, 50 yards south, and in plain view of the road. It is in St. Louis limestone just above the Ft. Payne chert.

This is a small cave situated under a ledge of sandy limestone. It is open for about 50 feet and is then blocked by a large rock. The earth on the floor is 4 feet thick and there are pools of water and a relatively large number of small stalactites.

No. 27. Pratt Cave.

Location.—Four miles southeast of Lillydale on the land of Jesse Phillips, 1200 yards southeast of Phillips' house in woodland about 50 feet below the top of the ridge. It is 400 yards from the Lillydale-Byrdstown road. It is in St. Louis limestone, 25 feet above the Ft. Payne chert.

The mouth is triangular, about 10 feet wide and 4 feet high and slopes downward for about 15 feet. It is a damp cave. There are a few pools of water but no stream in the main portion. There are a number of branches, some of which are 400 or 500 yards long, but they are narrow and there is practically no loose earth on the floor of them. The main part of the cave, which alone contains cave earth, is 100 yards long, 75 feet wide and 6 feet high in the center but only 3 feet or less at the sides.

There is a thick bed of dirt in this main portion. It is reported that it was worked for niter by one or two men for several years about 1890. The loose earth is from 5 to 7 or 8 feet deep. There are numerous stalactites and stalagmites formed against the wall and flattened at right angles to it.

No. 28. Harrison Cave.

Location.—On the farm of Mrs. Tom Harrison, 4 miles southeast of Lillydale, in thick woods a mile south of Mrs. Harrison's house, and three-quarters of a mile from the Byrdstown road. It was discovered by John Neal in 1915. It is in St. Louis limestone about 100 feet above the Fort Payne chert.

The mouth is a triangular hole and is very inconspicuous. It is located about 50 feet below the top of the hill, facing the mouth of Bone Cave, No. 29, and extends almost vertically downward for 12 feet. A little water drips from the roof of this cave but there is no stream or standing water in it. There are pockets and thin coatings of a white mineral that is possibly niter. The cave is about 75 yards long, 10 feet wide, and 15 feet high, and there is also a small branch nearly blocked by loose earth. The loose earth in this cave, probably averages over 5 feet in depth. It is possible to get to two more rooms by climbing over a bank 10 feet high. There are evidences that this cave was once used as a still. There are a few stalactites.

No. 29. Bone Cave.

Location.—On the farm of Mrs. Tom Harrison, 4 miles east-southeast of Lillydale, three-fourths of a mile south of Mrs. Harrison's house, a fourth of a mile south of No. 28 and in a similar situation. It is half a mile from the Byrdstown road.

The mouth is slit-like and only 2 feet in height and is in dense wood about 50 feet from the top of the hill. The present mouth was formerly walled up by the Indians and was discovered by accident. In the roof there is also a small opening. When this was covered over with snow a man lost his hunting boot in it. Through this opening a small boy was let down by a rope and he discovered rays of light entering where the present mouth is located. When the rocks blocking the mouth were removed and the light entered the cave, forty Indian skeletons were discovered lying on half decayed cane mattresses, hence the name Bone Cave. Just inside the mouth is a large round chamber at the back of which are two forks almost opposite each other which are each about 4 feet high, 6 feet wide and 50 yards long. The main chamber is 75 feet in diameter and 5½ feet high. The earth in the main chamber is probably 6 or 8 feet deep, for the bottom has never been reached, although much digging for Indian relics has been done. There are a few fringes of small stalactites hanging from the roof.

No. 30. Butram Rock Shelter.

Location.—On the land of Samuel Butram, 3 miles northwest of Byrdstown on Turkey Creek, a fourth of a mile west of J. L. Gunnel's house. It is beneath a hard layer of St. Louis limestone just above the Ft. Payne. The shelter is 150 yards long and averages 20 feet wide and 6 feet high. It is in the north bank of Turkey Creek 10 feet above water level, and extends in an elbow along the creek. The loose earth is 4 or 5 feet deep. It is about 400 yards from the public road. This shelter was used as a burial place by the Indians and eight or ten skeletons have been dug up here.

No. 31. Bear Cave.

Location.—On the land of James Dillon, 3½ miles northwest of Byrdstown, a half mile northeast of No. 30, down Turkey Creek, and about three-fourths of a mile from the public road. It is in St. Louis limestone, 100 feet above the Ft. Payne.

This cave has two mouths which connect about 100 feet from the outside. They are about 30 feet below the top of the bluff of Turkey Creek under an overhanging limestone ledge. The cave extends 100 feet in a southwesterly direction when it becomes so low that crawling is necessary to penetrate farther. The loose earth is at least 4 feet deep and farther back is probably deeper. It was once used as a hibernation place for bears. Small fragments of mica were picked up on the floor of the cave. In many places the earth is covered with a thin white coat, possibly of niter. Very little water drips from the roof and there are only a few small stalactites.

No. 32. Hood Cave.

Location.—On the land of the Hood heirs, 4 miles northwest of Byrdstown, a quarter of a mile east of Page Huddleston's house, at the head of a hollow that extends north to Wolf River. The public road is 400 yards south of the cave. It is in Mississippian limestone about 50 feet below the Lee sandstone. The mouth is about 100 feet wide and 5 feet high. It is located in thick woods about 25 feet below the top of Wolf River bluff. A stream flows through the cave, sinking into it about 300 yards south of the mouth near Huddleston Springs. The cave gets gradually smaller the farther one goes back and averages only about 3 feet in height and 6 feet in width. The earth is found mostly in the mouth and from it Indian skeletons have been dug up. There are very few limestone formations.

No. 33. Ice Cave.

Location.—On the land of the Hood heirs a half mile north of No. 32, a fourth of a mile east of John Hinsley's house in the thick woods 75 yards west of Rock Pinnacle and 500 yards from the road. It is in Mississippian limestone 30 feet below the Lee sandstone.

The mouth is near the center of a shallow bowl-shaped sink which was evidently formed by the caving in of the roof of the cave. It is peculiar in that it extends downward at an angle of 50 degrees away from Wolf River instead of toward it, although its mouth opens on the Wolf River bluff. Most of the cave is very narrow and its roof narrows upward into a fissure. This cave apparently is only the upper portion of a higher and more spacious cave that has been nearly filled up with fragments of rock. There must be another opening farther down on the Wolf River bluff. Near the mouth the cave is 12 feet high and 20 feet wide, while the rest of it averages 3 feet wide and 8 feet high. Its length is about 50 yards. Water trickles from the roof, but does not form a stream. The cave is unusually cold, snow being found near the bottom still unmelted in July. There seems to be much earth on the floor though much of it is covered with rocks. Where seen near the bottom end the earth is 4 or 5 feet thick. The cave is practically straight so that the mouth can be seen from the end. There are many talagmites and stalactites near the walls of the cave.

No. 34. Groce Rock Shelter.

Location.—On the land of J. C. Groce, 5 miles northwest of Byrdstown in the bluff of Wolf River, a mile below the mouth of Turkey Creek on the south side of the river, a half mile south of the Kentucky line. The shelter is at the top of the bluff and is about 400 yards long, 135 feet high, and 15 feet wide. It is just above the Chattanooga black shale. The earth on the floor of the shelter is about 2½ feet deep and is mixed with fragments of black slaty shale. The earth itself seems to be almost pure saltpeter stained with a little bluish dust from the shale. There are large cakes of the pure white niter on ledges of rock, also, and several tons of this mineral could probably be obtained here.

No. 35. Phillips Cave.

Location.—On the land of Martin Phillips, 4 miles northwest of Byrdstown, a quarter of a mile north of A. A. Thompkins' house, at the head of a short ravine leading to Wolf River, 200 yards from a wagon road. It is in Mississippian limestone, 50 feet above the Chattanooga black shale. The mouth is wide and slit-like and it is reported that only a few years ago the stream that now appears much lower down, flowed out of this opening. This cave is 75 feet wide just inside the mouth but is only 4½ feet high and gradually becomes lower the farther one gets from the mouth. There is earth about 4½ feet deep mixed with angular rock fragments on both sides of the old stream bed. The roof is practically smooth and free from stalactites.

Nos. 36 and 37. Bunkum Cave.

Sample No. 36 was taken just inside the mouth while No. 37 was taken farther back.

Location.—At the head of a hollow 1½ miles east of Obey River, on the land of Irving Amlett, a half mile southeast of Bloomington, and less than half a mile from the Byrdstown road. It is in Mississippian limestone about 100 feet above the Chattanooga black shale.

The mouth of this cave is probably larger than that of any other cave in the State and of course is correspondingly imposing. It is 150 feet wide and 65 feet high. A creek flows out of the cave and a small stream falls in a cascade from the thin ledge of limestone over the cave's mouth. The large stream flows through the entire length of the cave and forks several times. As many as 75 Indian skeletons and many relics have been dug up from the mouth of Bunkum Cave. The earth in the mouth is 10 or 15 feet deep and is mixed with large bowlders. This earth is quite dry and seems to contain much niter. There is also niter on the ledges projecting from the walls. There is a much larger quantity of earth in the mouth than there is farther back. The mouth is located in woods and the scenery surrounding it is quite wild. The main passage of this cave is 35 feet wide, 25 feet high and fully a mile long, and has a fork probably as long.

Most of the earth in the back of the cave has been worked over by the stream, and probably contains little niter. In many places there are wide ledges on which are beds of earth 2 or 3 feet thick which contain gypsum crystals, and in places a thin coat of white gypsum is found on the rocks. Toward the upper end of the cave there are many large, beautiful, and bizarre stalagmites, stalactites, and columns, some of which are pure white. The east fork of this cave contains a remarkable series of water-formed calcite terraces that extend for over a hundred yards in length while the vertical distance from the top to the bottom of the series is about 40 feet. Each terrace averages about 8 inches in height and forms a series of arcs or semi-circles that are themselves indented into smaller arcs in a peculiar manner. The top of each step or terrace is a shallow basin filled with the clearest and stillest water imaginable. The rims of these pools vary from an eighth of an inch to a foot in thickness and have been built up by the water which trickles over them in a thin sheet. Some of the pools in the basin-like depressions on the top of the terrace are 4 feet deep and the water is so clear that they seem empty. An old still was once located in the mouth of this cave and the name Bunkum originated from applying this term to the still.

Babbs Rock Shelter.

Location.—On W. J. Babbs' land on the north bluff of Wolf River a mile above Groce Shelter, a fourth of a mile north of John Gunnel's house. It is about the same size and similar to Groce Rock Shelter and probably contains considerable niter.

Woods Rock Shelter.

Location.—Two miles north of Byrdstown on the Albany road, 200 yards above Haile Ford in the Wolf River bluff. It is over 100 yards long. It contains Indian relics and is said to contain a quantity of niter. Two small caves extend into the bluff here also.

No. 37. Paris Rock Shelter.

Location.—On the land of Ross Paris, in the top of the Obey River bluff 5 miles west of Byrdstown, 300 yards from Philip Garrett's house. It is 400 yards long and averages 40 feet in height and 15 feet in width. The loose earth is 6 or 8 feet deep. Many Indian skeletons with fine wampum beads have been unearthed here, one having with it over a thousand such beads.

No. 38. Keislin Rock Shelter.

Location—On the land of Albert Keislin on the northeast bluff of Obey River, 5 miles west of Byrdstown a half mile north of No. 37. The shelter is 500 yards long and averages 25 feet high and 20 feet wide. There is considerable crust of almost pure niter on the earth and the earth, which is about 3 feet deep, seems to be impregnated also. According to reports there are many similar rock shelters on Wolf and Obey rivers that are said also to contain quantities of niter.

PUTNAM COUNTY.

No. 51. Milligan Cave.

Location.—Three-fourths of a mile north of Dug Hill on the land of Joe E. Milligan about half way to the top of the mountain, a fourth of a mile east of Doc Cobb's house, 12 miles south of Monterey and a half mile from the Calfkiller River. It is a fourth of a mile from the Sparta-Monterey road and 4 miles from the Nashville, Chattanooga and St. Louis Railway at Ravenscroft. It is in Mississippian limestone, 50 feet below the Lee sandstone.

The mouth is located at the base of a small sink-hole in the woodland and is about 20 feet wide and 7 feet high. The cave extends almost due south for 600 yards, and then turns east for about a quarter of a mile before it becomes too low to penetrate farther without stooping. The average width is 50 feet and the height 20 or 25 feet. It is slightly damp just inside the mouth, but throughout most of the cave it is dry and dusty. There is much loose earth just inside the mouth where the cave is largest and the old hoppers where saltpeter was extracted from the earth during the Civil War are fairly well preserved. In the back part of the cave the loose earth is apparently 6 or 7 feet thick. Pick marks show that it was once worked back there. The middle part of the cave is over half filled with loose rocks, some of which are very large.

No. 52. Johnson Cave.

Location.—Eight miles south of Monterey on the Sparta-Monterey pike, on the land of Lewis D. Johnson, a fourth of a mile southwest of Johnson's store, about half way up the mountain. The mouth is 500 yards up the mountain from the Sparta-Monterey road and 5 miles from the Nashville, Chattanooga and St. Louis Railway at Ravenscroft, but the Tennessee Central at Monterey is probably more accessible. It is in Mississippian limestone about 75 feet below the Lee sandstone.

The mouth is 8 feet in diameter and opens downward at an angle of about 75 degrees for 75 feet. It is in an open wooded pasture on the northeast side of the mountain. There is an old ladder about 80 feet long in the mouth. At the bottom and a little southwest of the mouth is a great dome-shaped chamber fully 200 feet wide, 300 feet long and 75 feet high. One small and three large forks extend in various directions from the main chamber. One of these averages 30 feet high and 25 feet wide for probably a mile. The writer explored this fork for about a mile. It is said to extend over two miles but nobody has ever been to the end of it, as there is great danger of getting lost owing to the number of side passages leading in all directions. There are several passages above the main cave.

Another large fork 20 feet high and 25 feet wide also extends for a mile or more. It is very rough in places and the floor rises and falls many times. It is said that men have walked for fourteen hours in this cave. It was worked during the Civil War for niter and remains of large hoppers may still be seen, while holes 15 or 20 feet deep have been dug in the main room. There are also great banks of earth along both of the larger forks as well as in the main chamber. The earth probably averages 4 feet in depth for the whole cave, although it is difficult to estimate this. It is damp in the main chamber, but in the forks it is almost dry. There are a number of short, thick stalacties and stalagmites and some terraces in the main cave. The roof and walls, especially of the main chamber, have been elaborately carved by water.

No. 53. Saltpeter Cave.

Location.—Seven miles south of Monterey on the land of Lewis D. Johnson, a mile northwest of Johnson's store and a mile west of No. 52 on the opposite side of the mountain a little nearer to the top. It is about a half mile from the Sparta-Monterey pike. It is in Mississippian limestone about 35 feet below the Lee sandstone.

The mouth is at the head of a cove in second growth woods, and is an irregular opening 100 feet long and 25 feet wide and extends vertically downward for 75 feet. It is possible to climb down over the irregular ledges of rock with the aid of a long smooth pole near the bottom. Just inside the mouth is a very large chamber, 250 feet wide and 100 feet high. Broken rocks are piled up all over the floor of this chamber. From the main room the cave extends southwest for only a quarter of a mile before it becomes too low to penetrate much farther. Excepting the main chamber, the average width is 60 feet and the height 15 feet. There are no formations in this cave.

The loose earth was originally 15 feet deep or more, but much has been removed though there are high banks of it at the back of the cave with the marks of picks plainly visible. Many workers were employed in this cave during the Civil War and it was worked much more than No. 52.

The old hoppers, troughs, and barrels, where the niter was leached out of the earth are in an excellent state of preservation and are still full of the hard, yellow clay which contained the niter. The hoppers in this cave are typical of those in most caves in this region. They are rectangular and about 10 by 6 feet at the top. The sides slope gradually together and at the bottom are about 4 feet wide. They were about 5 feet high and in shape somewhat resembled a very wide and deep, flat-bottomed boat. The bottoms are made of broad, flat boards which are laid across small logs that raise it a short distance from the ground. Under them wide V-shaped troughs or hollowed-out logs were placed to receive the water that filtered through the earth in the hopper. The sides of most of the hoppers are made of long hewn shingles with one layer overlapping the other as on the roof of a house. In some cases boards are nailed on the outside of these shingles to make the hopper stronger. These hoppers are very crudely made and probably the earth which has been leached still contains some niter. There were also fragments of iron kettles where the water containing niter was boiled down and barrels in which water was probably kept. Some of the wood is fairly well preserved while other pieces, although dry, can be crumbled between the fingers easily. These hoppers vary somewhat in different caves but the great majority are as described above.

No. 63. Bilbrey Cave.

Location.—Two and a half miles south of Booze P. O. on the land of Joe Bilbrey, 300 yards northwest of a small log schoolhouse and a mile north of Beaver Hill. It is in St. Louis limestone.

The mouth is in the low east bluff of a branch a few hundred yards west of the public road in cut-over woodland. It is 5½ feet high and 3½ feet wide. This cave is damp and has a small stream flowing through it. It is narrow and sinuous and has but little loose earth and but few stalactites. There was once a whisky still in it.

No. 64. Webb Cave.

Location.—A mile west of Beaver Hill on the land of J. C. Webb, 50 yards below Webb's house. This cave is about 60 yards from the wagon road and 4 miles north of the Tennessee Central Railroad. It is in St. Louis limestone about 250 feet below the Lee sandstone.

The mouth is about 30 feet wide and 5 feet high and has a spring in it. The average height is 4½ feet and it gradually becomes lower toward the back. The width is about 25 feet, while the length is about 150 yards. The earth averages about 5 feet in depth. It is said that niter was mined here at one time. About 15 feet back of the mouth the earth is dry and dusty. There are holes in the floor through which a stream may be seen about 15 feet below. The roof is smooth and even.

No. 65. Saltpeter Cave.

Location.—Two miles southwest of Beaver Hill, 7 miles northeast of Brotherton, on the land of A. Q. Qualls, 400 yards east of Qualls' house and store. It is in Mississippian limestone about 150 feet below the Lee sandstone.

The mouth is located in a sink-hole in an old field. The sink-hole is about 20 feet deep and 60 feet in diameter and is thickly overgrown by tulip tree saplings. The mouth slants downward for 20 feet and continues in a northerly direction for 400 yards. There is a stream at the back of the cave but the main part is almost dry. The average height is 20 feet and the width 30 feet. There are several holes in the floor through which a stream may be heard some distance below. Some years ago a whisky still was located here. There are banks of loose earth along both sides of the cave which average 3 or 4 feet in depth. Holes have been dug in this earth and it is said that niter was once mined here. There are several rather attractive stalagmites and a few stalactites along the walls of the cave and a few stalagmites on the floor.

No. 66. Ealy Cave.

Location.—Three miles north of Bilbrey Station on the land of O. A. Kirby, 500 yards south of Curtis Looper's house below his apple orchard. It is 2½ miles from the Tennessee Central Railroad, and a fourth of a mile from the public road. It is in St. Louis limestone.

The mouth is under a rock shelter of sandstone 25 feet high and 30 feet wide. It is in the woods near a dim road and there is a sinkhole 20 feet deep in front of the mouth. The mouth of the cave is about the middle of the rock shelter and is 8 feet high and 12 feet wide. The cave proper is small and the roof becomes only 3½ or 4 feet high 50 yards inside the mouth. The average width is 10 feet. The earth in the mouth is quite dry but that in the cave is wet and there is a small stream present. That in the mouth has been dug up and removed for a depth of 8 feet and ashes are mixed with it for a depth of at least 5 feet. This cave is noted because a man named Ealy hired hands and dug there for over a year until his money finally gave out. A woman then financed further digging but they never seemed to find what they were looking for. Soon after the man died. His body was placed in this cave at his request and the inhabitants of this region are very superstitious about it. It is said they were hunting for buried treasure which was supposed to have been hidden here by Indians. Many skeletons and trinkets were removed from the cave during the process of digging. There are no formations in this small cave.

SMITH COUNTY.

No. 1. Hughes Cave.

Location.—A mile south of Carthage in the west bluff of Cumberland River, 200 feet above the river and 200 yards north of the mouth of Caney Fork. There is a wagon road 100 feet below the mouth. This cave is in Ordovician limestone, 100 feet below the top of the bluff.

The mouth of the cave is 25 feet high and 20 feet wide and is very conspicuous in the bare limestone bluff.

About 50 feet from the mouth a peculiar thin ledge of limestone extends across the center of the cave about half way between the roof and floor. It varies from 8 inches to 2 feet in thickness. The cave is 150 yards long and averages 12 feet wide and 15 feet high. The floor slopes upward from the mouth at an average angle of 10 or 15 degrees.

The loose earth averages about 2 feet in depth and is mixed with fragments of limestone. There are a few small stalagmites and stalactites. Most of the stalactites are in rows on the edges of ledges that project from the walls of the cave though a few also hang from the roof. The cave is slightly damp though there is no stream in it. The loose earth is practically dry.

No. 2. Lee Cave.

Location.—In the southeast bluff of the Cumberland River 2½ miles southeast of Carthage, 150 feet above the level of the river and two-thirds of the distance to the top of the bluff, on the land of Mrs. S. B. Lee. It is a half mile from a wagon road and is between Cumberland River and Caney Fork, a mile southeast of the mouth of the latter. It is in Ordovician limestone.

The mouth is small and quite difficult to locate, being only 4 feet wide and 2 feet high. It is located at the top of a steep bluff in rather dense woods and near it there are a few cedar trees. The cave extends downward at a slight angle for 20 feet and then continues level.

There is no stream in the cave but it is quite damp inside. The main part of this cave is 150 yards long, 8 or 10 feet high and 15 feet wide and extends in an easterly direction, though there are many crooks and turns in it. The loose earth on the floor averages 3½ feet in depth and extends throughout the length of the cave. Many bones of Indians have been dug up from this earth. It is damp on the surface but becomes dry a few inches below the surface. There are very few stalactites or stalagmites. Most of the stalactites once there have been broken off. Near the end of the cave there is a stalagmite mass 8 or 10 feet long that resembles a frozen cascade.

No. 3. Piper Cave.

Location.—A mile west of Monoville on the farm of Jim Phillips, 100 yards south of Phillips' house. The mouth is about a half mile from a public road and easily accessible to the Tennessee Central Railroad at Carthage and the Cumberland River which is only about 2 miles from the cave at places. It occurs in Ordovician limestone about 50 feet above the Cumberland River.

The mouth of the cave is 6 feet high and 8 feet wide and is near the bottom of a small depression in a pasture. There is a rude wooden gate in the mouth.

A little water drips from the roof and forms pools but there is no regular stream in the cave. This cave is very large. It has two large and several smaller forks. The cave forks a quarter of a mile from the mouth. The northwest fork is the longest. It is definitely known to extend for 2 miles when it narrows to a small hole through which it is necessary to crawl in order to penetrate farther. This fork is said to extend another mile to the bluff of the Cumberland River. The south fork is a mile long and is damper than the northwest fork. In both forks there are numerous old hoppers that were used for making niter during the Civil War times. These are still in a fair state of preservation. Considerable quantities of saltpeter were mined by Jos. Piper who used to live near the entrance of the cave. However, a large amount of earth containing niter apparently still remains and clear crystals of niter can be found between rocks on the floor of the cave. The average thickness of loose earth is 5 or 6 feet though in many places it is as much as 10 feet. This appears to be one of the best prospects in the State for niter caves. The width of the cave is 35 feet and height 20 feet. There are a few large and beautiful stalagmites in it, but stalactites are rare.

No. 4. Buzzard Cave.

Location.—Two and a half miles west of Monoville on the west side of Cumberland River on the farm of Wm. Hull under an overhanging limestone cliff half way up the bluff. The mouth is 4 feet high and 6 feet wide and extends upward into a chamber whose size was not ascertained since the cave was being used as a breeding place by buzzards. The mouth is dry, and the loose material just inside is 3 feet deep.

No. 5. Hull Cave.

Location.—Two and a half miles west of Monoville on the farm of Wm. Hull, three-fourths of a mile north of Hull's house at the base of an overhanging cliff on the Cumberland River bluff. The cave is very convenient to the river but is rather inaccessible to the public road a half mile south of it. This cave has probably never been explored before and was penetrated only a half mile, though it extends farther. It is in Ordovician limestone, 60 feet above the river level.

The mouth is 5 feet high and 20 feet wide. The bluff in which it occurs is densely wooded wherever there is soil.

The cave extends eastward and has two main forks and several small ones. The longest fork turns abruptly northeast about 100 yards from the mouth while the other continues eastward for half a mile or more. The average height is 6 or 7 feet and the average width 6 feet. It is very nearly dry inside and there is no standing or running water in it. There is much loose earth on the floor, especially of the north fork. Its average depth is probably 6 feet. There are but few stalagmites or stalactites, and these are mostly near the walls. There are a few columns.

No. 6. Bridgewater Cave.

Location.—Two and a half miles northwest of Monoville in open pasture belonging to Mark Bridgewater, on a hill slope facing east toward the creek, 200 yards west-southwest of Bridgewater's house. This cave is 300 yards from Pleasant Shade road, about a mile from Cumberland River, and is easily accessible. It is in Ordovician limestone.

The mouth is about two-thirds of the distance to the top of the hill and is covered with poles and surrounded by weeds so that it is hard to find. It extends downward for 30 feet and then westward. Its dimensions are 5 by 4 feet.

The interior of the cave is damp but there are only a few puddles of standing water in it. The average height of the cave is 8 feet, though it varies considerably from place to place, and the average width is 25 feet. The cave can be penetrated only about 300 yards without crawling, when the passage becomes blocked by earth. The loose earth probably averages 6 feet in depth. Much was removed for niter during the Civil War and there are still many evidences of digging. The leaching hoppers were located outside of the cave. Needle-like crystals, some of which are half an inch long, glisten in the sticky yellow earth. Stalactites and stalagmites are abundant and beautiful and form fantastic patterns. Of the two the stalactites are the most prominent and most of them are unbroken. Some are 2 feet thick at their base. In many places columns have been formed. Most of these formations are about 250 yards from the mouth. There is an ash heap 6 feet high and 15 feet in diameter about 200 yards back from the mouth.

No. 7. Piper's Cave.

Location.—One and a half miles south of Difficult, a mile south of T. T. Kemp's store on the farm of Clare Piper, 300 yards southeast of Piper's house. It is in Ordovician limestone half way up a high hill.

The mouth is rectangular, 5 by 8 feet in size, and slopes downward steeply for 15 feet. The cave is damp inside but there is little or no standing or running water. This is a very beautiful cave with its fantastic formations. The longest fork extends about 400 yards before it becomes too low and narrow to penetrate easily. There are many passages several of which open back and forth into each other. The floor is very uneven. There are many steep grades and rough places and several small holes through which it is necessary to crawl. The average height is probably 10 feet though it varies greatly. The width also varies, but averages about 8 feet. There is no loose earth except near the mouth where it is 5 feet thick. It extends back 75 feet on the south side of the mouth.

The stalactites and stalagmites are very abundant and beautifully varied in size and shape. In many places the walls are covered with mushroom-shaped deposits an inch or less in length. In many places the stalactites and stalagmites have united and formed columns of various sizes and shapes. Many stalagmites form large, cone-shaped bodies.

No. 8. Ladd Cave.

Location. — A half mile south of Difficult at the base of the east bluff of Defeated Creek, 200 yards south of W. F. Ladd's house on the land belonging to Ladd. The mouth is only 50 yards from the public road and about 20 miles from the Carthage Branch of the Tennessee Central Railroad. It is in Ordovician limestone.

The mouth is only 3 feet by 5 feet and the average height of the roof for 100 yards is only 3 feet. Farther back it becomes much wider and higher, but is difficult to penetrate. The average width of the front part is 6 feet and it becomes about twice as great farther back. There are said to be some large rooms about 200 yards from the mouth.

The loose earth in the cave is very thick but is probably flooded at times by high water. The average thickness is about 5 feet or possibly more. It is reported that Dr. Kemp of Difficult analyzed earth from this cave and found niter.

No. 67. Little Petty Cave.

Location.—Two and a half miles north of Lancaster on the land of S. A. Petty on the southeast bluff of Caney Fork, 50 feet above the river, 200 yards east of Petty's house. The Tennessee Central Railroad is about a mile to the east. It is in Ordovician limestone, 75 feet below the Ft. Payne chert. There is a wooden door in the mouth and it is used for storing farm products. The mouth is under a rock shelter 10 feet wide and 40 feet long. The cave is small, there being three forks that extend about 100 feet each.

The earth is a foot deep in the rock shelter and 3 feet in the cave. There are a few cone-shaped stalactites.

No. 68. Big Petty Cave.

Location.—A hundred yards east of No. 67 on the same side of the river and in a similar situation.

The mouth is the most imposing part of this cave. It is 50 feet high, and 30 feet wide, and is roughly oval-shaped. It is cut out of the Caney Fork limestone bluff, which is almost perpendicular and 100 feet high. The cave is 200 yards long and is roughly funnel-shaped, being largest at the mouth. It is very straight, so that the light of the mouth can be seen at the back of the cave. The floor slopes upward gradually from the river and a small stream flows along it and sinks near the mouth. There is very little earth on the floor. The roof and walls are practically smooth.

No. 69. Rip Van Winkle Cave.

Location.—One and a half miles north of Sebowisha, near the top of the bluff on the opposite side of Caney Fork from Sebowisha Club House, on the land of W. M. Bellar.

The mouth is only about a mile from the Tennessee Central Railroad and is on the Caney Fork River, which is navigable up to this point. It is in Ordovician limestone, 30 feet below the Ft. Payne chert.

The bluff in which the cave is located is almost perpendicular and is wooded below the mouth of the cave. Above the mouth is an overhanging limestone bluff 30 feet high. When it was first discovered on February 1, 1916, by Harry Fisher, the mouth was very small and low, but it has since been enlarged so that entrance is easy.

The cave is very large and has two main forks. The southeast, or Dry Fork, is about a third of a mile long, while the northwest, or Wet Fork, is over half a mile long. There are also several smaller forks, especially on the Dry Fork, and at places there are other passages above the main ones. The average width is 40 feet and the height 75 or 100 feet. In the Wet Fork several bridges and flights of stairs have been built and many improvements made to accommodate tourists to whom the cave is open at certain times. Near the back of the Wet Fork is a small stream and the earth, which is heaped up in banks is wet. The earth in the Dry Fork is peculiarly dry and contains a great abundance of transparent crystals of gypsum. These gypsum crystals, some of large size, cover the walls and the stalactites and stalagmites with a coat of sparkling gems. The depth of the earth could not be determined accurately but it averages probably over 6 feet, and in places is as much as 20 feet deep.

This cave is the most beautiful of the 109 caves visited, even somewhat surpassing Wonder Cave near Monteagle. It does not contain as many stalactites, stalagmites and natural columns as Wonder Cave, but they are much larger and more varied than those of Wonder Cave. The roof is also very much higher and more fantastic. The limestone formations are abundant in both forks, but probably the most interesting are in the Wet Fork. There is one especially beautiful group of stalactites called the Wedding Bells that is 60 feet long and 25 feet in diameter at the center. These stalactites are of all sizes and when struck, give forth musical sounds resembling a pipe organ and ranging from the highest treble to the deepest bass. Most of them seem to be hollow. There are other stalactites and columns that are even longer and larger than the Wedding Bells.

Near the end of the Dry Fork there are many shallow basins separated from each other by very thin, wavy partitions of limestone about 10 inches high that have been built up by the water with which they are filled in winter. In the bottoms of these basins was a deposit of loose crystals resembling salt 3 or 4 inches deep. The odd basin-like formations are not peculiar to this cave but the knife-edge partitions here are unusually high. In most caves in which these basins are found they are filled with such clear water that they appear to be empty. There are in this cave, also, many beautiful dome-shaped and waterfall-shaped stalagmites, some of dazzling whiteness.

No. 70. Prichard Cave.

Location.—Three miles southwest of Lancaster on the land of John Prichard, on the east bluff of Smith Fork, a quarter of a mile up the creek from Dee Driver's house. It is in Ordovician limestone, 75 feet above the level of Smith Fork.

It is a small cave with two rooms. The mouth is in a steep bluff overlooking and in sight of, the public road. It is dry and the earth is 2 or 3 feet deep. The cave is about 100 yards long, 10 feet wide and 5½ feet high. There are a few stalactites and stalagmites.

No. 71. Fisher Cave.

Location.—Three miles southwest of Lancaster on the land of John B. Fisher in the west bluff of Smith Fork, about 100 yards northwest of the creek and 300 yards south of Fisher's house. The mouth is 150 yards from the Temperance Hall road, and 2½ miles from the Tennessee Central Railroad. It is in Ordovician limestone about 60 feet below the Ft. Payne.

This cave has two mouths about 40 feet apart. The main cave is over a mile long and has a fork extending southeastward for 300 yards that is much wider than the main fork. The average width of the cave is 15 feet but it varies very greatly at different points. The height is 25 feet. There is no stream in the southeast fork and none in the southwest, or main fork, for more than half a mile, but the earth is damp. Bowlders and rocks practically block the passage in the main fork in places. The loose earth is about 5 feet deep. There are a few stalactites near the mouth of the cave and about half a mile from the mouth there are several large stalagmites, but these formations are for the most part lacking. A strong breeze blows through the cave, and makes it quite cold in summer.

VAN BUREN COUNTY.

No. 83. West McElroy Cave.

Location.—Two miles southeast of Quebeck, 450 yards southwest of McElroy, on the land of Mrs. E. H. McElroy, 350 yards southwest of her house. It is in St. Louis limestone, 25 feet above the Ft. Payne.

The mouth is in a small sink in the woods about 50 yards from the edge of a field. It is 5 feet high and 15 feet wide and slants downward from the outside. The cave extends 400 yards almost due south and consists mainly of two large rooms with a narrow place and a high pile of earth between them. The average width for the main part is fully 50 feet and the height 25 feet. By crawling through narrow and low places it is possible to penetrate some distance beyond this main part.

The earth in the main part of the cave averages 10 feet deep, probably. This earth has been extensively dug and old inhabitants say it was carried to a nearby spring and leached for niter. There are some very beautiful stalagmites and stalactites but many have been broken off. The cave is nearly dry.

No. 84. North McElroy Cave.

Location.—Two and a half miles southeast of Quebeck, three-fourths of a mile south of McElroy, on the farm of Mrs. E. H. McElroy. It is half a mile from the public road and 2½ miles from the Nashville, Chattanooga and St. Louis Railway at Quebeck. It is in St. Louis limestone, 200 feet above the Ft. Payne.

The mouth is on the top of a small mountain south of McElroy's store in rather thin woods near an old house. It is in a sink-hole about 100 feet in diameter and overgrown with trees. The mouth is 5 feet high and 6 feet wide. The cave is damp but there is no permanent stream in it. There are four or five branches extending in various directions from a large room which is divided into three parts by walls of limestone. The length of the cave is about 250 yards and two of the branches are of about the same length. The average width is about 8 feet and the height is about the same. The loose earth averages 2 or 3 feet. There are few formations.

No. 85. South McElroy Cave.

Location.—Twenty-five yards south of No. 84, and in a similar location.

The mouth is 8 feet square. About 30 feet south of the mouth a dark hole or chasm fully 60 feet wide extends vertically down so far that a rock takes several seconds to hit the bottom. The cave extends westward about 50 yards. There is probably a much larger cave at the bottom of the chasm. Water can be heard at the bottom of the large hole. The cave is 30 feet wide and 15 feet high. The loose earth is scanty and there are only a few small stalactites.

No. 86. Big Bone Cave (Arch Cave Branch).

Location.—Three and a quarter miles south of Quebeck, near the head of a hollow or cove extending south from McElroy's store. The mouth is half a mile from the public road and 3 miles from the Sparta branch of the Nashville, Chattanooga and St. Louis Railway. It is in St. Louis limestone, 50 feet above the Ft. Payne chert.

The mouth is in open woods near the base of the mountain and near the head of the hollow. About 50 yards in front of the mouth is a wooden shed in which bat guano was stored. A tramway extends about 400 yards into the cave and enters the southwest or Arch Cave branch. It was used for hauling out bat guano which is found in considerable quantity in one part of the cave. Over a carload of this fertilizer has been shipped from Quebeck. Work, however, has now stopped. The mouth of this cave is 20 feet wide and 8 feet high. About 50 yards inside the mouth the cave divides into two branches, the southwest or Arch Cave Branch and the south or Bone Cave Branch. Both caves are very large, though the Bone Cave Branch is the longer and larger of the two. The Arch Cave is about 1½ miles long, is very sinuous and branches many times. The branches extend in various directions and some rejoin the main passage. About a half mile from the mouth is a round hole 4 feet in diameter, which is called the needle's eye, and somewhat farther is a broad level place called the muster ground. The floor of this branch is everywhere of earth and is surprisingly smooth. The average width of this branch is 7 feet and the height 8 feet. The cave is very dry and dusty. In several places as much as half of the earth on the floor consists of long, fibrous or needle-like crystals of gypsum. In other places the upper layer of the earth is coated with white powder as much as 2 inches thick. This is also found in lumps mixed with the earth. The earth is certainly 5 feet deep and probably more. This cave is very famous, and this branch, especially, has been visited frequently by people from all parts of the United States. This cave is peculiar in containing no stalactites or stalagmites.

No. 87. Big Bone Cave (Bone Cave Branch).

Location.—Same as No. 86. This is the south or southeast branch of this same cave.

It is larger than No. 86, but is very much rougher and full of broken rocks in places. It is said that nobody has ever been to the end of this branch, though it is known to extend 3 miles. The writer explored it for about a mile. The average width is 15 feet and the height 20 feet. It is dusty and dry except for about the first 100 yards, where the earth is muddy from water that has flowed in through the mouth.

Much work must have been done in this cave in Civil War times, for there are more than twenty hoppers each 20 feet long, 12 feet wide at the top, and 10 feet high, constructed with shingles as described in No. 53. The logs on which the hoppers rest are laid across a ledge on the walls of the cave and are raised about 5 feet above the present floor, which was probably lowered by the removal of earth. There are several ladders, a tramway and some scaffolding across another ledge above the hoppers with a network of beams and boards above them. These timbers are in an almost perfect state of preservation, while the timbers in most caves may be crumbled between the fingers even though they appear to be sound. There are several tons of dry, yellow, clayey earth, in each of the hoppers. It is thought that there is more niter in this cave than in Arch Cave, though more evidences of it, or rather of nitrocalcite, were found in the other branch. While much of the earth has been removed already, yet it is still at least 4 feet deep, but has large, flat limestone slabs mixed with it. In some places the earth is sandy. This branch extends south and then south-southeast and curves less than the other branch. There are no forks wide enough to penetrate far, and no stalactites or stalagmites. At one place the cave is nearly stopped up by sandy limestone that has fallen from the roof, and there are several rather low places. This branch has a very peculiar odor. There was no evidences of any soda in this cave. A few bats, as well as numerous rats, live in this branch at present. This cave was called Bone Cave because the skeleton or a large prehistoric animal, the Megalonyx, was found in it some years ago, together with other bones.

WARREN COUNTY.

No. 104. Hubbard (Bat) Cave.

Location.—Four miles southeast of Irving College, 8 miles north of Beersheba Springs on the land of J. S. Coppinger, a mile north of L. V. Scott's house, at the forks of the cove extending northeast from Scott's house. This cave is half a mile from the public road and 9 miles from the Sparta Branch of the Nashville, Chattanooga and St. Louis Railway at McMinnville. It is in St. Louis limestone, 500 feet below the Lee sandstone.

The mouth is a vertical opening about 70 feet in diameter and 30 feet deep. At the bottom of this large opening there are three passages, one extending north, one south, and a small one west. The west passage is extremely sinuous and in many places very narrow, but finally leads into a large cave that is probably 3 miles long with an aggregate length of all of its passages probably 6 or 8 miles. Some of these passages are high above the main cave and are reached by ladders. The north passage also finally leads into the largest part of the cave, although it is rougher and less direct. The south passage extends only about half a mile. There is a large saltpeter hopper in it near the mouth. The average width of the main part of the cave is 50 feet and the height is at least 60 feet with places above it much higher. The cave gradually gets narrower toward the top. Practically the whole cave is dry and dusty and probably contains much niter mixed with the earth. Some of this earth has been taken out by the forest nurserymen in this region and used as fertilizer. It is said to be excellent for this purpose. Needle-like crystals of gypsum cover the walls in thick coats and are mixed with the loose earth. They sparkle like gems on the walls and floor. The average depth of the earth is fully 10 feet, while in several places there are banks 30 feet high. This cave is even larger than the famous Big Bone Cave and comparatively little of the earth has been removed. The cave is very rough and there are several ladders, stairways and bridges.

No. 105. Woodley Cave.

Location.—This is a large cave near the head of Northcut's Cove, 8 miles southwest of Altamont, Grundy County. It contains many hoppers used in Civil War times, and much powder is said to have been made here. Indian skeletons were dug up in this cave. It was not visited by the writer.

No. 106. Rogers Cave.

Location.—Three and a half miles southwest of Irving College, 11 miles south of McMinnville, on the land of John Rogers, 400 yards northwest of Rogers' house. It is in St. Louis limestone, 700 feet below the Lee sandstone.

The mouth is in a small sink in thin woods, 100 yards above the corner of a field and 200 yards from the foot of the mountain. The cave is a quarter of a mile long and averages 20 feet in width and 6 feet in height. For the last 150 yards the roof becomes gradually so low that it almost joins the floor. The earth averages 4 feet in depth and a considerable quantity has been removed for niter. An old tramway has been built in the cave for 150 yards and it is now used to store apples and potatoes. Toward the back of the cave there are some short but interesting natural columns and stalagmites. The cave winds about a great deal, extending first north then west and then turning abruptly south and southwest.

No. 107. Henshaw Cave.

Location.—Five and a half miles southeast of McMinnville near the base of Cardville Knob on the land of Chas. Grove, a half mile northeast of Grove's house and the same distance southwest of Higginbotham Cave. This cave is a half mile from a good public road and about 5 miles from the Nashville, Chattanooga and St. Louis Railway. It is in St. Louis limestone, 700 feet below the Lee sandstone.

The mouth is small and is in the thick woods near the base of Cardville Knob. It extends downward at a steep angle for 15 feet. The cave is 400 yards long, 115 feet high and 25 feet wide. The earth on the floor is 4 feet deep. There are four good-sized hoppers near the mouth. On the east side of the cave and toward the back there are some very beautiful calcite deposits consisting of stalactites, stalagmites, terraces and rock-rimmed pools. At one place a small stream falls from a crevice in the roof into a deep hole in the floor.

Nos. 108 and 109. Higginbotham Cave.

Location.—Six miles southeast of McMinnville near the base of Cardville Knob on the land of Chas. Grove, a mile east of Grove's house on the north side of Blue Spring Cove. This cave is 6 miles from the Nashville, Chattanooga and St. Louis Railway, and a mile from the public road and is easily accessible. It is in St. Louis limestone, 700 feet below the Lee sandstone.

The mouth is 10 feet long and 5 feet wide and is situated in thin woods near the edge of an open pasture. The cave is very sinuous, but the general direction of the main passage is northwest. There is a small hole in the roof a short distance inside the mouth and very near it are a number of large natural columns and stalagmites known as the "Graveyard". The length of the main passage of this cave is 3 miles, while the numerous branches aggregate at least 5 miles or more. At the end of the main passage there is a large earth-floored room, 3 or 4 acres in area. There are two long ladders that it is necessary to climb up and two to descend, as well as many high places to climb over, one small hole through which it is necessary to wriggle, and a long, narrow passage through which one must crawl before reaching the Big Room. The way to the Big Room is marked by arrows, and there is a well trodden path for the whole distance. There are several places where the cave is damp and there are a good number of stalactites and stalagmites formed by the dripping water. Most of the cave, however, is practically dry and in some places even dusty. Where it is dry there are none of these formations. In places the walls are coated with gypsum crystals, though these are not so abundant as they are in No. 104. The earth also contains many tiny, sparkling crystals. The width and height of this cave vary greatly but average respectively about 10 feet and 15 feet. There is no stream anywhere in the cave. The depth of the earth varies greatly, also, but apparently averages 5 or 6 feet. Some of it has been removed for fertilizing purposes.

WHITE COUNTY.

No. 45. Ward Cave.

Location.—A mile north of Sparta on the bank of the Calf Killer River on the land of W. J. Ward. This cave has a dairy house in its mouth. The mouth is 50 feet wide and 7 feet high. The cave is a quarter of a mile long. It is very wet inside and a large stream of water runs through it. There is but little earth and all has been flooded. There are no cave formations.

No. 46. Cline Cave.

Location.—One and a half miles northeast of Sparta on the land of of W. M. Cline, in pasture land 100 yards south of Cline's house. It is in St. Louis limestone and about 300 feet below the Lee sandstone.

The mouth is small and low and extends downward for a short distance. The cave is damp inside but there is no stream. This is a small cave as it is only 60 yards long and averages 5 feet in height and 7 feet in width. The earth on the floor is about a foot deep. There are few cave formations.

No. 47. Harris Cave.

Location.—One and a half miles northeast of Sparta on the land of Hal Harris at the top of a hill a quarter of a mile south of W. M. Cline's house. It is in St. Louis limestone.

The mouth is almost at the top of the hill in open woods, very small and triangular in shape and opens downward vertically for 15 feet. The cave extends in a northwesterly direction for about 150 yards, and consists of two or three good-sized rooms with narrow places between them. The roof is high, averaging at least 20 feet. The average width is 12 or 15 feet, but the main room is 40 feet wide. The loose earth is about 2 feet in depth and is damp but not wet. The stalactites and stalagmites are few in number but the walls are beautifully scalloped and carved by water.

No. 48. Webster Cave.

Location.—Two miles northeast of Sparta, on the land of John Webster, 200 yards east of Sam Reese's house. It is in St. Louis limestone. The mouth proper is small and rectangular and is located in the southeast corner of a rather imposing rock shelter which is 50 feet wide and 6 to 10 feet high. The cave extends downward for a considerable distance after which it is very rough and irregular and for 50 yards narrow and sinuous. At the end of this narrow place it opens out into an almost circular room 100 feet in diameter. From here three or four small winding passages branch out. The length of this cave is about 300 yards and it averages 10 feet in height and 12 feet in width. It is damp near the mouth but in the main chamber the earth is almost dusty. Most of the loose earth seems to be in this chamber, where it is 6 feet deep or more. Stalactites are rare and there are no stalagmites, but the walls are fantastically carved by water. It is 200 yards from a road and 2 miles from the Sparta branch of the Nashville, Chattanooga and St. Louis Railway.

No. 49. Saltpeter Cave.

Location.—Three miles north of Ravenscroft in England's Cove on the land of J. S. Officer on the top of Cave Hill near the Sparta-Monterey road. It is in Mississippian limestone, 50 feet below the Lee sandstone.

There are two mouths, both of which have been enlarged by man. One is a round hole about 5 feet in diameter that extends vertically downward for 75 or 100 feet. Drill holes are plainly visible around the edges of the mouth and there are mounds of earth and broken rock about it. The other mouth is at the bottom of a sink-hole near the top of Cave Hill about 150 feet east of the first mouth. It slopes downward to the west for 30 feet and then opens downward vertically for at least 60 feet in a wide and deep chasm. There are drill holes at the back of this chasm and large mounds of earth near the mouth. It is said that much saltpeter was taken from this cave during the Civil War and was used in making gunpowder for the Confederacy. This cave was not explored because there was no way to get to the bottom. A sample was collected from inside the second mouth.

No. 50. Officer Cave.

Location.—Three miles north of Ravenscroft in England's Cove on the farm of J. S. Officer, on the hill north of Officer's barn and about 500 yards from his house. There is a public road about 500 yards from the cave and the railroad at Ravenscroft is only about 3 miles distant. It is in St. Louis limestone, 400 feet below the Lee sandstone.

The mouth is an oblong hole in the hillside and opens down into a good-sized chamber from which several forks extend in various directions. It is practically a dry cave. The main chamber is 75 feet in diameter and the roof is 20 feet high. There are three forks which extend for 50 yards or more, but become narrower toward the back. The loose earth is probably 5 or 6 feet deep and is coated by a thin white crust, possibly of niter. The main room of this cave is very beautiful, for stalagmites, stalactites, and natural columns of many curious and fantastic shapes and groupings are abundant on all sides. Some of the stalagmites are especially large and beautiful, many being as white as alabaster. There is one stalagmite or column just inside the mouth 17 feet high and 6 feet in diameter. A good deal of light enters the cave through the mouth and it has the characteristic green hue that the light entering through the mouth of a cave seems to possess, at least when leaves are on the surrounding trees.

No. 82. Journigan Cave.

Location.—A fourth of a mile northeast of Quebeck, on the land of F. Journigan, at the bottom of a sink-hole 30 feet deep and 50 feet in diameter, in an old field. This is a small, wet cave that extends about 50 yards and averages 4 feet in width and 5 feet in height. No stalactites or stalagmites are present, but the roof and walls are covered by a layer of yellow mud left by waters that have dissolved the limestone in which it occurred as an impurity. Practically the only earth in the cave has been washed in.

Discussion of the Chemical Analyses of the Cave Deposits of Tennessee

BY L. C. GLENN.

The examination of the caves of Tennessee, the results of which have been given in the preceding article by Mr. Thomas L. Bailey, was undertaken primarily to determine their value as a possible source of niter supply in case such should be needed in prosecuting the present war. It is well known that during the war of 1812 and again during the Civil War, the caves of Tennessee, Kentucky and other states were used to supply niter for making munitions, and they were in that way an important element in the prosecution of those wars. While the conditions of warfare and the type of explosives have greatly changed, nitrates are still essential in munition manufacture. It was anticipated that the quantity of material might not be great enough to make such source important under present conditions of warfare, but it was deemed of sufficient importance to warrant the investigation.

