

# CHATTANOOGA ATLAS SHEET.

## DESCRIPTION.

### GEOGRAPHY.

*General relations.*—The Chattanooga atlas sheet is bounded by the parallels 35° and 35° 30', and the meridians 85° and 85° 30'. It embraces, therefore, a quarter of a square degree of the earth's surface. Its dimensions are 34.5 miles from north to south, and 28.2 miles from east to west, and it contains 974.64 square miles. The adjacent atlas sheets are, on the north, Pikeville, on the east, Cleveland, on the south, Ringgold, and on the west, Sewanee. The sheet lies wholly within the State of Tennessee, the southern limit being within about a mile of the Tennessee-Georgia line. It embraces portions of Bledsoe, Rhea, Sequatchie, Marion, Hamilton, and James counties.

*Topography.*—The country included within the atlas sheet presents several widely different types of surface. The differences are due jointly to the character of the underlying rock and to the geologic structure—the relation of the strata to the surface. This connection between the geology and the topographic features will be explained later. Beginning in the northwest corner of the sheet and passing to the southeast, the following distinct areas may be noted: (1) the Cumberland plateau, (2) the Sequatchie valley, (3) Walden ridge, (4) the Tennessee valley, (5) White Oak mountain.

A small portion only of the Cumberland plateau, about 85 square miles, is embraced within the limits of the sheet. The general surface is level or rolling, elevated approximately 2,100 feet above sea level. The drainage is by streams flowing northwest to the Cumberland river and southeast to the Sequatchie. These streams have rapid fall and the larger ones have cut deep canyons several miles back from the edge of the plateau.

Toward the southeast the plateau is terminated by an abrupt escarpment, trending N. 30° E. and forming the western edge of the Sequatchie valley. On the eastern side of the valley is an escarpment, similar, but less broken by stream channels and somewhat higher than that on the west. The width of the valley between these two parallel escarpments is about four miles and its general surface is between 700 and 800 feet above sea level, or 1,300 feet below the adjacent plateau.

East of the Sequatchie valley is Walden ridge. This is not properly a ridge but rather a plateau which resembles in many respects the Cumberland plateau. Its area within the sheet is about 330 square miles, or one-third that of the entire sheet. The surface slopes gently toward the southeast from 2,200 feet above sea level on the western edge to 1,700 on the eastern. The drainage is wholly toward the southeast. A large number of streams head near the western side, frequently within a few hundred yards of the escarpment, and, flowing southeast in gradually deepening channels, emerge into the Tennessee valley from deep rocky gorges. As the streams debouch upon the valley their descent is less rapid so that they are able to carry less sediment, hence a part of the material eroded from the gorges is deposited in a kind of delta around their mouths. Since these deposits are composed wholly of coarse sand, gravel and boulders they are quite porous and most of the streams wholly or in part disappear from the surface for short distances. Toward the southern edge of the sheet Walden ridge is cut through by the Tennessee river, which at Chattanooga turns westward almost at right angles to its upper course.

East of Walden ridge is the valley of the Tennessee river, a portion of the great Appalachian valley which extends toward the northeast through Virginia and Maryland into Pennsylvania and toward the southwest through Georgia into Alabama. The area of the portion embraced within the atlas sheet is about 440 square miles. The elevation of the Tennessee river is between 670 and 700 feet above sea level, and the general surface of the valley is a little higher, but many hills and irregular ridges rise two or three hundred feet above the river. The actual flood-plain or bottom is nowhere extensive, and on one side or the other the river usually washes the base of a steep, rocky

bluff. At Chattanooga the river leaves the broad Appalachian valley, and sweeping past the foot of Lookout mountain enters the narrow canyon carved across Walden ridge. With steep wooded slopes rising from the water's edge and surmounted, a thousand feet above, by vertical cliffs of gray sandstone, the gorge affords some of the most picturesque scenery to be found in the southern Appalachians.

Compared with its upper valley, the gorge of the Tennessee below Chattanooga is extremely young and there is evidence that it has been occupied by the present river but a short time. Until recent geologic ages the Tennessee probably continued southward in the broad Appalachian valley directly to the Gulf of Mexico. Since it was diverted to its present course it has lowered its bed only about 250 feet, this being the height of the divide which separates its waters from those still flowing southward.

Crossing the southeastern corner of the sheet in a direction parallel to the edge of Walden ridge is White Oak mountain, a sharp ridge steep on its western side and sloping gently to the east, with an elevation from 1,300 to 1,500 feet above sea level. East of White Oak mountain are numerous ridges, in a general way parallel with it but lower and less regular. Grindstone mountain, however, has an elevation somewhat greater, and with its level top and steep sides it forms a small isolated plateau or mesa in all respects, except in its limited extent, similar to the Cumberland plateau in the western portion of the sheet.

