RINGGOLD ATLAS SHEET.

DESCRIPTIVE TEXT.

GEOGRAPHY.

General relations.—The Ringgold atlas sheet is bounded by the parallels of latitude 34° 30′ and 35°, and the meridians of longitude 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 28.3 miles from east to west, and it contains 980 square miles. The adjacent atlas sheets are Chattanooga on the north, Dalton on the east, Rome on the south, and Stevenson on the west. The Ringgold sheet lies mainly within the State of Georgia, but a narrow strip about a mile in width along its northern edge lies in Tennessee. It embraces portions of Dade, Catoosa, Walker, Whitfield, Chattooga, Floyd and Gordon counties in Georgia, and portions of Madison, Hamilton and James counties in Tennessee.

Topography.—The country embraced within the atlas sheet is marked by three distinct types of topography. These are determined both by differences in the character of the underlying rocks, and by geologic structure or the relation of the strata to the surface. The three types of surface are (1) plateaus, (2) sharp ridges, (3) undulating or level valleys.

The plateaus are confined to the western third of the sheet. They include Lookout and Pigeon mountains and a small portion of Sand mountain. Pigeon mountain is simply a spur of Lookout, separated from it at its northern point by McLamore cove, but merging with it toward the south. The plateaus have an altitude of about 2,000 feet above sea level, though numerous points about the edge rise from one to four hundred feet higher. The surface is generally level or rolling with a slight inclination from the edges toward the center, giving the mountains the form of shallow troughs. They are usually bounded by abrupt escarpments rising from 1,000 to 1,200 feet above the surrounding valleys. The drainage of the plateau is influenced by the inclination of the strata, which dip slightly from the escarpments toward the axes of the mountains. In the shallow troughs thus formed along the axes the streams flow for considerable distances before breaking through notches in the rim and descending by falls and rapids to the outer valley. Thus Little river, which rises on Lookout mountain opposite Johnson crook, flows toward the southwest for thirty-eight miles before leaving the summit of the plateau. Its channel becomes a deep rocky gorge a few miles before emerging upon the valley, though in its upper course it is but little below the general level of the plateau.

The second type of surface is confined to the eastern third of the sheet. The sharp ridges by which it is characterized are, like the plateaus to the west, produced by hard sandstones which offer much greater resistance to erosion than the rocks above and below. The difference between the plateaus on the west and the ridges on the east is due to the dip of the hard strata, which in the plateaus are nearly horizontal, while in the ridges they are steeply inclined.

The westernmost of these is Taylor ridge, which extends entirely across the sheet and continues northward as White Oak mountain. It preserves throughout the sheet an elevation of about 1,400 feet above sea level, or 500 to 600 feet above the valley. Its western face is steep and uniform, while its eastern face has a much gentler and less even slope. The next prominent ridge to the east is John mountain, which terminates abruptly nine miles from the southern edge of the sheet. Its trend is parallel to that of Taylor ridge, and its altitude is somewhat greater, as the Rockwood sandstones, which form the ridges, increase in thickness toward the east. Along the eastern edge of the sheet are Horn, Mill Creek, Chattoogata, and Rocky Face mountains, a series of short overlapping ridges, each terminating abruptly a few miles further toward the north than the one next westward.

Between Lookout mountain and Taylor ridge is a broad valley forming a belt of comparatively low land across the sheet. About the center of the sheet is the divide between the branches of Chickamauga creek, which flow northward into the Tennessee, and the Chattooga river, which flows south toward the Gulf. The divide is not a sharp line at which the waters part, but is a considerable area on which they flow indifferently in either direction. This has an elevation of only about 250 feet above the Tennessee at Chattanooga; hence, if the valley were lowered that amount the waters of the Tennessee would flow directly south to the Gulf instead of northwest to the Ohio river.

This low land between Lookout mountain and Taylor ridge is a part of the great Appalachian valley which extends from Pennsylvania to central Alabama. It is underlain by rocks which are more easily eroded than the hard sandstones of the adjoining highlands. They are mostly calcareous shales and limestones, which are removed largely by solution. The beds containing a large proportion of insoluble matter form low rounded hills and ridges, but these seldom rise more than 200 or 300 feet above the general level of the valley. East of Taylor ridge is a belt of low land similar to the one occupying the center of the sheet, but somewhat narrower and having its surface more broken by subordinate ridges. Its waters flow partly north to the Tennessee and partly south directly to the Gulf.

STRATIGRAPHY.

All the rocks appearing at the surface within the limits of the Ringgold atlas sheet are of sedimentary origin, that is, they were deposited by water. The materials of which they were composed were mud, sand and pebbles, derived from some older rocks, or the remains of plants and animals which lived while the strata were being laid down. 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 clayey shales. Their most striking peculiarity is the brilliant coloring which they display in sharply contrasted bands of red, purple, green and yellow. The thickness of these shales is not known, since they are always limited on one side by a fault, but at least 1,000 feet are exposed at some localities on the sheet. The name of the formation is taken from Apison, Tennessee, in the southeastern part of the Chattanooga sheet.