The analyses given below show that in none of the many caves examined is the percentage of nitrate high enough to make it possible to work the cave earth in competition with the Chilean nitrate deposits or with the nitrates fixed from the atmosphere. Nitrate occurs in the cave earth chiefly as calcium nitrate. In the manufacture of saltpeter in former days, this calcium nitrate was leached out of the cave earth with water and the resulting solution was allowed to percolate through wood ashes. During this percolation an interchange was made between the calcium of the nitrate and the potash of the ashes, transforming the solution into potassium nitrate. The process of manufacturing was crude and primitive and involved the burning of large quantities of wood to furnish ashes containing the potash necessary for the above chemical change.

The study of our Tennessee caves has not, however, been fruitless, since caves are objects of much popular and scientific interest aside from their use as a possible source of nitrate deposits. It is quite desirable that the people of the State may have such information concerning their many caves as Mr. Bailey has given in the preceding article. The number of caves will be a surprise to many. Those interested in caves may, with the guidance of the preceding article, more readily find and visit them than has heretofore been possible. The archaeologist, especially, will have his attention called to many of them as repositories of Indian remains and other relics and while many of them have been ransacked for such remains there are doubtless many rich finds still in store for those who dig in certain of the known caves, and probably other caves yet undiscovered like No. 29, Bone Cave, in Pickett County, containing Indian remains of great interest.

The chemical analysis of the cave deposits was begun by Dr. Paul C. Bowers, who analyzed twenty-three samples. The work was continued by Dr. J. I. D. Hinds, who analyzed sixty-five, making a total of eighty-eight in all. The only elements the chemists were asked to determine were potassium and nitrogen. The potassium has been computed in the following table as potassium oxide, K_2O and the nitrogen as nitrate iron, NO_3. Doctor Hinds reports that many of the samples contain sulphate, probably mostly calcium sulphate in the form of gypsum, and that many contain a very small amount of sodium chloride. One showed the presence of calcium fluorite while many also contain soluble carbonates. One sample was without number and is not included in the following table. It contained 0.03 per cent of K_2O and 0.12 per cent of NO_3.

ANALYSIS OF CAVE DEPOSITS OF TENNESSEE.

Sample No.	Laboratory No.	Per cent K_2O	Per cent NO_3	Analyst
1	293	trace	trace	Hinds
2	284	0.70	0.00	Bowers
3	281	0.04	trace	Bowers
4	289	0.11	trace	Hinds
5	280	0.04	0.02	Bowers
6	306	0.17	1.90	Hinds
7	274	0.05	0.00	Bowers
8	303	0.15	trace	Hinds
9	297	0.23	1.50	Hinds
10	272	0.01	0.00	Bowers
11	275	0.05	0.00	Bowers
12	307	0.20	0.45	Hinds
13	348	0.00	0.00	Hinds
15	347	0.35	0.48	Hinds
16	349	0.12	0.00	Hinds
17	351	0.03	0.03	Hinds
18	350	0.10	0.01	Hinds

Sample No.	Laboratory No.	Per cent K_2O	Per cent NO_3	Analyst
19	352	1.02	1.45	Hinds
22	322	0.05	0.00	Hinds
24	316	0.03	0.00	Hinds
26	287	0.00	0.00	Bowers
27	325	0.25	0.10	Hinds
28	326	0.13	0.15	Hinds
29	319	0.05	0.00	Hinds
30	320	0.15	0.26	Hinds
31	318	0.04	0.25	Hinds
32	311	0.11	0.00	Hinds
33	317	0.04	trace	Hinds
34	299	0.17	0.15	Hinds
35	321	0.04	0.00	Hinds
36	301	0.77	0.37	Hinds
37	302	0.70	0.18	Hinds
38	282	0.19	trace	Bowers
39	310	0.09	0.00	Hinds
42	288	trace	trace	Hinds
43	291	0.12	trace	Hinds
44	283	0.05	0.00	Bowers
46	269	0.10	0.00	Bowers
47	268	0.10	0.05	Bowers
48	271	0.04	0.02	Bowers
49	329	0.07	0.00	Hinds
50	327	0.07	trace	Hinds
51	324	0.32	0.42	Hinds
52	328	0.17	0.53	Hinds
53	323	0.05	0.30	Hinds
54	296	0.20	1.15	Hinds
56	312	0.14....	trace	Hinds
57	309	0.00	0.10	Hinds
58	294	0.68	0.93	Hinds
59	300	0.97	0.10	Hinds
60	315	0.38	trace	Hinds
62	265	0.16	0.02	Bowers
69	266	0.14	0.01	Bowers
71	332	0.25	0.11	Hinds
72	330	0.02	0.30	Hinds
73	340	0.04	0.75	Hinds
74	335	0.10	0.23	Hinds
75	334	0.07	0.45	Hinds
76	333	0.43	1.75	Hinds
77	345	0.22	0.50	Hinds
78	286	0.31	trace	Bowers
79	270	0.07	0.01	Bowers

Sample No.	Laboratory No.	Per cent K_2O	Per cent NO_3	Analyst
80	285	trace	trace	Bowers
83	277	0.03	0.01	Bowers
84	278	0.03	trace	Bowers
85	292	0.14	0.11	Hinds
86	276	0.28	0.16	Bowers
87	279	0.07	0.63	Bowers
88	344	0.03	0.10	Hinds
89	342	0.05	0.20	Hinds
90	339	0.00	trace	Hinds
91	337	0.03	trace	Hinds
92	336	0.44	1.12	Hinds
93	314	0.68	0.37	Hinds
95	305	0.06	0.00	Hinds
96	308	0.08	0.15	Hinds
98	295	0.18	trace	Hinds
99	298	0.01	0.00	Hinds
100	313	0.54	trace	Hinds
101a	290	0.37	2.39	Hinds
101b	304	0.87	0.75	Hinds
102	264	0.17	0.00	Bowers
103	267	0.04	0.01	Bowers
104	343	0.27	0.30	Hinds
106	338	0.05	0.30	Hinds
107	341	0.13	0.07	Hinds
108	331	0.32	0.09	Hinds

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—Economic Geology of the Waynesboro Quadrangle, by N. F. Drake.
Recent Water Power Development in Tennessee, by J. A. Switzer.
Two Natural Bridges in Tennessee, by Hugh D. Miser.
Road Materials of Tennessee, by A. H. Purdue.
Report on the Water Powers of Tennessee.

No. 4—The Need of a Soil Survey of Tennessee, by C. A. Mooers.
The Geology of Perry County and Vicinity, by Bruce Wade.
Indexes to Volumes III and IV.

Vol. V. No. 1—The Hydro-Electric System of Tennessee, by J. A. Switzer.
West Tennessee Gullied Lands and Their Reclamation, by R. S. Maddox.
The White Phosphates of Tennessee, by J. S. Hook.
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No. 2—Physiographic Influences in the Development of Tennnessee, by L. C. Glenn.
Care and Protection of Forests, by R. S. Maddox.
Two Natural Bridges of the Cumberland Mountains, by Wilbur A. Nelson. (Out of print).

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, Ten nessee, 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.

VOLUME VIII NUMBER 3

THE RESOURCES OF TENNESSEE

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

PUBLISHED
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BY THE
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NASHVILLE, TENN.

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Wilbur A. Nelson, State Geologist

UNITED STATES GEOLOGICAL SURVEY
George Otis Smith, Director

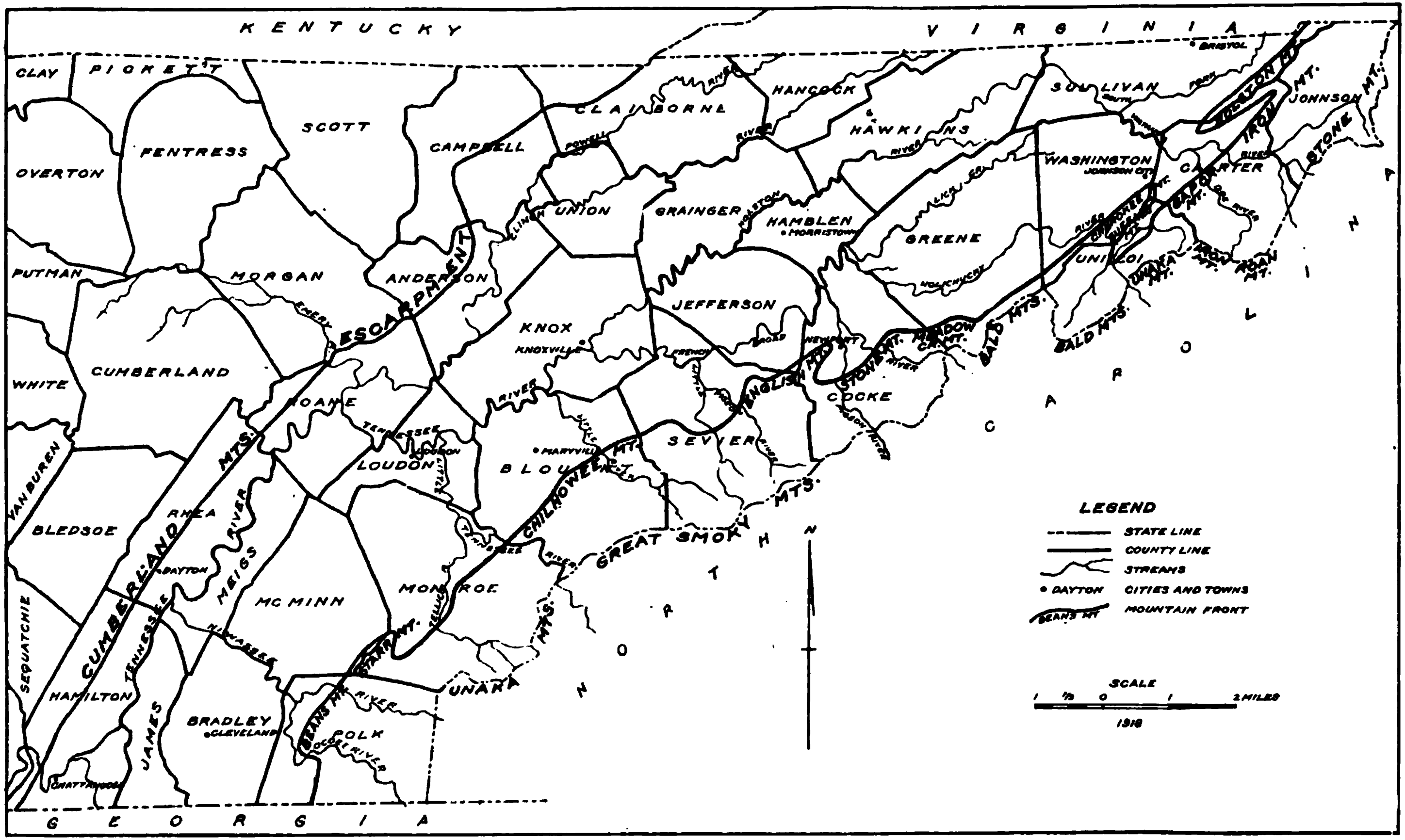

FIGURE 1. Map of East Tennessee showing the main drainage system, the front of the Appalachian Mountains, and the names of the principal mountain ranges.

Contents

List of Illustrations

Manganese Deposits of East Tennessee

By G. W. Stose and F. C. Shrader.[1]

Scope of Report

This report presents briefly the results of field work in East Tennessee by geologists of the U. S. Geological Survey in cooperation with and assisted by the State Geological Survey of Tennessee. All the operating mines and most of the prospects and known occurrences of manganese ore in this part of the State were visited, and the ore deposits were studied with a view to determining their relation to the underlying rocks and to the surface features. In the hope of stimulating the mining of manganese ore, and thus increasing the output of this mineral, so much needed in the steel industry during the prosecution of the present war, these geologists gave such professional assistance and advice as they could in the field to the operators of the mines and to the owners of property carrying manganese ore deposits. In this report are given not only a tabular statement of all the known deposits and descriptions of some of the typical mines, but suggestions are made as to where conditions may be favorable for further prospecting of the ore. In a later report in this quarterly the same writers expect to describe all the mines and prospects more fully and possibly give some definite recommendations for the prospecting of undeveloped tracts where detailed work will warrant it.

Acknowledgments.

In the examination of the manganese properties of the State the writers have been courteously received by the owners and operators, who gave every available assistance to the study of their mines and

[1]The field work in this area was done under a co-operative agreement between the State Geological Survey and the U. S. Geological Survey, the latter bureau being represented by Messrs. G. W. Stose and F. C. Schrader. This report is published by permission of the Director of the U. S. Geological Survey. The remainder of this report, consisting of a description of all mines and prospects, the manuscript of which is not yet completed, will appear in the October issue of the Resources of Tennessee. Mr. Arthur McFarlan, representing the State Geological Survey, assisted in this latter work.

properties. In many instances conveyance was furnished, accompanied by a man familiar with the property, which greatly facilitated the work. Special mention should be made of the Southern Manganese Corporation of Birmingham, whose President, Mr. Theodore Swann, arranged to have their representative at each mine and prospect, from Mountain City to Sweetwater. Assistance was rendered in return by the writers, who gave their opinion as to the ore and its relations and advice as to mining and further prospecting.

PREVIOUS WORK.

The occurrence of manganese ore in East Tennessee has been known for many years. Troost[1] refers to its occurrence in Cocke County as early as 1839. Safford[1*] in 1869 refers to its occurrence in several localities. Killibrew and Safford[2] in 1874 refer to deposits in Greene County. Bailey Willis,[3] in the Census report for 1880, gives analyses of samples of ore from Sevier and Carter counties. Penrose, in his report on manganese,[4] describes the deposits known in the State of Tennessee in 1890. Harder in his report of 1910[5] brings the information up to that date. Buchard in a report on the iron ores[6] refers to the occurrence of manganese with the iron ores of Monroe County. Nelson, in the first volume of the Resources of Tennessee,[7] calls attention to a new deposit in Tennessee. Purdue in the same publication for 1916,[8] reviews the known deposits of the State, and in the volume for 1918 describes another deposit in Bradley County. The present

[1]Troost, Gerard, Fifth Geologic Report on the State of Tennessee, pp. 22 and 23, 1840.

[1*]Safford, James M., Geology of Tennessee, pp. 224 and 505, 1869.

[2]Resources of Tenn.: State Board of Agric., pp. 268 and 400, 1874.

[3]U. S. Census Report, Mining Industries, Vol. 15, pp. 336 and 345, 1880.

[4]Penrose, R. A. F., Manganese, Its Uses, Ores, and Deposits: Ark. Geol. Surv. Ann. Rept. for 1890, Vol. 1, pp. 414-416, 1891.

[5]Harder, E. C., Manganese deposits of the United States: U. S. Geol. Surv. Bull. 427, pp. 72 to 76, 1910.

[6]Burchard, E. F., The Red iron ores of East Tennessee: Geol. Surv. of Tennessee Bull. 16, pp. 52-54, 1913.

[7]Nelson, Wilbur A., A new manganese deposit in Tennessee: The Resources of Tenn., Vol. 1, No. 6, pp. 220-228, 1911.

[8]Purdue, A. H., Notes on manganese in East Tennessee: Resources of Tennessee, Vol. VI, No. 2, pp. 111-123, 1916, and Vol. VIII, No. 1, pp. 46-47, 1918.

authors have made use of these earlier reports as well as those relating to similar deposits in Virginia.

GEOGRAPHY OF THE REGION.

SURFACE FORMS.

East Tennessee is partly mountainous, partly lowland. The Tennessee-North Carolina boundary for the most part follows the crest of one or another of the highest ranges of the Appalachian Mountains and has a general west-southwest direction. This crest is in part the watershed between Atlantic and Gulf drainage, but many of the larger tributaries of Tennessee River head in North Carolina and flow westward through deep gorges in the mountains. The Appalachian Mountains in this region comprise several high parallel ranges which are not of the same length but overlap one another and inclose deep reentrant valleys. These intermontane valleys open out into the Great Valley or Valley of East Tennessee, along the northwest foot of the Appalachian Mountains. In this valley are a few high knobs and single linear ridges which trend in the same general west-southwest direction. The east-facing Cumberland escarpment or edge of the Cumberland Plateau forms the western boundary of the Valley of East Tennessee.

Holston Mountain is the westernmost ridge of the Appalachian Mountains at the Virginia State line. It extends into Tennessee as a prominent mountain ridge over 4,000 feet high for 25 miles, terminating rather abruptly near Elizabethton. The narrow arm of the Great Valley which lies back of it is drained chiefly southwestward by Stony Run, but the upper part drains into Virginia. This shut-in valley draining northeastward is called Shady Valley. East of Stony Run and Shady Valley is another prominent ridge called Iron Mountain which also trends southwest and extends into Tennessee about 40 miles. Its southwestern part, however, is dwarfed and it generally dies down to such small hills that the names Gap Creek Mountain and finally Little Mountain are applied to it.

The main mass of the Appalachian Mountains lies still farther east and has various local names. Its main crest near the Virginia State line is called Stone Mountain. This is followed by the east boundary of Tennessee to the gorge of Watauga River. South of Doe River the crest is known as Roan Mountain, and is over 6,000 feet in altitude.

The State boundary turns westward here, following the crest of the range which is locally called Iron Mountain and further on Unaka Mountain and finally Bald Mountains. All of these mountains rise to about 4,500 feet in altitude. The main Bald Mountains bend sharply southwestward and form the mountain front in Greene County, where for a short distance the State line is not more than 3 miles from the Great Valley. The low irregular mountains which extend northeastward from this sharp bend in Bald Mountains merge into two distinct outlying ridges south of Johnson City called Cherokee and Buffalo Mountains, which correspond in position to Holston Mountain northeast of Johnson City. A reentrant arm of the Great Valley, similar to that of Stony Run, extends southwestward between Buffalo Mountain and Unaka Mountain and terminates above Erwin near Nolichucky River where the mountains close in.

Southwest of French Broad River the State boundary line follows the crest of the Great Smoky Mountains, a massive range which rises to an altitude of over 6,000 feet. Southwest of Little Tennessee River this great mountain range is known as the Unaka Mountains, but on the earliest maps of the region Unaka and Great Smoky were both applied to the whole of these higher ranges of the Appalachian Mountains. Where the high mountains break down at Hiwassee River the State line turns south directly to the Georgia State line. The mountainous tract northwest of the Great Smoky and the Unaka Mountains consists mostly of irregular ridges having local names, but English Mountain, southwest of Newport, and Stone, Neddy, and Meadow Creek mountains northeast of Newport form a more or less continuous frontal or outlying ridge corresponding in a general way to Holston Mountain. Chilhowee Mountain, which extends from Little Pigeon River to the Little Tennessee south of Knoxville, is a similar though less prominent outlying ridge, and Starr and Beans mountains are other outlying ridges near the southern boundary of the State.

DRAINAGE.

East Tennessee is drained practically throughout by Tennessee River. (See figure 1.) A very small part of the extreme southeast corner drains southward through the Conasauga River into the Gulf of Mexico. The small part of the northeast corner which drains northward into Virginia is in the Holston drainage system, a branch of the

Tennessee. Although the name Tennessee River is applied only to the river below Knoxville where the Holston and French Broad unite, the Holston above that point is the direct continuation of the main stream which flows in a general southwest course. Holston River heads in Virginia and its two main branches unite at Kingsport. Its North Fork lies almost wholly in Virginia. Its South Fork, which enters the State east of Bristol, is joined from the east by Watauga River 25 miles from the State line. The latter river and one of its main tributaries, Elk Creek, head in the mountains in North Carolina. With Doe River, another main tributary, they drain most of Carter and Johnson counties.

The French Broad River heads in the mountains of North Carolina and flows westerly. It is first joined from the south by Pigeon River, and then from the north by Nolichucky River, both of which head in North Carolina. The latter has a long tributary from the northeast, Lick Creek, which lies entirely within the valley and is a direct continuation of the main southwestward-flowing part of the Nolichucky and French Broad. Farther down stream, the French Broad is joined from the south by Little Pigeon River, which heads within the State and drains much of Sevier County.

A short distance below Knoxville, Tennessee River is joined from the south by Little River, which heads in the Great Smoky Mountains. Farther down stream, it is augmented by the Little Tennessee, a large stream which heads far back in the mountains of North Carolina and in the high mountains flows in a deep gorge which separates the Great Smoky and Unaka mountains. Its main branch, Tellico River, drains a large part of eastern Monroe County and joins the Little Tennessee near Morganton.

Hiwassee River is the main branch of the Tennessee in the southern part of the State. It heads in North Carolina and its main tributary, Ocoee River, heads in Georgia, and together they drain most of Polk County in the southeast corner of the State. A small part of the county is drained south to the Gulf by Conasauga River, as previously described. Just above Chattanooga the Tennessee is joined from the south by Chickamauga Creek, which heads in Georgia and drains but a small part of Tennessee.

All the above described tributaries of the Tennessee enter it from the east and therefore receive the run off from the Appalachian Moun-

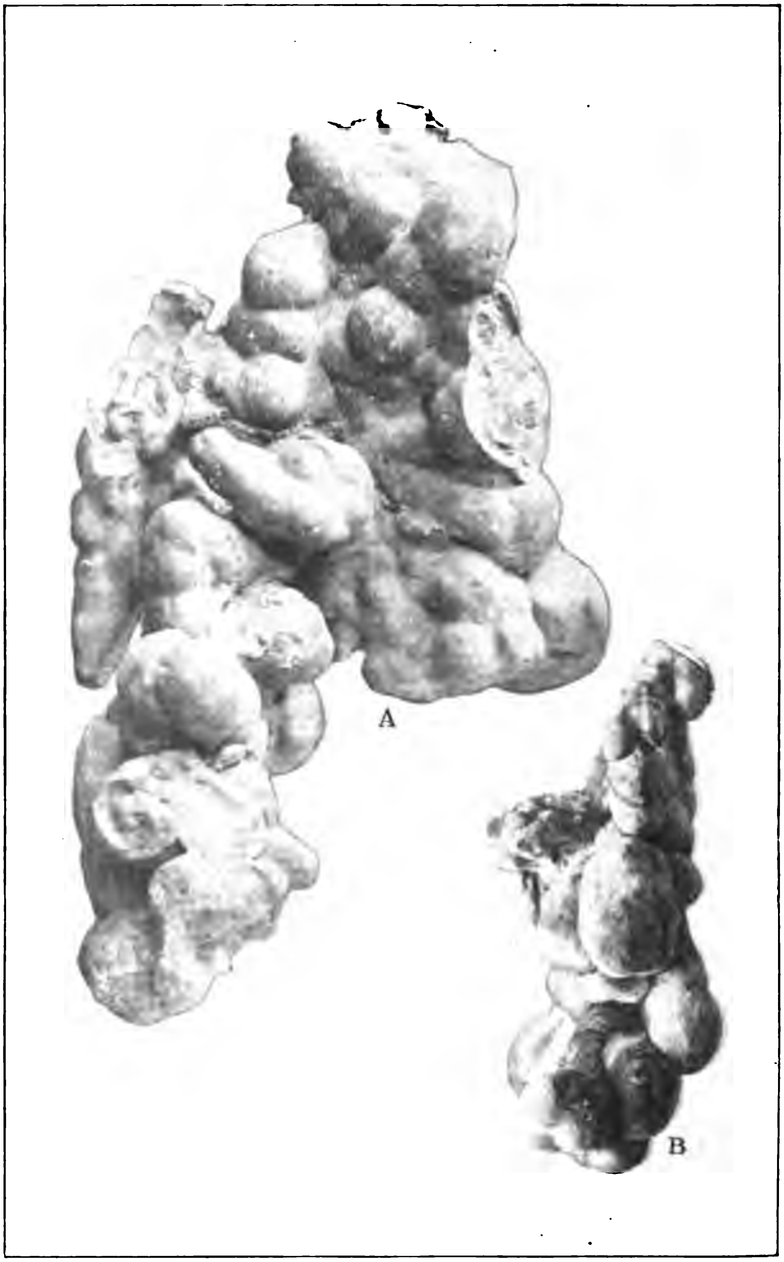

FIGURE 2. Nodular manganese ore, called grape ore, from Shouns' prospect near Mountain City, Johnson County.

tains. They are large streams and have steep gradients, so that they represent great potential water power. Some of this power is now being converted into electricity which is transmitted to distant parts of the State and is being utilized to light many of the larger cities and to furnish power to many industries. A new industrial South awaits the further development of the latent powers of these waters.

The only stream of any size which enters the Tennessee from the northwest is Clinch River. It heads in Virginia and flows southwestward. It is joined from the north by Powell and Emery rivers before it unites with the Tennessee near Kingston.

The Manganese Deposits.

Most of the known manganese deposits of East Tennessee consist of heavy, black, hard minerals which somewhat resemble iron ore in appearance and occurrence and are therefore frequently called black iron ore or steel ore by farmers. These minerals are oxides of manganese and occur most commonly in small masses in the soil and underlying clay, where they are discovered in plowing or in road cuts, or are found as float scattered over the fields. Within the clay they appear as scattered irregular masses ranging in size from minute particles to that of a bushel basket or larger, occurring as botryoidal masses, or rounded nodules, and are then called "nut" ore. The nodules may be united into clusters resembling bunches of grapes and then constitute "grape" ore. (See fig. 2.) Ore that is scattered through the clay must be washed to remove the clay and other impurities and is generally spoken of as wash ore. At and near the surface pebbles and fragments of rocks, usually quartzite and sandstone from the mountains, are mixed with the ore in the clay and must be washed away with the clay or must be removed by hand picking after washing. Some of the masses of manganese oxide ore are large enough to be mined as lump ore and are hand picked and shipped without washing. Other masses fill crevices and seams in sandstone and chert and the rock must be crushed and the ore separated by log washer or other machinery, or by hand picking. Only one deposit is known in the area in which the ore is not a manganese oxide. This ore, which is a carbonate of manganese, is light gray to white and the crystalline portion resembles coarse limestone in appearance but is heavier than limestone. It occurs as layers or lenses in solid bedrock.

Manganese Minerals.*

The manganese-bearing ores of the eastern United States fall into two general groups—manganese ores and manganiferous iron ores. Both of these occur in the Appalachian region of Tennessee. The manganese ores are of much greater value than the manganiferous iron ores and therefore in the past have been chiefly sought, but the greatly increased demand for manganese has caused a growing demand for manganiferous iron as well as manganese ores and these are now being mined in a number of localities in East Tennessee.

The manganese ores in this region are chiefly oxides, four of which are commonly present and will be here described. They belong to the group of brown to black oxides and hydrous oxides, several of which cannot be positively distinguished without analyses. In general a manganese mineral that is non-crystalline or amorphous and is hard is provisionally classed as psilomelane. One that is crystalline and fairly hard is classed as manganite, but if soft it is regarded as pyrolusite. If it is soft and shows no sign of crystalline structure nor of the compact firm amorphous structure of psilomelane, it is classed as wad. The following descriptions are in part summarized from Hewett[1] with modifications and additions.

Psilomelane.—Psilomelane (H_4MnO_5) generally with some K and Ba) is a bluish or grayish black dense amorphous mineral, usually having rounded or botryoidal surface form, concentric and somewhat radiate structure, and conchoidal fracture. A characteristic botryoidal form is illustrated in fig. 2. Psilomelane has a hardness of 5 to 6 (cannot be scratched with a knife), and a specific gravity of 3.7 to 4.7. Its composition is complex and apparently not definite. It always contains water, the quantity of which varies from 2.5 to 6 per cent, and it may contain as much as 17 per cent of barium and 5 per cent of potassium. These elements are believed by some to be mechanically admixed and not chemically combined. The percentage of manganese varies from 50 to 57. This is one of the commonest

*A simple way to distinguish manganese ores, from iron ores, in the field is by making a mark on a piece of white chert or quartz pebble with the ore to be determined. Manganese makes a black mark. Iron in the form of hematite makes a red mark, or in the form of limonite a yellowish brown mark. Iron containing some manganese generally makes a brownish black mark.—W. A. N.

[1]Hewett, D. F., Loc. cit., pp. 39 and 40.

manganese minerals in the Tennessee deposits and forms more than 75 per cent of the washed ore.

Manganese.—Manganese ($Mn_2O_3.H_2O$) is a heavy, black, generally crystalline mineral. It has a hardness of 4 (moderately hard), and a specific gravity of 4.2 to 4.4. It craystallizes in the orthorhombic form and the crystals are generally bladed, wedge-shaped, or needle like. The crystals are black, and brilliant and metallic in appearance. The needle-like crystals in "needle ore" are generally arranged radially and some form complete balls more than 2 inches in diameter. (See fig. 3.) In other needle ore the silky crystals are parallel, and are over 2½ inches long. The mineral contains theoretically 62.4 per cent of manganese and 10.3 per cent of water. It is frequently associated with psilomelane in the Appalachian deposits, in which case it generally lines cavities in the psilomelane ore. Its presence is generally regarded as an indication of high grade ore.

Pyrolusite.—Pyrolusite (MnO_2, generally with a little H_2O) is a grayish black to black mineral with crystalline or granular structure. It is decidedly soft, having a hardness of 2 to 2.5 (can be scratched by the finger nail), and a specific gravity of 4.8. Its color is steel gray, as distinct from the black of manganite. Some of the ore classed as pyrolusite, including certain soft powdery graphite-like ore, is of much lower specific gravity. Pyrolusite contains theoretically 63.2 per cent of manganese. It is believed to have been derived from manganite by the loss of water, and is known to have been so formed in specimens where the radiate crystal form of manganite is preserved although the mineral has become soft, light in weight, and steel gray or dull gray in color. Much of the mineral that has heretofore been identified as pyrolusite in the Appalachian deposits has the crystalline form and hardness of manganite. Chemically, however, it appears to be intermediate between the two minerals.

Wad.—Wad is a dark, very soft earthy mineral which is a mixture of manganese oxides, water, and other materials, such as clay, iron and barium. It is generally a loosely coherent brown or black powder, not sharply distinguished from the manganiferous clay with which it is usually associated. It contains from 30 to 42 per cent of manganese and 7 to 10 per cent of water, whereas the manganiferous clay carries only 5 to 10 per cent manganese.

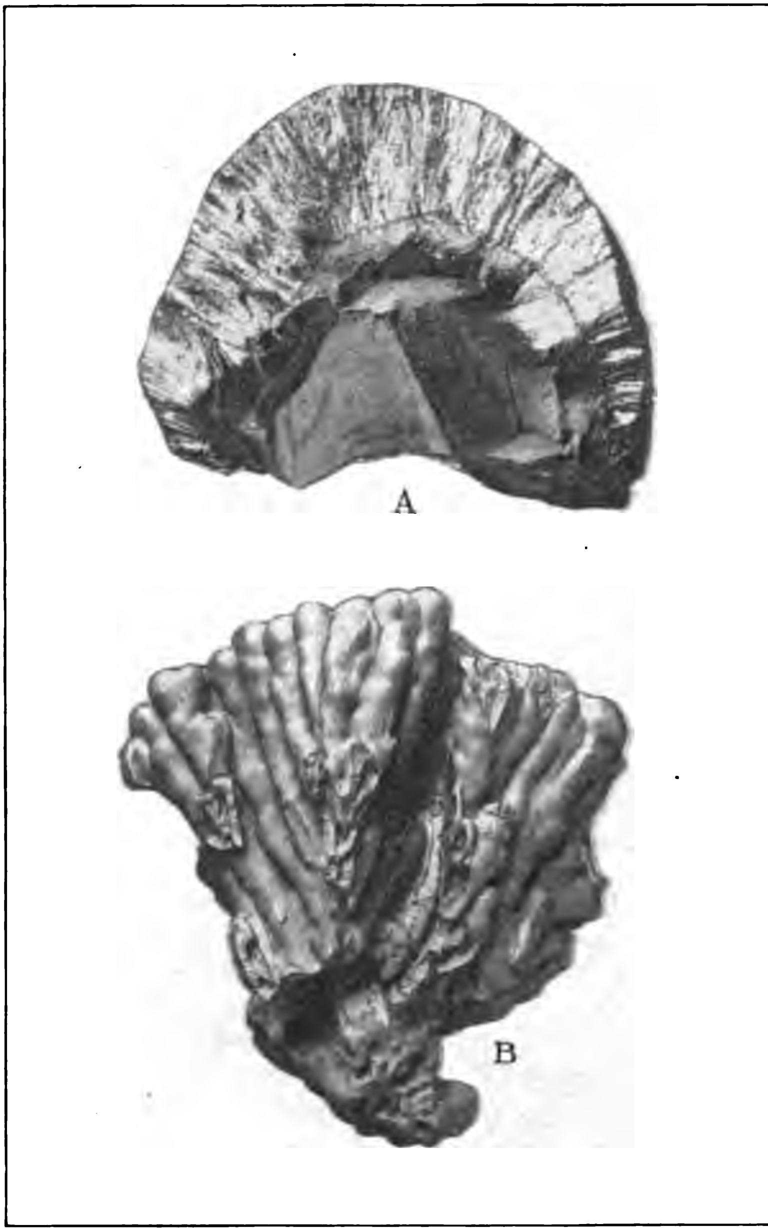

FIGURE 3. a, Needle ore. A shell of radiate needle crystals of manganite surrounding a nucleus of psilomelane. Embree mine, Bumpass Cave, Unicoi County.

b, Radiate cluster of "stalactitic" rods of psilomelane. Dry Run mine, Johnson County.

Manganiferous Iron Ores.—The manganiferous iron ores of the Appalachian region are simply mixtures of manganese oxides with iron ore in various proportions. The iron ore is generally brown ore ($Fe_2O_3+H_2O$) and contains a variable amount of water. The manganese is generally in the form of psilomelane, though manganite is common in some places. The iron and manganese oxides occur both as a mixture of the two minerals each readily distinguishable in the hand specimen and a mixture or compound in which the minerals are so intimately and minutely mixed that it is impossible to tell whether it is a mechanical mixture or a chemical combination. The amount of manganese in manganiferous iron ore varies from 1 to over 40 per cent. The higher grades are used in the manufacture of spiegleisen and ferromanganese, and the lower grades, down to 3 per cent, are used in the manufacture of high-manganese pig iron.

Rhodochrosite.—Rhodochrosite ($MnCO_3$) is a pink mineral, generally crystalline with a cleavage like calcite, but differing from that mineral in color and higher specific gravity. It has a hardness of 4, specific gravity of 3.6, and contains theoretically 48 per cent of manganese.

The crystalline mineral that resembles rhodochrosite, which is present in East Tennessee in only one deposit so far as known, is white and occurs in a mass made up of small rhombic crystals. An analysis of the crystalline rock shows the presence of considerable calcium and magnesium and the mineral is probably a calcium-magnesium-manganese carbonate not heretofore described. The analysis shows it to contain only 9 per cent of manganese. With the crystalline mineral is an amorphous or minutely crystalline substance, white to buff banded, containing thin laminae of a black metallic mineral, probably psilomelane. This banded material is apparently of later origin than the crystalline mass, and is also a manganese mineral, probably a carbonate like the crystals. An analysis of the banded white portion shows it to contain 26 per cent manganese and considerable calcium.[1]

---

[1]It should be stated in connection with the above description of manganese minerals that on account of impurities in the minerals themselves, and of the presence of foreign material such as rock fragments, clay, and sand associated with the ores a deposit never yields the full percentage of manganese that the predominant minerals theoretically contain.

Mineral association.—In many of the deposits of the Appalachian region psilomelane nodules are inclosed in wad and may have been formed from it by the reduction of its contained water. Many nodules of psilomelane, however, are shown on polished section to be composed of alternate thin layers of hard psilomelane and softer ore, probably manganite. Manganite also lines cavities and fills sharply defined veinlets in psilomelane, and it is here clearly later in origin. As manganite is more hydrous than psilomelane, there is shown to be no uniform order of deposition from the more hydrous to the less hydrous or *vice versa.* However, the observed alteration of manganite to pyrolusite and the supposed change of wad to psilomelane indicate progressive dehydration after their formation.

The clay in which the manganese ores occur is generally highly colored yellow to deep red by iron oxide, but some is gray to black with manganese where it merges into wad. Limonite and manganiferous iron ore are often intimately mixed with the purer manganese ores, but are more plentiful in the superficial layers associated with the sand and gravel wash. The iron ores are therefore apt to be siliceous and some are highly siliceous. Sericite is a common constituent of the metamorphosed shales associated with the bedrock and is present in some of the clay associated with the ore, but most of the clay close to the ore is free from it.

There are grains of quartz in the ore-bearing clay, especially in the superficial layers, which are residual from the decomposition of quartzose rocks, but quartz also occurs in other forms which are evidently secondary and was deposited after the decomposition of the rock. A microcrystalline variety occurs as thin veinlets in the clay and in places it forms rounded nodules up to 2 inches in diameter. Quartz also occurs in some deposits as minute doubly terminated needle-shaped crystals containing rounded nuclei of calcite. Bauxite and wavellite are associated with the manganese in a few places.

Rocks With Which the Ore is Associated.

The manganese deposits are associated with different groups of rocks in the different parts of the State, and the determination of the relation of the deposits to these groups of rocks is of much importance in the study of the deposits for the purpose of giving aid to mining or advice for further prospecting.

There are 8 modes of occurrence of the manganese ores in this region, based chiefly on the rocks with which they are associated, and therefore the rocks that occur in East Tennessee will first be briefly described.

The rocks of the region are chiefly limestone, sandstone, and shale which occur in layers one above the other in apparently no particular order or arrangement and are tilted at various angles from horizontal to vertical. They are called sedimentary rocks because they were originally sediments, such as sand, mud, and calcareous silt, deposited from water. On close study the various layers are found to have certain characters by which they may be identified, and each layer occupies a particular position with respect to the others. They have thus been classified and arranged one above the other in the order in which they are found in the rock exposures, and those which are at the bottom are the oldest, as they were deposited first.

The oldest rocks present in East Tennessee are crystalline rocks on which the sediments rest. These crystalline rocks include granite and allied rocks and schists, some of which were once lavas. They occur only in the Appalachian Mountains on the eastern border of the State. Although some manganese deposits occur in similar rocks in Virginia, none are known to so occur in Tennessee.

Overlying the crystalline rocks is a thick series of hard sandstones (called quartzite, grits, and conglomerates) and finer grained hard rocks such as slates and shales. A few thin layers of impure limestone and limy shale occur with some of the slates. These rocks are more resistant to erosion and solution than are the younger limestones and shales and therefore they form much of the Appalachian Mountains in the extreme eastern part of the State. There are many rock layers or formations which have been distinguished and named in this series but it is not necessary to give their names here. However, the uppermost formation of the series, a white sandstone or quartzite called the Erwin quartzite in places and the Hesse quartzite in others, is here referred to because one of the classes of manganese deposits occurs in the residual clays close to its top.

Overlying these sandstones and slates is a great thickness of limestones in which are a few shales and softer sandstones. These beds are in general rather soluble and are worn away faster than the harder sandy rocks previously described and therefore occupy low lands which lie northwest of the Appalachian Mountains and form part of the Valley of East Tennessee. The limestone at the base of this series is a coarse limestone which is called a dolomite because it is composed of both calcium and magnesium carbonates. It is readily soluble in the surface waters and therefore is represented by clay residue from its impurities in most places. As one of the classes of manganese deposits is closely associated with this rock or formation, the name Shady dolomite, by which it is generally known, will be used here. Next above is a clayey shale formation in which hard purple shale and calcareous shale and sandstone generally occur and because of their greater resistance to weathering than the adjacent limestones they form low hills. This formation also carries manganese deposits in certain parts of the State. It is known as the Watauga shale.

The limestones directly above the Watauga shale contain chert or flint nodules and these masses abound in the soil derived from this lime rock. As the chert masses are in many places seamed with manganese oxide and fragments of this manganese ore occur in the residual soil from the limestone, this formation will be referred to by its long-established name, Knox dolomite.

The upper beds of the limestone series are generally a gray to reddish crystalline limestone in East Tennessee. Some of the beds are of the proper texture to be called a marble and constitute the Tennessee marble for which the vicinity of Knoxville is noted. This crystalline limestone and other associated beds, some of which are shaly, argillaceous, and nodular to pure, blue, dense limestone, has been called the Chickamauga limestone and the marble layers are called Holston marble. Some of the best deposits of manganese occur at the contact of the marble with overlying red sandy limestone which weathers to porous sandstone and is known as Tellico sandstone. These formation names will therefore be used in the description of the ore deposits.

In the southwestern part of East Tennessee the limestone series is overlain by a thin black shale and this by white chert or cherty limestone. The latter contains in places manganese deposits, and its name, Fort Payne chert, will be used in the description of the deposits. In the table on page 26 the various formations are given in their proper order and the characteristics of each are briefly described.

Generalized Table of Geologic Formations in Areas Where Manganese Occurs in East Tennessee.

<table>
<tr><th>System</th><th colspan="2">Formation</th><th>Character of Rocks.</th></tr>
<tr><td>Carboniferous</td><td colspan="2">Fort Payne chert</td><td>Thin bedded chert.</td></tr>
<tr><td>Devonian</td><td colspan="2">Chattanooga shale</td><td>Black shale.</td></tr>
<tr><td>Silurian</td><td colspan="2">"Rockwood" formation</td><td>Sandstone and shale.</td></tr>
<tr><td rowspan="5">Ordovician</td><td colspan="2">Sevier shale</td><td>Yellow argillaceous shale and calcareous shale.</td></tr>
<tr><td>Tellico sandstone</td><td>Moccasin limestone</td><td>Red sandstone and sandy limestone.</td></tr>
<tr><td colspan="2">Athens shale (in places)</td><td>Fissile shale.</td></tr>
<tr><td colspan="2">Holston marble (in Chickamauga limestone)</td><td>Buff to red marble.</td></tr>
<tr><td colspan="2">Chickamauga limestone</td><td>White crystalline limestone, blue limestone, and shaly limestone.</td></tr>
<tr><td>Ordovician and Cambrian</td><td colspan="2">Knox dolomite</td><td>Massive dolomite and limestone, with nodular chert.</td></tr>
<tr><td rowspan="5">Cambrian[1]</td><td colspan="2">Nolichucky shale</td><td>Shale and thin bedded limestone banded with sandy layers.</td></tr>
<tr><td>Honaker limestone</td><td>Maryville limestone
Rogersville shale
Rutledge limestone</td><td>Limestone, dolomite, and thin shales.</td></tr>
<tr><td>Watauga shale</td><td>Rome formation</td><td>Purple sandy shale and sandstone, with some limestone.</td></tr>
<tr><td colspan="2">Shady dolomite</td><td>Light dolomite, largely coarse granular.</td></tr>
<tr><td>Erwin quartzite</td><td>Hesse quartzite</td><td>Hard white quartzite, containing scolithus tubes, and some shale.</td></tr>
</table>

[1]The upper part of this section represents conditions in the area west of Cleveland in Southeastern Tennessee, where the black shale (Chattanooga) is believed by some, including the writers, to be of carboniferous age. In northeastern Tennessee other formations of Silurian, Devonian, and Carboniferous ages lie above the Sevier shale, but are not referred to in this report.

System.	*Formation*		*Character of Rocks*
Cambrian	Hampton shale	Murray slate; Nebo quartzite; Nichols slate	Dark shale, slate, and quartzite.
	Unicoi formation	Cochran conglomerate; Hiwassee slate; Snowbird formation	Coarse arkosic sandstone, quartzite, conglomerate, and slate.
Pre-Cambrian	Granite and schist		Granite and schist.

Type of Deposits.

There are many kinds of manganese ore deposits in eastern Tennessee, but they may be grouped under eight types, depending chiefly on the groups of rocks with which the deposits are associated. These will be briefly described in the general order of the frequency of their occurrence, as follows:

1. Deposits in Shady dolomite.
2. Deposits in Watauga shale.
3. Deposits in Knox dolomite.
4. Deposits on Holston marble.
5. Deposits in Fort Payne chert.
6. Deposits along fault planes.
7. Deposits in terraced stream gravels.
8. Carbonate ores in the older dolomite.

The distribution of the areas in which each type of deposit prevails in East Tennessee is shown in figure 4. The fault and terraced stream gravel types cannot be shown, as they do not occur in prescribed areas.

STATE OF TENNESSEE
STATE GEOLOGICAL SURVEY
Wilbur A. Nelson, State Geologist

UNITED STATES GEOLOGICAL SURVEY
George Otis Smith, Director

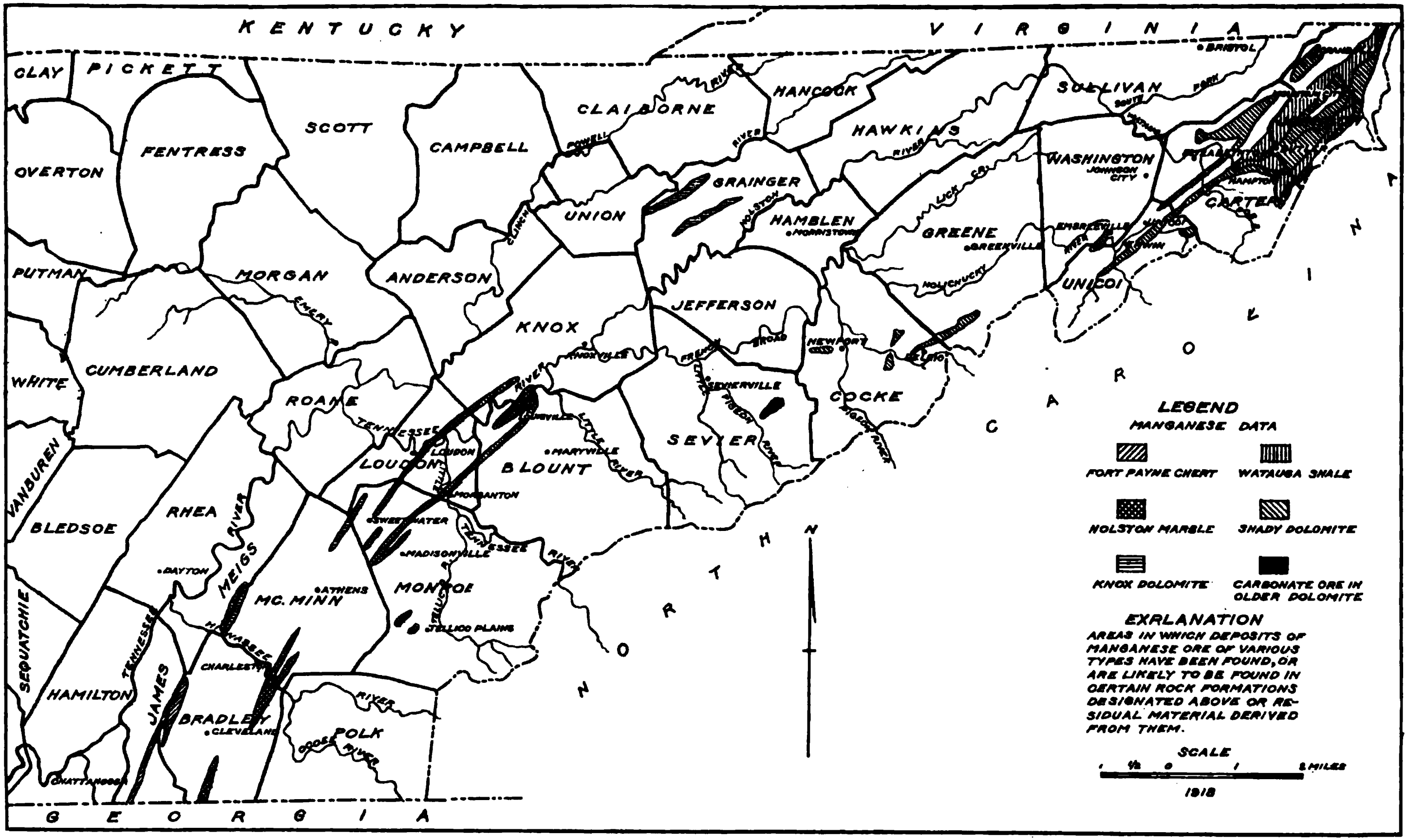

FIGURE 4. Map of East Tennessee showing distribution of areas in which certain types of manganese deposit occur.

DEPOSITS IN SHADY DOLOMITE.

Throughout Virginia and parts of eastern Tennessee manganese ores occur in the clays which are residual from the impure basal limestones of the Shady dolomite. Between the typical dolomite of the Shady and the uppermost white quartzite beds of the underlying Erwin are transition beds of various kinds, which, because they are partly soluble or readily weather to clay and soil, are generally classed with the Shady dolomite, which also usually weathers to clay. These transition beds are therefore seldom exposed, but in Stony Creek and Shady valleys in northeastern Tennessee and in portions of southwestern Virginia their character is well shown. They are about 100 feet thick and embrace yellow finely laminated clays, which evidently were originally calcareous shale, and shaly arkosic sandstones, some stained red and purple with iron, others of a greenish color due to contained glauconite grains. At the top are rusty, coarse grits of rounded quartz grains, from which the former calcareous cement has been mostly dissolved, leaving the bed a porous layer or a loosely coherent mass of quartz grains, in many places stained black with manganese or rusty with iron.

The manganese ores in the Shady dolomite are composed largely of masses of psilomelane scattered through the residual clay. Many of these masses are of irregular shape, but some are botryoidal and nodular. In some places cavities in the psilomelane are lined with crystalline manganite. Rarely the manganite forms distinct balls and rounded masses of radiate needle ore. Nearly all the ore must be washed to free it from the sticky clay. The ore when present in the adjacent quartzite must be crushed and the quartzite separated by washing or some other process. The ore that generally occurs in the wash overlying the residual clay is usually both ferruginous and highly siliceous, as it contains grains and pebbles of quartz that cannot readily be removed. Much of this must be rejected as of too low grade.