### STRATIGRAPHY.

All the rocks appearing at the surface within the limits of the Chattanooga atlas sheet are of sedimentary origin, that is, they were deposited by water. The materials of which they are composed were originally mud, sand and pebbles derived from the waste of some older rock, or the remains of plants and animals which lived while the strata were being laid down. Thus some of the great beds of limestone were formed largely from the shells of various sea animals, and the beds of coal are the remains of a luxuriant vegetation which covered low, swampy shores.

### CAMBRIAN ROCKS.

*Apison shale.*—The oldest rocks exposed within the limits of the sheet consist of slightly sandy or clay shales named from their typical development at Apison near the southeastern corner of the sheet. Their most striking peculiarity is the brilliant coloring which they display in sharply contrasted bands of red, purple, green and yellow. The thickness of the formation is not known, since it is always limited on one side by a fault, but at least 1,000 feet are exposed at its type locality.

A bed of gray siliceous limestone sometimes occurs between this and the succeeding formation, but though found both north and south of this region it does not occur within the limits of this sheet.

*Rome formation.*—Next above the Apison shale are the sandstones and shales of the Rome formation. They are between 3,000 and 4,000 feet in thickness, but on account of the folding and crumpling which the strata have suffered it is impossible to obtain accurate measurements. The lower part of the formation is composed of alternating layers of sandstone and shale. Passing upward the proportion of shale gradually increases, so that toward the top only a few thin siliceous beds occur, which can scarcely be called sandstone. The shales are usually brown or dark olive-green, while the sandstone beds are reddish brown or purple, with occasional layers of white quartzite. The sandstone beds show ripple-marks and other signs of having been deposited in shallow water, but the water was evidently growing deeper during their deposition, and the succeeding formation contains limestone and calcareous shale, which must have been formed on a comparatively deep sea bottom and remote

from any high land that could yield coarse sediments.

*Connasauga shale.*—This formation is composed at the base of thin limestones interbedded with shales, in the middle of yellow or greenish clay shales, and at the top of blue seamy limestone or calcareous shales. Some of the thin beds of limestone, especially those near the lower part of the formation, have a peculiar oolitic structure, being made up of rounded or flattened grains about a tenth of an inch in diameter. This oolitic limestone is sometimes absent. The boundary between the Rome and Connasauga then becomes very indefinite and their separation difficult. The same is true when the upper part of the Rome also contains beds of lime, as is sometimes the case. The thickness of the Connasauga shale probably varies between 1,500 and 2,500 feet, but on account of the great contortions which the beds have suffered, the same uncertainty attaches to their measurement as to that of the two older formations. The formation takes its name from the Connasauga valley, in Georgia, on the Dalton sheet.

The Cambrian formations occupy a comparatively small portion of the area of the Chattanooga sheet. Two narrow strips occur near the center of the Tennessee valley, and a somewhat broader belt crosses the extreme southeastern corner of the sheet. The latter is limited by faults upon both sides and consists wholly of the two lower formations, the Apison and Rome.

### SILURIAN ROCKS.

*Knox dolomite.*—The lowest division of the Silurian, the Knox dolomite, consists of from 3,000 to 3,500 feet of massively bedded and somewhat crystalline magnesian limestone. This limestone, or more properly dolomite, contains a large amount of silica in the form of nodules and layers of chert or flint. Upon weathering, that part of the rock which consists of the carbonates of lime and magnesia is dissolved, leaving behind the chert, usually imbedded in red clay. This residual material covers the surface to great depths and the dolomite itself is seldom seen except in the channels of the larger streams.

The Knox dolomite comes to the surface in a belt about two miles wide through the center of the Sequatchie valley and occupies the greater part of the Tennessee valley between Walden ridge and White Oak mountain. In both valleys its outcrops are marked by the characteristic low, rounded, chert hills, which rise from 300 to 400 feet above the level of the streams.

*Chickamauga limestone.*—The next formation is the Chickamauga limestone, which occupies a broad, continuous belt along the eastern side of the Sequatchie valley and a much narrower one, not entirely continuous, along the western side. The formation is here a pure, blue, thin bedded limestone, about 1,000 feet in thickness. It appears again on the eastern side of Walden ridge with much the same character as in the Sequatchie valley. East of Chattanooga and in the South Chickamauga valley are large exposures of the formation, where it has a thickness of about 1,600 feet and contains a considerable amount of earthy impurity. Along the western base of White Oak mountain is another broad belt showing a still further increase in thickness to about 2,200 feet, and also a greater proportion of earthy material, especially in the upper part of the formation. The Chickamauga limestone takes its name from the valley of Chickamauga creek, on the Chattanooga and Ringgold sheets, where it is typically developed.

*Rockwood formation.*—The Rockwood formation, which is the highest division of the Silurian in this region, varies widely in character and thickness within the limits of the sheet. It forms a narrow strip along the eastern side of the Sequatchie valley, with a thickness of about 200 feet, and is composed of calcareous shales and some beds of blue limestone. On the eastern side of Walden ridge it is 300 feet thick, and consists of calcareous

shales with some beds of sandstone. Still further east, in White Oak mountain, the formation attains a thickness of 1,000 feet, of which the lower 800 are made up of hard brown sandstone interbedded with sandy shale. The upper portion consists of sandy shale with a few calcareous beds. The formation is named from Rockwood, Tennessee. It is of great practical importance on account of the beds of red fossil iron ore which it usually contains. These are described under the head Mineral Resources.

### DEVONIAN ROCKS.

*Chattanooga black shale.*—Overlying the Rockwood formation is a thin stratum of shale which appears to represent the whole of the deposition which took place in this region during the Devonian period. Typical exposures of this shale appear in the north end of Cameron hill within the city limits of Chattanooga, from which locality it takes its name.

The Chattanooga black shale has a remarkably uniform character wherever seen within the limits of the atlas sheet, and for a long distance on either side north and south. It varies in thickness from 10 to 25 feet. The upper portion of the shale, three or four feet thick, is usually dark gray in color and often carries a layer of round concretions about an inch in diameter. The remainder of the formation is jet black, from an abundance of carbonaceous matter, and when freshly broken it emits a strong odor like petroleum.

This shale, on account of its distinctive and striking appearance, has attracted much attention from miners, and has been prospected in many places for coal and various ores, especially silver and copper. Such exploitation, however, has always been attended by failure, since the shale contains nothing of present economic importance. Although it contains a large proportion of carbonaceous matter which burns when it is placed in a hot fire, the amount is not sufficient to constitute a fuel, and no true coal is ever found associated with the shale. Small concretions of iron pyrites, which it often carries, have given rise to the commonly accepted but wholly erroneous belief that the shale contains valuable ores. The formation is of economic importance only as a starting point in prospecting for the red fossil iron ore which occurs below it and at a uniform distance, over considerable areas.

### CARBONIFEROUS ROCKS.

*Fort Payne chert.*—This formation consists of from 50 to 200 feet of very siliceous limestone. At the base, resting on the Chattanooga black shale, are usually heavy beds of chert with only a small amount of limestone or greenish calcareous shale. In the western part of the sheet the line increases toward the top of the formation and gradually replacing the chert it passes without an abrupt transition into the Bangor limestone above. It is there about 200 feet thick. In White Oak mountain and eastward the lower part of the formation is composed of heavy beds of chert, while the upper part contains coarse cherty sandstones which become porous by the solution of the calcareous matter they originally contained. The chert of this formation is readily distinguished from that of the Knox dolomite by the great number of fossils which it contains. It is often made up of a mass of erinoid stems imbedded in a siliceous cement; on weathering, the cement remains a porous chert filled with the fossil impressions. In some cases the fossils alone are silicified so that they remain in the soil after the solution of the calcareous cement. The formation occurs in a narrow strip on the eastern side of the Sequatchie valley, usually forming, with the Rockwood shale, a narrow ridge parallel to the mountain escarpments. Along the eastern base of Walden ridge the formation occupies somewhat larger areas though it is not entirely continuous across the sheet. It forms the greater part of Cameron hill in Chattanooga and the gentle eastward slopes of White Oak mountain. The formation name is taken from Fort Payne, Alabama.

*Floyd shale.*—As before stated, the chert, on the western portion of the sheet, passes upward directly into the Bangor limestone, but east of White Oak mountain another formation, the Floyd shale, comes in between them. This consists of from 600 to 850 feet of variable sediments, for the most part carbonaceous shales, containing local beds of fine grained, flaggy sandstone, and also some beds of blue limestone with nodules of chert. These calcareous portions are highly fossiliferous, though the black shales are generally quite barren of organic remains.

*Bangor limestone.*—The Bangor limestone is from 800 to 1,000 feet thick in the Sequatchie valley and on the eastern side of Walden ridge, where it forms the lower portion of the mountain slopes. East of White Oak mountain it is only 600 feet thick, resting on the Floyd shale, and only a single small area has escaped erosion, though it doubtless formed a continuous sheet over the whole of this region, and originally may have extended some distance farther eastward. The limestone shows with unmistakable clearness the mode of its formation. It is in many cases composed almost entirely of fragments of crinoids together with the calcareous coverings of other sea animals which died and left their remains on the sea bottom.