The manganese deposits associated with the Shady dolomite lie in clay derived from impure laminated limestones directly overlying the transition beds, and it is believed that the ore-bearing solutions came from these transition beds, in which manganese was originally disseminated with the other heterogeneous sedimentary materials. As described in more detail in previous reports on the manganese deposits of Virginia[1] the ore in most cases accumulated on the edges of the inclined beds at the base of the Shady dolomite which outcrops along the foot of ridges composed of Erwin quartzite which in turn dips beneath the Shady dolomite. Where the rocks are folded into gentle troughs parallel to the foot of the ridges so that the descending ore-forming solutions following the surface of less impervious layers were concentrated along their bottom, the deposits of manganese ore in the overlying clays are generally of greater thickness and value. Such is the case in the noted Crimora mine near Basic, Va. The quartzite beds in the adjacent Erwin quartzite are in places seamed and brecciated and the particles cemented together with manganese oxide. Some of the quartzite is also replaced by the ore. Although such deposits should properly be classed by themselves, they are of so little value in Tennessee and are so closely associated with the deposits in the Shady dolomite that the few that occur will be described under this type.

Manganese deposits in the Shady dolomite occur at many places along the west foot of the Appalachian Mountains in East Tennessee and on both sides of coves and re-entrant valleys within the mountains where the Shady dolomite lies at the foot of the steep slope of the Erwin quartzite ridges in the position just described. The deposits are, of course not continuous along this dolomite-quartzite contact as their accumulation in this position depends on the quantity of the manganese minerals originally present in the adjacent rocks, on the steepness of dip of the rocks, on the extent of decay of the bedrock, on the slope of the surface of the bedrock or its residual clay and the cover of wash on that surface through which the ore-bearing solutions could percolate slowly, for the ore is deposited more freely where the solutions move slowly. They are of course not present where the rocks have been faulted so that the dolomite is absent or is deeply buried.

In Shady Valley, Johnson County, the Erwin quartzite dips gently beneath the Shady dolomite from both Holston Mountain on the west and Iron Mountain on the east and the favorable conditions are evi-

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[1]Hewett, D. F., Some manganese mines in Virginia and Maryland, U. S. Geol. Survey Bull. 640, pp. 37-71, 1916; Hewett, D. F., Stose, G. W., Katz, F. J., and Miser, H. D., Possibilities for manganese ore on certain undeveloped tracts in Shenandoah Valley, Va., U. S. Geol. Survey Bull. 660, pp. 271-296, 1918; and a forthcoming report of the Geol. Survey of Va. by the same authors on The Manganese deposits along the foot of the Blue Ridge, Va.

denced by deposits of manganese on both sides of the valley, several of which have been prospected and mined. The dips are more gentle and therefore conditions more favorable for the deposition of ore on the western side. This basin is terminated at the north and south by the gentle rising of the strata in these directions. Minor longitudinal folding at the north end of the basin divides it into two troughs in the vicinity of Crandull. At these rising ends of the trough, conditions are most favorable for commercial deposits.

Southwest of Shady Valley, in the valley of Stony Creek, Carter County, which also lies between Holston and Iron mountains, similar geologic conditions prevail, but the deposits that have been discovered there are not so rich as those in Shady Valley. The ore-bearing formation extends to Keesburg on the west side of the valley and to Blue Springs on the east side of the valley. This eastern belt of the Shady dolomite follows along the northwest foot of Iron Mountain to Valley Forge and thence along the foot of Gap Creek Mountain and Little Mountain, the southwestward continuation of Iron Mountain, nearly to Unicoi, where it is terminated by a fault.

On the northwest side of Stone Mountain and on the slopes of the outlying ridges of Erwin quartzite in Johnson County, favorable geologic relations occur at many places, but most of the deposits of this type that have there been explored are small. Southwestward the deposits along the belt increase in value and have been mined at several places at the northwest foot of Stone Mountain in Carter and Unicoi counties from Cardens Bluff to Erwin, beyond which the Shady dolomite is cut out by faulting. In Bumpass Cove, a limestone valley shut in by mountains, the geologic relations are favorable only along the northwest side where the Erwin quartzite dips southeast under the Shady dolomite of the Cove.

Due to great faulting along the northwest front of the Appalachian Mountains from Erwin southwest to the State boundary the Shady dolomite and Erwin quartzite do not occur in their normal relations at the foot of the mountains. On the south side of Meadow Creek Mountains in the southern part of Cocke and Greene counties, the geologic conditions are locally favorable for the occurrence of ore but the few deposits that have been prospected there and at the east end of the mountain are apparently small. Again on the north end of English Mountain in Sevier County, deposits are being mined at the base of the Shady dolomite, where geologic conditions are again locally favorable.

DEPOSITS IN WATAUGA SHALE.

In the extreme northeastern part of Tennessee, as in the adjoining southwestern part of Virginia, deposits of manganese ore occur in the soft disintegrated beds of Watauga shale at certain places. Such deposits have been worked in Johnson County northeast of Mountain City, and in Doe Valley southwest of Mountain City, and have been prospected and mined on a small scale in both Johnson and Carter counties near Butler. The ore is largely psilomelane, but much of it is fine needle ore, manganite changing to pyrolusite. It fills pockets in the yellow clay and replaces porous, disintegrated yellow sandstone.

As the structural relations of the deposits in the Watauga shale have not been fully determined, little can be said at this time as to where other workable deposits of this type may be found. Those deposits which have been studied seem to be associated with basins or troughs in the shale. Therefore the central part of Doe Valley, which is a broad syncline, and the region south and west of Butler, where synclinal or trough-shaped folds occur, both of which are areas in which manganese ore has already been found in commercial quantities, are apparently the most favorable places to search for ore.

DEPOSITS IN KNOX DOLOMITE.

The chert in the Knox dolomite is stained black with manganese oxide at many places. Some of the chert masses have been broken up into fragments which are cemented together by manganese oxide and in part replaced by the ore, so that some masses of ore of large size may be formed in this manner. The chert and ore are set free by the weathering of the limestone and are found in the residual clay soil on the slopes of chert hills. Most of the ore in the chert is hard psilomelane, and some of the residual masses are very pure heavy ore with crystalline manganite in crevices. Nodular psilomelane (nut and grape ore) coated with red iron oxide also occur in the associated clay.

Ore in the Knox dolomite has been found throughout the valley of East Tennessee and it has been prospected at many places. One is apt to be misled by finding one or two large chunks of ore, often of high grade, and conclude that a workable deposit exists. Few deposits of promise have been opened in ore of this type, and such as are being mined, as the one near Rutledge, are at the contact of the

Knox dolomite and a shale, so that conditions are somewhat favorable for the accumulation of ore.

DEPOSITS ON THE HOLSTON MARBLE.

Marble beds, called the Holston marble, occur in the Chickamauga limestone at most places in East Tennessee but are not generally accompanied by manganese ore. Where the marble is thin and is overlain by red calcareous sandstone, called Tellico sandstone, high grade iron ore and some manganese ore generally occur. This is believed to be due to the irregular relations between the Tellico sandstone and Holston marble representing a break in the process of sedimentation between the deposition of lime silt and the overlying sand, at which time land conditions probably prevailed. (See Fig. 7a.) Such a break in sedimentation is called an unconformity, and such conditions are generally accompanied by the deposition of unusual material, the waste from the weathering of older sedimentary rocks that formed the old land surface. In this instance iron and manganese minerals were probably disseminated in the unconformable basal Tellico sediments and when the Tellico sandstone weathered and the soluble lime carbonate was dissolved out of it near the surface, the iron and manganese were concentrated by solution and redeposition in certain layers and formed beds of ore. Some of these beds of ore are found interbedded with the sedimentary rock and the impressions of the fossils of the original rock are preserved in the ore, but most of the ore is in loose masses in the residual sandy clay resting on the marble. The manganese ore is very pure psilomelane and crystalline manganite, and in most cases can be hand picked and shipped without washing. The associated iron ore is a high grade red hematite, including both fossil ore and fine shiny-pebble ore.

The only known occurrences of manganese ore in the Holston marble are in the vicinity of Sweetwater, Cleveland, and Louisville. Several belts of marble overlain by the Tellico sandstone occur east and south of Knoxville and small pieces of ore are found in the overlying soil, but only in a few places, chiefly in the vicinity of Sweetwater, have deposits of commercial value thus far been developed. In Monroe County between Sweetwater and Philadelphia several rich deposits have been opened, and on another belt 6 miles to the east other deposits have been worked in Monroe and Loudon counties. Further search along these zones of contact of the Holston marble and

Tellico standstone is urged, as other similar deposits are likely to occur. The Sweetwater belt is cut off by a fault at Sweetwater but reappears 6 miles south of Cleveland where it is again ore bearing and the ore belt continues out of the State into Georgia.

DEPOSITS IN THE FORT PAYNE CHERT.

The Fort Payne chert, where it makes low ridges in the southern part of the State, is impregnated in places with manganese oxide. The ore fills cracks and crevices in the chert ledges and in part replaces the chert itself, so that masses of ore of considerable size occur. On the slopes of the ridges the fragments of chert cover the surface and with them are accumulated the ore which had been set free by the weathering of the chert. Some of the manganese oxide also has been redeposited in the clay and loose material on the slope and some of these deposits are of workable size. The ore in the chert is bright psilomelane, and most of the ore in the residual clay is also psilomelane, in part nodular. At Walnut Grove, in Alabama, very rich needle ore and soft pyrolusite have been mined in residual clays at this horizon, but none have been observed in Tennessee.

Deposits in the Fort Payne chert have been mined and prospected in the White Oak Mountains west of Cleveland, and the same geologic conditions continue along the southeast side of these mountains into Georgia, and other deposits may be discovered in this undeveloped territory.

DEPOSITS ALONG FAULT PLANES.

Iron and manganese ores are deposited in the rocks adjacent to fault planes. Minerals scattered through the rocks are dissolved by circulating waters, which then rise along the fault planes, and the ores are deposited in brecciated zones, porous strata, or clays at or near the surface. Many of the deposits in the ore-bearing zones previously described may have been in part due to circulation of solutions along fault or joint planes, but only those are here referred to which are known to have been largely determined by this process. The character of the ore is controlled largely by the associated rocks.

There are many bedding or strike faults in East Tennessee whose outcrops follow the general trend of the rocks, and many are marked at the surface by belts of siliceous iron ore and ferruginous chert. Workable bodies of iron ore on fault planes have been mined at several places in the past and a few prospects of manganese ore are located on faults. The only manganese mine known to be located on a fault in East Tennessee is at Taylor Valley northeast of Mountain City. Other deposits of value may exist and can be sought by prospecting along the faults which are so common in the area, but the likelihood of finding workable deposits is not encouraging.

DEPOSITS IN TERRACED STREAM GRAVELS.

Nearly all manganese deposits include in their upper part a layer of surficial clay and mountain wash in which some ore is deposited. Only those deposits which occur in gravels and sand of stream origin and which do not continue down into the underlying bed-rock or its residual clays are included under this head in this report. The ore is apt to be siliceous and include fragments and grains of quartz. The ore at the Silver Lake mine north of Mountain City is also ferruginous.

The only known deposit of manganese ore in stream gravel in East Tennessee is in gravel and sand on a bench about 50 feet above the present drainage near Silver Lake, northeast of Mountain City. Such deposits must be derived from some nearby source of ore solutions and may be looked for in stream gravels on old terraces near known deposits of other types.

CARBONATE ORES IN OLDER DOLOMITE.

Carbonate of manganese has been found in dolomite in the old slates interbedded in the quartzites of the Appalachian Mountains at one place in East Tennessee, but may occur elsewhere under similar conditions. It occurs in lenticular beds in the contact of the dolomite and the inclosing slate, and is undoubtedly a replacement of calcareous rock along this zone. Manganese minerals were probably originally disseminated in either the dolomite or slate and were concentrated by waters circulating along fracture planes at the contact while the rocks were still below the zone of surface oxidation. The beds now stand vertically and the upper ends of the ore layers are altered to psilomelane and manganiferous iron in manganiferous clay. These oxide ores are found at the surface and only after mining to a depth of 6 to 10 feet was the carbonate ore encountered. The carbonate ore looks like a dolomite or limestone and is distinguished only by its weight and by its discoloration on exposing at the surface, a thin film of dark-gray oxide quickly coating it. The ore contains about 35 per cent manganese, but since it is a carbonate it is a flux in itself and when mixed with oxide ores reduces the amount of limestone necessary in the charge. It therefore has a higher value to smelters than the manganese content would indicate, and the price it commands should be proportionately larger.

The ore has been found at only one place in East Tennessee, that is in Sevier County, 13 miles east of Sevierville, but it may be expected at other places in the heart of the Appalachian Mountains where the older slates carry a similar body of dolomite. Such dolomite bands, especially those in the near vicinity, should be searched closely for other deposits.

Description of Mines and Prospects.

A complete description of the manganese mines and prospects in East Tennessee will be published in a later number of this magazine. Only one mine or prospect of each type will be here described, followed by a tabular list of all the mines and prospects that have been visited or have been authentically reported.

NEWPORT MINE.

Deposit in Shady Dolomite.

The Newport mine, formerly known also as the Yellow Springs mine and the Carson Springs mine, is in Cocke County at the northeast end of English Mountain, five miles southwest of Newport. The deposit was discovered in 1883 by George Francis, who is said to have mined and shipped for George Cole 120 tons of unwashed nodular manganese ore from a small pit at the mouth of the present working. Beyond this rich body the ore occurred only in sporadic small pockets but they finally led to the discovery of the deposit now being mined.

The property is owned by the Sant estate with headquarters at East Liverpool, Ohio. The mine is being operated by the Newport Manganese Corporation of Newport, Tenn., of which the Southern Manganese Corporation of Birmingham holds a controlling interest. The composition of the ore that has been shipped is said to have been approximately 37 per cent manganese, 8 per cent iron, and 12 per cent silica. In 1917 the mine shipped 120 tons of ore which averaged more than 40 per cent in manganese, part of the shipment going to E. E. Marshall, Philadelphia, Pa., and part to the Southern

Manganese Corporation, Anniston, Ala. The ore brought about $25 a ton.

The mine is on the northeast terminal slope of English Mountain where it descends into the valley of Pigeon River. It is located at the edge of a bench on the mountain slope, 1,700 to 1,750 feet in altitude. The floor of the main pit of the mine is at 1,680 feet elevation and several prospect pits, both old and recent, at approximately this same elevation show fair indications of ore extending interruptedly nearly one-fourth mile southwest of the mine. Both nodular and stalactitic forms of manganese ore are embedded in the clay and wash of this bench.

The deposit occurs in the Shady dolomite about 100 feet above the Erwin quartzite. The structure at the mine is monoclinal, the quartzite beds of the mountain only 200 feet away dipping 75° N. toward the valley. The clays in the mine show similar bedding dipping 60° toward the valley.

The main pit, which trends nearly east and west, is approximately 150 feet long by 50 feet wide, and 50 feet deep at the face. It is excavated chiefly in reddish and brownish clay derived from the Shady dolomite and transitional beds, although pure white sand or sand clay are also conspicuous. The clay of the south or foot wall is chiefly white and very siliceous, containing rounded disintegrated fragments of sandstone or quartzite, and was probably derived from a sandstone or sandy limestone. It is firm and compact, so that this wall of the pit stands well. The clay of the north or hanging wall is sticky and chiefly yellow, and was probably derived from limestone or dolomite. The ore is contained in a layer about six feet wide of banded and mixed red, brown, lavender, bluish, and white sandy clay and sticky yellow clay, which dips 60° N. The ore is sporadically embedded in this clay in the form of grains, nodules, and lumps, some as large as three feet in diameter. It is evidently in a brecciated layer at the top of sandy beds in the Shady dolomite, which has been enriched probably by the leaching of the ore from the porous sand below, now left white, and its redeposition in the beds next to the impervious clay roof.

The overburden, which consists chiefly of red clay and quartzite boulders, varies from 1 to 10 feet in thickness. In places, as shown locally in the north bank of the pit, the ore extends nearly to the surface.

As the ore is mined it is shoveled into the head of a flume 875 feet long to which water is pumped, and is conveyed to a double log washer 260 feet below the mine. In its passage down the flume, or launder, much of the ore is freed from the clay by the swift current, but a small per cent of the ore is lost by adhering to the sticky clay which is allowed to go in with the ore and is rolled into balls.

On leaving the trommel after passing through the washer, the ore which does not pass through the one-eighth inch mesh sieve is conveyed by carrier belt to the bin and is hand picked en route by boys and women. About 30 per cent of the washed ore passes through the screen and constitutes what is known as "fines." It contains too much silica to be shipped direct and must be jigged to further free it from silica.

DOE VALLEY MINE.

Deposit in Watauga Shale.

The Doe Valley mine, also called Fritz mine, is in Johnson County, seven miles southwest of Mountain City and about the same distance north of Mouth of Doe, both on the Tennessee division of the Virginia and Southwestern Railroad. It is on the farm of Mr. Fritz of Mountain City, and is being operated by the East Tennessee Mining Company, also of Mountain City, in which the Southern Manganese Corporation of Birmingham, Ala., holds an interest.

Sixty-two tons of high-grade manganese ore averaging more than 50 per cent in manganese were shipped in 1917 to the Southern Manganese Corporation at Anniston, Ala., and in 1918, up to May 24, 200 tons of similar ore had been shipped and forty tons more were ready for shipment.

The mine is located on a hill 150 feet above Doe Creek on the northwest side of Doe Valley. The hill is part of a dissected upland plain which forms a sort of upper valley floor about 2,500 feet in altitude into which the stream valleys are sunk.

The deposits occur in disintegrated Watauga shale, the ore largely replacing brecciated sandstone and soft weathered calcareous shale or yellow laminated clay. The overburden is about three feet of red clay and dark surface soil. The ore occurs largely in irregular zones or bands more or less comformable with the bedding of the rocks, which dip 40° to 70° southeast. Abrupt change in dip, minor folding and puckering, and slickensiding along the bedding planes are evidences that the rocks have been strongly compressed.

The deposits are opened by an open cut near the top of the hill, which trends N. 70° E. parallel with the strike of the rocks, and has a length of 120 feet, the width of the floor and height of the face being each 30 feet. A new entry about 70 feet long and 15 feet or more deep at the face is being driven in from the west at a lower level to tap the ore layer below the floor of the main opening. The pit is chiefly in soft yellowish laminated clay, or weathered shale, with which are interbedded layers of light-brown porous sandstone, one to three feet thick, generally brecciated and deeply disintegrated. Cutting across the bedding nearly at right angles are zones a foot or two wide of breccia made up largely of hard purple shale fragments, which resemble subterranean channel fillings. (See Fig. 5.) They are of ir-

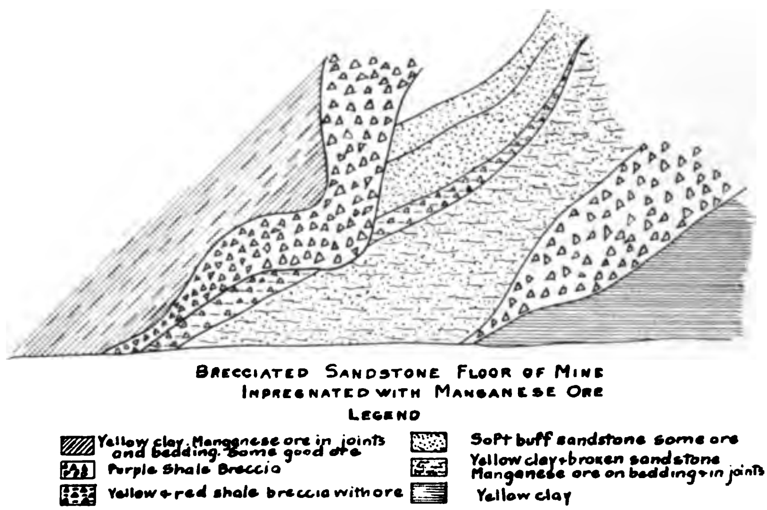

FIGURE 5. Sketch of right wall of entry to pit of Fritz mine showing irregular bands of purple shale breccia crossing the bedding.

regular shape, and in depth turn along the bedding planes, passing between laminated clay and brecciated sandstone layers. They seem to represent subterranean solution channels which connected with channels in the porous standstone beds. The brecciation of the sandstone and the irregular folding and puckering of the laminated shale were probably brought about by the settling and partial caving in of the rocks over the channels. The deep weathering and the penetration of the surface waters to this and greater depths occurred long ages ago when the tops of this hill and of the neighboring flat-topped hills were part of the general floor of the valley. This was before the present streams cut their valleys 150 feet deep to their present positions.

The ore consists chiefly of psilomelane and wad. A little manganite and pyrolusite are probably present. The manganese is distributed more or less throughout the rocks from near the surface to below the bottom of the cut, for its lower limit has not yet been reached. The ore, however, favors the arenaceous layers interbedded in the clayey shale, and is mostly contained in four such beds or zones, each from one to three feet in thickness. The ore is irregularly distributed in these arenaceous zones. It occurs to a considerable extent in seams ranging up to three inches in width which follow both the bedding of the rocks and the joints at right angles to it. Some of the seams are composed of psilomelane having stalactitic or comb structures perpendicular to their walls which meet and interlock at the center, showing deposition or replacement to have taken place simultaneously on both sides of the cavities. Many of the stalactites are coated with a brown velvety film, probably pyrolusite or some other manganese oxide. Some stalactitic forms are several inches in length and somewhat radiate, forming trumpet-shaped clusters. (See Fig. 3b.) At the junction of two planes at right angles, the stalactitic structures miter with each other, showing that the stems are perpendicular to the walls and not truly stalactites—i. e., pendant vertically from a roof. Some of the ore masses are aggregates of alternate layers of stalactitic structure and amorphous material about two inches thick of dark-brown dense wad or manganiferous clay of light weight. Even the stalactitic psilomelane weathers dull and in some cases disintegrates into light powdery fragments. Some of the forms are elongated mammillary, or nipple-shaped, with surfaces that have in part a bright black metallic luster.

The ore is removed from the mine by a short tram to a flume, and thence to a two-log washer at the foot of the hill, where it is treated and the products sorted into bins. Much of the ore is lump, over three inches in size, but the fines are also saved. It is estimated that the proportion of ore saved to material washed is about 1 to 15 or 20.

The material excavated, taken as a whole, is said to yield a ton of washed ore for each fifty cubic yards of ground excavated.

Prospect pits along the trench of the ore on the top of the hill indicate a total length of the deposit in the direction of at least 350 feet and a width of about 150 feet. Its known depth to the bottom of the deepest workings is about sixty feet, so that a considerable body of ore-bearing ground is still in sight.

RUTLEDGE MINE.

Deposit in Knox Dolomite.

The Rutledge mine is two miles southeast of Rutledge, Grainger County, on a branch of the Southern Railway between Knoxville and Morristown. It is on the farm of J. H. Lowe, of Rutledge, and is being operated by J. S. Swann of Knoxville. No ore had been shipped at the time of the visit but about 100 tons were on the dump, 30 tons of which had recently been mined. The ore is reported to average 33 per cent in manganese. It contains considerable silica which is mostly too fine to appear as grains, and much iron.

The mine is on the top of a prominent hill 650 feet above the railroad at Rutledge, to which place the ore must be hauled. The deposit occurs in the basal part of the Knox dolomite at or close to its contact with the underlying shale, which is presumably Nolichucky. The shale dips very gently southeastward into the hill, the structure being apparently monoclinal. However, relations at the mine and of the rocks on the slope below the mine are such as to leave doubt as to this structure and it is possible that the Knox is overthrust on the shale and that the shale is younger than the Nolichucky. Further study of the surrounding region is necessary to determine this point.

The mine consists of an open cut 150 feet long and 20 feet high along the northwest face of the hill. Several vertical bands of ore cross the face of the cut. The northern band is composed largely of botryoidal masses and nodules of black psilomelane more or less dulled by impurities and covered with iron oxide up to one-half inch in thickness, the outer coating being generally a brilliant red oxide. (See Fig. 6.) These are embedded in sticky yellow clay. A middle band is composed largely of a thick body of heavy psilomelane ore inclosed in dense yellow clay. At the south end of the cut yellow clay is laminated by manganese stains and thin layers of ore which dip

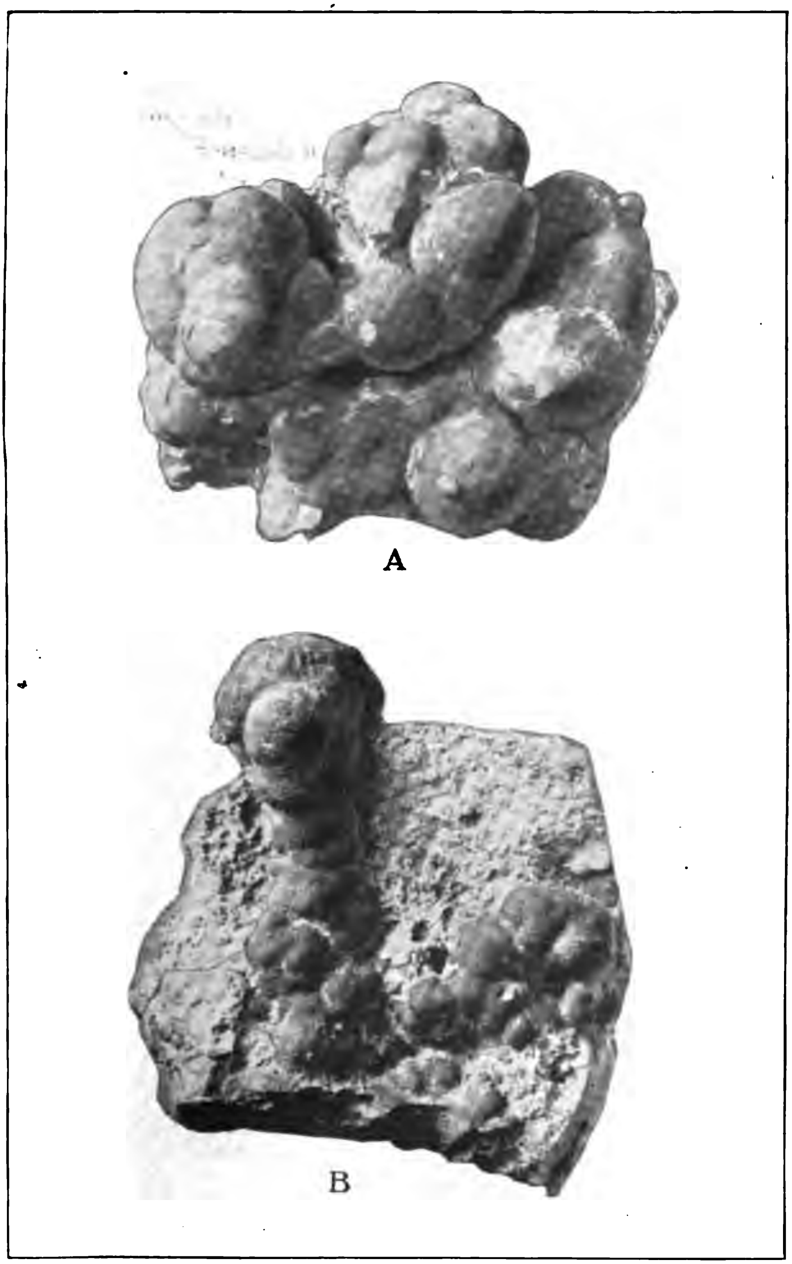

Figure 6. Nodular psilomelane ore coated with brilliant red oxide of iron. Rutledge mine, Grainger County. b. Manganese nodule in chert matrix.

10° to 30° NW apparently following the original bedding. It also contains chert partly replaced by manganese. The clays throughout the trench seem to be residual from weathered Knox dolomite, the vertical bands of ore also probably following the original bedding. The discordance of this supposed bedding with that of the underlying shale is one of the evidences in favor of faulting. There is a thin overburden of sandstone and chert wash at the top of the cut and the ore in it contains sand grains and more iron than that in the residual clay below. The top of the hill above the cut is covered with chert fragments in which considerable good manganese ore is present.

As the ore in the cut embedded in red and yellow sticky clay which fills the crevices and indentations in the botryoidal surfaces, it will require thorough washing to fit it for shipment. The problem of procuring an adequate water supply for this purpose has not been settled. The ore is the chert of the overburden and on the surface will require crushing and hand picking to remove the silica.

Although this mine is in Knox dolomite and consists in part of chert replaced by manganese ore, it is not typical of deposits in the Knox as it is at or close to a shale contact which may also be a fault contact. Most other deposits in the chert of the Knox, such, for instance, as that at McDonald's prospect southeast of Sweetwater, can be simply described as consisting of fragments of broken chert cemented together, and more or less replaced, by manganese ore which are scattered loosely in yellow to reddish residual clay on a chert hill in the midst of a broad belt of Knox dolomite. No original structure can be observed in the clay and therefore the relations of the ore to the rock formations can not be determined. The amount of manganese ore is generally so small and the ore masses though of high grade are so scattered that none of these deposits have proved of commercial value.

HAMBRIGHT MINE.

Deposit on Holston Marble.

The Hambright mine is in Bradley County, eight miles south of Cleveland and two miles northeast of Marble Switch on the Southern Railroad, to which point the ore is hauled. The property is owned by Mr. Hambright of Cleveland and the mine is being operated by Fitzgerald and Lanskey of Chicago, with office at Cleveland, who recently acquired the lease from Ryan and Thomason. Up to July 1st,

FIGURE 7. a, Sandy laminated limestone of the Tellico sandstone resting unconformably on Holston marble in which there is a thin seam of psilomelane (P). Pit of D. A. M. mine, Bradley County.

b, Pit of the Silver Lake mine, Johnson County. Large boulders from the stream gravel are gathered in piles at the face of cuts.

1918, the mine had shipped this year 120 tons of ore averaging more than 50 per cent in manganese, and about 50 tons of similar high grade ore lay on the dump. The ore was shipped to the Tennessee Coal, Iron and Railroad Co., Birmingham, Ala., and to the Carnegie Steel Co., Pittsburgh. The ore is hand picked and is shipped without washing.

The mine is in an open field on a gently rolling hilltop that trends northeastward and forms a terrace between the valley and a higher line of hills to the east.

The deposits occur chiefly at the contact of the Holston marble and the unconformably overlying Tellico sandstone. The structure in monoclinal, the rocks dipping from 25° to 80° SE. The marble is dark gray and crystalline, and in the northern end of the pit is well shown dipping 25° S and SE beneath the deposits. Southward in the pit the residual clay from the decomposed rocks dips 80° SE. The marble is sparingly seamed with brown ferruginous arenaceous material, in places changed or enriched to hematite.

The overlying beds of the Tellico sandstone, which are reddish limestones, contain grains of glassy sand, which are segregated more plentifully in thin layers so that on weathering the rock first becomes closely banded or ribbed, then a porous friable red sandstone, and finally red sand or sandy clay. That the sandy limestone is unconformable on the marble is clearly shown in pits of the adjacent D. A. M. mine, illustrated in Fig. 7. The iron and manganese set free by the weathering were redeposited in seams or in certain porous layers in the underlying marble (see Fig. 8) and were concentrated in places into a definite bed of ore at the contact of the marble and sandstone. (See Fig. 9.) The ore bed in part retains the original granular texture of the porous sandstone, and imprints of the fossils originally contained in the rock are still preserved. Glossy grains of quartz are contained in beds transitional from the sandstone to the solid psilomelane. As the inclosing rocks weathered away, fragments of this ore were scattered through the residual clay and sand, and are now found as loose blocky fragments.

The main opening is a pit 500 feet in length which trends N 30° E. (See Fig. 8.) The pit has a width of about 200 feet in its widest part near the north end, and a maximum depth of 30 feet. The ore occurs in the pit as irregular blocky or slabby masses and fragments several inches thick embedded in dark-red sandy clay, and also as a nearly vertical bed a foot or more thick which roughly follows the contact of the marble and sandstone. (See Fig. 9.) This nearly vertical bed of ore crops at intervals along the bottom of the 500-foot pit, in red sandy clay, which represents the Tellico, generally forming the southeast or hanging wall, and red and yellow blotched clay,

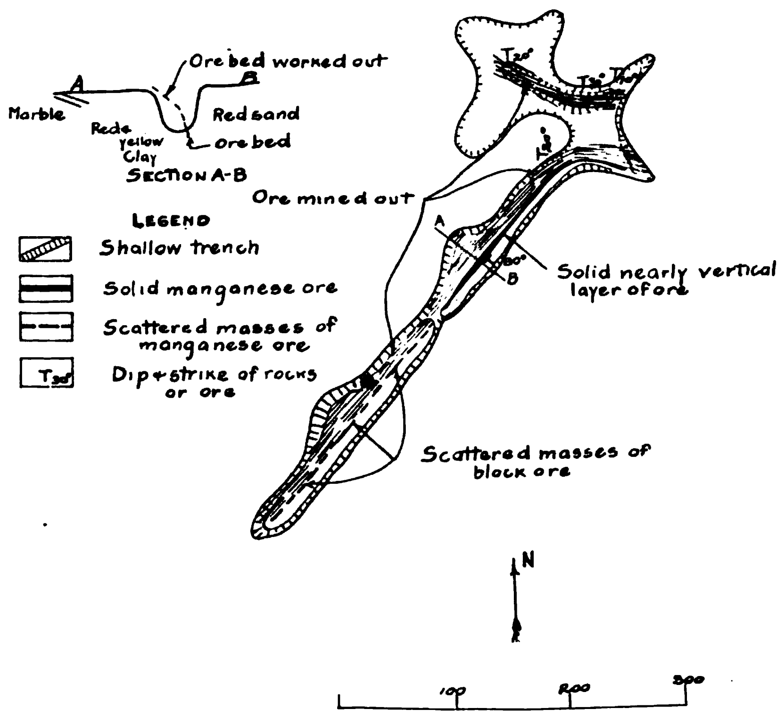

FIGURE 8. Rough sketch of the plan of Hambright mine pit, and cross section showing probable relation of ore.

which represents the Holston, forming the northwest or foot wall. This nearly vertical bed is said by the miners to have formerly flattened out toward the top of the excavation so as to dip gently southeast, in conformity with the bedding of the marble to the northwest, which accounts for the widening of the trench at the top in most places. Near the north end of the pit, the ore bed turns sharply eastward but is repeated again just beyond in the wider part of the pit by either sharp folding or faulting. Other masses or sheets of ore that occur in the clay west of this bed probably represent seams of ore deposited within the marble. Movement of the rocks along slickened joints, which cut the rocks nearly vertically, was so recent that the ore beds and stringers are offset slightly by these faults.

The ore consists chiefly of hard psilomelane but includes also some manganite, pyrolusite, and wad. The two latter minerals in places completely replace sandstone and constitute a friable mass locally known as "black sand" ore, some of which is now being mined from

FIGURE 9. View in north end of pit of Hambright mine. The nearly vertical layer of high grade ore is shown in the central foreground. It curves sharply to the right where the men are working.

the eastern part of the deep workings. Associated with the manganese ore is very pure hematite which also occurs in slabby blocks and preserves impressions of fossils and round pebbles with shiny surfaces, which probably were originally small limestone pebbles in the sandy lime silt and became smooth and rounded by calcareous accretion similar to the formation of oolite.

Several hundred feet south of the main opening, cross trenches 8 or 10 feet deep have been excavated in dark-red sandy clay in search of the ore zone but were not deep enough at the time of visit to determine its position. It seems reasonable however to expect the ore to continue both north and south of the present workings, although it may be offset by faulting. Cross trenching is therefore the best method of locating it.

WHITE OAK MOUNTAIN MINE.

DEPOSIT IN FORT PAYNE CHERT.

The White Oak Mountain mine is in Bradley County on the upper east slope of White Oak Mountain, eight miles northwest of Cleveland, which is on the Chattanooga division of the Southern Railway. The mine is owned and operated by the White Oak Manganese Corporation of Cleveland, Tenn., and Pittsburgh, Pa., of which J. E. Newlands is president. The property covers 998 acres, the title to a large part of which is now in litigation, and the mine has consequently been shut down.

The deposits are widely distributed along the mountain from its crest to near its eastern base, for a length of three miles, and are opened by a number of cuts, pits, and shafts, some to a depth of thirty feet. The ore occurs in part in the Fort Payne chert ledges the structure of which is monoclinal, the rocks dipping 10°-15° SE. At the south end of the property the manganese ore fills joints and fractures in the chert on the crest of the ridge and in part replaces it, forming tabular masses some of which are several inches in thickness. Owing to the paucity of the ore and the large amount of chert or silica which it contains the deposit at this place is probably not of commercial value.

At the north end of the property loose chert and manganese ore in the soil were dug up on the upper slope, and considerable manganese ore, much of it siliceous from the chert it inclosed, was obtained. The largest opening is on a bench about 100 feet below the top of the mountain in the north-central part of the property. It is a trench approximately 80 feet in length by 30 feet in width, and 15 feet in depth. A tunnel also goes into the hill at this place. The ore is in shaly chert dipping gently to the southeast, three layers of which are impregnated with ore. The ore-bearing layers are a foot thick in places, but dip with the mountain slope so that they do not go deep below the surface. About 1,000 tons of ore lie on the dump, of which about 40 tons are good psilomelane and may average 40 per cent in manganese. The rest of the ore is largely good brown iron ore much of which is manganiferous. A short distance south of the trench on the lower slope of the hill a large shaft has been sunk 75 feet, penetrating 22 feet into black shale below the ore-bearing chert. At the time of visit a four-inch diamond drill hole was also being sunk adjacent to the shaft in order to go deeper into the barren shale, a very wasteful procedure.

Both the iron and manganese ores at this pit can be shipped without washing, but elsewhere the ore will need to be cleaned of clay or silica. The ore will have to be hauled by wagon eight miles to the railroad, about half of the distance over rough hilly roads. The low grade of much of the ore, the scattered occurrence of the better grade of ore, the long distance the ore must be hauled, and the wasteful methods pursued are not encouraging for the development of the property into a profitable mine.

TAYLOR VALLEY MINE.

Deposit Along Fault Plane.

Taylor Valley mine, also called the Reece or Dollars mine, is at Matney, Johnson County, two miles east of Dollars, the nearest station on the Laurel Railroad. It is in the northeastern part of the county, ten miles north-northeast of Mountain City. The property is owned by Mr. Reece of Matney, and the mine is operated by the East Tennessee Mining Company of Mountain City, in which the Southern Manganese Corporation holds an interest. In 1917, 116 tons of ore were shipped to the Southern Manganese Corporation. In the first half of 1918, 142 tons were shipped and about 100 tons were in the bins at the mine. Recent shipments were made to the Tennessee Coal, Iron and Railroad Co. of Birmingham, Ala., and to the Southern Manganese Corporation at Anniston, Ala. The ore is reported to average about 36 per cent in manganese and to contain considerable silica, in some shipments as high as 20 to 25 per cent.

The mine is located on the southwest slope of a spur from Pond or Stone Mountain, on the east side of Owens Branch. It is at an elevation of about 2,900 feet, or about 200 feet above the creek and washer, and is about 100 feet below the crest of the spur. The deposits occur in brecciated sandstone, probably at the base of the

Watauga shale, and in residual clay of the underlying Shady dolomite, and are adjacent to a thrust fault which has brought pre-Cambrian purple schist against the dolomite and sandstone. The pre-Cambrian schist is an altered amygdaloidal lava, locally known as red mountain rock. On the lower slope of the spur northwest of the mine massive blue dolomite of the Shady outcrops with variable low dips to the southward. Northwest of Matney it is overlain by purple shale of the Watauga. Below the mine horizontal dolomite crops about midway up the slope, but the yellow clay and sandstone beds in the main mine pit are probably the basal beds of the Watauga. A thin overburden of three or four feet of clay and soil contains a little ore.

The ore consists chiefly of black impure psilomelane in the form of nodules and aggregates of small pea-sized nodules with concentric structure, some of which are very pure. Much of the psilomelane contains sand grains and larger fragments of silica. Some has a metallic slicksided surface.

The deposits are opened by several pits some of which trend in an easterly direction into the hill and one in a northwesterly direction across the spur. The lowest one, at the head of the flume to the washer, is only a small pit exposing an ore-bearing bed of dark red clay five to eight feet in thickness resting on barren dense yellowish clay or shale. The barren clay is probably residual from Watauga shale, and the overlying ore-bearing clay is probably washed from the ore beds above, in which ore has been redeposited. There is much good float ore on the slope of the hill.

The main pit, about 100 feet higher, is 80 feet long, 20 feet wide, and 15 feet deep. Beneath three feet of brownish chocolate-colored clay overburden horizontally streaked with ore in its lower part, are six feet of yellow clay horizontally seamed with thin streaks of manganese oxide, one foot of dark stiff clay called "buckfat," and three feet of yellow clay containing a considerable amount of good ore. The floor is a soft brecciated sandstone cemented and partly replaced by ore, which appeared to be of good quality. The clay in the southeastern part of the pit is bluish but also contains the same kind of ore. Much of the ore is gritty with sand grains, and nodules of the ore up to four inches in diameter contain much silica in their central parts.

The east pit, which is 50 feet in length by 25 feet in width and about 30 feet in depth, trends northwestward toward the upper end of the main pit. The lower part of the walls was badly caved at the time of visit. The west or foot wall is composed of apparently residual bedded yellow clay and dark manganese-stained clay with a little ore. The east or hanging wall is composed largely of a mixture of purple schist and white sandstone fragments in bluish sand. At its western endge are many slickened surfaces on steep joint planes. The ore occurs in a zone 20 feet wide of dark "buckfat" clay, much jointed and slickened in various directions, and some sand. The ore belt strikes N 20° W and dips 70° to 80° NE. The ore occurs in pockets of wad in the "buckfat" and is said to occur throughout the length of the pit, especially in its eastern half, and to continue to the bottom of the working which was abandoned not for lack of ore but because of the danger of caving of the undercut east wall. Some of the ore and black manganiferous clay is slickened, showing great compression and earth movement. This ore zone undoubtedly occupies a fault zone between the pre-Cambrian schist on the southeast and Watauga shale and Shady dolomite on the northwest. In the middle pit the fault zone has not yet been reached and the ore is distributed in the foot-wall shale. The deposit as a whole seems to be chiefly controlled, therefore, by the circulation of ore-bearing solutions along a fault plane.

A short tram at the mine carries the ore to the head of a flume which descends the hill slope to the two-log washer. Much of the washed ore is of low grade and carries much silica. The fines also contain much fine silica, which is removed by further washings or jigging.

The northward continuation of the ore body has not been determined. On the opposite side of the spur north of the mine and below the capping of overthrust amygdaloid, a test pit 12 feet deep has been sunk in contorted yellow clay, probably Watauga shale, and below in the valley the Shady dolomite crops out. Some psilomelane ore occurs in blotchy yellowish-brown clay in the pit and some large masses of float ore have been found on the surface.

SILVER LAKE MINE.

Deposit in Terraced Stream Gravel.

The Silver Lake mine is at Silver Lake station on the Laurel Railroad, in the north-central part of Johnson County, five miles northeast of Mountain City. It is only a few hundred feet distant from the railroad, and 80 feet above it. The property is owned by Wiley Southerland of Mountain City, who also manages the mine for the Silver Lake Mining Co., a local company. The company began operating in the early part of the present year and from February 1 to the date of visit, May 23, had shipped six tons of ore a day or a total of about 600 tons. Most of the ore was shipped to the Southern Manganese Corporation at Anniston, Ala., and the ore is said to have averaged 45 per cent in manganese. Eighty tons of similar high grade ore and 120 tons of fines averaging 35 per cent manganese were in the bins ready for shipment. About 40 tons of picked iron ore which came from an earlier surficial part of the working were on the dump. At the time of visit a force of 14 men were at work, seven at the mine and seven at the washer.

The mine is located in an open part of the valley of Laurel Creek on top of a small round flat-topped hill 80 feet above Laurel Creek, which flows near its base. The hill is composed of Watauga shale capped by sand and rounded stream gravel six to fifteen feet thick. The shale is in general flat but in minor folds the beds dip 35° SE. The shale is in part unweathered, hard and purple, and in part weathered to soft yellow clay shales. Low ridges on the harder beds trend northeast and the ore seems to lie or be more plentiful in the deeper filling of the troughs between the ridges. The stream gravel consists of red, yellowish, and brownish sand or sandy clay, the upper part of which contains numerous waterworn river pebbles and cobble. Some of the larger quartzite boulders are a foot or more in diameter. These sands and gravels were evidently deposited by Laurel Creek when the valley floor was at this level and the top of the hill was part of the stream channel. The pebbles are mostly clean and free from manganese stain.

Most of the ore occurs in the red sand near the base of the stream deposit, but some occurs in the gravel in the upper part. The ore is chiefly distributed in thin zones one to two inches thick, but rich pockets of nearly solid ore are also found.

The ore is mined from a large open cut about 100 feet across from which deep trenches run irregularly following richer streaks. These are about 10 to 15 feet deep. A shaft 20 feet deep is sunk into barren shale below the bottom of the stream gravels. The ore consists almost wholly of nodules of pure psilomelane some lumps of which are 2½ feet in diameter. Although the ore occurs largely in the lower part of the surficial deposit, there is enough distributed throughout the upper part to warrant treating all the ground removed from the bedrock to the surface in the two-log washer, which is located at the foot of the hill. Some of the clayey layers at the base of the surficial deposits from which a small amount of ore is recovered, may be residual clay from the decomposition of the bedrock.

EAST FORK MINE.[1]

Carbonate Ore in Dolomite.

The East Fork mine is in Sevier County on East Fork of Little Pigeon River, two miles south of the old East Fork postoffice and 13 miles southeast of Sevierville, the present terminus of the Knoxville, Sevierville and Eastern Railroad. It is in a rugged hilly country on the north flank of the Great Smoky Mountains, being located on a low hill south of the streám and about 200 feet above it. The land is known as the Widow Owen's property. It is now owned and operated by the Tennessee Manganese Co. of Knoxville, D. C. Campbell, President.

The mine has not yet begun to produce although a test car load of ore has been shipped. The carbonate ore which composes most of the ore body is apparently a white rhodocrosite containing considerable calcium and magnesium as impurities, or more likely a new mineral containing these three carbonates. It occurs in nearly vertical beds and lenses in slate and dolomite, and is oxidized at the surface to psilomelane and wad. The carbonate ore is reported by the company to contain 37.75 per cent manganese and the oxide ore 48.6 per cent.

The mine is located at the southeast end of a spur from a higher hill to the northwest and is opened by two open cuts, a tunnel, and

[1]This mine was examined by Arthur Keith and G. W. Stose in the spring of 1917 and a joint report was prepared, which may later be published. The description here given is from notes made by them.

FIGURE 10. Workings of the East Fork mine, Sevier County, where carbonate ore is being mined. The second open cut where shaft is now being sunk

a shaft, on opposite sides of the spur. There are also four other small open cuts on other spurs along the lead of the ore which trends S 40° W, covering a length of 4,000 feet. The ore zone follows the contact of slate and dolomite, the slate lying on the southeast, the dolomite on the northwest. The slate is one of the oldest sedimentary rocks in the Appalachian region, called Hiwassee slate, and the dolomite is apparently interbedded in it. The dolomite is about 60 feet thick and in places contains some blue thin-bedded limestone.

The main working, nearest East Fork, consists of an open cut about 60 feet long, ten feet wide, and about 60 feet deep with stepped face. A tunnel 100 feet long follows the ore from the bottom of the cut. (See Fig. 10.) The open cut was designed to take out the oxide ore, which is only five to ten feet thick over the vein, and the work was done mostly before the bedrock vein was discovered to be a manganese ore. The oxide ore is in the form of irregular small masses of psilomelane in wad and light manganiferous clay. Much of the latter is the product of weathering of the inclosing manganiferous dolomite. The tunnel passes into solid carbonate ore at about six feet from the portal. The ore body is lenticular and pinches out at the back end of the tunnel but a bore hole in the southeast wall shows another body of ore in that direction. The open cut above the tunnel also shows the lenticular character of the ore bodies which overlap each other. (See Fig. 10.)

The second working is also an open cut 80 feet long, 8 to 10 feet wide and 40 feet deep stepped in three benches. The carbonate ore is excellently exposed in the two lower benches, showing a body about 4 to 5 feet wide, which pinches out at the face of the lower bench and shows other irregularities in width as it pinches and swells. The upper bench is in oxide ore, chiefly wad with some psilomelane masses.

The shallow propects along the ore lead to the south expose wad and psilomelane mostly in narrow zones, but none of the pits are deep enough to determine the size or shape of the carbonate ore body which they represent. The northernmost of these openings, across the ravine from the second open cut, exposes the solid carbonate ore but its relations were not shown nor its width determined.

The carbonate ore is in part crystalline and in part compact and banded. The crystalline ore seems to have been deposited first, probably by direct replacement of calcareous rock, either the dolomite or calcareous slate. Manganese minerals which were probably originally disseminated in the dolomite or slate were dissolved by the deeper circulating waters and the manganese was redeposited as a mixed carbonate of calcium, magnesium, and manganese in the rock adjacent to the solution channels. The ore solutions apparently circulated along joints and fissures which follow the contact of the dolomite and slate where there may also have been some faulting. The rhombs of the crystalline mineral show marked zonal structure, the clearer outer portion probably carrying less manganese. The coarsely crystalline character of this ore indicates that it was probably deposited some distance from the surface, below the zone of surface oxidation. The banded amorphous or cryptocrystalline carbonate, in which thin layers of black oxide of manganese are interlaminated, seems to fill open spaces in the crystalline mass and is probably a later enrichment in the zone of oxidation near the surface.