It is probable that the lower portion of the Bangor limestone on the western part of the sheet and the Floyd shale on the eastern part were deposited at the same time, the former in a comparatively deep sea and the latter near the shore where the supply of mud and sand was abundant. Although they may be of the same age, the rocks differ so widely in character that they are given distinct formation names. The name of the limestone is taken from Bangor, Alabama, and that of the shale from Floyd county, Georgia.

The presence of the Floyd shale on the eastern and its absence from the western portion of the sheet, together with the changes already noted in the lithologic character of the Rockwood and Chickamauga, indicate that during their deposition the land, from which the sediments were derived, was toward the southeast while the deep sea was toward the northwest.

*Lookout sandstone.*—At the close of the period occupied by the deposition of the Bangor limestone there was an uplift of the sea bottom, so that the water became shallow over a wide area while an abundant supply of mud and sand was washed in from the adjoining land. These conditions were unfavorable for the animals whose remains are so abundant in the preceding formation, and instead of limestone a great mass of shale and sandstone was deposited. The surface also stood above sea level at various times, long enough at least for the growth of the luxuriant vegetation which formed the coal beds.

The Lookout sandstone includes 450 to 550 feet of conglomerate, thin bedded sandstone, sand and clay shales, and coal. Its upper limit is at the top of a heavy bed of conglomerate or coarse sandstone from 25 to 75 feet in thickness, which forms the principal cliff about the edge of Lookout mountain, south of Chattanooga and in the escarpments of Walden ridge and the Cumberland plateau. In the eastern part of the sheet the formation occupies but a single small area, capping Grindstone mountain, although it is probable that, like the other carboniferous formations already described, it once extended across the intervening region in a sheet continuous with that upon Lookout mountain.

*Walden sandstone.*—The Walden sandstone includes all the rocks lying above the Lookout conglomerate. Its sandstones, shales and coal beds were deposited under conditions very similar to those which prevailed during the deposition of the preceding formation. The conditions, however, changed less frequently and were somewhat more favorable for the accumulation of coal. What the original thickness of the Walden sandstone may have been can not now be determined, but it is certain that much of the formation has been removed by erosion. It is confined to the western part of the sheet, forming the surface of Walden ridge, from which it is named, and of the Cumberland plateau. Its greatest thickness of from 600 to 700 feet occurs in the Cumberland plateau a few miles west of Sequatchie valley, though there may be as great a thickness in the eastern part of Walden ridge near the center of the sheet.

These two formations, the Lookout and Walden sandstones, constitute the productive coal measures. The position and thickness of the various beds of coal will be described under the head of Mineral Resources.

At the close of the Carboniferous period this region was elevated permanently above sea level, so that the constructive process of deposition was stopped and the destructive process of erosion was begun.

#### STRUCTURE.

*Definition of terms.*—As the materials forming the rocks of this region were deposited upon the sea bottom, they must originally have been in nearly horizontal layers. At present, however, the beds are not usually horizontal, but are inclined to the surface at various angles. This is the result of compression in a northwest and southeast direction, by which they have been bent into a series of arches and troughs. In describing these folded strata the term *syncline* is applied to the downward bending troughs and *anticline* to the upward bending arches. A synclinal axis is a line running lengthwise of the synclinal trough, at every point occupying its lowest part, toward which the rocks dip on either side. An anticlinal axis is a line which occupies at every point the highest portion of the anticlinal arch, and away from which the rocks dip on either side. These axes may be horizontal or inclined. Their departure from the horizontal is called the pitch of the axis and is usually but a few degrees. In addition to the folding, and as a result of the continued action of the same forces which produced it, the strata along certain lines have been fractured, and the rocks have been thrust in different directions on opposite sides of the fracture: this is termed a *fault*.

*Structure sections.*—The three sections on the structure sheet represent the strata as they would appear in the sides of a deep trench cut across the country. Their position with reference to the map is on the line at the upper edge of the blank strip. The vertical and horizontal scales are the same, so that the elevations represented in the profile are not exaggerated, but show the actual form and slope of the land. These sections represent the structure, as it is inferred from the position of the strata observed at the surface. On the scale of the map they can not represent the minute details of structure; they are therefore somewhat generalized from the dips observed in a belt a few miles in width along the line of the section.

Faults are represented on the map by a heavy solid or broken line, and in the sections by a line whose inclination shows the probable dip of the fault plane, the arrows indicating the direction in which the strata have been moved on its opposite sides.

*Relation of topography to structure.*—The most prominent structural as well as topographic feature upon the sheet is Walden ridge. It will be seen from the sections that the nearly horizontal strata which underlie this plateau dip gently away from the edges toward the middle, forming thus a broad shallow trough; this is a typical *synclinal mountain*. In Sequatchie valley the strata are more steeply inclined and dip away from the middle toward the sides; this is a typical *anticlinal valley*. East of Walden ridge, in the Tennessee valley, also, a general arching of the strata is observed, though with less regularity than in the anticline of Sequatchie valley. In White Oak mountain the strata form a deep and narrow syncline, though it is the western edge of the trough which makes the mountain through the greater part of its length.

Thus there is an intimate connection between the structure and the present topography. The surface has been fashioned by the streams which flow upon it, and the action of the streams has been controlled by the position of the hard and soft layers of rock. The valleys in general are upon anticlinal arches, and the mountains are formed by synclinal troughs. This result has been brought about by the more rapid erosion of the hard beds at the tops of the arches than in the bottoms of the troughs. The streams must originally have flowed in the synclines, but they have gradually transferred their channels to the axes of the anticlines and the original relation of high and low land has been reversed.

*Folds and faults.*—The Sequatchie valley anticline is the westernmost of those remarkable parallel folds which characterize the Appalachian

region. West of this the strata are nearly horizontal though broad undulations can be detected by careful measurements. On the eastern side of the valley the strata dip beneath Walden ridge at angles varying from 15° to 20°; on the western side of the valley they are much steeper, being generally vertical or overturned. Along the western side of the valley there is a fault, and this, as explained above, is the further result of the action of those compressing forces which produced the fold. In consequence of this fault some of the formations which occur on the eastern side of the valley and which should occur on the western side are concealed by other formations thrust across their broken edges. Thus the Chickamauga limestone and Knox dolomite come into contact with the Bangor limestone, while intervening formations, the Fort Payne chert, Chattanooga black shale and Rockwood shale, are concealed. This is the reason that the red fossil iron ore of the Rockwood formation is not found along the western side of the valley.

The axis of the Walden ridge syncline is considerably east of the central line of the plateau. Thus there is a slight easterly dip from the western edge almost entirely across to the eastern escarpment. This fact has great practical importance since it insures easy drainage of coal mines and hence economical mining.

Between Chattanooga and the edge of Walden ridge there are three small folds shown in section C C of the structure section sheet. Of these the western extends southward, forming Lookout valley upon the Ringgold sheet, and northward to Falling Waters creek, but almost entirely disappears before reaching the line of section B B. This folded belt is cut off on the eastern side by a fault which passes through the east side of Cameron hill in Chattanooga and extends northward a short distance from the edge of the plateau to about Retro. Beyond this a narrow syncline extends to the edge of the sheet, forming Lone mountain and the ridge east of Coulterville. This narrow syncline is separated from Walden ridge by a faulted anticline which forms the valley of Sale creek. Section A A shows the manner in which the strata of Lone mountain have been thrust over upon the eastern edge of the Walden ridge syncline.

The Tennessee valley is developed for the most part upon the Knox dolomite, which lies in broad and rather gentle folds. Two sharp anticlines bring the underlying Cambrian rocks to the surface in long narrow strips of nearly vertical strata, while two strips of nearly horizontal Chickamauga limestone occupy portions of the synclines. The one between Chattanooga and Missionary ridge is bounded on the east by a fault, on which, as shown in section C C, the dolomite forming the ridge has been thrust across the overturned edge of the syncline.

Crossing the southeast corner of the sheet is a fault which brings the oldest rocks of the region against the youngest. The displacement along this line is much greater than in the faults further west, being fully 12,000 feet. This motion has not usually taken place upon a single plane, but is distributed among several fault planes within a narrow belt in which the rocks are greatly contorted and crushed.

#### MINERAL RESOURCES.

The mineral resources of the Chattanooga sheet consist of *coal, iron ore, limestone, building and road stone, and brick and tile clay.*

*Coal.*—The productive coal-bearing formations, consisting of the Lookout and Walden sandstones, occupy the surface of the Cumberland plateau and Walden ridge. They have an area within the atlas sheet of about 400 square miles, and contain from one to three beds of workable coal.

The accompanying vertical sections on the columnar section sheet show the position and thickness of the various coal beds. The sections are not generalized, but each represents the actual measurements made at a single locality. It will be seen that the beds vary considerably in number, position and thickness from one part of the field to another. The datum from which their position is measured up or down in the section is the top of the conglomerate. It is not always possible to determine this point exactly, so that some uncertainty is thus introduced into the cor-

relation of coal beds in the different parts of the field.

The vertical distance from the top of the Bangor limestone to the top of the conglomerate, that is, the thickness of the Lookout sandstone, varies between 450 and 550 feet. Wherever the rocks are well exposed, at least three beds of coal are seen between these limits and in some places as many as six. One bed immediately below the conglomerate, or heavy sandstone, is fairly constant in position though it varies considerably in thickness. From a few inches at the northern edge of the sheet it increases southward to three feet or more, and is worked at the Daisy, Ætna and McNab mines. Below this the Dade coal, which at the southern edge of the sheet has a thickness of about three feet and is worked principally at the Dade mines in Georgia, may be represented by one of the thinner beds seen in the sections further north. Of the remaining lower beds only one other is worked, namely, the lowest in the series, which is about 320 feet below the top of the conglomerate. It varies in thickness within distances of a few hundred feet from a mere streak to three or four feet.