An analysis of the carbonate ore made for the company is reported as follows:

Mn	37.75
SiO_2	7.
CaO	5.26
MgO	2.30

Analyses of two small fragments of ore, selected to represent the two types of ore, crystalline and banded, were made in the laboratory of the U. S. Geological Survey[1] as follows:

	Crystalline Carbonate Ore.	Banded Carbonate Ore.
Mn	9.29	26.33
CaO	22.10	11.58
MgO	11.63	3.
SiO_2	9.53	15.54

The ore body and wall rock contain considerable pyrite much of which, especially that in the wall rock, is rather coarsely crystalline (pyritohedrons), whereas minute crystal aggregates are scattered through the banded ore. Quartz is also common in small stringers, in some of which bright anthracitic carbon is inclosed. A few small calcite veinlets cut the ore.

Since the mine was visited an experienced engineer has been engaged by the company who is sinking a working shaft at the second

[1]Analyst, George Steiger.

opening, from which drifts will be run northeast into the hill and in the opposite direction below the ravine surface. A site has been purchased at Knoxville where it is contemplated to build an electric furnace to treat not only the ores of this mine but also the oxide ores from other mines in this part of the State. The great handicap of a haul of 13 miles from the mine to the railroad, one-third of which is over roads at present almost impassable, is offset by the short railroad haul to Knoxville if the furnace is established there and by the fact that the ore is partly self fluxing.

Although the analyses of samples of rock selected to represent types of mineral occurrence show but 9 to 26 per cent manganese, it is reasonable to believe that the run of mine will show a larger per cent of manganese possibly more nearly that obtained by the company from its sample, 37 per cent. Should the ore body prove to continue to a depth of 50 or more feet below the tunnel level at the north opening with an average thickness of 4 to 5 feet, as it appears to have in the surface exposures, the ore body will be of considerable size and tonnage, and should it be found to be of workable size throughout the length of the property toward the south, 4,000 feet, the tonnage will be many times greater.

List of Manganese Mines and Prospects in East Tennessee.

(Geographically by counties, beginning at the northeast corner of the State.)

County.	Mines and Prospects.	Location.	Owner.	Operator.	Distance to Railroad and Shipping Point.	Type of Deposit.
Johnson	Taylor Valley or Reece Mine	Matney	—— Reece	East Tennessee Mining Co.	2 miles to Dollars on Laurel R. R.	Fault plane
Johnson	Silver Lake mine	Silver Lake	Wiley Southerland	Silver Lake Mining Co.	On Laurel Railroad	Terraced stream gravel
Johnson	Wills mine	1 mile east of Wills	Oscar Wills	Laurel Mining Co.	1½ miles to Wills on Laurel R. R.	Shady dolomite
Johnson	King prospect	3 miles northeast of Mountain City	Nelson King	(Undeveloped)	3 miles to Mountain City on Laurel R. R.	Shady dolomite
Johnson	Shouns prospect	2 miles south of Mountain City	Virginia Iron, Coal & Coke Co.	(Undeveloped)	1 mile to Shouns on Southern R. R.	Watauga shale
Johnson	Davis mine	½ mile northwest of Crandull	W. P. Parker and E. N. Martin	George E. Davis and Southern Manganese Corp.	½ mile to Crandull on Beaver Dam R. R.	Shady dolomite
Johnson	Davis prospect (reported)[1]	2 miles (?) southeast of Crandull	....	George E. Davis	2 miles to Crandull on Beaver Dam R. R.	Shady dolomite
Johnson	King prospect	1 mile northwest of Shady	—— King	....	¼ mile to Beaver Dam R. R.	Shady dolomite
Johnson	Maxwell mine	1 mile southwest of Shady	....	Maxwell Manganese Mining Co.	½ mile to Beaver Dam R. R.	Shady dolomite
Johnson	Wright prospect	1½ miles southwest of Shady	—— Wright	Maxwell Manganese Mining Co.	½ mile to end of Beaver Dam R. R.	Shady dolomite
Johnson	Osborn prospect	2 miles southwest of Shady	Alec Osborn	Alec Osborn	1 mile to end of Beaver Dam R. R.	Shady dolomite

[1]Prospects marked "reported" were obtained by correspondence or through other persons and not by personal visit.

List of Manganese Mines and Prospects in East Tennessee—*Continued.*

County.	Mines and Prospects.	Location.	Owner.	Operator.	Distance to Railroad and Shipping Point.	Type of Deposit.
Johnson	Hopper prospect	2 miles south-southwest of Shady	—— Hopper	George E. Davis	1 mile to end of Beaver Dam R. R.	Shady dolomite
Johnson	Doe Valley or Fritz mine...	7 miles southwest of Mountain city	—— Fritz	East Tennessee Mining Co.	7 miles to Mouth of Doe on Virginia & Swn. R. R. ..	Watague shale
Johnson	Proffit prospect (reported)..	5 miles northeast of Butler.	Stacy Proffit	(Undeveloped)	2 miles to Mouth of Doe on Va. & Swn. R. R.	[illegible] „ Shady dolomite
Johnson	Wilson Hill or Superior mine	1 mile south of Neva	Superior Manganese Corp.	Superior Manganese Corporation	1 mile to Neva on Virginia & Southwestern R. R.	Shady dolomite (faulted?)
Johnson	Wagner prospect	5 miles northeast of Butler at head Little Dry Creek.	D. A. Wagner...	A. H. and J. J. McQueen...	5 miles to Butler on Virginia & Southwestern R. R. ...	Shady dolomite
Johnson	Dry Run mine	3½ miles northeast of Butler	....	A. H. McQueen	3½ miles to Butler on Virginia & Swn. R. R.	Shady dolomite
Johnson	Watauga River mine	2 miles southeast of Butler.	....	J. L. McQueen	2 miles to Butler on Virginia & Southwestern R. R. ...	Watauga shale
Johnson	Cable prospect	2 miles southeast of Butler.	—— Cable	—— Reece	2 miles to Butler on Virginia & Southwestern R. R. ...	Watauga shale
Johnson	Goss mine	2½ miles south of Casper..	....	Dr. Goss	5 miles to Butler on Virginia & Southwestern R. R. ...	Shady dolomite or Watauga shale?
Johnson	Moody prospect	2 miles south of Casper....	W. R. Moody...	C. H. White	5 miles to Butler on Virginia & Southwestern R. R. ...	Shady dolomite or Watauga shale?
Carter	Blevins mine	1½ miles northwest of Colesville	Mrs. Isaac Blevins	Captain Robinson	1½ miles to Colesville on branch of Va. & Swn. R. R.	Shady dolomite

Carter	Hatcher prospect	1 mile east of Sadie	—— Hatcher?	H. E. Graves	1 mile to Sadie on branch of Va. & Swn. R. R.	Shady dolomite
Carter	Grindstaff prospect	1 mile east of Sadie	G. L. Grindstaff	(Undeveloped)	1 mile east of Sadie on branch of Va. & Swn. R. R.	Shady dolomite
Carter	Keesburg prospect	1 mile east of Keesburg	Southern Minerals Corporation	Southern Minerals Corporation	1 mile to Keesburg on Va. & Swn. R. R.	Shady dolomite? Watauga shale
Carter	Cobb Creek prospect (reported)	2 miles northwest of Butler		A. H. McQueen	3 miles to Butler on Va. & Southwestern R. R.	Shady dolomite
Carter	Blue Springs mine	4 miles east of Hunter	Carrigan heirs	Walker and McKenna	4 miles to Hunter on Va. & Southwestern R. R.	Shady dolomite
Carter	Elk mine	2½ miles south of Butler	—— Hately	McQueen Manganese Co.	2½ miles to Butler on Va. & Southwestern R. R.	Watauga shale
Carter	Dubault prospect	2 miles southwest of Butler	—— Dubault	—— Reece	2 miles to Butler on Va. & Southwestern R. R.	Watauga shale
Carter	Younce prospect	2 miles southwest of Butler	S. S. Younce	—— Reece	2 miles to Butler on Va. & Southwestern R. R.	Watauga shale
Carter	Cardens Bluff mine	½ mile southwest of Cardens Bluff		A. D. Reynolds and L. L. McQueen	½ mile to Cardens Bluff on Va. & Southwestern R. R.	Shady dolomite
Carter	Cedar Hill mine	1 mile south of Hampton	Stiles heirs	Maxwell Manganese Mining Co.	1 mile to Hampton on East Tenn. & W. N. C. R. R.	Shady dolomite
Carter	Valley Forge mine	1 mile southeast of Valley Forge		H. W. and A. D. Reynolds.	1 mile to Valley Forge on E. T. & W. N. C. R. R.	Shady dolomite
Carter	Jenkins prospect	2 miles southwest of Valley Forge	Abe Jenkins heirs	J. N. Koch, Davis, and Smith	2 miles to Valley Forge on E. T. & W. N. C. R. R.	Shady dolomite

List of Manganese Mines and Prospects in East Tennessee—Continued.

County.	Mines and Prospects.	Location.	Owner.	Operator.	Distance to Railroad and Shipping Point.	Type of Deposit.
Carter	Hyder prospect	2½ miles southwest of Valley Forge	Hyder heirs	J. N. Koch, Davis, and Smith	3 miles to Valley Forge on E. T. & W. N. C. R. R.	Shady dolomite
Carter	Winter mine	6 miles southeast of Johnson City	Taylor heirs	Maxwell Manganese Mining Co. (inactive)	4 miles to Watauga Point on E. T. & W. N. C. R. R.	Shady dolomite
Carter	Patton mine	6 miles southeast of Johnson City	Taylor heirs	Maxwell Manganese Mining Co. (inactive)	4 miles to Watauga Point on E. T. & W. N. C. R. R.	Shady dolomite
Carter	Treadway prospect	6 miles southeast of Johnson City	Geo. Treadway ..	W. H. Kemler	3 miles to Carolina, Clinchfield & Ohio R. R.	Shady dolomite
Carter	Hodge prospect	6 miles southeast of Johnson City	Frances Hodge ..	W. H. Kemler	3 miles to railroad	Shady dolomite
Carter	T. J. Brummett mine	5 miles northeast of Unicoi.	T. J. Brummett..	Southern Manganese Corporation	5 miles to Unicoi on railroad	Shady dolomite
Unicoi	Susan Brummett mine.....	4 miles northeast of Unicoi.	Mrs. Susan Brummett	Southern Manganese Corporation	4 miles to Unicoi on railroad	Shady dolomite
Unicoi	Britt mine	3 miles northeast of Unicoi.	J. L. Britt	Southern Manganese Corporation	3 miles to Unicoi on railroad	Shady dolomite
Unicoi	Embreeville prospect	2 miles southwest of Embreeville	Embree Iron Co..	Embree Iron Co.	2 miles to Embree on mine branch, Southern R. R. ..	Shady dolomite
Greene	Haysville prospect	12 miles south of Greeneville	Unaka Development Corp. ...	Unaka Development Corporation	12 miles to Greeneville on Bristol-Chat. line, So. R. R.	Shady dolomite (faulted)

Greene	Sylvia prospect	14 miles south of Greeneville		Leroy and J. C. Park	12 miles to Greeneville on Bristol-Chat. line, So. R. R.	Shady dolomite
Greene	Lamb prospect	15 miles south of Greeneville	Scott Lamb	(Inactive)	15 miles to Greeneville on Bristol-Chat. line, So. R. R.	Shady dolomite
Cocke	Wood mine	5 miles northeast of Del Rio	Nick Wood	(Inactive)	5 miles to Del Rio on Morristown-Asheville line, Southern R. R.	Shady dolomite
Cocke	Huff prospect	4 miles nortnwest of Del Rio	Aleck Huff	(Inactive)	4 miles to Del Rio on Morristown-Asheville line, Southern R. R.	Shady dolomite
Cocke	Long Creek prospect	3 miles northwest of Del Rio	Aleck Huff	(Inactive)	3 miles to Del Rio on Morristown-Asheville line, Southern R. R.	Shady dolomite
Cocke	Adams mine	3 miles west-northwest of Del Rio	Jno. N. Adams	(Inactive)	On Morristown-Asheville line, Southern R. R.	Shady dolomite
Cocke	Blanchard mine	3 miles west-northwest of Del Rio	William Blanchard	Barium Lithophane Co. (Inactive)	1 mile to Morristown-Asheville line, So. R. R.	Shady dolomite
Cocke	Waddell mine	3½ milest west of Del Rio	John B. Waddell	(Inactive)	1½ miles to West Meyers on Morristown-Asheville line, Southern R. R.	Nebo quartzite
Cocke	Raines prospect (reported)	3¾ miles west of Newport	Barney Hurley	(Inactive)	3¾ miles to Newport on Morristown-Asheville line, Southern R. R.	Shady dolomite
Cocke	Jones and McMahon prospect	4¼ miles west of Newport	Jones & McMahon	(Inactive)	4¼ miles to Newport on Morristown-Asheville line, Southern R. R.	Shady dolomite
Cocke	Newport mine	4¾ miles west of Newport	Sant estate	Manganese Products Co.	4¾ miles to Newport on Morristown-Asheville line. Southern R. R.	Shady dolomite
Hamblen	Lotspeich ? prospect (reported)	3 miles southeast of Morristown?		J. N. Lotspeich?	3 miles from Southern R. R.	Knox dolomite?

List of Manganese Mines and Prospects in East Tennessee—Continued.

County.	Mines and Prospects.	Location.	Owner.	Operator.	Distance to Railroad and Shipping Point.	Type of Deposit.
Grainger	Rutledge mine	2 miles southeast of Rutledge	J. H. Lowe	J. S. Swann	3 miles to Rutledge on Knoxville-Bristol line, So. R. R.	Knox dolomite (base)
Grainger	Harmon prospect	2½ miles southeast of Rutledge	Joe Harmon	(Undeveloped)	2½ miles to Rutledge on Knoxville-Bristol line, So. R. R.	Knox dolomite (base)
Grainger	Young prospect (reported)	6 miles south of Rutledge	B. F. Young	(Undeveloped)	6 miles to Rutledge on Knoxville-Bristol line, So. R. R.	Knox dolomite
Grainger	Wallen prospect	Puncheon Camp, 4 miles northeast of Washburn	Wm. Wallen	(Undeveloped)	4 miles to Washburn on Knoxville-Morristown line, Southern R. R.	Knox dolomite (top)
Grainger	Frye prospect	1½ miles northwest of Washburn	Chas. Frye	(Undeveloped)	1½ miles to Washburn on Knoxville-Morristown line, Southern R. R.	Knox dolomite
Jefferson	Curren prospect (reported).	Near Jefferson City	George Currens	(Undeveloped)	Near Jefferson City on Southern R. R.	Not known
Sevier	East Fork mine	12 miles southeast of Sevierville	Tennessee Manganese Company.	Tennessee Manganese Company	12 miles to Sevierville on Knoxville, Sevierville & Eastern R. R.	Carbonate ore in older dolomite
Blount	Townsend prospect (reported)	13 miles southeast of Maryville	....	(Undeveloped)	1 mile to Townsend on K. & A. branch of So. R. R.	Fault plane?

Blount	Chilhowee prospect (reported)	12 miles south of Maryville.	....	H. E. Colton (deceased)...	2 miles ? to Chilhowee on T. and C. S. branch of So. R. R.	Fault plane?
Blount	Miller prospect (reported)..	9 miles south of Maryville.	Rufus Miller	(Undeveloped)	6 miles to Chilhowee on T. & C. S. branch of So. R. R.	Fault plane?
Blount	Louisville mine	4 miles southwest of Louisville	J. B. Cox	M. M. Whittle	1 mile from Louisville and Nashville R. R.	Holston marble (base)
Blount	—— prospect (reported) ...	2 miles southwest of Louisville	....	....	1 mile from Louisville & Nashville R. R.	Holston marble
Knox	Haworth prospect (reported)	2 miles northwest of Powell	W. L. Haworth..	(Undeveloped)	2 miles to Powell on Knoxville-Clinton branch of Southern R. R.	Knox dolomite
Anderson ...	Howell prospect (reported).	5 miles north of Clinton...	D. A. Howell?..	D. A. Howell and S. M. Bright	5 miles to Clinton on Louisville and Nashville R. R...	Watauga shale?
Loudon	Galbraith mine	8 miles southeast of Loudon	Charles Galbraith	Southern Manganese Corporation	8 miles to Lenoir on Southern R. R.	Holston marble
Loudon	Cates prospect (chiefly iron).	2 miles south of Loudon...	J. K. Cates	LaFollette Mining Co.	2 miles to Loudon on Southern R. R.	Fault?
Monroe	Mills prospect	8 miles east-northeast of Sweetwater	J. C. Mills	Southern Manganese Corporation	8 miles to Philadelphia on Southern R. R.	Holston marble
Monroe	McGuire mine	4 miles north-northeast of Sweetwater	Frank McGuire..	Southern Manganese Corporation	½ mile to Southern R. R...	Holston marble
Monroe	Vita mine (chiefly iron) ...	3 miles north-northeast of Sweetwater	....	Fitzgerald and Smith	½ mile to Vita switch on Southern R. R.	Holston marble
Monroe	Heiskell mine	1½ miles northeast of Sweetwater	Harry Heiskell..	H. L. Smith	1½ miles to Sweetwater on Southern R. R.	Holston marble
Monroe	McDonald prospect	3 miles southeast of Sweetwater	—— McDonald..	Southern Manganese Corporation	5 miles to Sweetwater on Southern R. R.	Knox dolomite

List of Manganese Mines and Prospects in East Tennessee—Continued.

County.	Mines and Prospects.	Location.	Owner.	Operator.	Distance to Railroad and Shipping Point.	Type of Deposit.
Monroe	Kembrough prospect (reported)	4 miles northeast of Madisonville	—— Kembrough.	(Undeveloped)	2 miles to Norfolk & Western R. R.	Knox dolomite?
Monroe	Ervin prospect	5 miles northwest of Tellico Plains	—— Ervin	—— Ervin	2 miles to Mt. Vernon on Louisville & Nashville R.R.	Holston marble
Monroe	Groundhog Mountain prospect	3 miles west of Tellico Plains	J. H. Curd	Southern Manganese Corporation	4 miles to Tellico Plains on Louisville & Nashville R.R.	Shady dolomite (faulted)?
Monroe	Dickey prospect (reported)	3 miles northwest of Sweetwater	—— Dickey	(Undeveloped)	3 miles to Sweetwater on Southern R. R.	Knox dolomite?
McMinn	Hansard prospect	3 miles southwest of Sweetwater	J. B. Hansard	(Undeveloped)	2 miles to Southern Railroad	Knox dolomite
McMinn	Webb prospect (reported)	10 miles northwest of Calhoun	—— Webb	(Undeveloped)	12 miles to Calhoun on Southern R. R.	Knox dolomite
McMinn	Patton prospect (reported)	10 miles northwest of Calhoun	—— Patton	(Undeveloped)	12 miles to Calhoun on Southern R. R.	Knox dolomite
McMinn	Red Hills prospect (reported)	3 miles east of Calhoun	....	(Undeveloped)	4 miles to Calhoun on Southern Railroad	Holston marble
Bradley	Underwood mine	4 miles southeast of Charleston	....	W. B. Underwood	4 miles to Charleston on Southern Railroad	Holston marble

Bradley	White Oak Mountain mine.	8 miles northwest of Cleveland	White Oak Manganese Corp. ..	White Oak Manganese Corporation	8 miles to Cleveland on Southern R. R.	Fort Payne chert
Bradley	Brown prospect (reported)..	8 miles west of Cleveland..	Jake M. Brown..	(Undeveloped)	6 miles to McDonald on Southern Railroad	Fort Payne chert
Bradley	Hambright mine	8 miles south of Cleveland.	—— Hambright .	Fitzgerald & Lanskey	2½ miles to Marble Switch on Southern Railroad ...	Holston marble
Bradley	Jones prospect	9 miles south of Cleveland.	M. V. Jones	M. V. Jones	2 miles to Marble Switch on Southern R. R.	Holston marble
Bradley	Sloan prospect	10 miles south of Cleveland.	W. B. Sloan	W. B. Sloan	3 miles to Marble Switch on Southern R. R.	Holston marble
Bradley	D. A. M. mine	10½ miles south of Cleveland	Davis, Artz & McCrossin	Davis, Artz & McCrossin..	2 miles to Weatherly Switch on Southern Railroad ..	Holston marble
Bradley	Lord mine	11 miles south of Cleveland	—— Boyd	C. H. Lord Corporation....	1¾ miles to Weatherly Switch on Southern R. R.	Holston marble
Bradley	Hannah prospect	13 miles south of Cleveland	Mrs. Hannah ...	C. H. Lord Corporation....	2½ miles to Weatherly Switch on Southern R. R.	Holston marble

War Work

The war policy of the State Geological Survey is to give its entire energy and resources to whatever degree necessary to war work and the winning of the war. We hear different slogans wherever we turn, "Saving will win the war;" "Food will win the war;" "Ships will win the war," and many others, all good and necessary, but the one great idea back of it all is that "Home production will win the war." Believing this, the Survey, as one of the home divisions of the army overseas, is devoting its whole organization to "carrying on."

To the State Geological Survey and to the new State Geologist just entering on his duties, there comes the great and vitally important work of locating all those necessities except food, so that once located, they may be developed and their production speeded up to the highest notch of efficiency.

It is hard for the public to realize the grave condition in which our country will find itself, unless sufficient war minerals are produced at home and produced quickly. How closely is victory tied to mining production can be recognized by all when they know that several hundred thousand dollars worth of shells and ammunition were often used in twenty-four hours on any one of the quiet sectors that were occupied by the United States troops when they first went on the battle front. This naturally represents a large tonnage of special ammunition metal produced by mining the different ores necessary for the mixture, smelting them and bring them together in the final metal alloy that is used in making the different guns and shells now used. In addition to the ores, that are mined and are used as the basis for these supplies, there is an enormous amount of coal necessary in each mining, smelting and manufacturing process through which the ore goes. It has been stated that for every ton of three-inch shells produced, it is necessary to mine and use four tons of coal.

In the past we have imported almost our entire supply of a number of necessary war minerals, most notable of which are manganese and pyrite. Without these minerals and their products the munition industry would come to a standstill.

Tennessee has the greatest number of minerals in workable quantity of any state in the Union, and we are especially fortunate in having deposits of both manganese, pyrite and other war minerals, both in known areas, now being worked and in undeveloped areas where new deposits may be found. Our manganese before the war came from Brazil, Russia and India, and our pyrite mostly from Spain. We have both the minerals in the United States but due to the low price at which these foreign ores were sold in our country, domestic production was impossible. Now everything is changed, these ores are cut off, due to lack of ships and internal conditions abroad.

In 1914, Germany, knowing how essential manganese was to present day warfare, had acquired a stock that she estimated would last her for two years. In the fall of 1917, it has been stated, that she was in dire need of a new supply of this ore. By utilizing scrap and all local supplies, that she could lay hands on, she was able to make out until 1917. When Russia collapsed, Germany obtained control of one of the world's largest manganese areas, by taking over Ukraine. Many people think that it was this ore in Ukraine, more than food, that made Germany occupy this region under a so-called peace agreement.

The State Geological Survey is now working continually to locate new deposits of manganese in Tennessee and to get them developed. In the past Tennessee was known as a place where manganese occurred more in the form of a specimen than anything else, while now it is recognized as one of the leading producing states. There are now 11 manganese washer plants in operation, and in addition, there are a number of dry mines now being worked that are producing considerable tonnage. In all of this work the State Geological Survey has received the full co-operation of both the U. S. Geological Survey and the U. S. Bureau of Mines and the progressive patriotic citizens of our country.

It has been said that the degree of civilization of a country can be determined by the amount of sulphuric acid that it uses. This acid is made from pyrite or brimstone and is much more an essential necessity of present day war than it is of civilization, for most of our explosives can only be made by the use of this acid. Our pre-war requirements for acid were insignificant when compared to our present estimated needs and this estimate increases monthly.

Ducktown, Tennessee, for years had the distinction of having the largest sulphuric acid plant in the world, and one that utilized the fumes from the copper smelters at that place. Now the plant at Ducktown is small compared to some mammoth plants constructed for war use, but Tennessee still has the distinction of having within her borders one of the largest of these mammoth plants. This is the plant at the government powder plant in Hadley's Bend, near Nashville.

When the government, at the beginning of the war, called for increased production of pyrite in this county, the operating mines responded and shipped a greater tonnage. The point was soon reached when all these mines were producing to their limit. Then it was necessary to find new supplies. To open new mines, even if they can be found, takes time. The question was how can the supply of pyrite be increased. So all the occurrences of pyrite were tabulated, and it was shown that the greatest possibility lay in utilizing the waste pyrite from the coal mines of our country. This was a by-product that most of the mines had considered a nuisance and thrown away. There was one mine in Tennessee that was saving its pyrite and shipping it to one of the chemical companies. Now every mine that has been visited has agreed to save pyrite and ship it to some acid producer. The coal operators have been put in direct touch with the acid producers and more pyrite is being saved for war purposes.

Another war activity of the State Geological Survey is on the ball clay deposits, suitable for crucible, glass pots and electric insulators. Mines are operating in West Tennessee on clays suitable for making these articles and new deposits are being prospected daily. Our Tennessee clays are replacing imported clays and giving satisfactory results to the clay manufacturers.

Each section of our state contains minerals necessary for winning the war, and each section is developing these minerals and doing its utmost for the needs of our country.

The Glenmary Oil Field

BY L. C. GLENN.

During the summer of 1916 a well, known as Pemberton No. 1, was drilled at Glenmary, Tennessee, and obtained oil from the Newman, or St. Louis, limestone, at a depth of 1,232 feet. A second well, known as the Todd No. 1, was at once started, but encountered numerous delays. While this latter well was still drilling the writer published an account of the oil find in the "Resources of Tennessee," Volume VII, Number 1, and this was followed in the next, or April 1917, issue of the "Resources of Tennessee," by an article by Dr. Purdue, describing the bringing in of the Todd No. 1 as a successful oil well. The completion of these two wells started an active drilling campaign about Glenmary that has developed some interesting features. It is the purpose of the present article to give a brief account of the developments since the drilling of the second, or Todd No. 1 well, and to point out the conclusions of a practical nature that may be drawn from a study of the wells so far drilled.

The Todd No. 2, drilled two hundred yards south of the Todd No. 1, obtained a little oil but soon went dry. The Todd No. 3 was drilled two hundred fifty yards northwest of the No. 1 and obtained gas and oil. Todd Nos. 1 and 3 are together now pumping between six and seven barrels of oil per day. This oil is delivered into a tank at Rugby Road and shipped by railway to Somerset, Kentucky, where it is delivered to the pipe line. An analysis of the oil from these two wells will be given later in this article.

The Williams No. 1 was drilled about three-fourths of a mile southwest of Rugby Road and obtained about two and one-fourth million feet of gas. The Rugby Land Company, No. 1, was drilled 900 feet west-northwest of the Williams No. 1 and has obtained about one and one-half million feet of gas that is so wet that the well is blown occasionally to clear the pipes of accumulated oil. Several hundred yards west of this last well, the Stonecipher No. 1 was drilled in the early part of May and when connected to a tank about a week later, is said to have pumped something like a hundred barrels the first day. It has not been possible to learn what its subsequent performance has been. It is west of, and structurally somewhat higher than, the Williams No. 1 or the Rugby Land Company No. 1, both of which obtain gas. Two other locations have been made near the Stonecipher No. 1 and will be drilled at once.

On the bank of Black Wolf Creek, 300 yards east of Pemberton No. 1, the Hagemeyer No. 1 starting at an elevation of 1,250 feet, found only a slight show of oil and gas. The Chattanooga Black Shale was found from 1,630 to 1,750 in depth and the well ended at 1,805 feet in a gray limestone.

About 400 feet southwest of the Pemberton No. 1, the G. Pemberton No. 2 has recently been drilled and will make a small well. Another location has been made 400 feet north of it and a mile west of it, near the old Strubbe well, still another well has been located.

Some 250 to 300 yards northwest of the Todd No. 3, the Jim McCart Nos. 1 and 2 have been drilled for the Fisher Oil Company. The more northerly of these, or No. 1, flowed at first and four 250 barrel tanks were filled. It had considerable gas and produced until the No. 2 tapped the gas fissures when it ceased flowing. It later came back again and then failed once more. The No. 2 showed considerable gas and sprayed a little oil for some time, but has since given out and been plugged. The pumping of these two wells affected each other and also affected the Todd No. 3, although the latter is still producing oil, while the others are not.

On top of the hill 500 yards southwest of the station at Glenmary and 175 feet above station level, which is given as 1,275 feet above sea level, the Ohio Fuel Company have recently gotten a gas well at a depth of 1,445 feet. The yield of gas was not ascertained. The well has been plugged.

A quarter of a mile south of the station the Anna Pemberton No. 1 starting at about 1,265 feet elevation, got oil at 1,347 to 1,362 feet depth in the Newman, or St. Louis, limestone and a few weeks after completion gauged about 340 barrels per day. The oil was accompanied by so much gas that after flowage had been started by pumping, it was maintained by the gas pressure. Oil was shipped by tank cars for some time, the total production being unknown, but probably amounting to several thousand barrels. Meanwhile, the Anna Pemberton No. 2 was drilled on the same level 400 feet south of the first well and obtained some oil and gas, at 1,390 feet. The difference in stratigraphic level between the rocks in the two wells is almost nothing, so that this oil came from slightly lower in the limestone than that in No. 1. When No. 1 was pumped, gas was soon taken from No. 2, showing that the fissures were connected. This connection was not free enough, though, to permit a free movement of oil between the two wells. Anna Pemberton No. 3, drilled 400 feet south of the last well, found only a show of oil at the general horizon at which it had been obtained in the two preceding wells. It was drilled deeper and obtained a further show of oil in a sand immediately above the Chattanooga Black Shale. This sand reported to be 26 feet thick, corresponds to the Beaver sand. When tested after standing 24 hours, 7 barrels were bailed from this well. The Anna Pemberton No. 2 was deepened to this lower sand and the two wells were pumped for sometime and a number of cars of oil were shipped. Later they both went dry and have since been plugged. In the Anna Pemberton No. 3, the Chattanooga Black Shale was found from 1,730 to 1,805 feet depth. The well ended in 20 feet of red lime—possibly the Clinton—at a depth of 1,805 to 1,825 feet, and ended at 2,050 feet in gray lime.

The oil from the Anna Pemberton No. 3 did not appear materially different from that from the St. Louis limestone. It seemed to the writer that it might have run down the hole from the St. Louis limestone, where a showing was reported, instead of having come from the Beaver sand. If the St. Louis showing had been cased off or the Beaver shut off by a packing, it could have been definitely determined just where the oil came from. The writer secured a sample of the oil and one from the tank into which the Todd Nos. 1 and 3 were pumped. These were submitted to the Survey Chemist, Dr. Hinds, for analysis, the results of which are appended to this article. These results agree so closely that the writer is inclined to think the two are the same oil.

Analysis of Petroleum, Todd Wells Nos. 1 and 3. Producers' Oil Company, Elgin, Tennessee.

Results:

Base—Paraffin.
Color—Dark brown.
Specific Gravity—15.5 degrees C. or 60 degrees F.
Picnometer—0.842.
Baume—36.2 degrees.

Water—Trace. Begins to boil at 45 degrees C.
Sulphur—0.17 per cent.

Distilled from Engler Flask, Moderate Separation.

	Per Cent by Vol.	Per Cent by Weight	Specific Gravity	Baume
Naptha—to 150 degrees C.	21.4	18.82	0.279	62.0 deg.
Burning oil 150 to 300 degrees	32.6	31.94	0.815	41.6 deg.
Residue	46.0	49.24	1.07	

Analysis of Petroleum, Anna Pemberton Well No. 3, Glenmary, Tenn.

Results:
Base—Paraffin.
Color—Dark brown.
Water—Trace.
Specific Gravity—15.5 degrees C. or 60 degrees F.
Picnometer—0.837.
Baume—37.9 degrees.
Sulphur—0.14 per cent.

Distilled from Engler Flask Without Beads, Moderate Separation.

	Per Cent by Vol.	Per Cent by Weight	Specific Gravity	Baume
Naptha—up to 150 degrees C.	19.5	16.36	0.721	63.7 deg.
Burning oil—150 to 300 degrees C.	33.5	32.21	0.805	44.1 deg.
Residuum—above 300 degrees C.	47.0	51.43	0.913	

Samples of the Beaver sand showed a finely chopped mixture of fine grained sandstone and dolomite. The dolomite was probably from a somewhat higher level.

Analysis of Beaver Sand from Anna Pemberton No. 3 Well at Glenmary, Tenn.

Residual insoluble in acids (silica mainly)	69.22
Fe_2O_3, Al_2O_3 and dissolved SiO_2	1.92
$CaCO_3$	16.75
$MgCO_3$	9.65
Undetermined	2.48
	100.00

The Anna Pemberton No. 1, after producing so freely for some time, suddenly went dry and since that time it has been possible to obtain only a barrel or two after letting the well stand for a week or more. When being pumped it would take the gas from the No. 2 well, in a couple of hours, and it is reported that No. 2 and No. 3 affected each other in a similar manner when either was pumping. The Anna Pemberton No. 3 is the deepest well at Glenmary. Its log is as follows:

Log of Anna Pemberton Well No. 3. Elevation About 1,270 Feet.

	Thickness:	From:	To:
Soil	5	0	5
Slate	35	5	40
Lime (really sandstone)	20	40	60
Slate	40	60	100
Lime (really sandstone)	20	100	120
Slate	245	120	365
Sand	10	365	375
Slate	130	375	565
Salt sand (base of Lee)	303	505	808
Slate	27	808	835
Lime	15	835	850
Redrock	10	850	860
Slate and shells (base of Pennington)	190	860	1,050
Lime (top of St. Louis)	20	1,050	1,070
Slate	36	1,070	1,106
Lime	34	1,106	1,140
Pencil cave (shale)	8	1,140	1,148
Lime	42	1,148	1,190
Slate	16	1,190	1,206
Lime—gas at 1,390	293	1,206	1,499
Sand, showing of oil	10	1,499	1,509
Lime	195	1,509	1,704
Sand, showing of oil (Beaver sand)	26	1,704	1,730
Chattanooga Black Shale	75	1,730	1,805
Red Lime—Clinton	20	1,805	1,825
Gray Lime (probably Ordovician)	225	1,825	2,050

Casing 10 inches, 28 feet; 8 inches, 808 feet; 6 5-8 inches, 1,206 feet. Completed February 21, 1918. J. C. Amsler, Contractor; Charles E. and W. L. Russell, owners.

About 175 feet west of the Anna Pemberton No. 2, the Joel McCart was drilled just west of the railroad, to a depth of 1,450 feet, but got neither oil nor gas, and off-setting well drilled about 60 feet from it, to a depth of 1,526 feet, was also entirely dry. These wells started only 10 feet or less above the level of the Anna Pemberton wells. They show that the limestone just where they were drilled was without oil bearing fissures. One location north of these, another rig was erected but no drilling has been done.

Near the old coke-ovens, three-fourths of a mile east of the Anna Pemberton wells, a well is now being drilled and has reached a depth of over 1,400 feet. It has so far obtained a showing of gas only.

OTHER WELLS IN THE REGION.

At Helenwood a well designed for a deep test is now drilling below 1,700 feet. The well mouth is at an elevation of about 1,365 feet and is ten feet below the top of the Lee formation. The base of the Lee formation was reached at 905 feet and the top of the St. Louis, or Newman limestone at 1,160 feet. So far only slight shows of oil and gas have been obtained. It is proposed to drill this well 3,000 feet or more, if necessary. If so, it will become the deepest test in the entire region. The deepest well, so far, known to the writer in that general region is the State's deepest test at Petros, which is 2,940 feet deep. This was drilled in 1898. The log is of considerable interest, has never been published, and is inserted here because of the light it throws on the deeper lying rocks of the region.

Log of Well No. 2, Drilled in Prison Yard at Petros. Elevation of Well Mouth 1,468 Feet.

	Thickness	Depth
Soil	10′	0-10′
Shale	15′	10′-25′
Blue Sandstone	59′	25′-84′
Blue Slate	15′	84-99′
Gray Sandstone	26′	99′-125′
Slate	115′	125′-240′
Sandstone	17′	240′-257′
Coal	3′ 6″	257′-260′ 6″
Sandstone	44′ 6″	260′ 6″-305′
Shale	145′	305′-450′
Coal	Thickness not given	
Shale	155′	450′-605′
Sandstone (top of Lee conglomerate)	80′	605′-685′
Shale	70′	685--755′
Sandstone	71′ 6″	755′-826′ 6″
Coal	3′ 6″	826′ 6″-830′
Sandstone	15′	830′-845′
Shale	62′ 6″	845′-907′ 6″

Coal	2′ 6″	907′ 6″-910′
Sandstone	100′	910′-1,010′
Coal	1′ 6″	1,010′-1,011′ 6″
Sandstone	96′ 6″	1,011′ 6″-1108′
Coal	2′	1,108′-1,110′
Sandstone	100′	1,110′-1,210′
Black Shale	88′	1,210′-1,298′
White Sandstone	5′	1,298′-1,303′
Black Shale	37′	1,303′-1,340′
White Sandstone	61′	1,340′-1,401′
Black Shale	54′	1,401′-1,455′
Sandstone	54′	1,455′-1,509′
Black Shale	21′	1,509′-1,530′
White Sandstone	37′	1,530′-1,617′
Slate and Shale	60′	1,617′-1,677′
White Sandstone	12′	1,677′-1,689′
Slate and Shale	23′	1,689′-1,712′
White Sandstone	5′	1,712′-1,717′
Shale	72′	1,717′-1,789′
White sandstone (base of Lee)	47′	1,789′-1,830′
Chester Shales	270′	1,830′-2,100′
St. Louis Limestone	840′	2,100′-2,940′

Two miles east of the Todd wells, there is a well drilling on a branch of Black Wolf Creek and eight miles east there is one drilling on Brimstone. Both of these have encountered many obstacles and the drilling has been much delayed. The drillers are now actively at work on these wells and it seems that they will soon be pushed to completion.

Six miles southeast of Glenmary, on a branch of Cowan Creek, a well has recently been drilled on the G. A. Chandler farm to a depth of 2,090 feet. The elevation of the well mouth is approximately 1,350 feet. The base of the Lee formation was reached probably at 1,040 feet, though the material between there and 1,100 feet is not entirely diagnostic and may also belong to the Lee. If so, the base of the Lee is at 1,100 feet, for the next item of the log is fifty feet of limestone and then comes typical Pennington Red Shale. The top of the St. Louis, or Newman, limestone is at 1,305 feet. From the log as given to the Survey, it seems that the Chattanooga Black Shale was not quite reached at 2,090 feet. A little gas was gotten at 1,608 feet and more gas, with a show of oil, at 1,985 to 2,025 in a white limestone. The gas was estimated at 100,000 feet. The well was plugged and abandoned.

At Sunbright a well has been drilled on the S. H. Jones farm. The elevation of the well mouth is between 1,360 and 1,365 feet and the well ended at 1,725 feet after passing through what is believed to be the Chattanooga Black Shale at 1,678 to 1,695 feet depth. The detailed log, although at hand, is not available for publication. The well obtained several shows of oil and gas.

A well has recently been drilled near Wartburg and another is now drilling in the same vicinity. So far, it has not been possible to secure detailed information concerning these wells. The one that has been completed is reported to be a dry hole.

From all that has been learned of the wells so far drilled in the Glenmary region, a number of facts seem clearly established:

First, The oil comes from fissures in the St. Louis, or Newman, limestone. These fissures are not at exactly the same stratigraphic level in even adjacent wells, but may vary as much as fifty or seventy-five feet up or down.

Second, The limestones are not fissured everywhere. One well may find an unusually open set of fissures, such as those encountered by the Anna Pemberton No. 1, while the next well may find the limestone entirely without fissures.

Third, Near-by wells may be entirely independent of each other or may show that the fissures are connected so that the pumping of one affects the other.

Fourth, Wells usually show some gas. This varies greatly in amount. The largest well so far, yielded two and one-fourth million feet when gaged. The gas in one of the largest wells is wet with oil.

Fifth, There is little, or no water reported anywhere in the St. Louis limestone, or in any of the deeper rocks.

Sixth, The general structure of the region is that of a monocline rising gently westward, and the distribution of the oil in the St. Louis limestone does not appear to be dependent on any terraced or anticlinal structure, but on the presence or absence of fissured zones in the massive St. Louis limestone. The largest gas wells, those southwest of Rugby Road, are in rocks that are structurally higher than at any of the wells that have produced oil, except the Stonecipher well.

Seventh, A well will suddenly go dry as several have done, when the oil in the system of fissures tributary to it, has been exhausted. If these fissures have tide ramification through the rock, the area drawn upon may be much larger and the life of the well be much more permanent. A few of the oldest wells, like the Pemberton No. 1 and the Todd Nos. 1 and 3, have in this way maintained a steady production of five or six barrels for a year or more, and show no signs of final exhaustion.

Eighth, Further drilling to the east and west will soon determine the conditions in these directions and throw much light on the possibilities of extending the field. If the St. Louis limestone can anywhere be found through slight, localized disturbance or other causes, such as dolomitization, to be more generally and uniformly fissured, it may be expected to furnish a pool with such staying qualities as would make it attractive to develop. The surface rocks have so far failed to show any such disturbance and if highly fissured areas exist in the St. Louis limestone, they apparently must be discovered by the drill and not by surface exploration. Unfissured areas in the St. Louis are numerous enough, as shown by dry holes, to increase considerably the hazard of such drilling.

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. 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. 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).

No. 2—State Supervision of Forestry, by L. C. Glenn.
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Building Precautions Against Earthquake Disasters, by Olaf P. Jenkins.

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The State Geologist and Conservation, by A. H. Purdue.
A Tripoli Deposit Near Butler, Tenn., by L. C. Glenn.

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.
Recent Water Power Development in Tennessee, by J. A. Switzer.
Two Natural Bridges in Tennessee, by Hugh D. Miser.
Road Materials of Tennessee, by A. H. Purdue.
Report on the Water Powers of Tennessee.

No. 4—The Need of a Soil Survey of Tennessee, by C. A. Mooers.
The Geology of Perry County and Vicinity, by Bruce Wade.
Indexes to Volumes III and IV.

Vol. V. No. 1—The Hydro-Electric System of Tennessee, by J. A. Switzer.
West Tennessee Gullied Lands and Their Reclamation, by R. S. Maddox.
The White Phosphates of Tennessee, by J. S. Hook.
(Out of print).

No. 2—Physiographic Influences in the Development of Tennnessee, by L. C. Glenn.
Care and Protection of Forests, by R. S. Maddox.
Two Natural Bridges of the Cumberland Mountains, by Wilbur A. Nelson. (Out of print).

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

No. 4—The Soils of Tennessee, by C. A. Mooers.
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Vol. VI. No. 1—Oil and Gas Conditions in the Central Basin of Tennessee, by A. H. Purdue.
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Sketch of the Work Done by the State Geological Survey in 1915.

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Structure of the Southern Part of Cumberland County, Tennessee, in Relation to the Possible Occurrence of Oil and Gas, by Charles Butts.
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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.

No. 4—The Conservation of Phosphate Rock in Tennessee, by W. C. Phalen.
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Vol. VII. No. 1—Administrative Report of the State Geologist, 1916.
By-product coke oven opportunities in Tennessee, by A. H. Purdue.
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Properties of moulding sand, by Robert E. Wendt.

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Manganese Deposits of Bradley County, by A. H. Purdue.
Barite Deposits of the Sweetwater District, East Tennessee, C. H. Gordon.

No. 2—Announcement. Election of New State Geologist, by L. C. Glenn.
Report on the Caves of the Eastern Highland Rim and Cumberland Mountains, by Thomas L. Bailey.
Discussion of the Chemical Analyses of the Cave Deposits of Tennessee, by L. C. Glenn.

VOLUME VIII NUMBER 4

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.

OCTOBER, 1918

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VOLUME VIII NUMBER 4

THE RESOURCES OF TENNESSEE

Published by the State Geological Survey
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CONTENTS

LIST OF ILLUSTRATIONS

Errata and Addenda to Part I.

Due to the fact that Part I of this paper was not seen in proof by the authors, several errors, some quite serious, have crept into the report and should be here corrected.

Both the cover and title page. The author's name should be F. C. Schrader, not F. G.

Figure 1, frontispiece, and figure 4, page 169. The bar scale should read 10 in place of 1, and 20 in place of 2. The scale should be 27½ miles to the inch in place of 2¾ miles.

Page 153, 9th line, 1st word, substitute material for mineral.

Page 161, 3rd line, Manganese, used twice, should read manganite.

Page 161. Add description as follows:

Braunite. Braunite ($3Mn_2O_3.MnSiO_3$) is a heavy nearly black mineral generally massive crystalline in form, streak brownish black, hardness 6 to 6.5, specific gravity 4.75, cleavage perfect. It may be distinguished from psilomelane by its browner streak, crystalline cleavage faces in the broken or polished rock, and slightly greater hardness. It is considerably harder than manganite, which also has a black streak. However, any of these minerals when weathered or impure may have a brownish streak and may be softer than the typical mineral, so that it is not always easy to distinguish them. Braunite has not certainly been identified in the minerals from East Tennessee, but bright cleavage faces in the dense psilomelane ore from several places mentioned in the descriptions are believed to be those of braunite.

Page 180, figure 5. The note below cut should read: Floor of mine is composed of brecciated sandstone impregnated with manganese ore. Scale, about 1 inch=2 feet, should be added.

Page 182, 3rd line, 5th word, should be trend instead of trench.

In the table on pages 167 and 168 and the accompanying pages of description the names of formations printed in the folios of the Geologic Atlas of the U. S. Geological Survey covering East Tennessee are used. From the fossils collected and the stratigraphic relations in the field recently observed by G. W. Stose and E. O. Ulrich in revising the geologic maps of the Red Hills area around Sweetwater and

Cleveland (Figs. 12 and 13) the following conclusions with regard to the Sweetwater-Cleveland area have been reached: The limestone called Chickamauga limestone is Lenoir,[1] named by Safford after the town of Lenoir in this area; the Holston marble, which is apparently continuous with the Holston marble of the Knoxville area, appears to be equivalent to the lower part of the Tellico formation in the more eastern belts, and may prove not to be of Holston age; the Tellico sandstone, which is here more calcareous and much thinner than in the more eastern belts, represents a marked change in the character of the sediments by the influx of red sands from former lands to the southeast, and although there may be no great unconformity at its base the abrupt change in sediment and the irregularity of its base in part filling channels between reefs, are evidence of unconformable relations at least within the formation. The Tellico sandstone as properly restricted is not the equivalent of the Moccasin limestone as stated in the table, but is older; the Sevier shale, including yellow shales, shaly limestones, and marbles, is equivalent to the Ottosee[1] shale of Chazyan age. The names employed in the geologic folios are, however, used throughout the folloiwng descriptions.

A composite section of the rocks exposed in the Sweetwater-Cleveland area is as follows, thicknesses being only estimated:

[1]The names Lenoir limestone and Ottosee shale are in current use but have not yet been adopted by the U. S. Geological Survey. They are fully described by Mr. Ulrich in Bull. Geol. Soc. of Amer., Vol. 22, 1911.

Formation	Feet	Description
Sevier shale (Ottosee shale of Ulrich)	10+	Soft reddish porous sandstone, formerly calcareous, carrying a small amount of hematite of no economic value, and prospected for iron at one place southeast of Cleveland.
	20+	Siliceous gray oolitic marble, reddish in part.
	40+	Shaly gray limestone.
	60+	White marble, mostly coarse granular, some fine saccharoidal. Reddish blotched and pink beds in lower part. Somewhat fossiliferous throughout.
	40+	Gray to greenish shaly limestone, very fossiliferous.
	50+	Soft greenish calcareous shales, weathered yellow, and some very fossiliferous shaly limestone at the base. The basal beds fill depressions and solution channels 20 or more feet deep in the upper surface of the underlying marble, representing a marked unconformity.
Tellico sandstone	90+	Coarse granular crinoidal red marble with bryozoa and coral reefs in the upper part.
	50	Pink crinoidal granular marble with crossbedded siliceous and ferruginous banding and small shiny hematite-coated pebbles. The ferruginous layers are workable ore beds in places, especially where the ore is concentrated in solution pockets in the underlying marble. Toward the southwest, yellow shale at one or more horizons is present in considerable quantity.
Holston marble	30	Thick-bedded pink marble with deep black stilolitic markings.
	10	White marble, in part light greenish, mostly coarse granular, but in part fine grained.
Chickamauga limestone (Lenoir limestone of Safford and Ulrich)	100+	Thin-bedded blue limestone with wavy partings.
Knox dolomite		Fine-grained even bedded light-gray dolomite and magnesian limestone.

Mention should be made of the important fact that the old land surfaces of past ages had much to do with the accumulation and concentration of nearly all the manganese ore deposits of whatever type. The deposits are dependent on deep weathering of the associated rocks, for the minerals are first dissolved from the weathering rock and are later deposited where there are deep soils and accumulation of waste material through which the solutions percolate. Therefore old level land surfaces, such as the bottoms of old valleys, which were the dumping ground of waste material from higher ground and were uneroded for long periods of time except by subsurface solution because of the stability of land conditions, afforded favorable places for the deposition of ores. Later erosion has cut the present valleys into these old valley floors and left their remnants as benches on the sides of the valleys or as isolated ridges and knolls, generally covered with deep soil and weathered rock debris, and in places deeply covered with mountain wash. Most of the ore deposits herein described will be found to occupy such positions.

The list of manganese mines and prospects on pages 199--207 should be corrected as follows:

Johnson County, Davis prospect (same as Neely mine) change to read 6 miles northeast of Crandull.

Hamblen County, Lotspeich prospect, change to read 3 miles northwest of Morristown.

Monroe County, Vita mine, change to read Vida mine, C. D. Smith owner, Vida Iron Co. operator. (The adjoining Ewing mine, owned by Robert Ewing, was operated by Fitzgerald & Smith.)

Monroe County, Kimbrough prospect, change to read 2 miles to Louisville & Nashville Railroad.