In the first 125 feet above the conglomerate is a group of from two to four coal beds, at least one of which is generally workable. Exact correlations of the beds within this group have not been made, and it is quite probable that a single bed in one part of the field may be separated by shale and sandstone layers into two or three in another part. This is the horizon at which occurs the coal so extensively worked at Tracy city and other points west of Sequatchie valley. A bed occurs in several of the sections at a quite uniform distance of from 250 to 275 feet above the conglomerate and is worked at the Daisy and Ætna mines. Finally the Richland coal, 630 feet above the conglomerate, is worked near Dayton, just off the north edge of the sheet. The rocks containing the Richland coal have been quite generally eroded, so that the workable area of the bed is not so great as that of beds lower in the series. This coal is found only in the deeper parts of the Walden ridge syncline and in isolated hills rising above the main floor of conglomerate. The same limitation in area is applicable to the next lower workable bed, the Ætna coal, though in a lesser degree.

In conclusion, without attempting strict correlation of individual beds, the coals of the Walden formation may be grouped at three horizons, at any one of which workable coal is likely to be found. The first is within 120 feet above the conglomerate and contains the beds worked over the widest area. The second horizon is from 250 to 275 feet above the conglomerate and contains the beds worked at Ætna and Daisy. The third is about 630 feet above the conglomerate and contains the Richland coal, but is restricted in area on account of erosion.

All the coals of this region are bituminous, and all so far tested are well suited for coking. A good quality of coke is made at Daisy, Rathburn and Dayton.

*Iron ore.*—Two varieties of iron ore, which differ widely in appearance and in modes of occurrence, are found on the Chattanooga sheet. They are *hematite*, or *red fossil ore*, and *limonite*, or *brown ore*.

*Hematite.*—The red fossil ore is associated with rocks of the Rockwood formation and is very similar to the ore occurring at the same horizon in such widely separated localities as Wisconsin, New York and Alabama. It is a regularly stratified bed, retaining a constant thickness and definite relation to other strata of the formation over considerable areas. Like any other rock stratum, however, it is not absolutely constant, so that, while the map indicates within narrow limits the areas within which the ore may occur, careful examination is required to determine whether at any particular locality its quantity and quality are such as to make it commercially valuable.

The proportion of iron in the ore usually decreases with distance from the surface, and at considerable depths it becomes simply a more or less ferruginous limestone. The decrease downward in the proportion of iron is due to the fact that near the surface the lime has been largely removed by percolating surface waters, leaving behind the insoluble iron oxide as the soft ore. The presence of lime in the ore is not objectionable, except as it renders mining more difficult, for

it removes the necessity of adding limestone as a flux in the furnace. The soft ore is very easy to mine, and considerable quantities are frequently obtained by trenching along the outcrop of the bed even when it is not of sufficient thickness to make deep mining now profitable. This is the character of all the ore workings on this sheet at present.

The outcrop of the Rockwood formation occupies a narrow strip along the eastern side of the Sequatchie valley, the strata dipping at low angles, 8° to 15°, toward the east under Walden ridge. The corresponding outcrop of the formation on the west side of the Sequatchie valley is concealed by a fault, as already explained. Although the ore is not worked along this strip within the limits of this sheet, it is probably present throughout its whole extent in workable quantity. The extensive Inman mines are just off the western edge of the sheet on the same belt. The ore bed is separated from the overlying Chattanooga black shale by about 60 feet of bluish calcareous shale. It has a thickness of 5½ feet at Inman.

On the east side of Walden ridge is a strip of Rockwood continuous from the north edge about halfway across the sheet, below which is a break of a few miles caused by faulting. Beyond this break the belt continues to the edge of the sheet. This southern portion is formed by two narrow parallel bands which are the outcrops of the formation on opposite sides of a narrow anticline. The ore in this belt east of Walden ridge has been extensively mined both north and south of the Chattanooga sheet, but within its limits only an inconsiderable amount of surface mining has been done.

In White Oak mountain the greater part of the Rockwood formation consists of hard, brown sandstones, and only the upper portion contains the calcareous shales which invariably accompany the iron ore. On the same belt some miles toward the northeast the ore forms a heavy bed and is extensively mined, but it decreases rapidly toward the south, and probably does not occur in White Oak mountain in workable quantities beyond the southern edge of the Chattanooga sheet. Considerable ore has been taken from the surface workings on both sides of the East Tennessee railroad.