Monroe County, Groundhog Mountain prospect, change to read J. H. Curd operator.

Additions to the list of mines and prospects should be made from the list on the map (Fig. 11) and descriptions in the text.

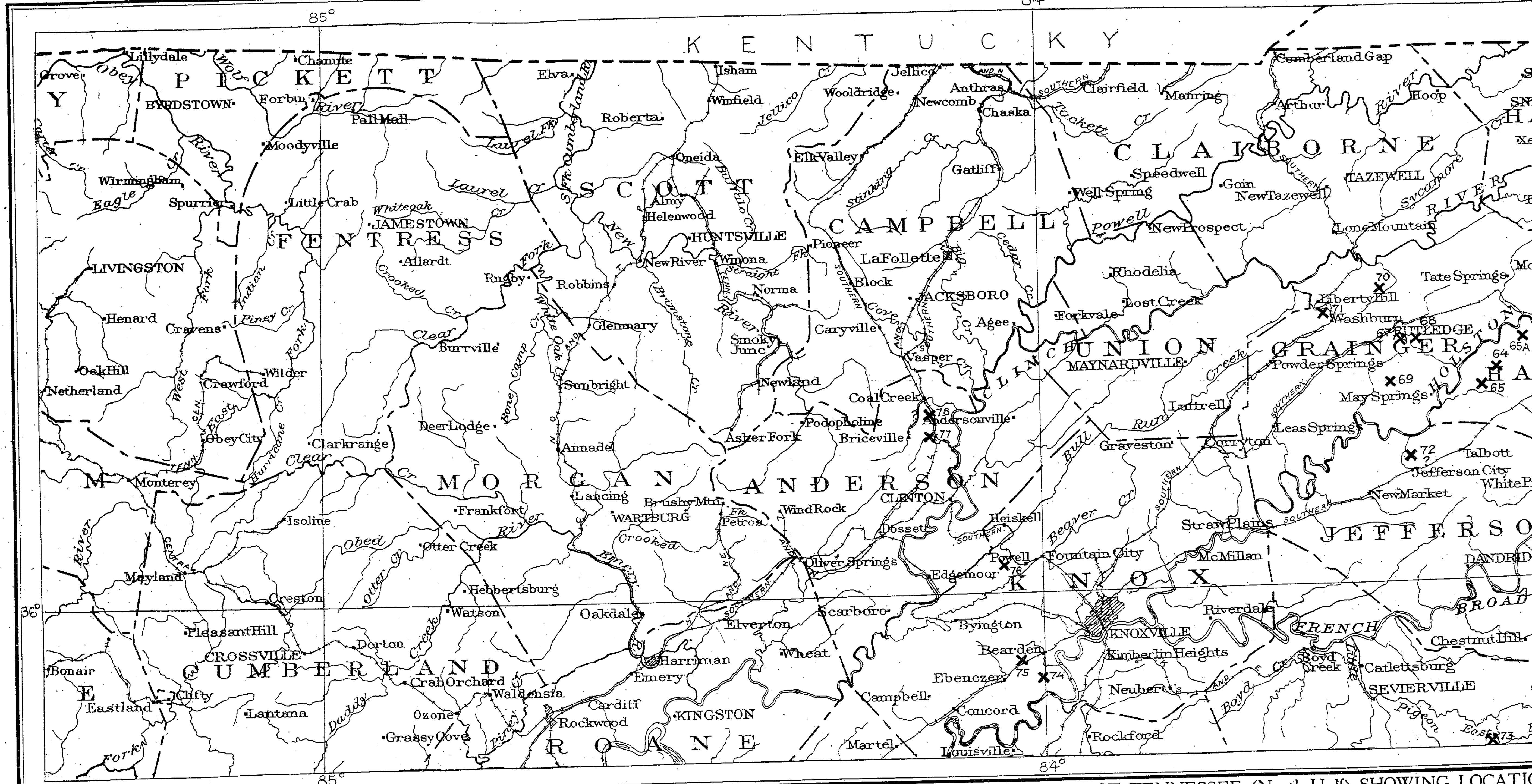
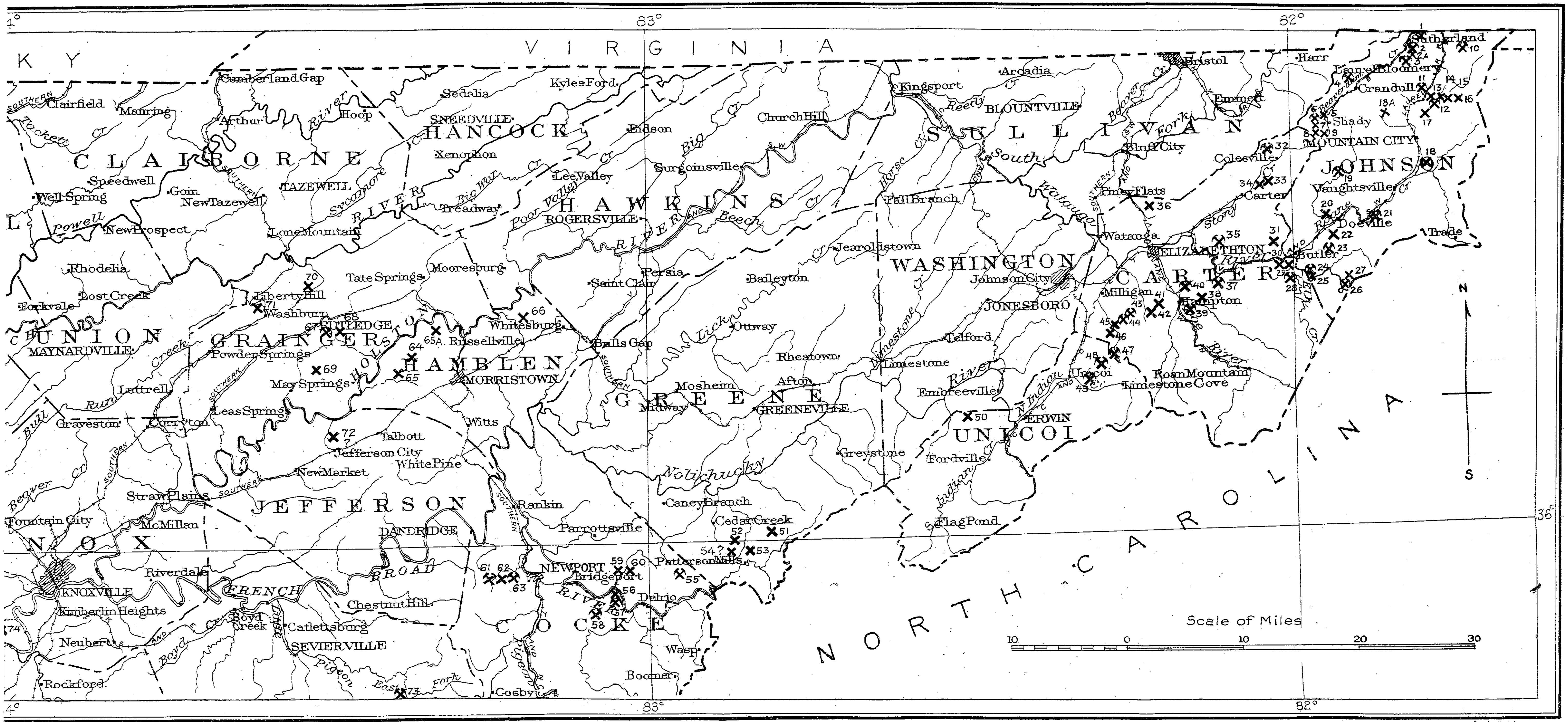


FIGURE 11, A. MAP OF EAST TENNESSEE (North Half) SHOWING LOCATIO
By G. W. Stose and F. C. Schrader.



OF EAST TENNESSEE (North Half) SHOWING LOCATION OF MANGANESE MINES AND PROSPECTS
By G. W. Stose and F. C. Schrader. 1918

Manganese Deposits of East Tennessee

PART II.

BY G. W. STOSE AND F. C. SHRADER.

DESCRIPTION OF MINES AND PROSPECTS.[1]

The manganese mines and prospects of East Tennessee, 116 or more in number, lie chiefly in a narrow northeast-southwest belt about 220 miles long extending diagonally across the State near its eastern border. A few unimportant deposits in Grainger County lie outside the belt to the northwest. The location of the mines is shown on the accompanying map (Fig. 11, A and B). Iron, lead, and zinc ores, pyrite, barite, marble, bauxite, kaolin, fluorite, limestone for flux, and phosphate are also mined in the belt, mostly on a small scale, however.

The mines and prospects will be described by counties in geographical order beginning with Johnson County at the Virginia State line in the northeast corner of the State. Manganese ore is known to occur in minable quantities in 17 counties, which are given in the following list in the order in which they are described.

Counties in which commercial manganese deposits occur in East Tennessee.

Johnson,	Washington,
Carter,	Greene,
Unicoi,	Cocke,

[1]This report, which is the second part of the report on the Manganese Deposits of East Tennessee by G. W. Stose and F. C. Schrader, was prepared under a co-operative agreement between the State Geological Survey and the United States Geological Survey, the latter bureau being represented by Messrs. G. W. Stose and F. C. Schrader. Mr. Arthur C. McFarlan, who represented the State Geological Survey, visited certain prospects and made the detailed maps of the Sweetwater and Cleveland districts (Figs. 12 and 13, opposite pages 304 and 316), the geological boundaries of which have been somewhat modified by Stose in the field.

The descriptions of the mines are based chiefly on the examination of the deposits by Stose and Schrader during a field trip in April to June, 1918, and short trips by Stose in October, 1917, and by Stose and Schrader in October, 1918.

Grainger,
Hamblen,
Jefferson,
Sevier,
Knox,
Anderson,
Blount,
Loudon,
Monroe,
McMinn,
Bradley.

Each description will include the location of the deposit, the extent of development of the mine, a brief account of the plant, the character and association of the ore, and its geologic relations. The probable extent of the ore and suggestions for further prospecting will be also given where warranted.

The deposits as a whole are estimated to contain 85,000 tons of ore available under present conditions, of which 75,000 tons is classed as manganese ore, but includes some ferruginous manganese, and 10,000 tons as manganiferous iron ore. To obtain these figures an estimate was made at each mine and prospect of the ore proven by prospecting and by geologic relations to be present and so accessible that it can be profitably mined at the present market prices. The total estimate is therefore conservative.

By the term manganese ore is meant ore that contains 35 per cent or more of metallic manganese. Ferruginous manganese ore contains from 10 to 35% of manganese and a percentage of iron commonly varying from 10 to 40. Manganese ore is used in the manufacture of ferromanganese. Ferruginous manganese ore is generally used in the manufacture of spiegeleisen but in some plants is mixed with higher-grade ores from which ferromanganese is made. The lower grades of ferruginous manganese ore are also used in making manganiferous pig iron. Iron ore that contains less than 10% and more than 1% of manganese is termed manganiferous iron ore. It is used in the manufacture of manganiferous pig iron, but does not have an increased value due to its manganese content.

(For table of Production of Manganese Ores in Tennessee, see page 324.)

The schedule of market prices of manganese ores in the United States fixed by the War Industries Board and the American Iron and Steel Institute[1] in June, 1918, is as follows:

[1]Engineering and Mining Journal, vol. 105, No. 23, p. 1053, June 8, 1918.


Citico
SOUTH

Schedule of prices for manganese ore.

(Dried at 212° F.)

Metallic manganese content. Per cent.	Price per unit f.o.b. South Chicago.		Average price per ton. (2240 lbs.)	
	Mined east of S. Chicago	Mined west of S. Chicago	Mined east of S. Chicago	Mined west of S. Chicago
35 to 35.99	$1.01	$0.86	$35.85	$30.53
36 to 36.99	1.05	0.90	38.32	32.85
37 to 37.99	1.09	0.94	40.87	35.25
38 to 38.99	1.13	0.98	43.50	37.71
39 to 39.99	1.15	1.00	45.42	39.50
40 to 40.99	1.17	1.02	47.38	41.31
41 to 41.99	1.19	1.04	49.38	43.16
42 to 42.99	1.21	1.06	51.42	45.05
43 to 43.99	1.23	1.08	53.50	46.98
44 to 44.99	1.25	1.10	55.62	48.95
45 to 45.99	1.27	1.12	57.78	50.96
46 to 46.99	1.29	1.14	59.98	53.01
47 to 47.99	1.31	1.16	62.22	55.10
48 to 48.99	1.33	1.18	64.50	57.23
49 to 49.99	1.35	1.20	66.82	59.40
50 to 50.99	1.37	1.22	69.18	61.61
51 to 51.99	1.39	1.24	71.58	63.86
52 to 52.99	1.41	1.26	74.02	66.15
53 to 53.99	1.43	1.28	76.50	68.48
54 and over	1.45	1.30	78.30+	70.20+

Prices are based on ore containing not more than 8% silica and not more than .25% phosphorus. Premium of 50 cents per ton for each 1% silica under 8% down to 5%, and of $1 per ton for each 1% silica under 5%; penalty of 50 cents per ton for each 1% silica in excess of 8% up to 15%, of 75 cents per ton for each 1% silica in excess of 15% up to 20%, and of $1 per ton for each 1% silica in excess of 20% up to 25%. Ore containing over .25% phosphorus subject to penalty and bought at the option of the buyer.

JOHNSON COUNTY.

Johnson County, the northeasternmost county of the State, is largely mountainous, and it is becoming that its county seat is named Mountain City. Its western boundary follows the crest of Holston and Iron mountains, and its eastern boundary, here the State line, follows the crest of Stone Mountain in much of its course. Doe, Dry Run, and Iron mountains, and smaller ridges and spurs divide the county into several longitudinal northeastward trending valleys in which manganese deposits occur. Description of the 27 manganese mines and prospects in this county follow.

SHADY VALLEY DISTRICT.[1]

Shady Valley is the flat-bottomed valley between Holston and Iron mountains which is drained northward by Beaverdam Creek in the northwestern part of Johnson County. Although the open valley ends a mile or so north of Crandull, where the stream enters a rocky gorge, the few mines and prospects lower down the creek near Sutherland will be included in the Shady Valley district.

Reynolds mine.[1]—The Reynolds mine is 1½ miles south of Damascus, Va., just south of the Virginia State line, and three-fourths mile northeast of Sutherland. The property is owned by A. D. Reynolds of Bristol. The Lehigh Valley Manganese Company, of Bethlehem, Pa., and Damascus, Va., have leased the property and began development in June, 1918. By October 100 tons of ore had been mined, about half of which had been shipped. It is reported to average 40% manganese, 13% silica. Over half of the ore is fines. Manganiferous iron ore was mined at the north end of the property many years ago.

The mine is on a terraced spur on the northwest slope of Iron Mountain, at an elevation of 2,400 feet, or 450 feet above the creek. It is in red and yellow clay, believed to be residual from the Shady dolomite, resting on Erwin quartzite. The structure may be locally synclinal, as the quartzite in the gulch to the north dips 40° S.

The deposit is opened by several cuts not over 10 feet deep and covering a vertical range of 50 feet on the slope. Most of them show nodular psilomelane wash ore in the clay, chiefly in the upper layers. Most of the ore is scattered in the clay, but irregular streaks and lenses also occur and show evidence of disturbance and movement by creep down the slope. A bed of soft ore about a foot in thickness was observed near the north end of the property. The indications are on the whole unfavorable.

The ore is sledded down the steep slope to the washer 230 feet below the mine and the washed ore is hauled in wagons to the railroad.

[1]Descriptions of most of the Shady Valley mines and prospects are by G. W. Stose.

[1]Description of the Reynolds, Neely, and Hogback mines are by F. C. Schrader after visit in October, 1918.

Neely Mine.—The Neely mine is one mile south of Sutherland on the east side of Beaverdam Creek, on the Government Forest Reserve. The manganese deposit was first opened by J. A. Neely, of Damascus. It is now being operated by the Laurel Mining Company, of Mountain City, in which the Southern Manganese Corporation holds one-third interest. It was worked about 1898 for iron ore. Twenty-seven tons of manganese ore, mostly from the old dumps, has recently been shipped and about four tons lie on the dump. The ore is dry-screened and is reported to run about 45% manganese, 4% silica when washed. A road from the mine to the railroad is to be built and a washer installed. The ore is at present hauled to the railroad on sleds.

The prospect is on a bench on the northwest slope of Iron Mountain, at 2,800 feet in elevation, 600 feet above the creek. It is in reddish-brown clay, probably residual from Shady dolomite, which rests on Erwin quartzite apparently dipping northwest into the Beaverdam syncline. The main opening is a 50-foot cut running northeast into the ridge, following an ore zone about 8 feet thick which dips 20° NNW. The pit is 20 feet wide and 15 feet high at the face. The ore is hard psilomelane in nodules and irregular mammillary fragments ranging up to a foot in diameter. Some wad and soft pyrolusite is also present. The ore shipped came from this pit, which is the original working reopened.

About 250 feet northeast of the main pit another old working is being reopened, and shows considerable scattered ore. It has been reported since the visit by the writer that a solid body of ore has been struck in this working. The prospects are bright for an active mine at this place.

Sutherland Prospect.—The Sutherland prospect is 1¾ miles southwest of Sutherland on lands of the U. S. Forest Reserve, which has recently been prospected under lease from the Government by Wiley and J. F. Sutherland, and the indications are reported to be exceptionally favorable. Geologic conditions are believed to be the same as at the Neely mine.

Hogback Mine.—The Hog back mine is 2½ miles south-southwest of Sutherland, on the Government Forest Reserve. It was first opened in 1888 by David Blevins, of Shady Valley, for William McGovern, of Pennsylvania. It has only recently been developed and is now operated by the Lehigh Valley Manganese Company, of Bethlehem, Pa., with an office at Damascus, Va. Operations began early in 1918, and by October they had mined and shipped about 80 tons and had a like amount at the mine ready to ship. It is reported to run 42% manganese, 8% iron, 12% silica. It is at present dry-screened and hand-picked, and in part washed by hose in loading the cars by gravity, but a washer is to be constructed.

The mine is on a bench on the northwest slope of Iron Mountain, at an elevation of 2,900 feet, 650 feet above the creek. The deposit is in brownish and red clay, in part wash and in part residual from Shady dolomite, resting on Erwin quartzite, which apparently dips northwest into the Beaverdam syncline. It is opened by several cuts about 10 feet deep with a vertical range of 100 feet, all showing ore. The best exposure is in a cut 60 feet long. The ore is largely psilomelane in nodular botryoidal forms distributed in zones or layers several inches in thickness and also sporadically isolated. Some wad and pyrolusite are also present. None of the ore is very hard. The upper part of the clay is banded parallel with the surface, indicating creep and surface deposition. Float ore is found on the surface below the mine and also along the slope on the same level as the mine. The indications are regarded as favorable for successful mining.

Davis Mine.—The Davis mine, called also Parker, or Crandull, mine, is just west of Crandull at the lower end of Shady Valley. The openings are on a flat-topped spur on the west side of the valley 100 to 200 feet above the present valley bottom, adjacent to the site of the old Heberlin mine, from which 800 tons of manganese ore are reported to have been taken years ago.[1] Since the time of visit of the writer, October, 1917, the mine has been leased to the Southern Manganese Corporation and is at present being actively operated by them.

The property was developed by George E. Davis, of Bristol, Va., who opened several pits and shipped a carload of ore, which is reported to have run about 43% manganese. The lower openings, on the outer edge of the terrace about 100 feet above the valley bottom, are on E. N. Martin's land and are shallow pits in yellow clay and dark manganiferous clay, showing considerable high-grade crystalline manganese ore, probably manganite, and some iron ore. Most of the manganite is cellular, forming the partitions of cells, some of which are now empty. The clay is residual from impure calcareous beds of the Shady dolomite lying just above soft red and green glau-

[1]Harder, E. C., U. S. Geol. Survey Bull. 427, 1910, p. 74.

conitic sandstones and about 70 feet above the coarse sandstone of rounded quartz grains at the base of the Shady which outcrops on the slope below in nearly horizontal position. The face of one small pit was almost solid ore, and although considerable ore is iron, the quantity of high-grade manganese ore from the pit looked very promising. Float ore and dark-brown soil above the pits indicate the probable extension of the deposit over most of the surface of the terrace, which is part of the old valley floor.

The higher prospects are a short distance farther back on the terrace, across a small ravine, on W. J. Parker's land. In June, 1918, this property was leased to the Southern Manganese Corporation, which is equipping it with machinery and will begin active operation at once. The tract includes the pits of the old Heberlin mine, whose waste dump contains sufficient nodules of psilomelane to be reworked and profitably washed. The new pits are dug into the side of the ravine about 20 feet below the top of the terrace and show excellent ore, largely psilomelane in stalactitic form, with crystalline manganite lining cavities and covering the stalactites. The best exposure showed the ore inclosed in wad and dark manganiferous clay, capped by a nearly horizontal layer of hard manganiferous brown-iron ore. Several tons of high grade lump ore in large masses lay on the dump of this small pit and the face of the pocket was still in ore. Several small pits farther up the ravine showed the ore to extend 100 feet or more back on the terrace. Analysis of a carload of the better grade ore shipped during 1917 ran 45.18% manganese, 9.77% iron, and 6.27% silica. A carload of ferruginous manganese ore from the caprock, also shipped in 1917, ran 20.17% manganese, 27.10% iron, and 13.94% silica.

The mine is near the end of a gentle minor syncline on the side of the larger Shady Valley syncline. The dips of the rocks are nearly flat and the geologic conditions are unusually favorable for the accumulation of ore. The quantity and high grade of the ore in the prospects also support this view. These favorable conditions probably extend northeastward on the terraced spurs, where some prospecting has been done, and also southwestward where there has been no prospecting so far as known. The thick layer of wash from the mountain slope which covers most of the terraced spurs makes prospecting difficult.

The mine has recently (October, 1918) been visited by Mr. Schrader, who reports marked activity. Lodging and commissary buildings to accommodate 80 men are nearing completion. The washer and pumping plant have been erected and electric lights are being installed so that the washer can be run day and night in two shifts. The present production of 16 tons of washed ore a day it is planned to increase to 40 tons. The dirt is removed by mule plows and scrapers, dumped through a trap door to undershot tram cars and conveyed by gravity over a double track trestle to the 25-foot double-log washer 60 feet from the lower end of the mine, where it is dumped by the tilting of the car. The washed ore is hauled by wagon to the railroad at Crandull. The pumping plant is at Crandull, on Beaverdam Creek, and has a capacity of 300 gallons a minute.

The face of the working is 30 feet high and shows good ore throughout, except for about 12 feet of lean overburden and some barren clay, which is removed by scrapers into the gulch below. The run of mine dirt concentrates 12 into 1. About 40% of the ore is fines, as so much of the ore is brittle crystalline manganite, and tables may be installed to reduce the silica, although this is generally done at the company's plant in Anniston. The ore shipped is reported to run 41% manganese, 10% iron, and 8% silica. The development work has been well planned by the company's engineers, and if the deposit proves as large as is hoped, the use of a steam shovel and other enlargements of the plant will also be made.

King Prospect.—Several small pits have been opened on the King property west of Shady village, in the upper part of Shady Valley, where several old abandoned ore banks occur. These are on a low terrace about 20 feet above the flat valley floor. The pits are in clay residual from the lower dolomite beds of the Shady, and apparently occupy a minor gentle syncline within the Shady Valley syncline, as the coarse porous sandstone layer at the base of the Shady dolomite outcrops in the axis of a small anticlinal fold about one-half mile to the south. On what is called the Five Acre tract at the north end of the property psilomelane nodules occur sparingly in dark manganiferous clay beneath a 2-foot layer of brown-iron ore, which was formerly mined for iron, but the amount of manganese ore appears to be insufficient to be mined profitably. Dolomite is exposed in the lower part of the pit. The pits had been abandoned some time when visited.

Only old slumped pits were to be seen at the south end of the property, but since the time of visit it is reported by Miss M. E. King, of Danville, Va., that ten shafts have been sunk at this place and ore having an average analysis of 49.80% manganese, with a premium for low silica, was abundant. The samples submitted to the writers were good-sized chunks of clean solid ore, largely crystalline manganite. From these samples the prospect appears very favorable and should be developed at once before the lumber railroad which now runs to the property is removed. The Southern Manganese Corporation has examined it and is understood to have been favorably impressed with it.

Maxwell Mine.—The Maxwell mine is located one mile northwest of Shady village, in the upper part of Shady Valley, on a tract of land of which the mineral right only is owned by the Maxwell Manganese Mining Company, of Elizabethton, Tenn. H. V. Maxwell, its president, was personally developing the tract at the time of visit, and a carload of washed ore was nearly ready for shipment to determine its grade and value. Considerable manganiferous iron ore had also been taken out, but the cost of transportation was such that it could not be shipped with profit. Iron ore had been mined on the property many years ago by Mr. Scott for a local forge.

The property is developed chiefly by two shallow trenches in a small stream bottom on the west side of the valley. This deposit is largely in clay and sand wash from the adjacent hillside which overlies residual clay of the Shady dolomite. Considerable ore was showing in pockets in the face of the pits, but water from the stream had flooded the pits and temporarily stopped the work. The deposit is badly located in this respect for economic handling. The ore is chiefly psilomelane, some of which is stalactitic, and occurs in irregular pockets in the yellow clay beneath a capping of manganiferous iron ore and in the iron ore itself. One specimen contained clear transparent rhombohedral crystals of siderate in cavities in the psilomelane. The ore was being washed by hand in a trough or sluice box in the stream, and the fines were therefore rather siliceous.

Several prospect pits were being opened on the top of the terrace just north of and 100 feet above the mine, which forms part of the old valley floor now deeply cut into by the present streams. These pits are in the clay residual from the Shady dolomite which directly overlies the coarse sandstone and purplish and greenish glauconitic shaly sandstone of the basal part of the Shady. The rocks dip about 5° SE toward the valley on the west side of the flat Shady Valley syncline. There was plentiful dark manganiferous clay in these pits, but not much hard ore was struck. Some soft nodular manganese ore of very light weight occurs in the clay which so closely resembles plumbago in its greasy feel and shiny streak that it is readily mistaken for that mineral. It is a form of soft pyrolusite apparently derived from nodules of radiate needle manganite, and although a high grade ore, it is too scattered to be saved. The quantity of ore exposed in these pits at the time of visit was insufficient to warrant mining.

Wright Mine.—A half mile south of the Maxwell mine is the old Wright bank, where 150 tons of manganese ore were reported to have been mined some years ago.[1] It had recently been opened again by the Maxwell Manganese Mining Company, which shipped two carloads of ore during 1917.

The deposit is opened by a pit about 20 feet square into the face of a terrace 100 feet above the valley bottom. The ore consists of an irregular layer of manganiferous iron at the base of 5 feet of surface wash, which rests on pink to white and yellow plastic clay, apparently residual from Shady dolomite, in which no ore occurs, although tested to a depth of 25 feet. The ore is a brown-iron ore so seamed and veined with psilomelane and crystalline manganite as to resemble a breccia in appearance. A carload of selected manganiferous-iron ore is said to have run 52% iron and 16% manganese, but the general run of such ore would be much less, probably not over 48% iron and 10% manganese. A carload lot of hand-cobbed manganese ore from the old ore dump ran 30.8% manganese, 6.18% silica, and iron undetermined. Although the ore bed is 6 feet thick in places, the deposit will probably prove unprofitable to work because of its general low manganese content and the irregular occurrence of the better grade ore in pockets.

Osborn and Hopper Prospects.—A small pit showing some psilomelane ore has been opened on Aleck Osborn's property about one-half mile south of the Wright bank. The ore was exposed in a stream bank on the side of a wash-covered bench well up on the west

[1]Harder, E. C., Op. Cit., p. 74.

side of the valley. The pit was too small to show relations or quantity of ore.

A short distance farther south openings have been recently made by George Davis, of Bristol, on the Hopper property adjacent to an old iron bank mined years ago and close to the old manganese pit of Alexander Cole. Good ore was thrown out, but the pit had caved in and relations could not be determined.

Both of these prospects are underlain by clay residual from the lower part of the Shady dolomite, but whether the ore lies in this clay or only in the surficial wash was not determinable from the poor exposures.

MOUNTAIN CITY DISTRICT.

The Mountain City district embraces the valley area between Iron and Stone mountains north of Mountain City, followed by the Laurel Railroad, and the valley area around Mountain City. The open valley of Roane Creek as far as Neva station and that of Doe Creek as far as Doeville will be included, as these valleys are most easily reached from Mountain City, although the Doe Valley mine ships by way of Doe station near Butler.

Taylor Valley Mine.—The Taylor Valley mine, also called Reece mine, is in the northeastern part of the county at Matney, 10 miles north-northeast of Mountain City and two miles east of Dollars Station on the Laurel Railroad. It is on the I. H. Reece property and is operated by the East Tennessee Mining Company, of which H. A. Donnelly, of Mountain City, is secretary.

The deposit occurs in the Shady dolomite along a fault by which the pre-Cambrian volcanic rocks are thrust from the east on to the dolomite. The mine is described in detail as one of the types of manganese deposits in Part I of this paper (Res. of Tenn., Vol. VIII, No. 3, pp. 190-192).

Recent reports from the mine state that an opening on the northeast side of the spur opposite the older workings and at about the same elevation had exposed an ore body 12 feet thick opened for a length of 50 feet, which runs one-third ore of 40% manganese. This ore lies along the fault plane observed in the older deep pit, and probably is continuous through the ridge. The new pit is worked by mule plows and scrapers, the dirt being dumped into undershot tram cars on tracks leading around the end of the hill to the head of the flume. The production has thereby been increased to 60 tons a month.

Silver Lake Mine.—The Silver Lake mine is in the north central part of the county at Silker Lake station, on the Laurel Railroad, five miles north of Mountain City. The property is owned by the N. F. Sutherland heirs, of Silver Lake, and the mine is operated by the Silver Lake Mining Company, of Mountain City. The ore deposits occur in terraced stream gravels which lie on Watauga shale. Analyses of the better grade ores shipped in 1917 and 1918 ran 42 to 45% manganese, 6 to 7% iron, 3 to 8% silica. Shipments of lower grade fines ran 25% manganese, 18% iron, 14% silica. It is planned to supplement the washer with jigs to improve the grade of the finer ore. The mine is described in detail as one of the types of manganese deposits in Part I of this paper (Res. of Tenn., Vol. VIII, No. 3, pp. 193-194).

Wills Mine.—The Wills mine is located near the north-central part of the county, a mile east of Wills station on the Laurel Railroad, and four miles northeast of Mountain City. It is owned by Oscar Wills, and is being worked by the Laurel Mining Company, of Mountain City. The company began operations April 10, 1918, and since that date has shipped several carloads of ore averaging about 40% in manganese and 15% in iron. The mine has recently been sold to the American Minerals Company, of Cincinnati, which is enlarging the plant.

The mine is at the west end of a low flat-topped hill or low terrace, whose surface was probably once part of the valley floor. This is underlain by Shady dolomite, which in general dips northward away from a hill of Cambrian quartzite southeast of the mine, but on the slope just below the mine it is horizontal. The deposit is chiefly in the surface wash and may pass down into the underlying residual clay of the Shady dolomite. It is opened by several pits to a maximum depth of 20 feet, but there are two main pits on opposite sides of the hilltop in a N 35° W direction, which may be the trend of the deposit.

The walls of the pits expose a thickness of 5 to 15 feet of surface wash of reddish-brown clay and quartzite fragments overlying yellow to brownish-buff and blackish residual clay. The ore lies chiefly in the lower part of the wash and in the residual clay just below.

The ore is chiefly psilomelane and occurs in nodules and lumps, some of large size, sporadically embedded in the clay and wash. One lump 2½ feet in diameter was seen in one pit and another lump is reported to have yielded a ton of good-grade ore. Some of the nodules have a thin coating of red iron ore and are classed as ferruginous manganese ore.

The ore is treated in a double-log washer at the foot of the hill and is sorted into several grades and sizes, of which the best grade, or lump ore, contains about 45% manganese, the medium grade 35%, and the screenings, which were so sandy that they need further treatment before shipment. Ferruginous manganese ore containing about 25% manganese and 25% iron is also present. The average production is about four tons of ore a day derived from 40 tons of run-of-mine dirt put through the washer, a concentration of 10 into 1.

Silver Lake and Wills Prospects.—Several prospects have been opened on the Oscar Wills farm. The Silver Lake Mining Company has three shallow pits on a low terrace a few hundred yards northwest of the Wills mine, just across a small ravine. The pits are in surface wash containing some rather siliceous manganese ore which may improve in quality with depth if the ore continues into the underlying residual clay of the Shady dolomite. The pits covered a length of more than 100 feet along the terrace front, but the evidence of the presence of workable deposits is not yet convincing.

About one-fourth mile east of the Wills mine a number of pits were dug by Mr. Wills himself on the top of a flat-topped hill about 300 feet higher than the lower terrace where the mine is. This may represent an older valley floor. The rocks are deeply weathered and the pits are in residual clay and chert of the Shady dolomite which here dips northward away from the hill of Cambrian quartzite exposed in the anticline. The pits are about 6 feet deep and are scattered over the hill with a vertical range of 60 feet. A little good nodular ore was found in some of the pits and others were barren. The indications are not favorable for workable deposit.

Cornett Prospects.—One-half mile east-northeast of the Wills mine a prospect has been opened on the farm of Newton Cornett, of Mountain City. Several pits have been sunk to depths of about 12 feet on the upper south slope of a low ridge which is the northeastward extension of the Wills mine hill but about 300 feet higher, at the same general level as the Wills prospect. They disclose good nodular ore sporadically embedded in dull mottled residual clay of the Shady dolomite. The ore is mostly psilomelane, but includes a little manganite.

Three-fourths mile east-northeast of the Wills mine a prospect has been opened on the Mary Cornett farm. It is on the lower north slope of the same ridge on which the Newton Cornett prospect is, about 50 feet below the general level of the hill tops. It is in residual clay of the Shady dolomite and is opened by a narrow cut 40 feet long and 7 feet in maximum depth, showing practically throughout its extent good ore embedded in the clay. The ore is mostly psilomelane. About a ton of ore from the cut lay on the dump.

The developments on this and the Newton Cornett tracts were made by the Laurel Mining Company, of Mountain City. The indications are somewhat encouraging for a workable deposit.

Wright Prospect.—One-half mile east of the Mary Cornett prospect, across the small ravine, manganese ore has been recently reported to occur on the old Ward Iron Company property. It has been bought by W. C. Wright, of Mountain City, who is prospecting it, the results of which are said to be favorable.

Nelson King Prospect.—On the south side of the anticline adjacent to the Wills mine, especially on the farm of Nelson King two miles south-southwest of the mine, the surface of the cultivated fields carries float of nodular and lump ore among the chert fragments derived from the Shady dolomite. Some of the ore fragments are of good grade manganese ore, but considerable is manganiferous iron. Some of the road cuts in this vicinity also show dark manganiferous clay streaks with a little ore in the yellow residual clay. It will bear testing by inexpensive pits. but the surface indications are not very promising for a concentrated deposit.

Shouns Prospect.—The Shouns prospect is 2½ miles south of Mountain City and a mile south of Shouns Station, on the Virginia & Southwestern Railroad. It is on the south end of a low hill. part of a large tract owned by the Virginia Iron, Coal, & Coke Company, of Birmingham, Ala. It is undeveloped except for old shallow openings made for iron ore many years ago, one 60 feet above the valley bottom and others, including a shaft 20 feet deep, near the top of the hill 100 feet above. The shaft is in a massive, blocky, yellow glistening chert ledge, stained and slightly seamed by iron ore, which is believed to lie at the base of the Watauga shale in this region.

The manganese prospect consists of float ore scattered over the surface for about 100 feet up the front slope of the hill, below the chert talus. Although the ore is chiefly nodular and botryoidal psilomelane, it is somewhat impure and dull of luster. Some of it replaces chert breccia, which is derived from the weathering of the Watauga shale, but the nodular ore lies loose in the sandy soil on the slope. An unusually good example of the so-called grape ore, consisting of rounded nodules about the size of a large grape, firmly united together and forming a cluster 8 inches in length by 4 inches across, and tapering at one end, closely resembling a bunch of grapes, is illustrated three-fourths natural size in figure 2A of the first part of this paper (p. 158).

Little Doe Prospect (*reported*).—The Little Doe prospect is about three miles southwest of Mountain City, near the village of Little Doe. It is on the property of the Virginia Iron, Coal, & Coke Company and is undeveloped. Low grade manganese ore is reported to be abundant and appears to be worthy of thorough prospecting because of its convenient location and accessibility. It is apparently in Watauga shale, with relations similar to those at the Doe Valley mine to the southwest.

Doe Valley Mine.—The Doe Valley mine, also called Fritts mine, is seven miles southwest of Mountain City and about the same distance north of Doe Station on the Virginia & Southwestern Railroad. It is on the E. C. Fritts farm and is operated by the East Tennessee Mining Company, of Mountain City. Recent reports from the mine state that it is producing 60 tons of ore a month. A recent shipment ran 53% manganese, 4% iron, 6% silica. The best ore bed at present is in a cut 12 feet below what was the floor at the time of visit. It is 50 feet below the surface and is said to be the best body of ore yet encountered.

The deposit occurs in decomposed Watauga shale. The mine is described in detail as one of the types of manganese deposits in Part I of this paper (Res. of Tenn., Vol. VIII, No. 3, pp. 179-182).

Proffit Prospect (*reported*).—A prospect is reported on the Stacy Proffit property, 1½ miles northwest of Doe Station on the Virginia & Southwestern Railroad, and four miles north-northeast of Butler. It was undeveloped and was not visited by the writers. The Cambrian quartzite, which is brought to the surface in a sharp anticlinal fold at the southwest end of Doe Mountain and is possibly also faulted somewhat, is reported to be crushed and broken and re-cemented by manganese into a breccia, probably with some replacement of the quartzite by ore. The deposit is reported to have been recently prospected by H.

V. Maxwell, several trenches having been dug in the vicinity of the brecciated ledge, and may prove to be a milling proposition.

Wilson Hill Mine.—The Wilson Hill mine, also called Superior mine, is in the south-central part of the county, eight miles southwest of Mountain City and a mile south of Neva on the Virginia & Southwestern Railroad. It is owned and operated by the Superior Manganese Corporation, of Elizabethton. Since commencing work, early in 1918, the company by May 25, the time of visit, had done considerable prospecting and development work and had taken out more than 80 tons of manganese ore, but had made no shipments. The installation of mining and concentrating machinery and means of transporting the ore down the hillside were being planned, and were expected to be in operation early in August. In July it was reported that a pumping plant and a 40-ton double-log washer had been installed on Mill Creek, at the southeast foot of the hill, to which the ore is to be flumed from the mine. The water is to be raised about 600 feet to the mine.

The mine is on top of a high outlying knob at the northeast end of Dry Run Mountain, just west of the small settlement called Baker Gap. The ridge is about a mile long and rises steeply 600 to 800 feet above the adjacent valley bottoms. The southeastern slope is somewhat less steep than the northwestern and is covered with chert fragments and yellow clay apparently derived from Shady dolomite. Large masses of chert and chert breccia lie along the crest of the ridge and form ledges in places. Just below the northwest crest a quartzite, believed to be the Erwin, outcrops. It is brought up on a sharp anticlinal fold probably faulted on its northwest side. There is apparently also some faulting between the Shady dolomite and the quartzite along which line of movement the massive chert beds were developed by the replacement of the dolomite by silica from circulating waters, for massive chert is not normally present at the base of the Shady. Such chert beds have been observed at many fault contacts of the dolomite in the Appalachians. The manganese deposits occur chiefly in the clay and chert derived from the dolomite, on the upper southeastern slope of the ridge, between elevations of 2,600 and 2,800 feet. The development consisted of twelve or more openings spaced at intervals along the top of the ridge for about 2,000 feet from its northeast end, beyond which iron ores occur and were formerly mined near the southwest end of the ridge. The openings comprise deep narrow pits or wells, trenches, and larger open cuts, some having a depth of 30 feet.

The ore is chiefly dull, somewhat impure, nodular psilomelane with a small amount of crystalline manganite enclosed in banded yellowish and dark waddy clay. Some of the waddy clay has also thin laminae of shiny ore and crystalline nuggets. In the chert ledges adjacent to the quartzite the ore is in a gangue of white crystalline secondary quartz, full of drusy cavities. Some of the ore on the southeast slope is brown iron with thin leaves of feathery manganite crystals.

The best showings are in the main opening at the north end of the hill. This trench is about 30 feet long by 10 feet wide and 10 feet deep, with a pit in the bottom about 13 feet deep, throughout which wash ore occurs in bands in the clay. The banding of yellow clay and dark manganiferous clay is about parallel to the foot wall of massive chert, which dips steeply to the southeast and probably represents original bedding. Most of the ore taken out came from this pit. About one-fourth of the ore consists of nodular lumps ranging up to 10 inches in diameter. The remainder is wash dirt. The nodules occur mostly in the yellowish clay. A short distance south of this opening is a cross trench 18 feet deep from which about ten tons of wad ore was obtained.

Back of these openings on the northwest crest of the ridge a shaft or narrow pit was being sunk in a ledge of siliceous rock carrying a little ore. It is largely vitreous, crystalline quartz enclosing numerous small, detached, oriented plumose, dendritic, manganese nodules which vary in size and number and may increase in quantity with depth, as claimed by the owners, so that it would become a workable milling ore, but at the time of visit a depth of 12 feet had not shown up such an ore. These plumose nodules are very interesting and seem to have been formed in the quartz mass when it was still gelatinous, for although they are isolated they have parallel orientation and the quartz was deposited around them with comb structure facing the small spaces between.

The next opening to the southwestward is a 25-foot trench 7 feet wide and 5 feet deep excavated in reddish-brown clay at the crest of the ridge, which is said to have yielded two tons of nodular lump ore and ten tons of wash ore. Several hundred feet beyond along the crest a wide shallow pit exposes massive chert covered at the surface with thin sheets or shell-like plates of ferruginous manganese.

Toward the southwest end of the tract the hill rises more rapidly and the soil and clay deepens. Several narrow round pits or wells have been sunk along the crest from 5 to 30 feet deep in yellowish to purplish clay containing chert fragments and a little lump and wash ore. Only in the deepest pit at the south end of the belt was any amount of ore seen, and the showing in these pits as a whole was not favorable.

On the mid-east slope of Wilson Hill several hundred feet southeast of the crest there are four pits closely spaced up and down the slope, and have a maximum depth of 18 feet. The deposit here consists chiefly of manganiferous iron ore in a liver-colored dense ferruginous chert ledge with a little psilomelane and thin plates of feathery brilliant manganite.

Another opening, a few hundred feet diagonally down the slope northward, is a shaft 22 feet deep, nearly all in slide material and showing thin layers or sheets of maganiferous iron ore and soft wad dipping southeastward approximately parallel with the surface. Still farther down the east slope, about 200 feet vertically below the highest pit on the crest of the hill, is a cut 9 feet wide and 3 feet deep at the face exposing a layer 8 feet wide composed largely of massive manganese ore which extends into the hillside beneath a covering of 1½ feet of surface soil and yellowish clay. A ton of lump manganese ore, two tons of wash ore, and a ton of manganiferous iron ore lie on the dump.

All these deposits are associated with the chert which is developed in the Shady dolomite apparently adjacent to a fault between it and the quartzite. The ore varies from nodular psilomelane to manganiferous iron ore, with a predominance of the latter, and although considerable tonnage can probably be developed, the better grade manganese ore will be only a small part of the whole.

BUTLER DISTRICT.

The Butler district includes the area around Butler, extending up the valleys northeastward between Doe Mountain, Dry Run Mountains, and Stony Mountain, southward up Elk Creek, and westward down Watauga River and up Cobb Creek. As Butler is near the western side of the county, several of the mines and prospects in the district are in Carter County and will be described under that heading.

Wagner Prospect.—The Wagner prospect is at the head of Little Dry Run, five miles northeast of Butler on the Virginia & Southwestern Railroad. It is on the D. A. Wagner property and the prospecting is being done by A. H. and J. J. McQueen, of Butler, under a lease. The deposits occur on a wash-covered terrace underlain by yellow residual clay of the Shady dolomite. A pit 12 feet deep shows wad and a little hard bluish psilomelane with rough exterior and partly stalactitic in structure, sporadically embedded in the terrace wash and in the underlying variegated dark and yellow residual clay. Larger lumps of float ore are found on the surface, but the heavy cover of wash conceals most of the showing of ore. Further prospecting is necessary to determine the presence of workable deposits, but the fact that it lies in the same syncline as the succesful Dry Run mine is favorable.

Dry Run Mine.—The Dry Run mine is 3½ miles northeast of Butler on the Virginia & Southwestern Railroad. It is owned and operated by A. H. McQueen, of Butler, but has recently been reported sold by him. In 1917 nearly 600 tons of ore were shipped. The better grade of ore, comprising the lump and larger size wash ore, averaged 44.5% manganese, 1.55% iron, and 1 to 10% silica; and the lower grade, comprising the medium and fine wash ore, averaged 38.5% manganese, 1.75% iron, and 21% silica. Shipments of corresponding grades of ore during 1918 ran: 43.5% manganese, 1.75% iron, 13.9% silica for the better ore, and 35.63% manganese, 1.75% iron, 25.83% silica for the lower grade. The ore is seen to be nearly free from iron, but rather high in silica. The washed ore has an unusually clean appearance.

The mine is on a low rounded hill at the foot of the northwest slope of Dry Run Mountain, 200 feet above the creek and about 2,350 feet in altitude. An 1,800-foot tram descends from the mine to a 22-foot double-log washer on Little Dry Run Creek where the ore is washed, the water being supplied from the creek by a gravity flume. The enclosing dirt is black and is easily washed away, yielding a clean product.

The deposit occurs in residual clay of the Shady dolomite which occupies the synclinal valley between the Dry Run Mountain and Little Dry Run Mountain anticlines. Although there are no rock outcrops nearby, the chert bed in the pit apparently dips southeastward so that it appears to lie on the northwestern limb of the syncline. The chert forms the foot wall on the northwest side of the deposit. The deposits have been opened up for a length of 800 feet and the ore zone varies in width from 2 or 3 feet to a maximum of 15 feet.

There are three main openings. The southern one is a large pit 20 feet deep at the face. The ore lies in a bed, 4 to 6 feet thick, of dark manganiferous clay with psilomelane nodules, which strikes N 20° E and dips 65° SE. It is overlain by barren yellow clay containing streaks or layers of angular purple shale fragments in its upper part, and is underlain by dark-drab clay with some wad, which rests on the chert footwall. The purple shale streaks in the yellow clay are apparently old solution channel fillings.

The report that the ore bed runs about 75% ore seems to be justified by the exposures seen. The ore bed has been left unmined at several places where the overburden was heavier than elsewhere, but it is apparently of the same high grade and can be mined with profit, especially by steam shovel or drag-line scraper. The ore is mostly psilomelane, but contains also a little pyrolusite and manganite. The washed ore is almost all nodular or botryoidal. An unusual specimen comprising a cluster of radiating stalactitic rods is illustrated in Part I of this paper (Fig. 3B, p. 162).

The middle working is a tunnel 80 feet below the open pit, which runs westward into the hill 108 feet. It was not enterable at the time of visit, but is said to have passed through 30 feet of wash ore. It was not being used at the time of visit.

The northern pit is a deep hole filled with water, from which 16 carloads of ore had been shipped. It is reported to be 45 feet deep and the ore bed to be 14 feet wide. It was abandoned because of the increased overburden with depth, following down the dip of the ore bed to the southeast. At the time of visit the water was being drawn off so that the deposit could be again worked. A steam shovel or some other similar machinery was being considered to handle the large overburden economically and make accessible the deeper ores. Although a large quantity of ore has been removed from the mine, there is apparently still a considerable amount of ore present in depth and probably also in both directions along the strike. So far prospecting in these directions has not revealed the ore bed, but the area of bench land between the mine and the Wagner prospect to the north deserves careful prospecting.

Watauga River Mine.—The Watauga River mine is two miles southeast of Butler on the Virginia & Southwestern Railroad. It is operated by J. L. McQueen, of Butler, who has just installed a double-log washer in the gulch a few hundred feet below the mine on the wagon road near the river. The mine is on the upper northwest slope, about 30 feet below the crest, of a low ridge which is the southwestward continuation of Dry Run Mountain. The hilltop is 400 feet above the river, 2,400 feet in elevation, about the level of the old upper valley floor in this region. The deposit occurs in decomposed Watauga shale, which here dips 35° SE. A half ton of manganiferous iron ore lay at the mouth of the pit.

The mine consists of an open cut about 40 feet wide and an old shaft 30 feet deep, from the bottom of which a 50-foot drift runs southeastward into the hill. A trench was being driven lower on the hillside to open up the pit wider and deeper. The pit shows decomposed Watauga shale weathered to yellow sandy clay, with black waddy clay and some nodular ore filling a pocket 20 feet deep on the west side, with a vertical east wall of shale, resembling a solution pocket filling. The lower workings are said also to carry ore, but were not accessible at the time of visit and the mine was not running.

Cable Prospect.—The Cable prospect is two miles southeast of Butler on the Virginia & Southwestern Railroad. It is on the Cable property and the prospecting has been done by J. E. Reece, of Butler. It is on the lower southeast slope of the same ridge as the Watauga River mine, 2,200 feet in elevation and about 500 feet distant. The deposit occurs in decomposed Watauga shale, which dips 35° SE, and the deposit follows the bedding.

The openings consist of an old tunnel at the foot of the ridge, which is driven across the structure of the shale, and a shaft 60 feet higher than the tunnel. Although these old workings were in quest of iron ore, some manganese ore was encountered. The shaft, although caved, showed an ore zone of yellow clay containing scattered nodules of psilomelane and wad, which seemed to have a thickness of 8 feet, overlain by a layer of iron ore. The tunnel is in harder purple shale, with interbedded thin layers of residual, yellow, sandy clay containing scattered nodules of manganese. The amount of ore seems too small to mine.

Goss Mine.—The Goss mine is five miles southeast of Butler on the Virginia & Southwestern Railroad, and about two miles south of

Casper. It is at the southwest end of Stone Mountain, about 300 feet above Watauga River, from 2,300 to 2,360 feet in elevation. It is operated by the W. C. Goss Manganese Company, of Butler, J. E. Lineback, manager, which had recently shipped a carload of ore said to run 40% in manganese. The deposit occurs in residual clay and chert, presumably of the Shady dolomite, adjacent to hard purple Watauga shale and in the overlying wash. It is opened by two open cuts 20 to 30 feet deep, which cover a vertical range of more than 100 feet.

In the lowest or main opening, which is a narrow trench in the hillside 30 feet deep at the face, thinly laminated yellow clay is interbedded with chocolate buckfat clays which strike N 25° E and dip 80° SE. The ore occurs as small nodules and irregular bodies sparsely scattered through the yellow clay. It is chiefly psilomelane, but contains considerable silica in small crystals lining cavities in the ore. The ore is cleaned in a double-log washer at the foot of the slope to which it is carried by a steep flume. It is hauled to Casper over rough roads and thence to Butler, a total distance of over twelve miles. Apparently this siliceous ore is not mined and hauled this distance with profit.

Moody Prospect.—The Moody prospect is five miles southeast of Butler on the Virginia and Southwestern Railroad, just northeast of the Goss mine, on the north slope of the same ridge. It is on the W. R. Moody property and was opened by C. H. White, of Elizabethton. About three tons of ore were mined and were washed at the Goss plant and shipped with the ore from that mine. The mineral zone lies along the foot of the steeper northwest slope of Stone Mountain on a bench about 2,500 feet in elevation, in the residual clay of the Shady dolomite, which dips steeply away from the Erwin quartzite on the mountain, and may be somewhat faulted. It has been prospected at several places along this belt for a distance of one-fourth mile northeast of the Goss property.

The main openings are narrow deep trenches and pits up to 18 feet deep at the southwest end of the property adjacent to the Goss mine. Other shallow prospects have been sunk at the northeast end. They expose yellow clay and soil and many chert fragments characteristic of the Shady dolomite, and dolomite outcrops below the northeasternmost pit. Small irregular bodies of wad and scattered nodules of psilomelane occur in the clay, but in rather small quantities. Some of the psilomelane nodules are dense and heavy and contain some crystalline manganite. The prospect of finding a profitable deposit is not encouraging.

CARTER COUNTY.

Carter County, of which Elizabethton is the county seat, lies southwest of Johnson County and adjacent to the North Carolina State line. It is largely mountainous, only its western part being occupied by valleys. There are eighteen or more manganese mines and prospects in the county, about half of which have been productive and some of which are still producing. They occur mostly along a narrow belt on the northwest slope of Gap Creek and Iron mountains, which trends northeastward through the center of the county. Some lie on the south and southeast slopes of Holston Mountain in the northeastern part of the county.

BUTLER DISTRICT (CONTINUED).

Elk Mine.—The Elk mine is near Lineback, on Elk Creek, 2½ miles south of Butler on the Virginia & Southwestern Railroad. It is on the Hately and Lunsford properties and is operated by the McQueen Manganese Company, of Butler, of which A. H. and J. L. McQueen are the chief owners. It has produced about 60 tons of ore, with an average analysis of 38.07% manganese, 38% iron, and 19.27% silica. The last carload is said to have averaged 42.76% manganese.

The mine is on two small hills on opposite sides of a gulch west of Elk Creek. It is 130 feet above the creek where the log-washer is located, which is reached by an incline tram from the mine 1,600 feet in length. The older opening is on the northwest side of the gulch, more recent prospecting having been done on the southeast side. The deposits occur in decomposed Watauga shale, the general structure of which is monoclinal, the beds striking N 35° E and dipping on an average of 45° NW, but somewhat folded.

The main older opening is an open pit 20 feet wide and 40 feet long, on the northwest side of the gulch, from which an irregular incline descends along the ore zone to a depth of 40 feet. The shale is largely weathered to soft yellow sandy clay, but some less-weathered beds are still purple. An overburden of from 2 to 8 feet of earthy soil and purple shale fragments covers the residual clay. The ore is mostly psilomelane disseminated in one of the soft yellow sandy clay beds, probably a disintegrated calcareous sandstone. This ore-bearing bed is thin and the ore is not equally distributed in it, so that the incline which follows it down is very intricately ramifying. Most of the ore mined came from a depth of more than 15 feet.

The opening on the southeast side of the gulch is a cross trench 15 feet deep, in the bottom of which is a narrow pit or shaft 60 feet deep, largely in purple shale, with a drift at its bottom in soft yellowish clay, in which most of the ore occurs. At the time of visit a tunnel was being driven to strike the ore zone below the present workings, which had caved, but this was later reported abandoned. About one-fourth of a ton of coarse cellular lump ore and twenty tons of wash ore lie on the dump, and more than forty tons have been shipped. The cavities of the lump ore are lined with crystalline manganite, and this ore is said to average more than 40% manganese. The cellular ore is made up of thin, platy walls which apparently formerly filled interstices of a brecciated rock, or more likely were deposits along joint and bedding planes of the original calcareous rock, which has also been more or less replaced by the ore, and the unreplaced portions of the rock have subsequently been dissolved out. The wash ore is mostly of nut to pea size.

The exposed ore seems to have been largely worked out, and it is not surprising that the mine was reported as closed down in July, 1918. However, as the ore in the decomposed layers of Watauga shale is so variable in its occurrence and at present cannot be predicted where it may be found, there may be other equally good deposits in the vicinity not yet discovered.

Dubault Prospect.—The Dubault prospect is on the Dubault farm, two miles southwest of Butler, and was opened by J. E. Reece, of Butler. It is on a low, flat-topped hill, 2,100 feet in elevation, on the north side of a deep narrow valley draining into Elk Creek. The deposit is in a narrow northeast trending belt of yellow residual clay and chert fragments probably derived from impure dolomite beds in the Watauga shale. Such dolomite beds in the formation are exposed on Elk Creek. It lies between hard, purple sandy shale on the west and whitish shale on the east. Only one hole was dug, an open cut 6 feet deep, which shows a few scattered nodules of psilomelane and wad in chocolate-colored clay. A little float ore is also at the surface, but the indications are not favorable.

Younce Prospect.—The Younce prospect is two miles southwest of Butler, one-fourth mile west of the Dubault prospect, on the farm of S. S. Younce. It was originally opened by the McQueen Manganese

Company, but is at present being developed by J. E. Reece, of Butler. About one-third ton of ore is on the dump. The openings are on a flat-topped hill, 2,180 feet in elevation, near the head of the narrow valley draining into Elk Creek. A deep, narrow, irregular pit follows down a thin bed of residual, sandy clay in Watauga shale, which carries the ore, to a depth of 50 feet. Several shallow trenches also are dug along the outcrop of this bed. The rocks strike N 80° E and dip 80° S.

The deposits consist of small nodules of psilomelane and streaks of wad in a 4-inch bed of yellow, sandy clay. The footwall is yellow, laminated clay in which is a thin bed of chert 12 inches below the ore zone. The hanging wall is banded yellow and drab clay with a little wad. The ore zone is so thin that even if it were much richer than is shown in the present pit it could not be profitably mined.

Cobb Creek Prospect.[1]—The Cobb Creek prospect is 2½ miles northwest of Butler, on a hill west of Highhealth, on Cobb Creek. It is on the farm of C. S. Morley, of Butler, and was opened by A. H. McQueen, of Butler. The deposit occurs in disintegrated Watauga shale on the top of a flat-topped hill or terrace, and seems to be in the same structural belt as the Doe Valley mine to the northeast. It is opened by a trench 40 feet by 50 feet and 3 feet deep. A ton of ore, mostly high grade, is on the dump. The prospect of a profitable deposit is regarded favorable.

STONY CREEK DISTRICT.

The Stony Creek district extends from Elizabethton sixteen miles northeastward to the county line, comprising Stony Creek Valley, about five miles in width, between Holston Mountain on the northwest and Iron Mountain on the southeast.

Blevins Mine.—The Blevins mine is located in the northeast corner of the county, 1½ miles up Blevins Hollow northwest from Colesville on the Stony Creek branch of the Virginia & Southwestern Railroad. The property is owned by Mrs. Isaac Blevins, who lives on the place. Captain Robinson, of Elizabethton, opened up the mine several years ago and shipped a carload of ore in 1917. His option has expired and has not been renewed.

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[1]From notes by A. H. McQueen and Nelson Dale.

The mine is on the top of a small terraced spur of Holston Mountain, at an elevation of approximately 2,500 feet, part of the old valley-floor bench. The deposits occur in surface wash of light-brown to chocolate-colored clay 8 to 10 feet thick and in underlying yellow residual clay derived from Shady dolomite, which overlies greenish sandy shales of the basal part of the Shady.

As exposed by a dozen or more openings scattered over the upper part of the hill the deposit has a horizontal extent of more than 500 feet. These openings are mainly round pits or wells 8 to 10 feet deep, and on the north side of the hilltop a larger open cut extends to a maximum depth of 18 feet. The ore in most of the pits is nodular psilomelane with dull luster, sporadically embedded in the clay chiefly at a depth of 8 to 10 feet, near the base of the surface wash. In the large north pit there are also two or three layers each 1 foot thick of soft black wad and pyrolusite interbedded in the underlying light-yellow to chocolate-colored residual clay dipping low toward the north. Lumps of dull, earthly psilomelane on the dump are somewhat impure and apparently will not run over 35° manganese.

Hatcher Prospect.—The Hatcher prospect is in the northeastern part of the county one mile east of Sadie Station on the Stony Creek branch of the Virginia & Southwestern Railroad. It is on the Hatcher land and was opened fifteen years ago by Col. J. N. Adams, of Charleston, Tenn. H. E. Graves, of Bristol, has been recently prospecting it.

It is on a terraced spur on the lower northwest slope of Iron Mountain, at an elevation of approximately 2,350 feet. It is about 150 feet above the opening of the Hatcher sulphur mine, where iron pyrites has been mined in the upper layers of the Erwin quartzite.

The deposit occurs in residual clay of the Shady dolomite just above the Erwin quartzite, which dips 40° NW away from the mountains. A pit 4 feet deep on the top of the terrace is in dark-reddish soil characteristic of the Shady dolomite ore zone, in which are a few nodules of psilomelane and iron ore. A few fragments of float ore are also scattered over an acre of the upper surface of the ridge. The amount of ore is apparently very small.

Grindstaff Prospect.—The Grindstaff prospect is located southwest just across the small hollow from the Hatcher prospect, on a similar terraced spur. It is owned by G. L. Grindstaff, by whom it has been prospected by auger borings to a depth of 4 feet. The geologic and surface relations are similar to those at the Hatcher prospect.

Other Prospects in Stony Creek Valley.—There are several old iron mines on the northwest slope of Iron Mountain, all of which are now closed, but their scars on the mountain slope are plainly visible from the valley bottom. Some of these are on benches along the slope like those at the Hatcher and Grindstaff prospects, and the reported occurrence of manganese ore float at such places is to be expected. None had been opened by pits, however, so far as known. Prospects on the southeast slope of Holston Mountain were also reported, but no openings were to be seen. Excellent float iron ore, locally called "cannon" ore because of its denseness, hardness, and weight, occurs on this mountain slope and is especially plentiful west of Winner Station, chiefly on the Government Forest Reserve.

Blue Springs Mine.—The Blue Springs mine is in the north-central part of the county one-half mile south of Blue Springs and four miles east of Hunter Station on the Virginia & Southwestern Railroad. It is owned by the Carrigan heirs and is operated by Walker & McKenna, of Elizabethton. It is credited with a production of 500 tons of manganese ore, of which eleven carloads were shipped many years ago and 75 tons more recently by Col. J. N. Adams, of Charleston, Tenn., who had a log-washer just below the mine. A carload was also mined and shipped about one year ago by H. V. Maxwell for H. E. Graves, of Bristol.

The mine is on a terraced spur on the lower northwest slope of Iron Mountain. This bench is at an elevation of 2,000 to 2,200 feet, which corresponds with the tops of many neighboring spurs and ridges that are regarded as remnants of the old valley floor.

The old mine workings were deep open cuts on the hillside, which are now largely caved in. They still show a considerable amount of good wash ore on their dumps, particularly the higher ones, which are on the Virginia Iron, Coal, & Coke Company's land, which is being absorbed into the Government Forest Reserve and has not been recently worked. The recent workings comprise several trenches 8 to 10 feet deep and short tunnels. Most of them expose dark clays at the surface overlying horizontally banded clays. The latter are apparently residual clay derived from beds in the lower part of the Shady dolomite. The ore lies in the chocolate-colored sandy clay, which is generally not over 5 feet deep, the yellow clay beneath being mostly barren. In the upper tunnel the yellow clay is locally overlain by jointed dry white clay, which is stained by iron along the joints.

The ore is chiefly hard psilomelane in nodules ranging up to 8 inches in size and in larger irregular masses. There is also present a considerable amount of soft black ore, in part pyrolusite, which will be largely lost if passed through the washer. The concentration of the ore in the wash dirt was not determined. The areal extent of the deposit is large and considerable minable ore is believed to be still in the ground.

Keesburg Prospect.—The Keesburg prospect is in the western part of the county, three miles north of Elizabethton and a mile east of Keesburg on the Virginia & Southwestern Railroad. It is on the property of the Southern Minerals Corporation, of Boston, Mass., adjacent to their brauxite mine, and has recently been opened by them. It is on the terraced spur at the southwest end of Holston Mountain, known as Red Bird Hill, at an elevation of 2,200 to 2,300 feet, and is a little higher than most of the hilltops in the vicinity which seem to be a remnant of the old valley floor.

The deposit occurs in residual dark-red clay of the basal part of the Shady dolomite and in the adjacent Erwin quartzite. The quartzite strikes N 30° W and dips 40° SW, and its outcrop at the top of the hill back of the terrace is brecciated and cemented by manganese ore. Although this ledge has been prospected, it is too siliceous to be profitably mined. The deposits on the terrace below the quartzite hill are opened at several places. On the front-edge of the terrace manganese ore float in scattered over the surface with chert fragments, and is found in the upper surficial layers of reddish and pale-lavender clay in the bauxite pits and cuts. The ore is chiefly nodular and stalactitic psilomelane, some of which is coated with black shiny iron ore and contains a little crystalline manganite. On the northwest slope of the hill a few shallow cuts expose a little ore in similar dark-red clay.

The amount of ore in all the pits is too small to be profitably mined except possibly as a by-product to be saved in mining the bauxite.

HAMPTON DISTRICT.

The most important district as a manganese producer in the county is the Hampton district, which comprises the region around Hampton. It includes not only the valley between the Stone Mountain-Pond Mountain group on the southeast and Gap Creek-Iron Mountain group on the northwest, in which Hampton is located, but also the edge of the great valley at the northwest foot of the latter ridges.

Cardens Bluff Mine.—The Cardens Bluff mine is located in the central part of the county about four miles northeast of Hampton and one-half mile southwest of Cardens Bluff, the nearest railroad station on the Virginia & Southwestern Railroad. It is owned and operated by A. D. Reynolds, of Bristol, and L. L. McQueen, of Butler. In 1917 182 tons of ore were shipped, which averaged 36.56% manganese, 9.05% iron, and 22.51% silica. Several carloads were in the bins at the washer at the time of visit, and it has since been reported that 400 tons were shipped during the first half of 1918, having an average analysis of 30% manganese, 10% iron, and 25% silica.

The mine is on the upper west slope of a prominent terrace at the northwest foot of Pond Mountain, at an elevation of 2,130 to 2,200 feet, about 300 feet above Watauga River. The terrace is a remnant of the old valley floor. The deposits occur in yellowish to reddish residual clay and chert fragments of the Shady dolomite. Just below the mine the unweathered dolomite outcrops dipping 85° NNW. The overburden is about 3 feet of soil and clay.

A large trench about 80 feet across and extending up the hill 200 feet, opens up the face in three benches each 6 to 12 feet deep. The ore came chiefly from a zone 1 to 6 feet below the surface, which was well exposed in the face of one of the benches for a width of 20 feet. In the deepest part of the working ore-bearing clay continues to the bottom of the cut. The chert in the clay is partly replaced by ore.

The ore is conveyed from the mine by a short hand cable incline to a loading platform and thence by a gravity-horse tram to the log-washer, which is located about one-fourth mile to the west on a small creek.

The ore is chiefly wad, psilomelane, and pyrolusite, much of it being soft and sooty, but some is crystalline pyrolusite. The washed ore is dirty looking, resembling earthy, chocolate-colored lumps of clay. The analyses show it to contain much silica, or insoluble matter, which is probably in part aluminum. The ore is so high in silica and low in manganese that it is not surprising to learn that the mine has recently closed down.

Teaster and Ray Prospect.—Two miles southwest of the Cardens Bluff mine prospecting has been done along the Hampton road by M. G. Teaster and T. J. Ray, of Elk Park, N. C. The property is on a low hill south of the road at the head of the small branch of Doe River. A pit 4 feet deep exposes lumps of psilomelane in earthy clay containing sandstone fragments and the deposit is probably in wash lying on the old valley floor. On the spur of Pond Mountain, southeast of the prospect, about 500 feet above the road, manganese is reported to have been found below the quartzite ledges, from which the wash deposit was probably derived.

Cedar Hill Mine.—The Cedar Hill mine is one mile south of Hampton and one-third mile from the East Tennessee & Western North Carolina Railroad. It is owned by the Stiles heirs, of California. It was worked for iron twenty to thirty years ago, and was only recently leased and opened for manganese by H. V. Maxwell, of Elizabethton. At the time of visit (May 16) he had just begun operating with a force of ten men, and had shipped a carload of ore washed in a single 20-foot log-washer. It was planned to install a double-log washer and to equip the incline with larger cars to increase the production. The carload shipments reported to date analyzed from 46.51 to 48% manganese, 8 to 8.45% iron, 4.5 to 5.65% silica, 2.11 to 4.92% alumina.

The mine is located on the top of a terraced spur at the northwest end of White Rock Mountain at an elevation of 2,150 feet, or about 350 feet above the adjoining lowland of Doe River where the washer is in operation. The water is flumed to the washer from a low dam in the river. The ore is brought to the washer by a cable incline down the slope 1,400 feet long and a gravity-mule tram on the valley bottom 900 feet long.

Small pits have been opened on the top of the terrace adjacent to old iron pits in one of which a ledge of good brown-iron ore is still exposed. Clay containing yellow chert with drusy cavities, probably derived from Shady dolomite, lies on the slope below the ore zone and Erwin quartzite outcrops on the mountain slope above. Yellow and white clay with a little manganese ore occur in the pits.

The main opening is a large open cut on the north crest of the hill running southeast into the hill. It has a face about 30 feet high, with a tunnel at its end, all more or less slumped. The new opening on one side, 20 feet wide, has a face 15 feet high which is almost all dark manganiferous clay and soil interbedded with some yellow clay. The yellow clay carries nodules of psilomelane, and the dark soil also contains some hard ore, but has large pockets of soft ore, graphitic in character, nodular in form, and with radiate needle structure. Most of the soft ore crushes to powder on handling and would be lost in the washer, so it it is bagged at the pit and shipped unwashed. The nodular psilomelane is mostly small, resulting in nut ore, pea ore, and screenings, and the analyses would probably run much lower in manganese if the higher grade soft ore were not saved and mixed with it. A 5-foot horse of barren buckfat yellow clay is exposed in the midst of the cut. This appears to be the unmoved residual clay of the Shady dolomite, whereas the ore-bearing clay is apparently residual clay that has slumped and settled into solution depressions and pockets on the old land surface or valley floor and has been impregnated with ore.

The ore shipped is of good grade and the quantity appears ample to justify the proposed enlargement of the plant. A considerable area of prospective ground is still available on the hilltop. It was stated by Mr. Maxwell that float ore has been found all along the northwest foot of the mountain from his mine to the Cardens Bluff mine, and as the geologic and surface relations are favorable for ore accumulation in this belt, other good deposits may be expected on the benches of the same elevation as these mines along the foot of the mountain.

Valley Forge Mine.[1]—The Valley Forge mine, formerly known as the Toncray mine, is in the central part of the county, three-fourths mile east of Valley Forge on the East Tennessee & Western North Carolina Railroad. It is owned and operated by the Valley Forge Mining Company, of Bristol, Va., composed chiefly of H. W. and A. D. Reynolds. It is reported to have shipped in 1917 about 800 tons of ore, of which 50 tons averaged 43% manganese, 3% iron, and 6% silica. At the time of visit the company expected to ship 500 tons in the first half of 1918. Average analyses of carload shipments of this ore were later reported to have run 42 to 46% manganese, 4.8 to 8% iron, 9.2 to 12% silica.

The mine is located on the northwest slope of the southwest end of Iron Mountain, at an elevation of about 2,240 feet, or about 500 feet above Doe River, which is about three-fourths mile distant to the south. It is in the upper part of a short terraced ridge projecting to the northwest, which is a remnant of an eroded old high valley floor. Similar terraced spurs at about the same level to the northeast are

[1]Description by F. C. Schrader.

favorable places to prospect. Old caved pits and dumps corroborate the report that immediately adjacent portions of the ridge were mined for iron many years ago.

The deposit occurs in residual clay of the Shady dolomite near its contact with the underlying Erwin quartzite on the southeast. The structure is monoclinal, the dip of the rocks being about 60 degrees to the north-northwest. The clay is mostly dark reddish or earthy and chocolate-colored. In this clay the ore is sporadically embedded in the form of hard nodules and botryoidal aggregates consisting chiefly of psilomelane.

The deposits are mostly contained in a mineralized zone about 60 feet in width, which trends 400 feet or more east-northeast, seemingly through the trunk of the spur on both sides of which they are exposed. They have a known vertical range of about 160 feet. On the northeast slope of the spur developments begin at an elevation of 2,100 feet in yellow clay, but no ore was found below an elevation of 2,175 feet, from which point the developments and deposits extend interruptedly up the 35° slope to where the tram crosses the ridge at 2,280 feet in elevation. Surface indications of ore continue up the spur to the top at 2,340 feet elevation.

Several tunnels on the northeast slope of the spur not enterable at the time of visit form a considerable part of the development. The lowest tunnel is 150 feet in length. It is driven southwestward into the hill in yellow clay and encountered no ore. The intermediate tunnel, 100 feet in length, runs south into the hill and is said to have found a trace of gravelly manganese ore in red clay in the face. The upper tunnel starts near the collar of the shaft, near the lower limit of the main deposit, and runs westward into the hill, and is said to be 120 feet long with ore present all the way. However, the ore is said to be best developed at depths between 10 and 15 feet, and about all the ore which has thus far been mined seems to have come from depths not exceeding 30 feet. The seat of present operations is an open pit on the northeast side of the spur at about 100 feet below the crest in the vicinity of the upper tunnel and a little higher than the shaft. The shaft passes through 5 feet of dark-reddish ore-bearing clay, then 18 feet of barren yellow buckfat clay, below which ore is again encountered. The ground now being worked in the pit seems to be the same as that in the upper part of the shaft.

The ore is mostly hard psilomelane. It occurs in rough nodules and in slabs or fragments of aggregate botryoidal and mammillated forms. There is present, however, a moderate amount of soft crystalline and sooty pyrolusite and wad. Nodules 2½ inches in diameter of dark-brown wad seemingly of good grade were noted.

The equipment consists chiefly of a four-log washer and pump, with about 4,000 feet of pipe line, one-half mile of tram, cast iron flume, gasoline engine, and several buildings. The washer, just installed, is located on the southwest slope of the spur at a point about midway between the mine and the river, whence a gravity tram extends southward to the railroad at the river, where the pump is stationed which forces water to the washer and mine. From the mine the ore is raised by gasoline engine up a short incline tram to the crest of the ridge, 80 feet above, from which point it is conveyed through a cast-iron flume to the washer. When fully equipped, the company expects to produce about forty tons of ore a day.

Jenkins and Hyder Prospects (reported).—The Jenkins prospect is two miles southwest of Valley Forge on the East Tennessee & Western North Carolina Railroad. It is owned by the Abe Jenkins heirs and was opened by J. N. Koch, W. P. Davis, B. Aubrey Smith, and Henry Hudson, of Knoxville, in 1917. A carload of ore was mined and shipped in 1917, and the prospect was then abandoned as not profitable. A test analysis of the ore was reported to run 36.20% manganese, 4.78% iron, 17.71% silica.

The prospect is on a terraced spur about 2,200 feet in elevation on the northwest slope of Gap Creek Mountain, near its northeastern end. It is in residual clay of the Shady dolomite, and the ore was said to consist chiefly of nodular psilomelane. Float ore is reported on adjacent terraced spurs at this general level on the northwest slope of the mountain, and deposits probably extend along its whole length.

The Hyder prospects are about three miles southwest of Valley Forge, one mile beyond the Jenkins prospect. One is on Eliza Jane Hyder's farm and another is southwestward on Oscar Hyder's farm, both on terraced spurs of Gap Creek Mountain, about 2,200 feet in elevation. Another pit still further southwest near Gap Creek is on Marion Hyder's farm on a similar bench 2,150 feet in elevation. These are all small surface openings in dark manganiferous clay on yellow clay residual from Shady dolomite and show some psilomelane. They were opened by J. N. Koch and associates, of Knoxville, and were abandoned without enough work being done to determine their worth.

Winter Mine.—The Winter mine, also known as the Taylor mine, is seven miles southeast of Johnson City and four miles south of Watauga Point on the Tennessee & Western North Carolina Railroad. The property is owned by the Taylor heirs and was opened by the Maxwell Manganese Mining Company, of Elizabethton, which mined and shipped a carload of ore, including some from the nearby Patton mine, said to have analyzed 45.9% manganese. About forty tons of good wash ore, mostly nut and pea size, lie on the dump at the mine and twenty tons of washed ore are at the washer. The mine has recently been leased by the old company to the Max Mining Company, Braemar, Tenn., of which H. V. Maxwell, of Elizabethton, is the active representative, and they are now installing a double-log washer which is expected to be in operation about October 1. The Patton mine, also on the Taylor property, is to be included under the same operation.

The mine is on a terraced spur 2,200 feet in elevation on the northwest slope of Gap Creek Mountain, about two miles southwest of the Hyder prospects. The trough in which the ore was washed is on a small headwater branch of Powder Creek a short distance below the mine, to which the ore was hauled by wagon.

The deposit occurs in banded residual clay containing round cherts, derived from lower beds of Shady dolomite. Two layers of wad and ore in dark clay, each 1½ feet thick, alternate with banded yellow to red clay, in part streaked with manganese films and stains along the foliation planes. These beds strike N 60° E and dip 80° SE. Purple shale of the Watauga crops on the lower slope of the spur with the same dip, which indicates a steeply overturned monoclinal structure. Erwin quartzite fragments cover the surface of the steep slope above the mine.

The ore consists of psilomelane and manganite, much of which is pitted and lined with crystals. More than 50 per cent of the ore is apparently crystalline manganite. The ore occurs in nodules and irregular lumps, some several hundred pounds in weight having been reported. Its pitted or cellular condition is apparently due to rock fragments which have been dissolved out of the ore. Some ore still firmly incloses chert fragments.

The deposits are opened chiefly by a 40-foot cut, 16 feet deep at the face, and by an incline shaft 20 feet or more in depth. The cut is in clay laminated by dark manganese stain and crossed by a zone 4 feet wide, which contains nodules and much soft ore in a narrow band. The shaft is 8 feet to the left of the cut and follows the ore zone down the steep dip.

Small shallow pits extend 50 feet or more northeast of the mine toward the old workings near the crest of the spur and deposits are probably distributed over an area of several acres adjacent to the mine. Float ore is reported to have been traced northeastward along the slope of the mountain for more than a mile. Southwest, across the small ravine, other small pits on the steep slope of the next interstream terrace reveal some good nodular ore in characteristic dark-red soil which indicates that this terrace is probably also underlain by similar deposits. Another opening on the lower northwest part of the same spur is in purple Watauga shale but shows only iron and a little manganese ore.

Patton Mine.—The Patton mine is six miles southeast of Johnson City and lies one-half mile southwest of the Winter mine, on the same mountain slope. The property is owned by the Taylor heirs. The deposit was first opened in a small way in 1908 by S. Joberg, who shipped some ore. In 1917 it was operated by the Maxwell Manganese Mining Company, of Elizabethton, which produced thirty tons of ore averaging 42.27% manganese, 6.16% iron, and 13.48% silica. The mine is now leased to the Max Mining Company, to be operated in conjunction with the Winter mine.

The mine is opened by a deep pit at the base of the steep north bank of a narrow gulch containing the headwaters of Powder Branch. The pit extends into the bottom of the gulch, whose stream was diverted around it, but it is now filled with water. The 20-foot high face of the cut is yellow clay streaked with layers of wad and cut by red-clay seams. The clay is residual from the Shady dolomite and dips 55° S, probably overturned in a steep monocline. The ore-bearing layer of dark waddy clay has a width of about 20 feet and carries good ore masses nearly to the surface.

The ore is nodular psilomelane with considerable crystalline manganite. Several masses 2 feet in diameter of good ore were noted on the dump. The high grade of the ore, the favorable showing in the bank, and the large amount of ore said to have been taken from the pocket are favorable indications that the bank and terrace above contain a deposit of workable ore.

Treadway Prospect.—The Treadway prospect is six miles southeast of Johnson City and 1½ miles southwest of the Patton mine, on the east side of Dry Creek gap. It is in a small ravine on the lower northwest slope of Gap Creek Mountain along the same belt as the Patton and Winter mines, at an elevation of about 2,100 feet. The property is owned by George Treadway, of Okolona, and was being prospected by W. H. Kemler, of Johnson City.

The deposit is in dark residual clay of the Shady dolomite, apparently close to the contact with the Erwin quartzite. The structure is believed to be monoclinal, the Watauga shale standing vertical and striking parallel to the mountain on the slope below. A pit 12 feet deep at the face is driven into the north side of the ravine, exposing dark dry powdery clay and sandy wash containing a few small nodules of hard psilomelane and irregular bodies of wad. Some larger pieces of good float ore occur below the pit. Samples of this ore are reported to have yielded 40% manganese. A few hundred yards east of the opening a little manganese float and iron ore cementing quartzite breccia extends up the slope of the low-terraced ridge. The showing, however, is not promising.

Hodge Prospect.—The Hodge prospect is six miles southeast of Johnson City, on the southwest side of Dry Creek gap, one-half mile from the Treadway prospect. It is on a low terrace on the northeast end of Little Mountain. The property is ownd by Frances Hodge, of Okolona, and was being prospected by W. H. Kemler, of Johnson City.

The deposit is in residual clay of the Shady dolomite and in the overlying sandy wash. A small offset of the mountain front at the gap is apparently due to a local syncline in the underlying quartzite and the Shady dolomite at the prospect apparently lies in this syncline. At the creek dolomite outcrops in vertical beds, but on the terrace it is deeply decomposed to clay. Several pits about 6 feet deep show only siliceous manganese ore in reddish clay. Some large masses of good psilomelane ore were plowed up in the fields below, which are reported to have analyzed 40% manganese.

Although the showing in the pits is poor, the high grade float ore on the slope and the apparent synclinal structure are favorable for a deposit of workable size, and further prospecting on the top of the terrace above the present pits is advised.

UNICOI DISTRICT.

This district is chiefly in Unicoi County and will be described under that heading. One mine in this district is in Carter County.

T. J. Brummett Mine.—The T. J. Brummett mine is at the head of Dry Creek, close to the county line in the southwestern part of the county, four miles northeast of Unicoi on the Carolina, Clinchfield & Ohio Railroad. It is on the farm of T. J. Brummett, of Unicoi, and is operated by the Southern Manganese Corporation, of Birmingham, Ala. Some prospecting, presumably for iron, was done here in early days, but no further work was done until the spring of 1918, when the deposits were opened for manganese by W. H. Kemler, of Johnson City. By the middle of May an open cut 20 feet deep and several smaller pits had been dug and ten tons of ore were on the dump. The ore was said to run about 52% in manganese.

The mine is on the north side of a small hill on the divide between Scioto and Dry creeks, connecting little Mountain and Stone Mountain. Little Mountain is the southwestward continuation of Gap Creek Mountain. The mine is on a bench approximately 2,400 feet in elevation, which is also the elevation of the stream divide and of other old, valley-floor remnants. The small hill at the divide rises 150 feet higher.

The deposit occurs in residual clay of the Shady dolomite close to the Erwin quartzite. The Scioto-Dry Creek valley is in general a syncline between quartzite mountains, faulted on the northwest side and inclosing Watauga shale in the center. Erwin quartzite is brought up on a local anticline on the small knob back of the mine and the narrow syncline to the southeast of this apparently plunges southwestward down Scioto Creek and merges with the larger syncline. It was not traced northeastward down Dry Creek. The Shady dolomite outcrops on the northwest side of the hill adjacent to the quartzite, striking N 45° E and dipping 75° NW. The mine is in the clay residual from this dolomite on the north slope. Watauga shale outcrops at the west foot of the hill. The deposit thus occurs on a steep monocline at the contact of the Erwin quartzite and Shady dolomite.

The ore is chiefly psilomelane and occurs as nodules, lumps, and irregular bodies embedded in dark-red clay. Some lumps 2½ feet in diameter were seen, but most of the ore is smaller than 3 inches across. Some of the ore has a botryoidal and mammillated surface and much of it is more or less cellular. Some is composed of thin, wavy, concentric layers. On the east side of the main pit the ore is sandy and apparently replaces the Erwin quartzite at the contact. At the west side next to a bed of iron ore the manganese ore is speckled with small flakes of iridescent or peacock-colored hematite.

The main cut is 40 feet in length, 15 feet in width, and 15 feet in depth at the face. It runs southwesterly into the hillside apparently at the Erwin-Shady contact. Greenish and red sand inclosing white quartzite masses veined with manganese on the east side apparently represent the quartzite ledges on top of the hill. Between this and the dark-red soil of the Shady dolomite is a vertical layer of red hematite iron ore and black clay with manganese ore, and there is another vertical layer of manganese and iron ore on the west side of the pit. The red clay between contains good nodular ore throughout, and has yielded most of the ore thus far mined. Its lower limit has not yet been reached.

Fifteen feet back of the main cut is an old shaft 10 feet deep which exposes some good ore beneath an iron capping. Forty feet farther southwest a trench 80 feet long and 15 feet deep in red clay shows considerable manganiferous-iron ore from the surface down, with a small amount of manganese ore in the lower part. Forty feet to the westward a 7-foot pit in red clay shows ore in its lower part.

About 300 feet southwestward from the main cut, and 15 feet higher up the slope, a 12-foot cut with a face 5 feet high in dark earthy-looking clay shows good psilomelane, pyrolusite, wad, and manganite from the surface to the bottom, which has yielded considerable wash ore on the dump. The deposit has thus been exposed by prospecting for a length of about 500 feet and a width of 150 feet, but it is not all minable ore, and its depth has not been determined, but is probably not great. ....

Unicoi County.

Unicoi County adjoins Carter County on the southwest and is a narrow mountainous county adjacent to the border of the State. The State line follows the crest of Iron, Unaka, and Bald mountains, and the western boundary of the county follows the crest of Buffalo Mountain and other mountains to the southwest. The long valley between these two ranges of mountains is chiefly tributary to Nolichucky River, which cuts the county in two, transversely, at its narrowest part. The two active mines in the county, Susan Brummett and Britt, together with the T. J. Brummett mine in Carter County, are in the Unicoi district. A few prospects in the northwestern part of the county are in the Bumpass Cove district.

UNICOI DISTRICT.

The Unicoi district embraces the area around the town of Unicoi, and includes the valley of North Indian Creek and of its several tributaries. At present mining is restricted to the Scioto Creek valley.

Susan Brummett Mine.—The Susan Brummett mine is in Scioto Creek valley in the northeastern part of the county three miles northeast of Unicoi on the Carolina, Clinchfield, & Ohio Railroad. It is on the farm of Susan Brummett, of Unicoi, and is being operated by the Southern Manganese Corporation, of Birmingham, Ala. It produced some ore in the early eighties, since which time it lay idle until it was recently reopened by W. H. Kemler, of Johnson City. At the time of visit, May 3, 1918, a double-log washer was being installed and storage bins were being built to supply the washer for night work so as to run day and night. The scarcity of water in the local branch prevented the operation of the plant during the summer and it was proposed to run a pipe line from North Indian Creek, near Unicoi, to the mine.

The mine is on a low terrace about 50 feet high, on the east side of Scioto Creek, at the northwest foot of Stone Mountain. It is in dark-red clay, which lies between Watauga shale at Scioto Creek and Erwin quartzite on Stone Mountain, and is evidently residual from Shady dolomite on a northwestward dipping monocline, although nowhere does the dolomite outcrop. The surface below the mine is strewn with chert from the Shady. Surface indications of this ore zone are reported to have been traced from the vicinity of Unicoi five or six miles northeast along the southeast side of Scioto Valley. Part of this land is now included in the U. S. Forest Reserve and mining privileges have not yet been obtained.

The deposit is opened mainly by an open cut 50 feet long northward into the hill from a small ravine. It is 10 to 20 feet wide and 20 feet deep at the face. The ore is apparently deposited chiefly at the bottom of the surface wash, but some is in the underlying dark-red residual clay. Most of it is psilomelane with a little manganite and pyrolusite. The ore is rather low grade, much of that from the surface wash enclosing sand grains, and it is reported to average only 38% manganese. The company planned to wash all the dirt handled, as it was believed to run one-third ore.

Britt Mine.—The Britt mine is also in Scioto Creek valley in the northeastern part of the county, one mile southwest of the Susan Brummett mine and two miles northeast of Unicoi on the Carolina, Clinchfield, & Ohio Railroad. It is on the farm of J. L. Britt, of Unicoi, and is being operated by the Southern Manganese Corporation, of Birmingham, Ala. It was first opened and a carload of ore shipped in 1898 by Colonel Kirk, and was later reopened by W. H. Kemler, of Johnson City. At the time of visit a double-log washer was being installed.

The mine is on a low-terraced hill on the east side of Scioto Creek, about 50 feet above the creek, at the northwest base of Stone Mountain. The deposit is in surface wash, which overlies brownish variegated clay of the Shady dolomite near its contact with the underlying Erwin quartzite on the southeast, the structure being monoclinal. No rock outcrops were observed and the dip was therefore not determined.

The deposits are opened by a series of about ten narrow cuts running northwest into the hill from a small side ravine and spaced over a distance of 300 feet. The longest cut is 60 feet, and the deepest 22 feet at the face. Other prospect pits were reported several hundred yards north of the mine, but these were not visited. Little ore was seen in the walls of most of the pits. The largest and deepest pit, which is at the southeast and apparently close to the sandstone contact, shows two layers of dark wad carrying hard manganese ore interbedded with dark slickened clay enclosing sandstone fragments which extend to the bottom of the cut.

The ore is chiefly nodular psilomelane, much of which incloses grains of quartz and some is coated with red oxide of iron. Small fragments of crystalline manganite and soft black pyrolusite and wad are also present. Considerable iron ore is also on the dump. The ore had been washed in a trough by a strong current of water from a flume and several tons of washed screenings were on the dump. Also about 80 tons of small gravelly wash dirt and a few tons of coarser red-coated ferruginous manganese ore were in piles. The ore is thus seen to be of low grade, high in iron and silica, and it is doubtful if it can be profitably worked unless all the dirt handled is wash ore.

Other Prospects.—Several other prospects or surface showings of ore were reported in the vicinity of Unicoi on Government Forest Reserve land, but at the time of visit were not being actively prospected. Old iron pits occur on the slopes of the surrounding hills and manganese indications were seen in the road cut at the south end of Little Mountain. Manganese float was reported on the bench 2,100 to 2,200 feet in elevation all along the northwest foot of Little Mountain. As the geologic and surface conditions are favorable for the occurrence of manganese ore, and as it is in the same zone as the good deposits at the Winter and Patton mines, this bench from Unicoi northeast to Dry Creek Gap is a desirable place to search for workable ore deposits.

BUMPASS COVE DISTRICT.

Bumpass Cove lies southwest of Embreeville and is partly in Unicoi County and partly in Washington County. As most of the opened manganese prospects are in Unicoi County, they will be described here under the head of Bumpass Cove district. The cove is almost surrounded by mountains. In the past it has been the source of much iron, lead, and zinc ores, and now manganese is being prospected there.

Embreeville Prospect.—The Embreeville prospect is at the northwestern border of the county near the head of Bumpass Cove, three miles southwest of Embreeville. It is on the Embree Iron Company's railroad, which connects with the Embreeville branch of the Southern Railroad from Johnson City. The deposit extends northeastward across the county line into Washington County.

The land is owned by the Embree Iron Company, of Embreeville and Chicago. Iron ore was mined by the company for many years, but more recently zinc and lead have been chiefly mined. Manganese has been only recently discovered and prospecting by the company began in 1918. The prospects are on a terrace on the northwest side of the cove at about 2,070 feet elevation, which is a remnant of an old valley floor.

The deposit lies in dark-reddish and yellowish clay residual from the Shady dolomite close to the contact with the underlying Erwin quartzite. The structure is monoclinal, the quartzite dipping 45° SE. In the valley bottom Shady dolomite outcrops nearly horizontally in the bottom of the Bumpass Cove syncline. The deposit trends northeast, parallel with the strike of the rocks, and is opened for a distance of one-half mile by pits, shafts, and cuts to depths of about 20 feet, the indications in which are at least encouraging. The openings in the surface wash on the terrace carry more iron ore than manganese, but larger amounts of manganese ore may occur at greater depth in the residual clay beneath.

The ore consists largely of psilomelane in nodules and small lumps of irregular size and form. It contains also a considerable amount of soft black, pulverulent ore consisting of pyrolusite and wad, locally called "plumbago." Crystalline manganite in the form of "needle" ore is also present in considerable amount. Some nodules several inches in diameter are composed of psilomelane and needle manganite arranged in alternating concentric layers, and a piece of one of these is reproduced in Part I of this report as Fig. 3A (p. 162).

The most southwestern prospect is just east of the Clark Creek Gap road. It is a shallow pit which runs northeast into the terraced hill about 50 feet above an outcrop of Erwin quartzite and exposes clay containing chert and sandstone fragments. Psilomelane nodules and soft pyrolusite ore are present sparingly. Other small pits scattered over the top of the hill have not been sunk through the thick cover of wash and contain chiefly iron ore. Whether manganese ores occur in depth was not determined. An old iron-ore pit scars the east slope of the hill, and at its northeast side a deep pit has been recently driven in from the small ravine. Considerable good ore shows in its walls and it was here that the large nodules of needle ore were obtained. In the ravine manganese occurs in banded clay in the face of an old iron pit. The clay is full of cherts and is probably residual from the basal part of the Shady dolomite. On the slope above this pit a ledge of brecciated quartzite, which has been cemented and partly replaced by manganese ore, has been opened by a pit. It is too siliceous to be worked as an ore, however.

There are several prospects on the terraced hill to the northeast, especially at its northeast side where there are two deep cuts exposing considerable ore, some of which is good needle ore. Bands 6 to 8 inches thick of black wad alternate with yellow buckfat clay, dip northwest at a low angle into the hill, suggesting a syncline. A large ledge of brecciated ferruginous quartzite to the northeast across the ravine is apparently the Erwin quartzite on the southeast limb of the syncline which is rising northeastward and terminates the syncline in that direction. Farther northeast, in Washington County, manganese is being prospected for by a Keystone churn drill, the lower slope of the mountain being systematically drilled to a depth of about 200 feet for zinc and lead and incidentally manganese.

Although no manganese ore has been shipped, several tons of high grade ore are at the railroad and enough such ore is showing in the walls of the prospects to warrant mining on a small scale. The tops of the terraces, where the thickest deposits may be expected, have not been tested in depth because of the thick cover of wash, and deep bore holes or wells should be sunk there to thoroughly test out the deposits. If no large pockets are encountered the deposits will not warrant an expensive plant, but probably can be worked on a small scale with profit at the present prices.

WASHINGTON COUNTY.

Washington County, of which Johnson City is the county seat, lies west of Carter and Unicoi counties, and includes a small part of the Appalachian Mountains along its southeast border, in which manganese ores have been reported. Those in Bumpass Cove have already been referred to. Vague reports of a deposit at the head of Dry Creek, between Cherokee and Buffalo mountains, were heard, but as no development work has been done, it was not visited. A small area there is underlain by clay residual of the Shady dolomite inclosed in a syncline faulted on the southeast side, according to the geologic map of the U. S. Geological Survey,[1] and is therefore favorably located for such deposits.

GREENE COUNTY.

Greene County, of which Greeneville is the county seat, lies west of Washington County. Its southeast boundary is also the State boundary which follows the crest of the Bald Mountains. It contains several manganese deposits, all of which occur 10 to 14 miles south of Greeneville in the southern part of the county in the intermontane valleys of the Appalachian Mountains. The deposits include the Hayesville, Sylvia, Lamb, and Payne prospects, all in the Hayesville district.

HAYESVILLE DISTRICT.

The Hayesville district includes the area around Hayesville, but chiefly the region south to the State line. It centers around the old iron mines and furnace at Hayesville.

[1]Roan Mountain folio of the Geologic Atlas of the United States, by Arthur Keith.

Hayesville Prospect.—Hayesville and the old Hayesville furnace are 10 miles in direct line south of Greeneville, or about 14 miles by road. The deposits are a half mile southwest of the furnace at the site of the old Hayesville iron mine. The property is owned by the Unaka Development Co., of Greeneville, Tenn., which is at present doing exploratory work under Leroy Park, of Greeneville, superintendent. About a year ago the Virginia Iron, Coal, and Coke Company opened up many new pits and tunnels on the property, exposing iron ore and some manganese.

The iron and manganese deposits occur on a terraced hill at the northwest foot of a low spur of Bald Mountain. Dolomite exposed on the lower north slope of the hill dips 80° S, probably overturned, and also occurs at the south crest and on the south side of the hill. Quartzite masses at the crest and in the dump from the shaft suggest that the body of the hill is Hesse quartzite, but this was not fully determined. The geology is evidently complicated but the the structure appears to be a local sharp anticline of Hesse quartzite faulted and overthrust northwestward on to Shady dolomite, with a shallow syncline on the southeast inclosing Shady dolomite between the small hill and the main mountain slope.

This low hill southwest of the furnace is covered with old workings for iron, chief of which is a tunnel 750 feet long running northwest into the hill from a small branch of Back Creek and connecting with a shaft 180 feet deep from the top of the hill. Several large open cuts on both the north and south slopes of the hill mark the extent of the iron mining industry. The overburden covering the iron-ore ledges and bedrock is 10 to 30 feet of clay and wash, which contain small fragments of iron ore and some manganese. Most of the iron ore mined is said to have contained about 5 per cent manganese.

A short distance north of the shaft, down the slope, at an elevation of about 1,650 feet, is a large old open cut 100 feet wide and 80 feet high at the face. Several tons of soft pyrolusite ore were recently taken out and lie on the floor of the pit. The ore is partly of fine gravelly or shot type and partly soft and powdery. Some ore was bagged and shipped to New York for paint and a substitute for lamp black. It is too low grade for chemical ore, although it was reported to have assayed more than 50% manganese with but little iron or silica. Some harder psilomelane and iron balls with soft waddy ore inside are also present in the old pit. The deposit lies in pockets in residual clay and chert of the Shady dolomite and was mined from short tunnels and pits near the bottom of the large pit. In one pit the soft waddy clay stands vertical, parallel to a 3-inch seam of barren clay, probably representing original bedding. A ledge of weathered buff chert exposed in the upper part of the old pit face, coated and seamed along joint planes with manganese, is also about vertical, dipping 80° S, probably overturned. A tunnel recently driven southward into the face of the big open cut penetrated a considerable amount of soft clayey and ferruginous wad, and farther into the hill encountered some excellent manganese ore. Up to the present time not a large amount of high-grade ore has been found, but there is a possibility that a good body may yet be encountered. However, the ore is somewhat inaccessible because of the great depth at which it occurs, and much of the ore is soft and is expensive to mine because of the care necessary in handling it.

In the most southerly well about 30 feet deep, on the saddle connecting the hill with the main mountain and close to the quartzite of the mountain, a lump of very high-grade psilomelane was struck. It lies in yellow clay derived from the Shady dolomite, and fresh dolomite is encountered in adjacent pits. Judging from the hundred or more prospect pits that have been sunk, the Hayesville tract is mainly an iron ore property, although much of the iron ore is manganiferous and good manganese ore has been encountered in several places. Further prospecting may possibly bring to light workable bodies of high-grade manganese ore.

Sylvia Prospect.—The Sylvia prospect is 11 miles south-southwest of Greeneville and 4 miles southwest of Hayesville furnace. It was operated as an iron mine by the old Hayesville Iron Co. prior to 1874 and has only recently been opened for manganese by Leroy Park and J. C. Park, of Greeneville, who have acquired the property.

It is on a terraced spur at the northeast end of Meadow Creek Mountain at about 2,170 feet in elevation. This bench is a remnant of the old valley floor. The old mine is reached by a good wagon road from Cove Creek to the east.