**Limonite.**—The limonite ore does not occur in this region as a regularly stratified bed, but in irregular surface deposits. Hence the limits within which it may occur can not be indicated with the same certainty as in the case of red ore. Although iron oxide is very widely distributed throughout the rocks and soil, it is only when it becomes segregated in large quantities and in a comparatively pure condition that it is commercially valuable as an ore. The agency by which the segregation is effected is the percolating surface water, which contains small quantities of weak acids derived from the atmosphere and decaying vegetation. These acids dissolve the iron disseminated through the rocks. When the solution is exposed to air either at the surface or in cavities under ground the iron becomes insoluble and is precipitated as the slimy yellowish substance generally seen about mineral springs. This substance gradually hardens and, where it collects in sufficient quantity, forms a bed of limonite or brown iron ore.

The only considerable deposits of brown ore known to occur within the limits of the sheet are along the eastern side of the Sequatchie valley. The conditions were favorable for its accumulation near the contact of the Fort Payne chert and the Bangor limestone. Heavy deposits occur in this

position at Kitner gap but they have never been worked.

**Limestone.**—The supply of limestone on the Chattanooga sheet, suitable for blast-furnace flux and for lime, is abundant and convenient of access. The Bangor limestone is most largely used on account of its freedom from impurities and its close proximity to the furnaces or to lines of transportation. It generally contains an appreciable amount of magnesium carbonate, which sometimes reaches as much as 35 per cent. The magnesium limestone of the Knox dolomite is also somewhat used as a flux, especially in the basic steel process, and is burned for lime very extensively at Graysville, just off the southern edge of the sheet.

**Building stone.**—Stone adapted to architectural uses occurs in nearly every formation on the sheet. That which has been most largely used is in the lower part of the Chickamauga limestone. At Hickson, on the Cincinnati Southern railroad, and near Chickamauga, on the Western and Atlantic railroad, are quarries of blue or dove-colored earthy limestone. The stone is evenly bedded, quite easily worked, and makes a fine building material. Sandstones especially well adapted for foundations occur in the Rockwood formation of White Oak mountain and in the Lookout and Walden sandstones. These have as yet been quarried only for local use and in a small way.

**Road material.**—The hard blue Bangor and Chickamauga limestones furnish an abundant supply of macadam material requiring but little transportation. The residual chert or flint of the Fort Payne and Knox dolomite formations is an ideal road material and has been used very largely in surfacing the macadam roads in the vicinity of Chattanooga.

**Clays.**—The residual deposits resulting from the solution of the Chickamauga limestone are red or blue clays, and are generally well adapted for making brick. Some portions of the Bangor limestone leave a residual clay suitable for brickmaking, and also for drain tile. Several beds of fire clay which are associated with the coal probably contain material well adapted for making fire brick, but they are as yet wholly undeveloped.

#### SOILS.

**Derivation and distribution.**—Throughout the region covered by the Chattanooga atlas sheet there is a very close relation between the character of the soils and that of the underlying geological formations. Except in limited areas along the larger streams and on the steepest slopes, the soils are derived directly from the decay and disintegration of the rocks on which they lie. All sedimentary rocks such as occur in this region are changed by surface waters more or less rapidly, depending on the character of the cement which holds their particles together. Siliceous cement is nearly insoluble and rocks in which it is present, such as quartzite and some sandstones, are extremely durable and produce but a scanty soil. Calcareous cement, on the other hand, is readily dissolved by water containing carbonic acid, and the particles which it held together in the rock crumble down and form a deep soil. If the calcareous cement makes up but a small part of the rock it is often leached out far below the surface, and the rock retains its form but becomes soft and porous; but if, as in limestone, the calcareous material forms the greater part of the rock, the insoluble portions collect on the surface as a mantle of soil varying in thickness with the character of the limestone, generally quite thin where

the latter is pure, but often very thick where it contains much insoluble matter.

When derived in this way from the disintegration of the underlying rock, soils are called sedimentary. If the rock is a sandstone or sandy shale the soil is sandy, and if it is a clay shale or limestone the soil is clay. As there are abrupt changes in the character of the rocks, sandstones and shales alternating with limestones, so there are abrupt transitions in the character of the soil, and soils differing widely in composition and agricultural qualities often occur side by side. As the attitude of the strata determines the breadth of outcrop of each formation in different places, it also determines the area of the particular soil derived from each. Where the strata are nearly horizontal at the surface, as the Chickamauga limestone at Chattanooga, the corresponding soil covers a broad area, but where they outcrop in a nearly vertical position, as the same formation at Dayton, its resulting soil occupies only a narrow strip.