The deposit occurs in residual clay of the Shady dolomite close to the contact with the underlying Hesse quartzite which forms the spur just back of the mine. A small knob north of the mine is composed of soft sandstone which is nearly vertical and probably represents a small anticline of the underlying quartzite, so the structure at the mine seems to be a small local syncline. This structure is not certain, however, as the geology is complicated by faulting. A shaft and several pits not over 12 feet deep have recently been dug in the old iron opening, but they had fallen shut. A little manganese ore disseminated in yellowish-red clay and fragments of buff chert with white wavellite seams are on the dump. The ore is psilomelane of good grade in small nodules and irregular fragments. Samples of ore are said to have analyzed 52% manganese, but the run of ore will not average that much. The quantity of ore seems very small and unless further prospecting shows up a better deposit it will not be profitable to work.

Lamb Prospect.—The Lamb prospect is near the south corner of the county about 13 miles south of Greeneville and 2½ miles south of Limestone Springs. It is on the Scott Lamb farm, south of the Allen Stand road, in an open field a short distance west of the tenant cabin.

It is in the lower northwest slope of the mountains just east of Cove Creek, about 1,800 feet in elevation, in the saddle of a terraced ridge which is a remnant of an old valley floor.

The deposit occurs in red clay residual from the Shady dolomite near the contact with the overlying Watauga shale, the structure being monoclinal. It is opened by a shallow shaft sunk many years ago for manganese, it is said. The shaft is now caved. A specimen of fairly good nodular psilomelane was found on the dump. It is reported that a series of old manganese prospects extends eastward from the shaft for one-half mile or more, some of which looked encouraging.

Payne Prospect.—It is reported that good ore has been obtained from property owned by Henry Payne and opened by Leroy Park of Greeneville. It is said to be on the south slope of Meadow Creek Mountain near its summit and to be 9 miles from the railroad. It was not visited by the writers and its geologic relations and possibilities are not known.

COCKE COUNTY.

Cocke County, of which Newport is the county seat, lies southwest of Greene County adjacent to the North Carolina State line. The southeastern part of the county is mountainous and the manganese deposits occur at the foot of the mountain slopes on or near remnants of the old valley floors of the French Broad and Pigeon rivers. They occur in the Del Rio and Newport districts, but mention is made by Harder[1] of manganese ore also near Cosby, west of Denny Mountain.

DEL RIO DISTRICT.

The Del Rio district is in the eastern part of the county in the heart of the mountains around the town of Del Rio, which is on the French Broad River and on the Morristown-Asheville line of the Southern Railroad. The more important mountains in the district are the Meadow Creek, Neddy, and Stone mountains on the northwest and the northeastward continuation of the Great Smoky Mountains on the southeast, the crests of which is followed by the State line.

Wood Mine.[1]—The Wood mine is 5 miles northeast of Del Rio on the south slope of Meadow Creek Mountains. It is owned by Nick Wood of Del Rio. It was last worked in 1906 by J. N. Adams and associates of Charleston, Tenn., at which time some ore is reported to have been shipped. It is on the steep south slope of the mountains, at an elevation of 2,170 feet. It is in brownish to chocolate-colored residual clay resting on the Hesse quartzite near its contact with the overlying Shady dolomite and seemingly at or near a parallel east-west fault.

The principal opening is a pit 15 feet in diameter by 8 feet deep, which formerly was somewhat deeper. Its approach is a 50-foot cut which runs N 60° E into the hill. Ore is shown more or less throughout the walls of the pit and the cut, and about two tons of shipping ore and 10 or 12 tons of wash dirt lie on the dump. The ore is almost entirely of the coarse hard nodular or lump type. It consists almost wholly of massive psilomelane with very little concentric banding or botryoidal and stalactitic forms. Much of the weathered portion

[1]Harder, E. C., Op. Cit., p. 76.

[1]Descriptions of the Wood, Adams, Blanchard, and Waddell mines and of the Huff and Lamb prospects, the latter in Greene County, are by F. C. Schrader.

of the ore is more or less pitted. This feature is also present in the croppings at the southwest edge of the pit where massive coarse bouldery ore stands 6 to 8 inches above the surface for a width of 6 feet. The preservation of the croppings seems to be due to the presence of quartz and wavellite in the ore. Wavellite is also more or less plentiful throughout the ore, where it seems to be secondary in the form of small irregular stringers and veinlets filling fractures, small lenticular bodies, and beads in cavities. On flat surfaces of the ore it occurs as fan-shaped bodies of radiating fibrous crystals up to one-half inch in length. The ore probably contains considerable phosphorus from the wavellite.

The manganese deposit trends a little north of east parallel with the mountains and seems to dip to the southeast approximately conformable with the country rock which is exposed in Laurel Branch Valley to the southwest. Shallow prospect pits and trenches dug at intervals in the gently rising surface for a distance of 400 feet east of the mine show traces of ore similar to that at the mine.

The deposit probably contains considerable manganese ore, but owing to the presence of phosphorus in the ore and the distance of haulage, 4 miles of which is over a rough mountain road, it cannot at present be profitably worked.

Adams Mine.—The Adams mine is 2 miles northwest of Del Rio in the steep lower slope of the northeast end of Stone Mountain. at an elevation of 1,600 feet. It is 400 feet above the railroad and about 3/10 of a mile distant. It is owned by John N. Adams of Charleston, Tenn. It was last worked in 1908 when it is reported to have produced and shipped to Johnson City, Tenn., for the manufacture of polish. 8 carloads of ore, totalling about 300 tons, which is probably an overestimate. The ore was shipped in bags, unwashed, and is said to have averaged 47% manganese.

The deposit occurs in residual clay resting on the Hesse quartzite near its contact with the overlying Shady dolomite which seems to be also a fault contact. Much of the quartzite is deep yellowish brown from impregnations of limonite. The deposit dips westward into the mountain and is reported to have a thickness of more than 50 feet, its lower limit not having been reached in a 40-foot shaft sunk from the bottom of a cut 15 feet deep. Croppings and surface debris indicate that the deposit probably extends southwestward up the mountain slope. The containing clay is mostly light brownish, but is variegated by small to large masses which are chocolate colored or black. It contains fragments of partially decayed quartzite and cherty material resembling a fault breccia.

The ore consists chiefly of layers or beds of massive, soft, sooty wad and pyrolusite, with considerable hard nodular material composed of manganite and psilomelane. The manganite occurs mainly in radial fibrous needle crystals in concentric bands alternating with hard blue psilomelane. It is said that only the soft ore was shipped for the manufacture of polish. A ton or two of soft shipping ore and three or four tons of unwashed ore lie on the dump.

Blanchard Mine.—The Blanchard mine is about 2 miles northwest of Del Rio, a half mile south of the Adams mine on the same spur of Stone Mountain. It is owned by William Blanchard of Del Rio. It was last worked by the Commercial Mining and Milling Co. of Del Rio in 1902, when it is said about 200 tons of unwashed ore averaging 47% manganese was shipped. It is now being operated by the Barium Lithophone Co. of Philadelphia, whose development consists of five or more openings in the steep east slope of the mountain, of which the more important are 250 feet higher than the Adams mine, at elevations between 1,750 and 1,900 feet.

The openings are in the Hesse quartzite or perhaps in transitional beds at the contact with the Shady dolomite, which seems to be also a fault contact. They appear to be in the southward continuation of the mineral zone at the Adams mine. The ore is principally hard, concretionary, nodular manganese ore, but includes also some manganiferous iron ore.

At one of the main openings, in the north side of an eastward-sloping spur at 1,850 feet elevation, the deposit seems to consist of a six-foot bed of good nodular manganese ore in soft white sandstone which dips 40° to the southwest. The ore adheres to the walls of sandstone and partially impregnates it. About 50 tons of ore of the 1902 shipment is reported to have come from this opening. At another opening on the opposite or south slope of the spur, 1,790 feet in elevation, conditions are similar except that the workings are more extensively caved and overgrown with vegetation and the quartzite includes a fine conglomerate with small white quartz pebbles. One hundred and forty tons of ore from this opening were included in the

1902 shipment, and the ore is said to have averaged 47% manganese. Approximately 4 tons of ore still on the dump is of the good concretionary nodular type and consists of hard massive psilomelane and of crystalline manganite with radial and parallel fibrous needle structure. One lump is 2½ feet in diameter. Some specimens show mutually facing, comby structure apparently denoting deposition in fissures.

The next opening a short distance down the ridge to the southeast, is a tunnel. The deposit here consists mainly of a 2½-foot thick (?) tabular body of ore in red clay and sandstone, dipping 60° WSW into the mountain. The walls consist chiefly of altered, liver-colored, ferruginous silica rock which the ore deeply penetrates and replaces. The ore is similar to that just described, though in places it is slightly waddy and siliceous from finely crystalline glassy quartz lining small irregular cavities. Some of the ore has stalactitic structure. The tunnel, which was badly caved at the time of visit, is reported to have been more recently reopened and conditions looked encouraging. From this opening some high grade ore was shipped. Several tons of concretionary nodular ore lie on the dump.

Waddell Mine.—The Waddell mine, also known as the Pigeon Roost mine, is 3½ miles west of Del Rio and 1½ miles south of West Myers station on the Southern Railroad. It is owned by John B. Waddell, of Springfield, Mo. It was worked in 1892 by Sugars and Oliver, but so far as learned no ore was shipped. In the early part of 1918 it was worked by the Southern Manganese Corporation, P. J. Harkins being in charge, who reports that 10 tons of manganese ore were taken out, which exhausted the deposit.

The mine is on the south slope of an eastern ridge of Stone Mountain, at an elevation of 1,900 feet, on the west side of a gulch that drains southward into Big Creek. A newly made mountain wagon road from the Dicky kaolin mine nearby to West Myers station passes the mine.

The deposit occurs in a dark-reddish ferruginous quartzite, which is believed to be the Nebo quartzite, and in overlying clay which may be residual from Hiwassee slate. The geologic relations are not fully known. At the time of visit a caved pit 25 feet in diameter, which originally may have been 25 or 30 feet deep, was the only opening. The ore bed seemed to dip to the northwest and appeared to be 8 or 10 feet in thickness.

About 20 tons of ore on the dump consists chiefly of hard psilomelane nodules or bouldery masses in which radial and parallel, aggregate, stalactitic structure is dominant. The surfaces of some fragments are blistery or botryoidal on a small scale. The ore heavily incrusts joint planes and fracture surfaces of the quartzite and commonly penetrates or impregnates it to the depth of several inches. At a point several hundred feet to the northwest of the mine dark wad in clay is exposed in shallow cuts of the wagon road to the kaolin mine.

Huff Prospect.—The Huff prospect, commonly known in the region as the Huff mine, is north of Waddy Mountain, on the Newport-Del Rio wagon road about 4 miles from Del Rio. It is in the lowland north of the road on the farm of Aleck Huff of Del Rio.

It was first opened for manganese in 1892 by Mr. Icewall, of Atlanta, Ga., who excavated the large pit just northwest of the barn near the road, but no ore was shipped. The pit is in Watauga shale near its contact with the underlying Shady dolomite. The shale outcrops a short distance to the west and there dips 60° E.

In 1918 John N. Adams, of Charleston, Tenn., is reported to have dug the 50-foot open cut or trench with a face 8 feet high in the barnyard. This cut is in red clay containing black or dark-gray angular blocks of the so-called ore ranging up to 2 feet in diameter. The so-called ore, many tons of which, from both the old pit and the newer cut, appear in the stone fences inclosing the barnyard and adjoining fields, is a fine-grained chert stained and slightly impregnated with manganese, and contains 75 to 80% of silica and very little manganese or iron. Some of the material is finely porous with scattered cavities one-half inch in diameter, closely resembling slag. Some of the cavities and crevices are thinly coated with crystalline manganite. It is too silicious to be an ore of manganese and has no commercial value.

Long Creek Prospect.—Long Creek prospect is on the east side of Long Creek, one-half mile northeast of the Del Rio-Newport wagon road, and 3 miles north-northwest of Del Rio. It also is on the farm of Aleck Huff of Del Rio.

It is on the side of a low spur at the southwest end of Meadow Creek Mountains, and is in chert and clay residual from the Shady dolomite at its contact with the underlying Hesse quartzite. The beds at the prospect seem to be vertical along a fault. In the creek near the road fresh Shady dolomite dips 45° SW.

The developments are old workings that have caved. A tunnel, which runs north into the hill from the small branch of Long Creek, follows a ferruginous chert, which lies at the contact of the quartzite on the east and dolomite clay on the west, which is apparently a fault line. Several slumped trenches show reddish clay and a very small amount of psilomelane on the dumps. Masses of iron ore, which may be manganiferous, up to 1½ feet in diameter occur as float.

NEWPORT DISTRICT.

The Newport district includes the area around the town of Newport in the western part of the county. The known deposits are on the north end of English Mountain.

Newport Mine.—The Newport mine, formerly known as the Yellow Springs mine and the Carson Springs mine, and also spoken of as the English Mountain mine, is at the north end of English Mountain 4 miles southwest of Newport. The property is part of the John Sant & Son estate of East Liverpool, Ohio. The mine is being operated by the Newport Manganese Corporation, of Newport, of which the Southern Manganese Corporation, of Birmingham, holds a controlling interest. Analyses of carload lots of high-grade ores shipped in 1918 ran 42.85% manganese, 6.25% iron, .8% silica. Carload lots of the poorer ore ran 34.78% manganese, .11% iron, 12.10% silica. Complete analyses of some of these shipments are reported as follows:

Moisture	5.77	4.68
Manganese	37.57	33.89
Fe	7.44	8.63
SiO_2	9.42	13.73
Al_2O_3	6.51	6.55
$CaCo_3$	.37	1.05
$MgCo_3$	.40	2.41
BaO	2.10	2.63

Recent reports from the mines state that mining is being done from 4 tunnels, the end of the lower one being 55 feet below the surface. The tunnels follow an irregular bed containing masses of high-grade ore, ranging up to 300 pounds in weight. The washer running only every other day produces 50 tons of ore a month, which carries 40% manganese.

The deposits occur in clay residual from basal beds in the Shady dolomite. The mine is described in detail as one of the types of manganese deposits in the State in Part I of this paper (pp. 177-179).

Jones and McMahon Prospect.[1]—The Jones and McMahon prospect is 4 miles west-southwest of Newport and about one-half mile east of the Newport mine. It is on a terrace at the foot of the north end of the east prong of English Mountain, east of Sinking Creek Gap. The property is owned by Jones and McMahon of Newport. The prospect consists of manganese ore float on the surface, no openings of any consequence having been made. It was not visited by the writers. The ore is reported to be of irregular and stalactitic form and very sandy. The deposit occurs in wash and possibly in the underlying clay derived from the Shady dolomite.

Raines Mine.—The old Raines mine is 3 miles southwest of Newport and about 1 mile east of the Newport mine. It is on a terrace at the northeast end of English Mountain, which is covered with surface wash and is underlain by clay residual from Shady dolomite. The mine was opened years ago for a short time. The development exposes brown sandstone replaced by small specks and stringers of manganese ore which in places is concentrated enough to be a low-grade siliceous ore. Irregular masses of psilomelane are scattered through the overlying clay.

The George L. Gray farm, on which the old Raines mine is located, has recently been bought by Barney Hurley of Newport, who expects to develop it.

HAMBLEN COUNTY.

Hamblen County, of which Morristown is the county seat, lies west of Greene County and northwest of Cocke County. Manganese ore is reported at several localities in the vicinity of Morristown, chiefly in the chert ridges northwest of the city. They are in the Boatman Ridge district. Deposits in red clay southeast of Morristown referred to by Penrose[1] were not visited.

[1]The descriptions of the Jones and McMahon prospect and Raines mine are largely from E. C. Harder, Op. Cit., p. 76.

[1]Penrose, R. A. F., Op. Cit., p. 416.

BOATMAN RIDGE DISTRICT.[2]

The Boatman Ridge district is northwest of Morristown, comprising several parallel, northeast-trending chert ridges on which manganese ore has been reported.

Prospects Northwest of Morristown.—Several prospects occur in the chert ridges northwest of the city, particularly on top of Boatman, or River, Ridge. On land in which J. N. Lotspeich, of Morristown, is interested, 3 miles northwest of the city, the top of the ridge shows manganese and manganiferous iron at a number of places and has been prospected by shallow pits. It is reported by Mr. Lotspeich that from one large mass of ore taken out several years ago 2 carloads of manganese ore were shipped. At present but little ore is showing in the slumped pits.

Two other prospects farther southwest on the same ridge are on adjoining farms of Monroe Mays and G. N. Ivy, 5 miles west of the city. The pits are shallow and slumped, so that little ore is to be seen. Other prospects are reported on the northeast end of this ridge south of the Noeton ferry near the Tate Springs road.

The deposits are all in residual chert and clay of the Knox dolomite, close to yellow shales and limestones of the underlying Nolichucky shale. The rocks dip 15° to 20° SE. The ore is psilomelane in chert which is brecciated and cemented and partly replaced by the ore. The amount of ore seems small and is highly siliceous, as the chert cannot be readily separated from the ore. Iron ore is also associated with it. None of the prospects are promising.

Curry Prospect.—The Curry prospect is 7 miles northeast of Morristown on the Bright Mills road. It is in the chert hills of the Knox dolomite, at about the same horizon as those on Boatman Ridge. Here a small amount of psilomelane and iron ore occur as a fissure filling and replacement of the chert. The showing indicates that the deposit has little value.

GRAINGER COUNTY.

Grainger County, of which Rutledge is the county seat, lies west of Hamblen County, Holston River forming the boundary line. It is mostly valley land but its western part is crossed by Clinch and Log

[2]The descriptions of prospects in this district are largely from notes by Arthur C. McFarlan of the Tennessee Geological Survey.

mountains. Manganese is reported from several localities, three of which are in the Rutledge district and two in the Washburn district.

RUTLEDGE DISTRICT.

The Rutledge district includes the area around Rutledge, the known prospects lying in the hilly Richland Knob country southeast of the town.

Rutledge Mine.—The Rutledge mine is 2 miles southeast of Rutledge on the farm of J. H. Lowe of Rutledge, and is being operated by J. S. Swann of Knoxville. The deposit occurs in residual clay and chert of the Knox dolomite close to its contact with the underlying shale. The analysis of shipments reported in 1918 ran 25.86% manganese and 3.57% iron. On account of the low grade and small quantity of ore, it was reported that the mine would probably be abandoned. It is described in detail as one of the types of ore deposits, in Part I of this paper (pp. 182-184).

Harmon Prospect.—The Harmon prospect, on the farm of Joe Harman of Rutledge, is 2 miles southeast of Rutledge. It is leased by J. S. Swann of Knoxville, who planned to open it up.

At the time of visit the deposit was exposed in the bed and bank of a small branch of Richland Creek. It occurs in yellowish and dark-banded clay apparently of the Nolichucky formation just below the Knox dolomite, the rocks dipping 10° SE. A 3-foot bed of banded clay with dark manganese laminae and a little ore crosses the bank diagonally, and considerable psilomelane float ore lies on the surface. The pebbles in the stream gravels of the valley bottom are cemented with black manganese ore, and the present waters of the stream blacken the pebbles in it, showing that the streams are still carrying manganese in solution.

Other Prospects in the Richland Knobs.—Manganese float ore is reported on the farm of B. F. Young, of Knoxville, 6 miles south of Rutledge and 2 miles south of Doyal postoffice. It is in the Knox dolomite and occurs as small fragments in the soil mixed with pieces of chert. Its quality or quantity is not known as it has not been prospected. It was not visited by the writers or by Arthur C. McFarlan.

Samples of manganese ore have been found on several other farms southwest of the Rutledge mine, one of which, about 6 miles distant, looked so favorable that J. S. Swann had secured an option on the property and expected to develop it. It is on top of the high front knobs similarly situated to the Rutledge mine.

WASHBURN DISTRICT.

The Washburn district includes the area around Washburn on the Knoxville-Middlesboro line of the Southern Railroad, particularly the valley country northwest of Clinch Mountain. Indications of manganese are reported at several localities.

Wallen Prospect.—The Wallen prospect is 5 miles northeast of Washburn, on the lower south slope of Copper Ridge, 1½ miles northeast of Puncheon Camp. It is on the William Wallen farm, and the mineral rights were leased by R. B. Bundren, of Washburn. It is undeveloped and consists merely of a few large masses and smaller sized fragments of very good psilomelane ore which are found at the surface of cultivated fields. One lump of ore weighing 60 pounds is said to have been found. The psilomelane is solid and massive and contains a little manganite and apparently braunite. The latter mineral is not certainly identified because of the difficulty of distinguishing it in the massive crystalline form. Some iron ore is also present in the dark-red clay soil. The ore occurs in the soil resting on Knox dolomite near its contact with the overlying Chickamauga limestone, which dips about 40° SE. Although the ore is of high grade, the indications are that there is very little ore present.

Frye Prospect.—The Frye prospect is 1½ miles northwest of Washburn and the same distance southeast of Liberty Hill, both on the Knoxville-Middlesboro line of the Southern Railroad. It is on a small spur on the northwest slope of Copper Ridge at about 1,400 feet elevation, not far from Williams Creek. The land is owned by Charles Frye of Washburn. It is undeveloped and consists merely of nodules and small fragments of manganese ore and waddy clay in the soil of cultivated fields on the Frye and neighboring farms and similar ore is reported on John Dozier's farm 3 miles southwest.

The chert and clay in the soil are derived from basal portions of the Knox dolomite, and the underlying Nolichucky shale outcrops in the run near by. Some of the manganese ore has what appears to be a fine shot-like structure which suggests that it may be pseudomorphic after oolitic chert, also present in the soil and stained by manganese, but the structure is simply layer upon layer of botryoidal psilomelane.

Considerable crystalline manganite is present with the psilomelane and the ore is of high grade, but there is apparently very little ore present.

JEFFERSON COUNTY.

Jefferson County lies south of Grainger and Hamblen counties, and, like the latter, is crossed by many low ridges. Only one manganese prospect is reported and its location in the county has not been determined.

JEFFERSON DISTRICT.

The Jefferson district embraces the hills and valley around Jefferson, where manganese may be expected to occur in the chert of the Knox dolomite.

Currens Prospect.—Ore has been reported on the property of George Currens of Jefferson City. The location was not determined, but it is believed to be a deposit in the chert of the Knox dolomite which composes many of the ridges of the valley in the neighborhood. It was not visited by the writers and a detailed description cannot be given.

SEVIER COUNTY.

Sevier County lies southwest of Cocke County along the southeast border of the State. Sevierville is the county seat. The southern half of the county is mountainous, including the northwest slope of the Great Smoky Mountains, the summit of which is followed by the State and county line. The northwestern half is partly hilly. The only manganese deposits known in the county is at the East Fork mine, at the edge of the mountains. It will be described under the East Fork district.

EAST FORK DISTRICT.

The area within the mountains around East Fork of Little Pigeon River, where deposits of manganese are likely to be found, will be included in this district.

East Fork Mine.—The East Fork mine is on the East Fork of Little Pigeon River near East Fork postoffice, 13 miles southeast of Sevierville. It is owned by the Tennessee Manganese Co. of Knoxville which is at present developing it. The mine is on a terraced spur on the southeast slope of a prominent ridge at an elevation of about 1,200 feet. The ore is a carbonate of manganese in dolomite beds in Hiwassee slate. The property is described in detail as one of the types of ore deposits in Part I of this paper (pp. 194-198).

KNOX COUNTY.

Knox County lies northwest of Sevier County. It is crossed by several low ridges which trend northeast across the valley. A few manganese prospects are reported from the Knoxville district, south of Knoxville, and one from the Copper Ridge district, northwest of Knoxville.

KNOXVILLE DISTRICT.

The Knoxville district includes the area around Knoxville, especially the lines of Red Hills south, southwest, and southeast of the city, where manganese ore has been reported at several places.

Prospcts Southwest of Knoxville.[1]—Several belts of Red Hills lie south of Knoxville, two of which extend many miles to the northeast and southwest. These hills have long been known to carry some ore, high-grade hematite iron ore being the most common but very pure manganese ore is also present in many places. Further prospecting should be done along both belts, particularly along the contact of the red Tellico sandstone and the underlying Holston marble, where rich deposits of ore occur farther southwest, but up to the present the indications in the Knoxville district are not favorable.

The Fitzgerald prospect is about 6 miles southwest of Knoxville and 3 miles south of Bearden station on the Southern Railroad. It is on the farm of J. H. Giezentanner and is being worked on shares by Paul Fitzgerald. It has only recently been opened to the depth of 10 feet, and about 15 tons of ore had been taken out and lies on the dump. The ore has considerable clay in it and is of medium grade. Brown iron ore also occurs with it. The ore is in a shaly phase of the Tellico sandstone whose dip is generally to the southeast but varies greatly. It occurs in thin irregular seams which follow the bedding planes of the rocks. Near the northern boundary of the property considerable sandy float ore occurs, and on the adjoining farms of Mrs. W. C. Badgett and L. F. Currier large amounts of iron ore are reported.

On the farm of J. C. Green, 2 miles southwest of Bearden station, a small amount of manganese float ore occurs scattered over the

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[1]These descriptions are largely from notes by Arthur C. McFarlan.

red hill and a pit 3 feet deep has been dug exposing similar ore. It is mostly light-weight pyrolusite and waddy clay in a small seam in the clay. The Tellico sandstone on the hill dips 58° SE.

On the adjoining property to the south, C. S. Morel's farm, a little psilomelane and sandy iron-ore float occur. Northeast of the Green property a large amount of good hematite occurs on L. D. Tyson's farm and several large pieces of high-grade manganese ore have also been found.

COPPER RIDGE DISTRICT.

The Copper Ridge district includes the prospects in the belt of chert ridges lying northwest of Powell, which trend northeast. Only one prospect is here described.

Haworth Prospect (reported).—The Haworth prospect is reported to be 8 miles northwest of Knoxville and 2 miles northwest of Powell on the Coster Division of the Southern Railroad. It is on the farm of W. L. Haworth of Knoxville on the top of Copper Ridge. There has been no development of the property, the showing of ore consisting of float psilomelane cementing and partly replacing chert from the Knox dolomite. It was not visited by the writers or by Mr. McFarlan.

ANDERSON COUNTY.

Anderson County is northwest of Knox County. Clinton is the county seat. The northwestern part is mountainous, being occupied by the Appalachian Plateau, a dissected or eroded plateau composed of coal-bearing rocks. In the southeastern valley portion a few prospects of manganese ore have been reported, chiefly along Pine Ridge north of Clinton.

PINE RIDGE DISTRICT.

Pine Ridge is a low ridge trending northeast along the foot of Walden Ridge, the front mountain of the Appalachian Plateau. The district known to carry ore lies northwest of Clinton along the ridge for a length of about 3 miles.

Bright and Howell Prospect (reported).—D. M. Bright and D. A. Howell of Knoxville have an interest in a property on the northwest side of Pine Ridge, 5 miles north-northwest of Clinton at the Cane Creek gap in the ridge. A pit has been sunk and is reported to expose good manganese ore. The ridge is composed of shales and sandstones of the Rome formation, equivalent in part at least to the Watauga shale farther northeast in the valley, which dips southeast in general. According to the geologic map in the U. S. Geological Survey Atlas[1] it is faulted along its northwestern side against Chickamauga limestone. The ore apparently is associated with this fault. It was not visited by the writers or by Mr. McFarlan.

Manganese ore is reported to show in the road cut through Pine Ridge 3 miles northwest of Clinton. It is believed also to be in the Rome formation, but it is not prospected.

Wallace Prospect.—A prospect is reported near Coal Creek on the farm of Hack Wallace, of Clinton, Tenn. It is probably also on Pine Ridge, although its exact location is not known. It was opened in 1914 and 1 ton of ore analyzing 48% manganese, 1.60% iron, and 8.0% silicia was shipped. Nothing further was done with the property until 1918 when it was leased to T. F. Narramore who is reported to have started developing. It was not visited by the writers and the relations of its deposits and the character of its ore are not known.

Blount County.

Blount County, of which Maryville is the county seat, lies southwest of Sevier County along the southeast border of the State. The southeastern part of the county is mountainous, the State and county boundary following the top of Great Smoky Mountain which is over 5,000 feet in altitude in places.

Several deposits of manganese ore are reported in the county: the Townsend prospect in the Tuckaleeche Cove district, the Louisville mine in the Louisville district, several prospects in the Chilhowee Mountain district, and prospects northeast of Greenback.

TUCKALEECHE COVE DISTRICT.

Tuckaleeche Cove is a flat-bottomed valley on Little Pigeon River within the mountain area southeast of Maryville. It is hemmed in on the southeast by high steep mountains and on the northwest by lower ridges through which the river passes in a gorge. Manganese ore is reported at only one place in the cove.

[1]Briceville folio, by Arthur Keith.

Townsend Prospect.[1]—The Townsend prospect, known also as the Webb prospect, is in the eastern part of the county in Tuckaleeche Cove, a half mile north of Townsend station on the Knoxville-Elkmont branch of the Southern Railroad. The pospect is across Little Tennessee River from the railroad, which is not here bridged, on the farm of A. H. Webb. On the west slope of a hill just south of the farm house a large amount of float ore is present, chiefly in small fragments which were fairly abundant in gullies that trench the surface. The ore is a good grade of psilomelane of high specific gravity. Seams of black manganiferous clay ranging up to 4 inches in width are also exposed in the gullies. The ore seems to follow along a small ridge trending northeast. On the adjacent farm of M. A. Webb fragments of psilomelane cementing and replacing chert occur with iron ore, which was once mined. The surface is strewn with well-rounded stream-worn quartzite cobbles ranging up to 6 inches in diameter. The geologic relations are not known, but the region is underlain by Knox dolomite, and the manganese ore is probably derived from the weathering of cherty dolomite.

LOUISVILLE DISTRICT.

The Louisville district includes the lowland around Louisville, southwest of Knoxville. Manganese ore is reported from the hills with deep red soil in this region, but only one deposit has been worked or prospected extensively.

Louisville Mine.—The Louisville mine is in the northwestern part of the county 3½ miles southwest of Louisville and less than a mile by road from the Louisville and Nashville Railroad. It is on the J. B. Cox farm and is leased by the Unaka Minerals Co. of Knoxville, of which M. M. Whittle is secretary and E. F. Buffat manager of the mine. It is a new mine, having begun mining in June, 1918. No shipments have yet been reported, but 25 tons of manganese ore had been mined and concentrated in the log washer in operation at the time of visit.

The mine is in the open lowland country of the Tennessee Valley on the gently sloping north side of a low, flat-topped ridge 1,050 to 1,100 feet in elevation. This bench is part of an old valley floor preserved on the tops of the hills in the vicinity. The deposit occurs

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[1]The Towensend prospect is described chiefly from notes by Arthur C. McFarlan.

in residual clay of the Chickamauga limestone or Holston marble. Nodular gray limestone of Chickamauga type outcrops both on top of the hill and below the mine with gentle southwest dip. The ore-bearing clay, however, is of the kind derived from marble of the Holston type. The deposit is therefore of the Holston marble type associated with sandy, manganese-bearing beds in the marble similar to those in the red Tellico sandstone above.

The ore-bearing clay is dark chocolate-colored soil and mottled red and yellow clay, about 10 feet thick. It rests on a thin bed of yellow barren clay from one to several feet thick which overlies the bed-rock of nodular gray limestone or impure marble. It is overlain by a thin overburden of reddish earthy soil generally a foot thick which is stripped with plow and scraper before mining. Banding in the clay dips 20° NW, about parallel with the surface slope, in part due to creep. Some of the marking is irregular and fragmentary, suggesting brecciation. It may possibly be a solution cavity filling, similar to that at the Vida iron mine near Sweetwater.

The ore is mostly psilomelane and occurs in rough-surfaced nodules, lumps, and grains in dark-clay streaks more or less parallel with the inclined structure. The lumps range up to nearly a foot in diameter. Some of the ore is hard and botryoidal and some is porous with cavities lined with soft black sooty pyrolusite. Ore from the top of the slope above the pit is full of sand grains and is so siliceous that it is not used. Much of the good ore is of the "bird shot" or "fish egg" type consisting of innumerable small, round, shiny, black pellets imbedded in red clay and probably derived from pebble structure in the marble. These small pellets give a dark-brown powder when crushed and are probably ferruginous. Three-fifths of the ore consists of grains and nodules less than one-half inch in diameter, and a jig is needed to save the small particles which pass through a 24-mesh sieve. A small washer for screenings, devised by the management as an adjunct to the main washer, is saving most of it.

The ground is worked by a hydraulic sluice and flume system composed of 5 converging ground sluices. All the dirt beneath the overburden is passed through the washer. As the wash dirt is mined, it is shoveled, or washed by a powerful stream of water from a nozzle, into a ground-sluice and is flumed down the slope to portable flumes which converge into a large hopper at the head of the washer. This requires more water for steady operation than 120 gallons a minute, the amount now available. The area stripped and now being mined is semicircular with a radius of 70 feet, the deepest part of which, in the middle sluice, is 6 feet deep. The wash dirt passed through the washer is reported to concentrate 8 into 1, 8 tons of mine dirt yielding a ton of washed ore which averages more than 40% manganese.

About a quarter mile south of the mine but on the same property the surface of a hill 1,160 feet in elevation, is covered with good float brown-iron ore which is seamed with red, translucent, radiate, fibrous göthite in layers up to one-half inch thick. On the northwest upper slope of the hill some manganese occurs with the iron ore and seems to be worthy of inexpensive prospecting. A few well-rounded river cobbles are scattered over the surface of this hill and of the lower ridge at the mine. Other hills of this elevation toward the northeast, also covered with deep-red soil, are apparently just as favorable ground for the occurrence of manganese ore, for the geologic and surface conditions are similar to those at the Louisville mine, and should be prospected.

Manganese ore was reported from the Red Hills southeast of the railroad, 2 miles east of the Louisville mine, but as no recent development had been done the deposit was not visited. It is probably at the contact of the Holston marble and the overlying Tellico sandstone, the horizon at which high-grade ore is present farther southwest.

CHILHOWEE MOUNTAIN DISTRICT.[1]

The Chilhowee Mountain district includes that part of Chilhowee Mountain and vicinity in the southern part of the county near Tennessee River where several prospects of manganese ore have been reported.

Prospects Near Chilhowee.—The Sellers prospect is located on the lower southeast slope of Chilhowee Mountain in the southern part of the county 1½ miles northwest of Chilhowee station on the Tennessee and Carolina Southern Railroad. It is on the farm of William Sellers and the mineral rights are owned by J. M. Green and C. A. Benscoater of Knoxville. The two old openings on the place have caved, so that relations could not be observed. Several small pieces

[1]The descriptions of the prospects in the Chilhowee and Greenback districts are largely from notes by Arthur C. McFarlan.

of pyrolusite and manganiferous limonite were found on the old dump, in one of which the manganese minerals occur as cement in a fine quartz conglomerate.

The region is underlain by brownish-gray quartzite and conglomerates, presumably the Hesse quartzite, in which the openings are made. Overlying the sandstone are blue limestone and slate, probably older Hiwassee slate which has been overthrust on it from the southeast.

A small amount of float manganese ore was reported on the Sam McMurray farm, one mile west of Chilhowee, but no openings were made on the property. Henry E. Colton, of Knoxville, is reported to have had an option on a tract about a mile from the McMurray farm, where high grade ore had been found some years ago. Ore is also reported six miles northeast of Chilhowee, on Rufus Miller's place, southeast of Montvale Springs, on the southeast side of Chilhowee Mountain. It was not visited. The relations are probably the same as at the Sellers farm.

GREENBACK DISTRICT.

The Greenback district includes the open-valley country in the western part of the county chiefly northeast of Greenback, where manganese deposits are reported.

Prospects Northeast of Greenback.—A number of prospects, several of which are here described, occur northeast of Greenback, which is on the Louisville & Nashville Railroad. They lie in the clay and chert of the Knox dolomite at or near its contact with the underlying Nolichucky shale. The structure is monoclinal and overturned, for the dolomite dips 50° SE. The ore is a replacement of chert in the dolomite and occurs largely as nodules and fragments mixed with chert in the residual clay and soil.

The Williams prospects are three miles northeast of Greenback. They are on adjoining farms belonging to T. S. and Mrs. A. J. Williams, the mineral rights on which have been recently leased for the development of the deposits. Numerous pieces of good manganese float ore are found in the road and a number of shallow test pits and trenches have been dug on both properties. The ore is psilomelane, small nodules of which lie loose in red residual clay. Some of the nodules are concentrically banded with botryoidal surfaces, and some have an outer shell of brown-iron ore. Iron ore is also abundant, and the 5 tons of ore on the dump consist chiefly of cherty limonite.

The Curtis prospect is 2½ miles northeast of Greenback, on the farm of T. G. Curtis. A small amount of manganese float ore is scattered over the farm, and southwest of the barn the ore is more plentiful and of higher grade. It is a replacement of chert in the Knox dolomite, the replacement in most cases being complete. Some brown-iron ore is also present with the manganese ore.

The Aiken prospect is 2¼ miles northeast of Greenback, on the farm of John R. Aiken, which adjoins the Curtis property on the southwest. Manganese float ore is abundant near the crest of the hill just back of the house, but no openings have been made.

Manganese ore is also reported on the nearby farm of David Crisp, and also on the J. E. Klepper farm, the mineral rights of which have been recently leased for development; also on the farm of James H. Eakers, of Greenback.

LOUDON COUNTY.

Loudon County adjoins Blount County on the west. The town of Loudon, near the center of the county, on the Tennessee River, is the county seat. The surface is a broad open valley crossed by low hills, which trend northeast.

Manganese deposits are reported at two localities, the Cates prospect in the Loudon district and the Galbraith mine in the Fork Creek Knobs district, the latter district lying largely in the adjoining Monroe County.

LOUDON DISTRICT.

The area around Loudon is included in this district, particularly the Red Hills, covered with deep-red soil, south of the town where iron and manganese deposits are reported. This belt is a direct continuation of the ore belt northeast of Sweetwater, where some of the highest-grade ore is being mined.

Cates Prospect.—The Cates prospect is 1½ miles south of Loudon. It is on the farm of J. K. Cates, of Loudon, and is leased by the Lafollette Iron Company, of Lafollette, Tenn. It is on the crest of a low spur or bench on the northwest slope of a higher hill which trends northeast. The higher hill is composed of chert from the Knox dolomite, which is apparently overthrust on the Holston marble, the ore lying on the Holston near the fault.

The deposit consists chiefly of siliceous brown-iron ore, with no pure manganese ore, some of the iron ore probably carrying some manganese. The siliceous ore covers the surface of the low hill and has been gathered into piles. A trench about 15 feet long and 9 feet deep exposes deep-red sandy clay soil with similar ore. The pit does not reach the bottom of the ore-bearing clay and ore higher in manganese may be struck at greater depth. Probably 50 tons of this ore have been gathered, but none had been shipped. The deposit lies in the red clay derived from Holston marble, which carries rich manganese and high-grade iron ores in places to the southwest, where it is associated with the overlying red Tellico sandstone. The Tellico is not present at the Cates prospect, but comes in just to the northeast and may there carry better ore. The Cates ore may be related to the fault plane and its deposition has been accomplished by mineralized waters circulating along the fault. The deposit appears to be too siliceous to be of value.

FORK CREEK KNOBS DISTRICT.

This district embraces the Fork Creek and adjacent Bat Creek Knobs, which lie chiefly in Monroe County but extend across the southeast corner of Loudon County. Manganese and iron ores are reported from many places on these hills, and the geologic formations are similar to those in the Sweetwater district to the west, where high grade deposits occur. Only the Galbraith mine will be here described.

Galbraith Mine.—The Galbraith mine, also called the Henley mine, is located 8 miles southeast of Loudon and about the same distance from Lenoir, both on the Southern Railway, and 1 mile southeast of Jackson Ferry on the Little Tennessee River, from which point the ore is conveyed by boat down stream to Lenoir. The property is owned by P. C. Henley, of Loudon, and the mineral rights by H. N. Curd, of Lenoir. The deposit was first opened in 1901, and more recently has been leased and operated by Charles Galbraith and Judge Webb, of Knoxville. The operation of the mine was taken over under lease in the summer of 1918 by the Southern Manganese Corporation, of Birmingham. At the time of visit (May, 1918) about 100 tons of manganese ore had been mined and washed, one carload of which had been shipped, part of it to New York for chemical uses, and another carload was being transported to the railroad.

The mine is located on a small knoll 920 feet in altitude on the northwest slope of a prominent ridge, the northeast continuation of the Fork Creek Knobs. The deposit occurs in the Holston marble, which dips 30° SE into the knoll, the latter having a synclinal structure, and was probably formerly capped by Tellico sandstone. The ore is embedded in residual red clay of the Holston marble covered by a few feet of wash, which contains rounded river cobbles and pebbles.

The principal opening at present is a cut into the northwest slope of the knoll 100 feet long by 30 feet wide and 12 feet deep at the face. The ore begins in the superficial wash close to the surface and extends down into the residual deep-red clay. The deeper part of the pit had been filled in, but the ore was said to continue to a depth of 30 feet. Test pits at the side of the cut are not deep enough to determine the lateral extent of the deposit, but some good ore was found. Considerable iron ore covers the surface north of the mine and was formerly mined for iron.

The ore consists chiefly of small lumps of psilomelane with a little soft pyrolusite and some manganiferous iron. The ore is washed in a double-log washer and screened at the mine. The washed ore ranges in size from fine screenings up to lumps 4 inches in diameter, but most of it is less than 2 inches in diameter, and much of it is screenings. It is very clean, and is estimated to average 45% manganese. It is shipped in bags and barrels.

The mine is equipped with a small cable tram about 200 feet long between the mine and the washer. A simple jig was formerly used, but was discarded as unsatisfactory. A flume and pump were being installed to supply a larger amount of water. The ore is of high grade, and although the exposures in the pits showed little ore at the time of visit, other good pockets may likely be found, but a large production cannot be expected as the area of ore ground is small.

Monroe County.

Monroe County, one of the southeastern border counties of the State, adjoining Blount County on the west and Loudon County on the south. Although its southern boundary and the State line follows the crest of the Unaka Mountains, whose foothills occupy the southeastern part of the county, the large northwestern part of the county is valley, crossed by many parallel lines of low hills trending northeast.

Madisonville is the county seat. Manganese deposits occur at several localities, which are grouped into 3 districts.

FORK CREEK KNOBS DISTRICT.—(CONTINUED.)

Mills Prospect.—The Mills prospect is 8 miles northeast of Sweetwater and 2 miles south-southwest of Eve Mills in the northern part of the county. It is on the property of J. C. Mills, of Sweetwater, and is being developed under lease by the Southern Manganese Corporation of Birmingham, Ala. The deposit is on the upper northwest slope of a prominent ridge, part of a belt of red hills called the Fork Creek Knobs. It is at the unconformable contact of the Tellico sandstone on the Holston marble, the structure being monoclinal, the rocks dipping about 30° SE into the ridge. The Holston marble on the steep western slope is overlain by red sandstone of the Tellico. The crest of the ridge is composed of gray sandy marble in the Tellico.

At the time of visit no openings had been made, but there were ample indications of high-grade, red-hematite iron ore on the western slope just below the base of the Tellico sandstone, and with it a little manganese float. A large mass, 1½ feet across, of high-grade psilomelane ore was found on the east crest of the ridge, associated with the marble interbedded in the Tellico sandstone. The small amount of manganese-ore float on the western slope was not encouraging, but the high character of the ore and the generally favorable conditions for ore accumulation warrant prospecting to determine the quantity of the ore. It has been recently reported that such prospecting has been done by the Southern Manganese Corporation since the writers' visit, and only 3 tons of ore analyzing 41% manganese were taken out during the exploration, so that the property was abandoned.

Kimbrough Prospect.—The Kimbrough prospect is reported to be 4 miles northeast of Madisonville, and about 1 mile southeast of Fagan station, on the Louisville and Nashville Railroad. Although it is strictly not in the Fork Creek Knobs district, it will be here described for convenience, as there are no other prospects to be described with it under the Madisonville District, where it belongs.

Iron ore was mined here years ago, and it has recently been prospected for manganese, high-grade ore having been reported. The mine was not visited by the writers. It is apparently in chert and clay residual from Knox dolomite close to its contact with the underlying Nolichucky shale. The Southern Manganese Corporation recently leased the property with the intention of developing it as an iron mine. It is reported to have found very little manganese ore and, although the quantity of iron ore seemed large, it has abandoned its lease.

TELLICO PLAINS DISTRICT.

The Tellico Plains district, in the southwestern part of the county, embraces the flat valley from Tellico Plains to the Red Knobs on the west and to Starrs Mountain on the southwest. The Ervin prospect just within the Red Knobs region will be included under this district for convenience in description.

Ervin Prospect.—The Ervin prospect is in the southwestern part of the county, 4½ miles northwest of Tellico Plains and 1½ miles south of Mt. Vernon on the Tellico Branch of the Louisville & Nashville Railroad. It is on the farm of Carrol Ervin, of Tellico Plains, and is being prospected by the Southern Manganese Corporation of Birmingham, Ala.

It is on a low terrace on the northwest slope of a prominent ridge of the Red Knobs close to Shoal Creek. It is in the Tellico sandstone, near its contact with a gray fossiliferous marble, probably Holston. The structure is a small syncline on the side of a larger syncline, probably faulted within.

The principal opening is a transverse cut running 75 feet northwestward across the rock structure, and having a depth of 10 feet. Two smaller cuts are lower on the slope. The ore is chiefly thin shells of siliceous iron with some psilomelane and a little manganite. The iron is largely in a solid ledge or crust, but the manganese ore is a wash ore in clay. The surface of the terrace to the northeast is literally covered with the siliceous iron ore crusts which seem to be a partial replacement of sandstone beds.

The hill is capped with sandstone fragments and iron crusts. Thin, buff to green shale which crops below, dips 30° SE on the northwest side of the syncline and strikes N 60° E and dips 75° NW on the southeast side. Beneath the shale on the northwest side is fossiliferous blue to gray, crystalline limestone or marble, probably Holston, dipping 30° SE. The limestone was not observed on the southeast side and may be cut off by a fault, which would account for the large quantity of siliceous iron ore on that side of the hill top. The syncline plunges northeast.

The iron ore is too siliceous to be a workable deposit, and the amount of manganese ore showing is too small to be of commercial value.

A similar deposit of brown-iron ore and a little manganese is reported on W. J. Cardin's property southwest of the Irvin property. It is on a small hill adjacent to the Red Knobs and lies in the shale overlying marble. An old cut mined for iron is on the property, but the showing of manganese ore is very small.

Groundhog Mountain Prospect.—The Groundhog Mountain prospect is 3 miles southwest of Tellico Plains on the northwest slope of Groundhog Mountain. It is on the farm of J. H. Curd, of Tellico Plains, and was opened some time ago for manganese.

Groundhog Mountain is composed of scolithus-bearing white quartzite, believed to be Hesse quartzite, with coarse dark-gray glistering dolomite, believed to be Shady, which is brecciated and largely changed to chert on the northwest upper slope. On the lower slope are shales which dip southeast into the mountain and overlie Chickamauga limestone at the road and are therefore probably Athens. The Hesse quartzite and Shady dolomite are apparently overthrust on the Athens shale, and the dolomite is both silicified and mineralized. The lowland is strewn with fragments derived from the mountain, consisting of scolithus-bearing white and red sandstone and pitted chert with drusy cavities.

The principal opening is an old cut 25 feet long and 15 feet deep at the face, midway on the northwest slope, 1,130 feet in elevation. The ore is in part embedded in dull-yellowish clay and in part replaces a dolomite and chert ledge. The ore is mostly nodular psilomelane, with a little manganite and soft crytalline pyrolusite. Some of it shows crude concentric platy replacement, and is siliceous. Smaller old pits are on the slope above and below the main opening. Those below, however, seem to have only float ore and show only a few small pieces of manganese-bearing chert similar to that at the main opening. Along the crest of the ridge on the quartzite, iron ore was extensively mined during the Civil War.

The manganese ore appears to be of good grade, but the quantity seems to be small. More prospecting along the line of outcrop of the replacement zone is desirable.

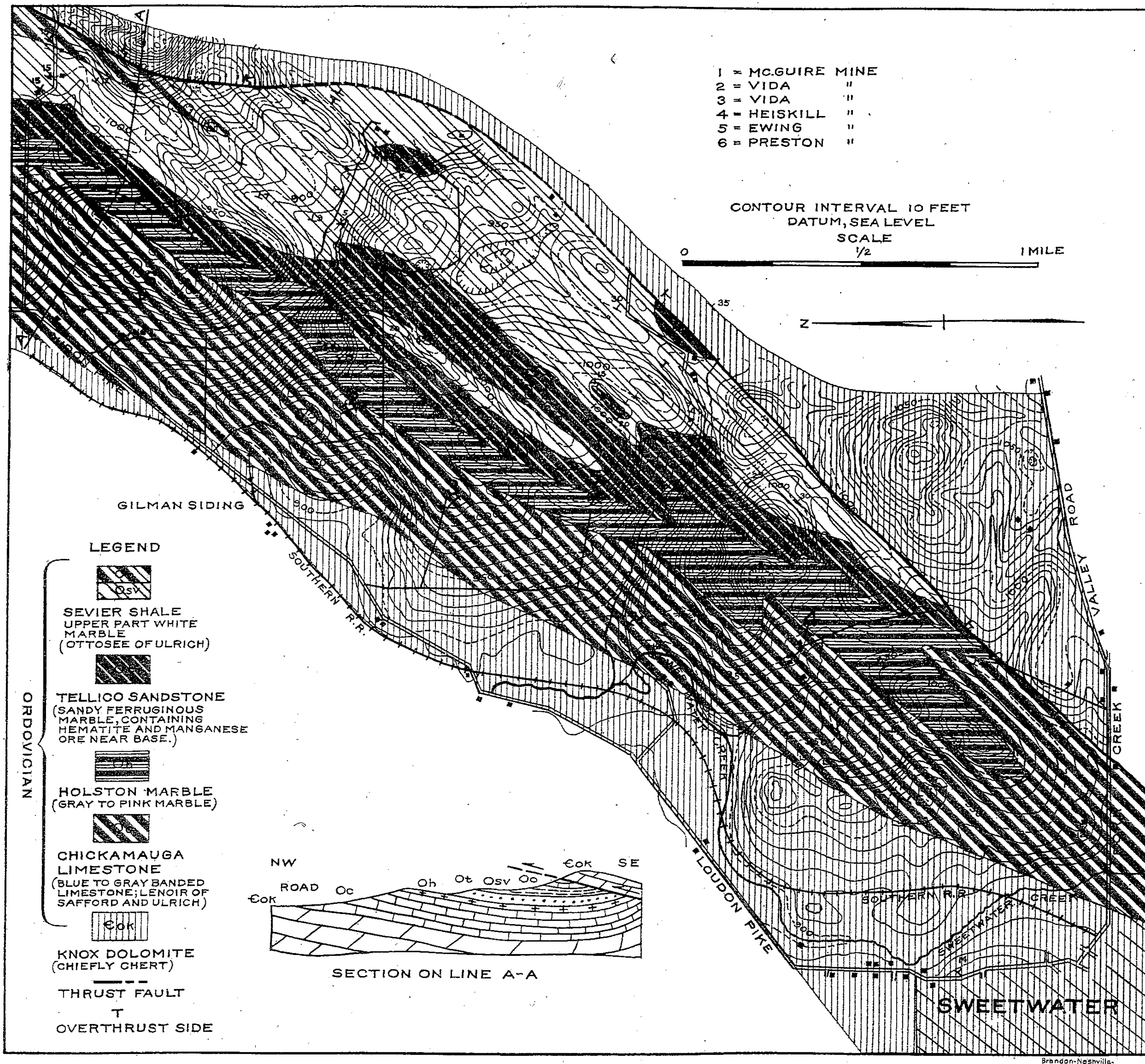

FIGURE 12. GEOLOGIC MAP OF THE RED HILLS AREA NORTHEAST OF SWEETWATER, TENN., SHOWING LOCATION OF MANGANESE MINES AND PROSPECTS.
By Arthur C. McFarlan, partly revised by G. W. Stose. 1918

Other Prospects Southwest of Groundhog Mountain.[1]—The Beaty prospect is southeast of Jalapa, about 3½ miles southwest of Tellico Plains and just southwest of Groundhog Mountain. It is on the land of N. H. Beaty. On a small knoll underlain by variegated shale, believed to be the Watauga, manganese ore occurs in considerable quantities as float ore in the soil. The ore is hard and of high specific gravity, and is probably good grade psilomelane. It apparently replaces the shale. It is said that large pieces of manganese ore were obtained from a pit on the property.

Other manganese and iron ore prospects are reported along the belt of low hills southwest of Groundhog Mountain, especially one on the Kilby farm, 4 miles southwest, where the manganese indications are said to be favorable.

SWEETWATER DISTRICT.

The Sweetwater District includes the ore-bearing belt of Red Hills from Sweetwater to Philadelphia, east of the Southern Railroad, and the lowland on either side. One deposit in the district, Hansard prospect, lies in the adjoining McMinn County, and will be described there. Figure 12 is a geologic map of the Red Hills mineral belt.

McGuire Mine.—The McGuire mine is on J. Frank McGuire's farm, 3½ miles northeast of Sweetwater and 3 miles south of Philadelphia, both towns being on the Southern Railway. The mine is only 1 mile from Gilman switch on the railroad. Ore was first mined here in the early nineties. The present mine is being operated by the Southern Manganese Corporation of Birmingham, Ala. It is in the same belt of mineralization as the Heiskell mine near Sweetwater and is similarly situated on the lower northwestern slope of the low Red Hills, at the frontal edge of a westward facing terrace 950 feet in altitude and about 100 feet above the valley bottom.

At the time of visit the main development, which consisted in part of reopened old workings, extended to the depth of 35 feet and had yielded 3 tons of high-grade ore which lay on the dump. A carload of this ore shipped since the writers' visit is reported to have run 41.13% manganese. The ore consists of psilomelane chiefly in slabby fragments and is mined in masses about 2½ feet in length by 5 or 6 inches thick. The deposit is at the unconformable contact of Tellico sandstone on the underlying Holston marble. The ore occurs chiefly

[1]Description is largely from notes by Arthur C. McFarlan.

in depressions and solution channels in the surface of the marble. filled with weathered products of the overlying formation. The structure of the rocks is monoclinal, the dip being approximately 25° SE.

The largest opening is a 40-foot cut made in the front of the terrace, at the south end of the property. It followed an old tunnel which ran southeastward in the clay filling a depression between rock pinnacles. The open cut has a depth of 20 feet at its face. Its northwest, or foot-wall, side consists of granular, grayish Holston marble capped by sandy-banded marble of the Tellico. On the southeast, or hanging-wall, side 10 feet of yellowish-red clay grades downward into 10 feet of reddish-black clay, both of which are somewhat ore bearing. The marble is banded, medium to coarse grained, and fossiliferous, containing abundant remains of crinoid stems, bryozoa, and a few brachiopod shells. Small lenses of ore occur in the sandy marble of the Tellico, and tabular pieces 6 inches thick, and rounded boulder-like masses ranging up to 2½ feet in diameter, are scattered in the residual clay which fills fissures and fractures enlarged to solution channels in the marble. The ore is mostly hard massive bluish psilomelane containing a cleavable crystalline mineral believed to be braunite, similar to that at the Heiskell mine, the identity of this mineral, however, not being certainly established.

A shaft on the terrace about 30 feet east of the face of the cut was sunk in residual clay and is reported to have struck a 3-foot bed of manganese ore at a depth of 23½ feet, and another shaft about 50 feet farther east passed through a bed of ore 7 inches in thickness at a depth of 33 feet. The ore in the shafts is similar in composition to that in the open cut but is softer, and is believed to be the same body of ore dipping southeast with the bedding.

As seen on a visit in October, 1918, a tunnel is driven into the face of the open cut and the mine is opened by a main inclined tunnel 165 feet long with lateral drifts to both sides 60 to 100 feet long, connected by other inclined longitudinal drifts. The workings follow a bed of ore more or less continuous near the bottom of the decomposed rock, which is the sandy ferruginous Tellico. The floor, where unweathered, is apparently Holston marble, but the ore in places lies within the decomposed sandy rock. It appears that the Tellico is in general decomposed to a soft mass of dirty brown sand to a depth of about 40 feet over this part of the terrace surface, the bedding being preserved in most places in the decomposed rock, undisturbed and parallel to the bedding in the bedrock. In places the decomposition is much deeper than elsewhere and the bedding in the disintegrated material is much disturbed, the material being cut by many steep slickened planes, indicating that it has moved or settled down, probably into a solution channel in the underlying marble. The ore which is believed to have been originally disseminated in these sandy beds was dissolved by the descending water which decomposed the rock and was concentrated in the lowest porous beds through which it could flow. Where a boss of undecomposed rock stands as a pinnacle the ore is thin or absent. Where a cave-in occurred and the decomposed material fills a solution pocket or channel, the ore is apparently thicker and more continuous. The ore bed varies from 6 to 18 inches in thickness and from solid shiny psilomelane to sooty black ore. The dirt removed in the workings is said to run 5% manganese and 33% iron, the rest being largely quartz. The mine is reported to be shipping 40 tons of ore a month, averaging 44% manganese.

At the north end of the property many deep circular shafts or "wells" have been sunk. Most of these are on the flat top of the hill, 950 feet in altitude, and are sunk in soft residual sandy red clay between high steep-walled pinnacles of marble. These pinnacles are subsurface erosion forms and many of their walls are vertical and even overhanging, one well following such a vertical solution wall 30 feet in depth. The rocks dip 22° SE. The sandy beds of the Tellico, which disintegrate into the red sandy clay in which the ore occurs, out-crop at the west crest of the hill. Some yellow shale present in the pits is believed to have been let down in these solution pockets and not to be interbedded in the marble in place. The ore is reported to lie on the marble below the shale. Although the ore is of fairly high grade, much of it is deeply pitted and breaks into small fragments or crumbles to a soft powder, so that mining will be expensive if not impracticable. Several tons of such ore were on the ground at the time of visit, but mining had ceased. Other pits on the lower western slope of the hill, 920 feet in altitude, are in similar soil-filled depressions in the marble, and although excellent psilomelane ore was taken out, the quantity is relatively small.

Preston Prospect.[1]—The Preston prospect is 3½ miles northeast of Sweetwater, near the Loudon pike. It is on the west slope of a low ridge just west of the McGuire mine, on the farm of J. N. Preston, of

[1]Description chiefly from notes by Arthur C. McFarlan.

Sweetwater, and is being prospected under option by Joe Corn. The low rounded ridge is composed of Chickamauga limestone, which dips 12° SE, the structure being monoclinal. The showings consist in part of float ore in the form of nodular pieces of psilomelane scattered in considerable quantities along the crest and western slope of the ridge for more than half a mile. With the manganese ore is also a large amount of good hematite float. About 1½ tons of iron and manganese have been gathered in piles, and several tons of high-grade ore were sold to the Southern Manganese Corporation.

Some of the psilomelane replaces chert, and the occurrence of a few pieces of leached Tellico sandstone in the soil suggests that the ore may have been derived from the rocks on the ridge to the east where the McGuire mine is located, having been worn away and transported by hillside wash before the small intervening valley was eroded.

Vida Mine.—The Vida mine is 3 miles northeast of Sweetwater. about a half mile southeast of Gilman siding on the Southern Railroad. It is owned by C. D. Smith, of Memphis, Tenn. It was mined for iron several years ago by W. D. Gilman and is described by E. F. Burchard in Bulletin No. 16 of the Tennessee Geological Survey on the Red iron ores of East Tennessee. The ore was taken from two large pits, a half mile apart, 20 to 30 feet deep, in soft dirty, red, dry, sandy clay. The ore was largely soft, but many fragments of harder ore are still scattered over the ground. These are largely blocky to platy fragments of dark iron ore, somewhat earthy and apparently containing considerable manganese. Lumps of good bright psilomelane having rounded shiny surfaces are also rather plentiful. Although the pits are underlain by Chickamauga (Lenoir) limestone or Holston marble, the ore lies in yellow shale or clay and earthy red sandy clay with steep bedding, believed to be the decomposed overlying Tellico let down in a solution cavern in the marble. East of the pits highly ferruginous sandy marble of the Tellico outcrops, which is believed to be the rock which was the source of the ore. Thin leaves of bright hematite lie along joints and bedding planes in the marble. Much of the surrounding territory appears to be equally favorable for manganese ore and there may be a sufficient quantity to be worked, for this ore carries 43 to 46% manganese. No effort has been made recently to mine the property.

Ewing Mine.—The Ewing mine is ½ mile south of the Vida mine and about ½ mile from Gilman siding on the Southern Railroad. The property is owned by Robert Ewing, and was worked for soft iron up to June, 1918, by J. J. Fitzgerald and H. L. Smith, of Sweetwater. The mine is on the Holston marble near the contact with the Tellico sandstone. Considerable manganese ore is also present, and the mine may be workable for manganese. It was closed down and was not visited by the writers.

Heiskell Mine.—The Heiskell mine is in the northwestern part of the county, 1 mile northeast of Sweetwater. The land is owned by Harry Heiskell, of Sweetwater, and the mine was being operated by H. L. Smith, also of Sweetwater, on an option to buy the mineral rights. It is on a hillside which slopes gently northwestward to Sweetwater Creek. The soil of the hill, which is about 950 feet in altitude, is deep red, and the hills are therefore called the Red Hills. The ore is all lump ore and is shipped without washing. The inclosing clay is dry and pulverulent and is removed in handling. Therefore no plant is required, and the cost of mining is very low. The mine is credited with a production of more than a hundred tons of high-grade manganese ore. At the time of visit (April 25) a carload of ore had recently been shipped, and about 40 tons lay on the dump. The ore is said to run 58% manganese.

The ore is unusually pure, solid, compact psilomelane and occurs chiefly in thick blocky pieces, some a foot or more across, embedded in residual red sandy clay. The blocks have irregular or pitted surfaces. The mineral breaks with a conchoidal fracture and a freshly broken or polished surface presents a poikilitic or mottled effect due to cleavage faces of included crystals of manganite and braunite. The latter mineral is not certainly identified, but some of its characteristics have been observed. Associated with the manganese ore are fragments of very pure red hematite. The deposit has been opened by 4 pits covering a length of about a thousand feet. Two of the openings are on the hillside, and two on the lowland at the foot of the hill.

The northern opening, which is on the upper part of the hillside, shows the original relation of the ore. The deposit is at the contact of the Holston marble and the unconformably overlying Tellico sandstone. The ore lies in dark-reddish sandy clay which fills deep solution hollows in the upper surface of the marble. This deep weathering occurred when the flat top of the hill, now 950 feet in altitude, was part of the floor of the valley. The rocks dip 22° SE, and coarse red sandy granular marble beds of the Tellico sandstone cap the Holston marble at the top of the hill. Iron and manganese oxides were deposited in the pores and small crevices of this capping rock, which is called the hanging wall of the deposit, as the lime was dissolved out, and it probably now carries an average of 3 to 5% of manganese and a larger amount of iron. The red sandy clay, in which the pit is dug, is the residuum of similar beds of Tellico sandstone which formerly overlay the Holston marble.

The manganese and iron oxide ores were concentrated into beds and lenses of ore in favorable places in the Tellico sandstone by solution and redeposition in the process of weathering, and have been broken up and left as residual masses in the residual sandy clay. Some of the ore preserves molds of the fossils in the original rock, showing gradual replacement. From a small excavation, at no point more than 6 feet in depth, 33 tons of large hand-picked blocky psilomelane ore, probably averaging 58% in manganese, had been mined. At the time of visit this ore was still on the ground, and its immediate shipment was urged by the writers. One carload shipped from this upper hole was reported to have run only 52% manganese and carried from 2 to 3% iron, but this was not a representative analysis.

At the south end of the property on top of another low hill close to the road iron ore was formerly mined in a pit similarly located at the Tellico-Holston contact. No ore has been taken out recently, although good hematite and some manganese ore still show in the pit.

The pit that was being actively worked at the time of visit lay at the south foot of the hill on which the north opening occurs. The pit was 18 feet deep in dull dark-reddish sandy clay, largely residuum of Tellico sandstone which had moved down the slope by creep and hillside wash and accumulated at its foot. Fragments of porous fossiliferous sandstone from the Tellico, and of ore derived from the deposit above, were sporadically distributed in the clay, the fragments of ore being much smaller than those in the upper pit and more widely scattered. They extended, however, to the bottom of the pit. The mining methods at present employed are wasteful and considerable ore is believed to have been left in the ground and covered with waste from the mine.

The northeastern opening is also in the lowland at the foot of the hill. This pit is 10 feet deep in sandy, red clay wash from the hillside. The ore is chiefly hematite, but some good psilomelane has been taken out. About 8 tons of fair grade manganese ore lay on the dump.

Manganese ore is reported on the Red Hills northeast of the Heiskell mine, but no prospects were opened so far as known. All the land between the Heiskell and McGuire mines has favorable geologic and surface conditions for the occurrence of high-grade manganese and iron ores and should be thoroughly prospected. These geologic conditions do not continue southwest of the Heiskell mine, so search in that direction will be fruitless.

Dickey Prospect.—The Dickey prospect is 1½ miles north-northwest of Sweetwater on the farm of A. J. Dickey. It is on the top of Black Oak Ridge, a chert ridge in the Knox dolomite. About 20 years ago George Loring and James Schell, of Sweetwater, opened up the deposit and, according to reports, shipped 2 carloads of good manganese ore. The property has since been idle.

McDonald Prospect.—The McDonald prospect is 4 miles southeast of Sweetwater and about that distance from the Southern Railway. It is on the McDonald farm in the lowland near the head of Fork Creek. Prospecting was being done by the Southern Manganese Corporation of Birmingham, Ala., which had acquired a lease of the mineral rights.

The prospect is located on the northwest side of a low hill about 50 feet above Fork Creek. It is in residual clay and chert of the Knox dolomite, the ore replacing the chert. The overburden consists of about 4 to 5 feet of red clay and chert fragments.

The opening is a pit 10 feet across and 15 feet deep, which exposes about 5 feet of red surficial clay overlying yellowish residual clay in which is a little ore, especially at its top where 1½ feet of darker clay contains some ore in blackish blotches, streaks, and disseminations. The ore is psilomelane, inclosing small angular fragments of chert which give it the appearance of a breccia. About 400 pounds of ore were on the dump. It was said to average 43% manganese, but this has reference to the ore free from silica and not as it runs, which will be much lower. The small amount of ore from the pit and the little float on the surface were regarded unfavorable.

McMinn County.

McMinn County, of which Athens is the county seat, lies directly west of Monroe County. It is largely a lowland or valley crossed by many low straight ridges which trend northeastward. Manganese deposits are reported at four localities, the Hansard prospect in the Sweetwater district, the Patton and associated prospects in the McMinn Ridge district, the Gilbert prospect in the Athens district, and the Bishop and associated prospects in the Charleston district. The Underwood mine, also in the Charleston district, is in Bradley County.

SWEETWATER DISTRICT—(CONTINUED.)

Hansard Prospect.—The Hansard prospect is near the eastern border of the county, 3 miles west of Sweetwater and therefore in the Sweetwater district. It is on the farm of J. B. Hansard, of Sweetwater, the mineral rights of which are leased by the Southern Manganese Corporation of Birmingham, Ala.

The prospect occurs on the northwest edge of a chert ridge overlooking the valley of Pond Creek near its head. The ore replaces chert of the Knox dolomite and is found in scattered masses on the surface and in the soil. The ore mineral is good psilomelane, said to run 51% manganese, cementing brecciated chert and in part replacing it. A few masses of such ore 1 foot across containing much chert were found along the road. A small amount of ore embedded in yellow clay was recently dug from a well near the barn. On the northwestern slope of the ridge it had been prospected by several shallow pits which at the time of visit showed mostly iron ore. It was reported that from these pits and the surrounding fields about 600 pounds of ore averaging 52% manganese were recently shipped, but it is probable that the general run of ore will not average more than 40% manganese on account of the silica content. There appears, furthermore, to be very little ore present.

MC MINN RIDGE DISTRICT.

The McMinn Ridge district embraces the chert hills in the western part of the county, where manganese deposits have been reported.

Patton Prospect.[1]—The Patton prospect is 8 miles west of Riceville on the Southern Railroad, close to the western boundary of the county. It is on the farm of G. I. Pierce, of Riceville, 2 miles from the wagon road to Vigor and has been prospected by W. M. Patton, of Cleveland, who has an option on the mineral rights. The deposit is in the Knox dolomite, which is weathered to a very cherty soil.

It is opened by a pit 6 feet deep, which shows considerable psilomelane replacing chert. There is also a large amount of brown-iron ore present which makes up more than half the ore. The manganese ore is said to run 52% manganese, but the amount of chert present, which cannot be removed without an expensive plant, will make the ore analyze much lower.

Several new prospect pits recently sunk along the trend of the ridge from the old pit are reported to show a better grade of ore, and indicate that the ore follows a certain horizon in the rocks. But, like most deposits in the chert of the Knox dolomite, this prospect is not of much promise.

Manganese ore replacing chert is also found on the Henry Reed farm southwest of the Pierce property on the same chert ridge. Conditions are probably the same as at the Patton prospect.

ATHENS DISTRICT.

The Athens district embraces the portion of the Red Hills around Athens. They lie south, southeast, and northeast of the town. A few prospects are reported south of town.

Gilbert Prospect.—The Gilbert prospect is a mile southeast of Athens on the farm of I. W. Gilbert, just north of the Etowah pike. It is undeveloped, and consists of showings of ore in residual yellow clay soil of the Tellico sandstone, which here dips about 30° SE.

A small black streak of soft pyrolusite and wad is exposed in a wagon road on the property, and similar material shows at several places in a small creek near by, where it is continuously exposed for nearly 50 feet, apparently being a seam along the bedding. No hard manganese ore was seen, although good red hematite occurs on the ridge top.

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[1]The descriptions of the Patton, Bishop, and Gilbert prospects are largely from notes by Arthur C. McFarlan.

On the J. H. Jones farm, which joins the Gilbert farm on the east, float manganese ore and considerable iron ore occur. Some of the manganese was of good grade pyrolusite. This deposit is in the shale overlying the Tellico sandstone and mapped as Sevier shale on the Cleveland folio of the Geologic Atlas of the U. S. Geological Survey.

The showing at these prospects is very poor, and further prospecting does not seem warranted.

CHARLESTON DISTRICT.

The Charleston district embraces chiefly the area of Red Hills lying east of Charleston and Calhoun. They trend northeast, and begining as a small hill at Climer, east of Tasso, expand northeastward to a belt 2½ miles wide, and continue as such past Athens. Several prospects and a mine occur east of Charleston.

Bishop Prospect.—The Bishop prospect is in the southern part of the county near Hiwassee River, on the farm of J. M. Bishop. It is on one of the Red Hills which in this region make a belt 2½ miles wide. The deposit is apparently in the Holston marble near the contact of the overlying Tellico sandstone. The rocks are about horizontal, but in general dip slightly to the southeast. The Tellico is here a pronounced sandstone, not as calcareous as southwestward near Cleveland where some of the best deposits in this formation are being mined.

The deposit has not been opened by pits, the prospect consisting of nodules and fragments of high-grade psilomelane lying loose in red sandy clay exposed in the road. The nodules are small, but one piece 3 inches in diameter was found. The ore is similar to that being mined in the Red Hills district south of Cleveland, and although the showing is small, the immediate vicinity is well worth further prospecting.

A small amount of manganese and larger quantities of iron ore occur on the adjoining properties in the Red Hills, particularly on the farms of J. B. Liner, J. M. Lawson, and T. M. McKnight. Sandy iron ore and sandy psilomelane which occur generally on all the properties, is a replacement of the binder of the Tellico sandstone by ore. It is generally underlain by alternating yellow shale and sandstone near the base of the Tellico sandstone.

Bradley County.

Bradley County, southwest of McMinn County, from which it is separated by the Hiwassee River, is the southernmost county of the manganese belt. Cleveland, its county seat, is near its center. The country is crossed by many low ridges which trend northeast and give it a hilly appearance. The western boundary follows White Oak Mountain, a somewhat higher ridge standing out in the valley. The county contains a number of successful manganese mines and many prospects, most of which occur in the Holston marble, but two of which are in the Fort Payne chert.

CHARLESTON DISTRICT—(CONTINUED.)

Underwood Mine.—The Underwood mine is 3½ miles south-southeast of Charleston and 1 mile south of the Hiwassee River. It is on the farm of I. M. McAllister, but the deposit is also prospected on the adjoining farms of other members of the McAllister family and on Jack Thompson's farm. It was opened by W. B. Underwood and is now being operated by W. E. Hamilton & Company of Columbus, Ohio, W. B. Underwood manager, leased on a royalty basis. At the time of visit about a ton of rather low-grade manganese ore and several tons of iron ore lay on the dump. Later A. C. McFarlan reported 5 or 6 tons of psilomelane and iron ore on the dump.

The deposit occurs on the slope of a prominent red hill about 1,000 feet in elevation. The top of the hill is capped by Tellico sandstone which is underlain by thin yellow shale and light-gray marble, probably Holston. The structure is a minor synclinal with gentle dips.

The principal opening is a 70-foot cut on the northwest face of the hill 80 feet below the top. It runs northeastward along the hillside and has a width of 12 feet and a depth of 20 feet at the face. The manganese ore is chiefly psilomelane, occurring as loose fragments and chunks which range up to several hundred pounds in weight, and some wad, lying in dark-red clay with dark waddy sand streaks. Good hematite and some brown-iron ore are also present. Blocks of weathered red sandstone are also inclosed and the deposit is evidently an accumulation of wash from the hillside above. The irregular occurrence of the streaks of ore-bearing sandy clay, exposed in the trench and in a deep pit lower down on the slope, harmonize with this view. The amount of ore is small compared with the material removed from the trench.

Higher up the hill, in a saddle between knobs, a circular pit 20 feet deep penetrates nearly barren yellow shale to firm gray marble at the bottom, lying about horizontal. A few thin seams and stringers of ore penetrate the marble. Another pit on the southeast side of the hill is in barren yellow shale. Soft red sandstone overlies the shale at the top of the hill. Float ore is reported along the crest of the hill to the northeast, and recent prospecting there is said to have been more favorable. The indications are sufficiently favorable to warrant further careful prospecting, as the presence of some good ore is established and the horizon is known to be highly ore-bearing in an adjacent belt to the southwest.

CLEVELAND DISTRICT.

The Cleveland district embraces not only the vicinity of Cleveland, but the area of Red Hills 5 to 12 miles south of town to the State boundary, where some of the best deposits of manganese have been found. Figure 13 is a geologic map of the Red Hills mineral belt.

Hambright Mine.—The Hambright mine is 8 miles south of Cleveland and 2 miles east-northeast of Marble Switch, the nearest station on the Southern Railroad. It lies in the Red Hills east of the Cleveland-Dalton pike. It is owned by H. F. Hambright. of Cleveland, and is operated by Fitzgerald & Lanskey, of Chicago. The deposit occurs on the Holston marble at its contact with the overlying Tellico sandstone and is described in detail as one of the types of deposits in East Tennessee in Part I of this paper on pp. 184 to 189.

The mine has been recently equipped with six-wheeled scrapers which move the dirt more rapidly and economically. These are especially needed in the new development at the north, where a cross trench 60 feet wide is being cut across the ridge to give access to and to drain the deeper workings along the ore body. It is to be cut 40 feet deep. A steam shovel may be installed later.

The farm of Bird Hambright, north of the mine, also has some indications of ore. Good float manganese ore and red hematite occur at several places on the slopes of the Red Hills, but small prospect pits have thus far failed to strike the ore body, probably because they are not deep enough. The property is not at present leased for mining purposes, so far as known.

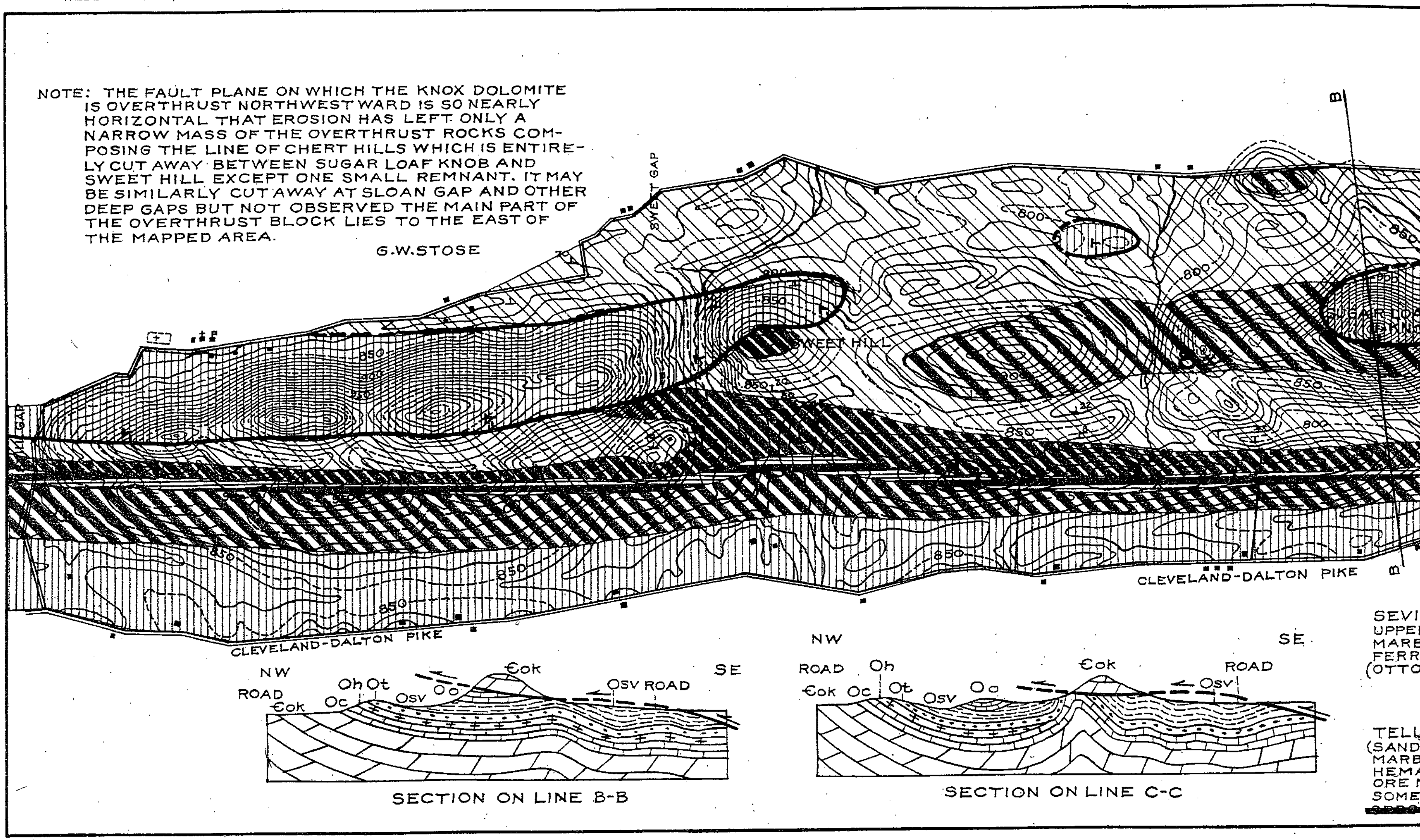
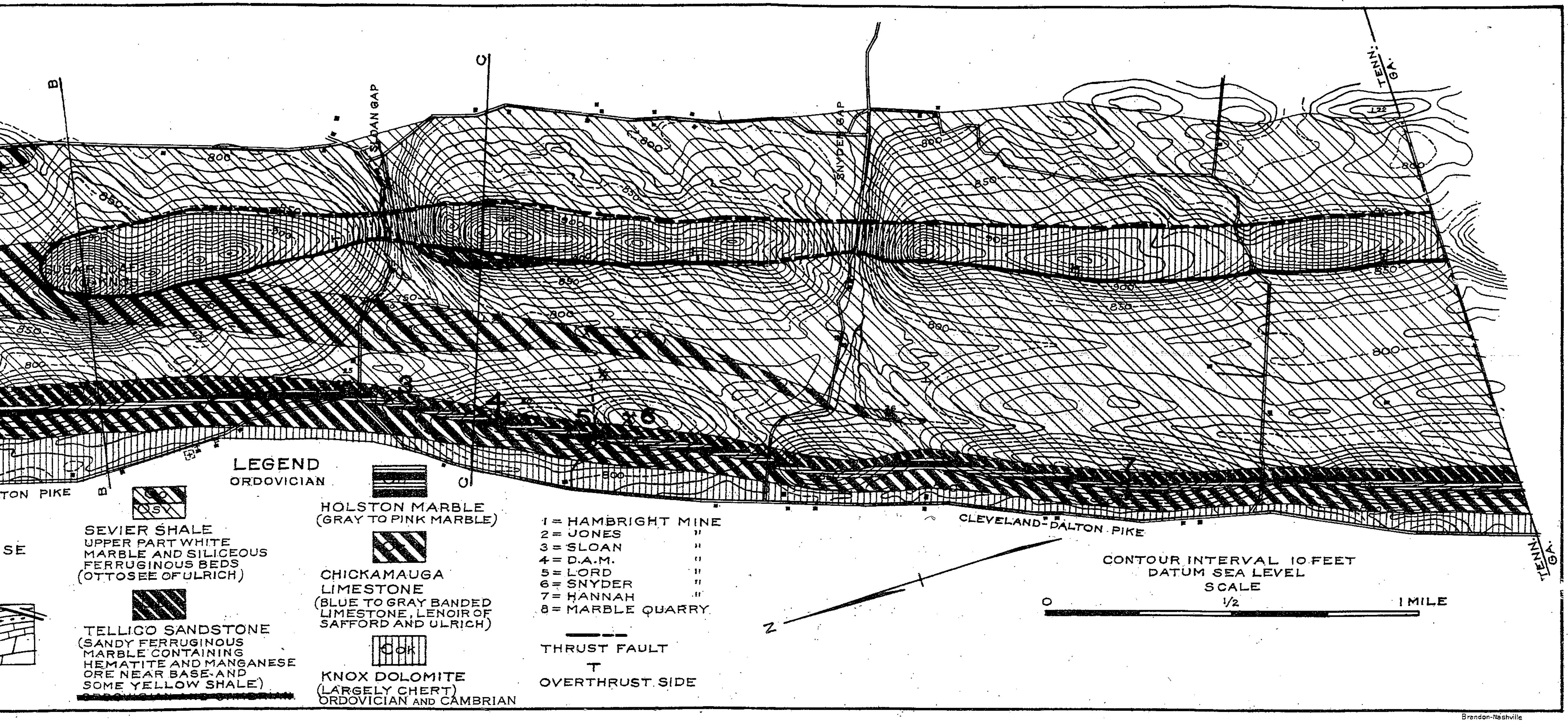


FIGURE 13. GEOLOGIC MAP OF THE RED HILLS AREA SOUTHEAST
By Arthur C. M



OUTHEAST OF CLEVELAND, TENN., SHOWING LOCATION OF MANGANESE MINES AND PROSPECTS
Arthur C. McFarlan, partly revised by G. W. Stose. 1918

Jones Prospect.—The Jones prospect is about three-fourths mile south of the Hambright mine and 2 miles east of Marble Switch on the Southern Railroad. It is in the open fields on the upper slope of the low red hill east of the road on M. V. Jones's farm. It is in Tellico sandstone at its unconformable contact with Holston marble. The structure is locally synclinal, the dips on the western slope being 35° SE, and on the top of the hill are about horizontal, but on the east slope are southeast again.

Within an area of about 300 feet in diameter on the top and upper western slope of the hill near the north end of the property the deposit has been prospected by pits and shafts to a maximum depth of 25 feet. They show only small amounts of soft manganese ore with pulverulent iron ore and black wad in deep-red clay. No amount of solid manganese ore was found. Near the south end of the property, just north of the Rock Quarry Gap road in the middle of the west slope, there are 6 or more pits from 6 to 20 feet deep in red sandy clay lying in hollows between marble pinnacles. One circular shaft exposes the irregular vertical wall of such a pinnacle to a depth of 20 feet. Fragments of high-grade hematite are abundant, but no manganese ore other than small traces of wad and pyrolusite were found. The marble is banded with dark highly ferruginous material and probably contains on the average at least 5% of iron. The marble and the thin overlying yellow shale, which here intervenes between the marble and red sandstone, are highly fossiliferous, containing chiefly bryozoa as at Sweetwater. Similar geologic and surface conditions are found south of the Rock Quarry road on the property of J. H. Jones. The mineral rights to both Jones properties are reported leased to the Tennessee Manganese Company, and, although the indications at present are not favorable for a good deposit of manganese ore, further search, probably to the southeast at greater depth down the contact zone, may be fruitful.

Sloan Prospect.—The Sloan prospect is about 1 mile south of the Jones prospect on the same line of Red Hills. It is 1½ miles southeast of Marble Switch on the Southern Railroad, close to Flint Springs. The property is owned by the Sloan heirs and is farmed by W. B. Sloan, one of the heirs. It was developed under option by E. C. O'Brien for the Seaboard Steel and Manganese Corporation, of Temple, Pa., and its purchase by that company was considered, but has not been consummated.

The prospect is at the north end of the low ridge on which the Lord and D. A. M. mines are located, at the west base of the hill on a level with the road and not over 200 feet from it. The deposit occurs in impure Holston marble, which is overlain by seamy calcareous Tellico sandstone. The structure is monoclinal, the rocks dipping 30° SE. The deposit is opened by a pit running into the hill 20 feet and about 25 feet deep at the face, exposing brown even-grained marble dipping 20° SE. At the top of the hill, 20 feet above, is soft ferruginous red sandstone of the Tellico. The ore is embedded in red sandy clay which fills large solution pockets in the marble. About 2 tons of high-grade hematite and good manganese ore, mostly in the form of slabs ½ to 1½ feet across, lie on the dump. Little ore was showing in the sides of the pit, but considerable float ore occurs in the soil of the fields on the hill back, and to the southeast of, the pit. This has been slightly tested by auger borings, but should be thoroughly prospected by pits to determine the direction of the Holston-Tellico contact, which is the zone of most concentrated ore. Although not enough prospecting has been done to prove up the property, it is believed to have large possibilities and should be developed by some responsible company.

D. A. M. Mine.—The D. A. M. (abbreviation for Davis, Artz, and McCrossin, the owners) mine is nearly 2 miles southeast of Marble Switch on the Southern Railroad, and not one-half mile south of the Sloan prospect. It was the first mine in the district to be opened and is reported to have early shipped about 300 tons of 50% manganese ore and more recently to have shipped 50 tons. The recent shipment is said to have averaged 53% manganese. The mine has been operated by Davis, Artz, and McCrossin, of Cleveland, but was idle when visited. It was reported that it had been sold early in 1918 and that its operation would be resumed soon.

The mine is located on the same low terraced ridge as the Lord mine, which adjoins it on the south. The workings are extensive and lie in a belt 200 feet wide trending north-northeast, which has been opened by pits for a length of 500 feet. The workings are mostly open cuts in the upper southeast slope of the ridge which follow solution crevices at the contact of the Tellico sandstone and the Holston marble, going down with the dip of the rock at an angle of about 25° SE. Most of the workings are shallow, but at the north end of the property a 30-foot shaft descends from the bottom of a 15-foot pit.

It followed a mass of sandy clay filling a vertical solution crevice between firm fresh siliceous marble on the southeast and decomposed marble on the northwest, both strongly marked with impure ferruginous laminae like the Tellico. Thin seams of hematite and a little manganese ore still occur along the bedding planes of the marble walls down to the bottom, and ore probably occurred throughout the clay in the pocket. The shaft is reported to have passed through an 18-inch bed of ore at a depth of 32 feet, probably at the base of the Tellico. The manganese ore is a high-grade massive psilomelane, and the iron ore a pure red hematite, the latter preserving excellent impressions of fossils which were replaced in the marble.

The deposit is thus seen to occur in the Tellico sandstone at its contact with the underlying Holston marble, which is unconformable in most places. The structure is monoclinal, the dip of the marble being 25° ESE at the north end to 50° ESE at the south end of the property. The overburden is in general about 2 to 8 feet of dark-red residual soil and sandy clay, and is much deeper in solution pockets and channels. The ore solutions seem to have been derived from the disintegration of beds in the lower part of the Tellico sandstone, and to have descended through the disintegrated rock at the surface into solution channels. The basal beds of the Tellico seem to be the most easily percolated, and solution channels are most plentiful at the base of the sandy beds. The ore was deposited both in the channels and in small crevices along the bedding and joints in the wall rock of the channel. A solid layer of ore at the contact of the marble and sandstone, such as has been described at the Hambright mine, was not observed here, but may have been encountered in the shaft. It is probable that the larger masses of ore in pockets have been mined out in the open pits, but there is every reason to believe that other workable pockets of high-grade ore are still in the ground in the unworked spaces between the pits, and down the dip below the present workings. The latter will have to be worked largely by inclined shafts and tunnels.

Lord Mine.—The Lord mine adjoins the D. A. M. mine on the south and is 10 miles south of Cleveland and 1½ miles east of Weatherly Switch on the Southern Railroad. It is on the Boyd farm, the mineral rights being owned by the C. H. Lord Corporation of Chicago, Ill., and is being operated by the Tennessee Manganese Company of Cleveland, Tenn., under lease. It is credited with a production in 1917 of 650 tons and in the first half of 1918 with 1,500 tons of high-grade ore, said to have averaged 58 to 60% manganese.

The mine is on the low broad-topped red hill on which the D. A. M. mine is located which, together with the other low red hills of this valley, are remnants of an old valley floor which now stands at 950 feet altitude. Round river cobble of quartzite occur on the tops of several of the ridges, indicating that some large stream once had its channel in this valley on this old valley floor. The deposit occurs in the Tellico sandstone at its unconformable contact with underlying Holston marble. The structure is monoclinal with the strike of the rocks N 30° E and the dip 40° SE. The disintegrated sandstone carrying the ore fills pockets and solution channels in the upper surface of the marble, some of which follow down the dip of the rocks.

The deposit is opened by an east-west pit 300 feet long by 100 feet in width in the side of the hill. At its face, in the highest part of the hill, the pit has a maximum depth of 50 feet. The excavation is chiefly in dark-red sandy clay with yellow clay bands and patches, but exposes unweathered marble at several place in the bottom. The face and eastern part of the pit are in dark-red sand with thin yellow clay bands dipping 40° SE, which preserve all the features of the sandy marble of the Tellico with thin yellow calcareous-shale streaks from which it was derived by decomposition, the calcareous matter having been entirely removed. The unaltered marble ribbed with ferruginous, siliceous banding, somewhat cross-bedded and lenticular, is exposed in depth. Thin lenses and stringers of hematite are deposited along the bedding and joint planes. Along the contact of the siliceous marble and the purer marble is a layer of nearly pure manganese ore, 6 inches to 2 feet thick, which had been exposed along a solution channel down the dip below the bottom of the pit, and is regarded as the main body of ore and the source of much of the lump ore in the sandy clay in the western part of the pit. It seems to be continuous across the whole width of the pit for 40 feet along the strike.

To the west of the sandstone-marble contact the red sandy clay is not regularly bedded, but is banded in various directions and contains masses of yellow clay resembling a coarse breccia. The sandy clay has many slickened planes, coated with bright-red clay. The material was evidently derived from the disintegration of Tellico sandstone which formerly covered the marble and was let down on the irregular surface of the Holston marble pitted by solution under cover. Rounded bosses of fresh marble exposed at the bottom of the pit 5 or more feet high are covered with a layer 6 to 10 inches thick of pulverulent clay soil in which most of the loose ore fragments occur, and this is generally covered with a thin layer of bright-yellow barren clay separating it from the overlying, soft, dark-reddish sandy clay derived from the Tellico sandstone. Figure 14 is a rough sketch of the conditions in the pit when visited.

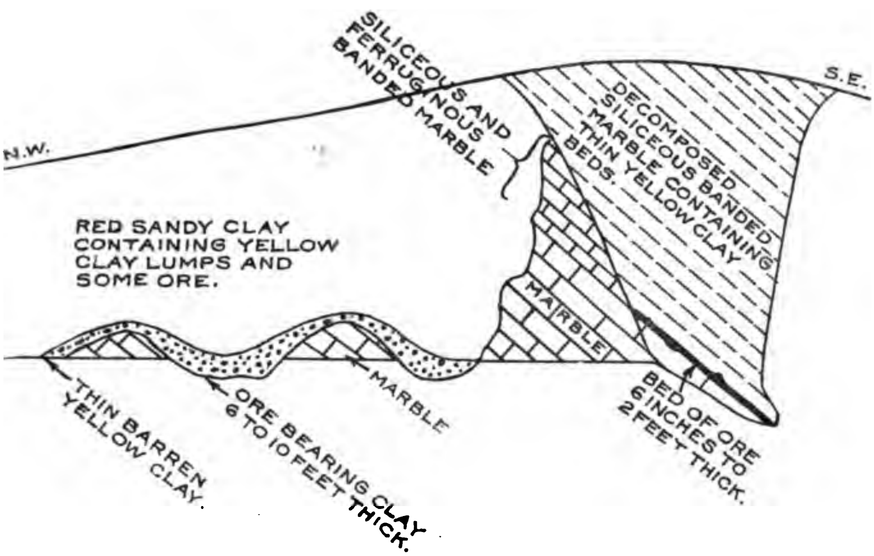


Figure 14. Sketch section across pit of the Lord mine, showing ore layer in place and relation of ore-bearing clay to the bedrock and to the red sandy clay. Scale, *about* 1 *inch*=30 *feet.*

About 50 feet east of the face of the main pit a vertical double-compartment shaft was started on the east slope 15 feet below the top of the ridge to reach the main bed of ore and mine it by drifting. It passed through 10 feet of red clay at the surface, then 32 feet of yellow clay, and at the time of visit had passed into soft black waddy earthy sand. It has recently been reported to be down 60 feet, the bottom in Holston marble, and to have struck the ore bed which improved with depth.

The ore is chiefly massive hard psilomelane, but includes also a little soft ore consisting of pyrolusite and wad. Some of the ore contains a small amount of white wavellite with a radial fibrous structure. The ore is all lump ore and is shipped without washing. Overlying the manganese ore in the western part of the mine is considerable soft, pulverulent red hematite, greasy to the feel. The mine was equipped with an expensive derrick-like apparatus about 60 feet long with cable and bucket, but it was found unsuited for the work. A drag line scraper was being used at the time of visit, but it is reported that the mine has recently been equipped with an automatic loader and dumper type of scraper with a bucket capacity of 1½ cubic yards.

An old tunnel goes into the hill from the valley east of the mine, but it did not reach the ore. Two small prospects have been recently opened on a small knoll across the valley from the mine about 500 feet to the east. They are trenches about 6 feet deep in red clay and strike a little wad and some hematite, but very little hard manganese ore. The deposit is on a marble bed associated with yellow Sevier shale (Ottosee) higher than the ore bed at the mine.

Snyder Prospect.[1]—The Snyder prospect is just south of the Lord mine, a mile and a half from Weatherly Switch on the Southern Railroad. It is on the Snyder farm and is undeveloped. A short-time option on the property is held by the Tennessee Manganese Company.

It is on the east slope of Red Ridge, in Tellico sandstone near its eastern contact with Knox dolomite along a thrust fault. The chert of the Knox dolomite forms a prominent ridge with white soil just east of the fault. The Knox is thrust against red sandstone of the Tellico dipping steeply southeast, apparently on the east limb of an overturned syncline which incloses Sevier shale in the middle.

The best mineral showing consists of good float ore along the base of the chert ridge close to the fault. The ore is fairly abundant and consists chiefly of high-grade psilomelane very similar to that of the Lord mine. The surface indications are regarded as favorable for finding a workable ore deposit, and prospecting is recommended.

Hannah Prospect.—The Hannah prospect is 1¼ miles south of the Lord mine and about 2 miles by road from Weatherly Switch on the Southern Railroad. It is on Mrs. Hannah's farm and has been

[1]The descriptions of the Snyder, Gee, and Brown prospects are largely from notes by Arthur C. McFarlan.

prospected by the Tennessee Manganese Company, which has a lease on the mineral rights. It is reported to have produced 8 tons of ore from clay close to the limestone floor beneath several feet of residual red sandy clay. The deposit is in Tellico sandstone overlying Holston marble.

The prospect, now caved, is located in the west slope of a Red Hill south of the hill on which is the Lord mine. The trench is 10 feet deep in residual red sandy clay resting on siliceous banded marble containing yellow shale bands which dip 45° SE. On the slope below the pit coarse crystalline marble is underlain by white and blue limestone of the Chickamauga. No ore was seen in the walls because of slumping.

Gee Prospect.—The Gee prospect is 10 miles south-southwest of Cleveland, just west of the Cleveland-Dalton pike and about a half mile west of the Lord mine, on the farm of Burley Gee. It is on the crest of a chert ridge in the Knox dolomite, and except for a small prospect pit is undeveloped.

The ore is psilomelane filling fractures and cementing, and in part replacing, fragments of chert. It occurs in considerable amount scattered over the surface and embedded in the residual clay. Similar showings are said to occur also on the neighboring Davis farm. Such deposits, however, have very deceptive surface showings and can only be proved up by prospecting.

WHITE OAK MOUNTAIN DISTRICT.

White Oak Mountain lies 7 miles northwest of Cleveland, its crest being the western boundary of the county. It begins north of the latitude of Cleveland and runs southwest to the State line. Manganese ore is reported in the mountains from several places west of Cleveland.

White Oak Mountain Mine.—The White Oak Mountain mine is near the west boundary of the county 7 to 8 miles northwest of Cleveland. It is owned and operated by the White Oak Manganese Corporation of Cleveland, and has produced about 40 tons of manganese ore and about 1,000 tons of manganiferous-iron ore which lie on the dump at the mine, no shipment having been reported. The mine is on the crest and upper east slope of White Oak Mountain, at elevations ranging from 950 to 1,100 feet. The deposit occurs in the Fort Payne chert. The mine is described in detail as one of the types of manganese deposits in Part I of this paper, pages 189 to 190.

Brown Prospect.—The Brown prospect is 3 miles northwest of McDonald station on the Southern Railroad, in White Oak Mountain. It is on the farm of Jake M. Brown on a hill 200 feet above the valley bottom. It is underlain by Fort Payne chert, and the relations are similar to those at the White Oak Mountain mine 6 miles northeast.

The property is undeveloped. The ore indications are abundant float ore in places, composed of psilomelane cementing fragments of chert and partly replacing it. The ore fragments in the soil are filled with chert and are too siliceous to be shipped without crushing and separating the chert. At one place a thin seam, not over 1 inch thick, of psilomelane, accompanied on either side by about a foot of soft decomposed manganiferous and ferruginous rock was observed. The indications are not regarded as favorable.

A similar manganiferous-iron ore deposit was exposed in a small pit on the crest of the mountain on James Wolf's farm, 2 miles west of McDonald.

PRODUCTION OF MANGANESE ORES IN TENNESSEE.[1]

	35% Mn. and Over.	10 to 35% Mn.
1886 to 1914	2,680 (approx.)	....
1915	250	....
1916	529	....
1917	2,294	83
1918—		
1st quarter	451	231
2nd quarter	389	728
3rd quarter	1,536	839

The production of manganese ore and ferruginous manganese ore in Tennessee for the last four years is shown in detail in the above table. On account of the delay in publishing this issue of "The Resources of Tennessee," it was possible to procure the production figures for the third quarter of 1918. In the first nine months of 1918, more manganese ore was mined than during 1917.

[1]From U. S. Geological Survey records.

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