Knowing the character of the soils derived from the various geological formations, their distribution may be approximately determined from the map showing the areal geology, which thus serves also as a soil map. The only considerable areas in which the boundaries between different varieties of soil do not coincide with the formation boundaries are in the river bottoms and upon the steep slopes where soils derived from rocks higher up the slope have washed down and covered or mingled with the soil derived from those below. The latter are called overlaid soils, and a special map would be required to show their distribution.

**Classification.**—The soils of this region may conveniently be classed as (1) Sandy soils; derived from the Walden and Lookout sandstones, some parts of the Floyd shale, the Rockwood formation of White Oak mountain and the Rome sandstone. (2) Clay soils; derived from the Bangor and Chickamauga limestones, the Rockwood west of the Tennessee river, the upper part of the Floyd and the Connasauga and Apison shales. (3) Cherty soils; derived from the Fort Payne chert and the Knox dolomite. (4) Alluvial soils; deposited by the larger streams upon their flood plains.

**Sandy soils.**—Cumberland and Walden plateaus are formed by sandstones and sandy shales, and their soil is a sandy loam. At the surface it is gray, while the subsoil is generally light yellow, but varies to deep red. In some places it consists largely of sand, but more often contains sufficient clay to give the subsoil considerable coherence, so that a cut bank will remain vertical for some years. The depth of soil on the plateau varies from a few inches to a dozen or more feet, depending chiefly on proximity to streams and the consequent activity of erosion. A large part of the plateau retains its original forest growth, chiefly of oak, chestnut and hickory, while pines clothe the steep sides of the stream channels. The practice of burning off the leaves each fall prevents the accumulation of vegetable mold and has delayed a just appreciation of the agricultural possibilities of this region. The Rockwood formation of White Oak mountain is made up of sandstones and sandy shales, and its outcrops have sandy soils. This is less important than that of the plateaus, since the strata are steeply inclined so that they produce ridges, and some beds of hard sandstone break up into blocks which cover most of the surface. Some calcareous sandstones near the top of the formation produce the small areas of deep fertile soil which are found at intervals along the summit of White Oak mountain. The strip of

Rome sandstone east of White Oak mountain yields sandy soil, while the surface is rocky and ridgy so as to be scarcely tillable.

Since the sandstones of this region occupy the highest land, the overlaid soils, or those washed down to lower levels, are mostly sandy. They are especially abundant at the foot of the escarpment surrounding the plateaus, where the Bangor limestone and its clay soil are often wholly concealed. The delta deposits formed by streams emerging from gorges cut in the plateaus also give considerable areas of sandy soil overlying rocks which would themselves produce clay or cherty soils.

**Clay soils.**—The most productive of these are derived from the Bangor and Chickamauga limestones, and their distribution coincides with the outcrops of those formations as shown on the geologic map. They sometimes have a deep red color, but where the mantle of residual material covering the rock is thin it is often dark bluish gray. This is its character west of Missionary ridge and of White Oak mountain where the largest areas of the limestone occur. The rocks generally weather more rapidly where they have a steep dip than where they are nearly horizontal. Hence the soil is deeper and more highly colored on the narrow belt of limestone east of White Oak mountain than on the broader belts of the same rocks above mentioned. The clay soils derived from the Cambrian shales are somewhat less productive. The Apison, Connasauga and Rome shales make stiff bluish gray soils which are usually thinner than those covering the limestones, the shaly structure often appearing a few inches below the surface.

All of these clay soils are well fitted to retain fertilizers, and hence with proper treatment may be brought to a high state of productiveness.

**Cherty soils.**—More than half of the area east of Walden ridge is underlain by the Knox dolomite. The soil derived from this formation consists of clay in which chert is imbedded. The proportion of chert to clay is variable; in some places only occasional fragments occur, while in others the residual material is made up almost wholly of chert. Where the clay predominates the soil is deep red, but becomes lighter with the increase in amount of chert, and in extreme cases is light gray or white. Even when the proportion of chert is very large this is a strong productive soil, especially adapted to fruit-raising. The soil derived from Fort Payne chert is similar to that from the Knox dolomite, but the areas of the Fort Payne are much smaller and usually on steep slopes, so that its soil is relatively unimportant.

**Alluvial soils.**—Excepting the gorges of the Tennessee through Walden ridge, the streams of this region flow in broad valleys but they are rapidly cutting narrow channels below the general level of these valleys, so that these flood plains, the alluvium covered bottom lands, are nowhere extensive. The largest flood plains are along the Tennessee river northward from the entrance to its gorge. A strip of bottom land from a quarter of a mile to half a mile wide usually occurs along one side of the river with a bluff upon the opposite side. The soil of these bottoms is a rich sandy loam, containing a considerable proportion of fine mica scales derived from the crystalline rocks far to the east. Some areas of alluvial soil also flank the smaller streams, especially South Chickamauga creek and Sequatchie river, constituting the most continuously productive land of this region.

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