Rome formation.—Next above the Apison shale are the sandstones and shales of the Rome formation. They are probably 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 portion of the formation, from 1,500 to 2,000 feet thick, 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 thin 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 shales, 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 limestone, as is the case in the central part of this sheet. 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 in the case of the two older formations. The formation takes its name from the Connasauga valley, in Georgia, on the Dalton sheet.

The Cambrian rocks come to the surface in a narrow strip of nearly uniform width, which extends through the center of the sheet, forming Chattooga and Peavine valleys. Another similar strip occupies the eastern part of the Chattooga valley, terminating a few miles from the southern edge of the sheet. In these Cambrian areas west of Taylor ridge only the Connasauga is exposed, or if the upper portion of the Rome comes to the surface it is so calcareous as to be indistinguishable from the overlying formation.

East of Taylor ridge is a somewhat broader area of Cambrian rocks. It is bounded by a fault on its western side, and against this fault strips of the oldest rocks appear. These are followed by the later formations in successive parallel bands toward the east. On the extreme eastern edge of the sheet, in its southeastern corner, are Cambrian rocks, which are also bounded on the west by a fault with some peculiar features to be described later.

Of the Cambrian formations only the Rome sandstones make ridges, all the others giving rise to low, level valleys.

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 forms a broad area east of Lookout mountain extending southward to a narrow point in McLamore cove. It also forms a strip on either side of the Cambrian rocks of Chattooga and Peavine valleys. Its outcrops are marked by the characteristic rounded chert hills, which rise between 300 and 400 feet above the general level of the valley in Missionary ridge and Chickamauga hills. The formation also occurs in a number of less regular strips between Taylor ridge and Chattoogata mountain, in some of which the chert forms well marked ridges.

Chickamauga limestone.—This formation shows a decided change in character between its exposures on the western and the eastern sides of the sheet. In Lookout valley it is a hard, blue, flaggy limestone, about 1,000 feet thick, and highly fossiliferous. In the narrow strip along the eastern side of Lookout mountain, and in the broader area of West Chickamauga valley, from which the formation takes its name, it is mainly a blue limestone, but it contains some beds of mottled, purple and dove-colored limestone. In the belt along the western side of Chattoogata mountain, the formation shows a still further increase in thickness and in the proportion of earthy impurity which the limestone carries. It consists of about 1,800 feet of purple or dove-colored earthy limestone with some blue fossiliferous beds and others which weather to yellow shales.

Rockwood formation.—This upper division of the Silurian varies widely in character and thickness within the limits of the sheet. On the western edge of the sheet in Lookout valley and Johnson crook, it consists of about 600 feet of calcareous shales with some blue limestone interbedded. East of Lookout mountain it is somewhat thicker and contains no limestone, but some beds of rather sandy shales. In White Oak mountain it is from 1,100 to 1,300 feet thick, and consists largely of hard, reddish brown sandstones, with sandy shales above and below. On the eastern edge of the sheet, in the ridges of the Chattoogata range, the Rockwood formation reaches the thickness of about 1,500 feet. It is here capable of subdivision into three parts, and is so represented on the map. The lower portion consists of thin purple sandstones interbedded with yellow sandy shales. The middle portion of about 400 feet consists of heavy sandstone with a few interbedded shales. One bed of coarse sandstone and conglomerate, from 50 to 75 feet thick, forms the sharp crest of the ridges. The upper portion of the formation is composed of yellow shales and coarse porous sandstone which probably contained a considerable amount of calcareous matter.

The formation is named from Rockwood, Tennessee, on the Kingston atlas sheet. It is of great practical importance on account of the red fossil iron ore generally associated with it. The ore, however, is not always present, and on this sheet it is confined to the portions of the formation which are found west of Taylor ridge.

DEVONIAN ROCKS.

Chattanooga black shale.—Overlying the Rockwood formation, except in the extreme eastern part of the sheet, 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. This formation, called the Chattanooga black shale, has a remarkably uniform character wherever seen within the limits of the sheet and for a long distance on either side, north and south. In the western part of the sheet it is about 35 feet thick, in Taylor ridge 11 feet, and it is wanting in the ridges of the Chattoogata range. Whether the shale was originally deposited over the whole of this region and then eroded before the succeeding formation was laid down, or was never deposited in the eastern portion, is a question not yet satisfactorily answered. The upper portion of the shale, three or four feet in thickness, 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 at a uniform depth, over considerable areas.

CARBONIFEROUS ROCKS.

Fort Payne chert.—This formation consists of from 75 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 lime 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 Taylor ridge 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 numbers of fossils which it contains. It is often made up of a mass of crinoid 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 each side of Lookout valley and along the eastern side of Lookout and Pigeon mountains, usually forming, with the Rockwood shale, a narrow ridge parallel to the mountain escarpments. In the eastern part of the sheet the formation covers somewhat larger areas, occupying the gentle eastward slopes of the high Rockwood ridges. The formation name is taken from Fort Payne, Alabama, on the Fort Payne sheet.

Floyd shale.—As before stated, the chert, on the western portion of the sheet, passes upward directly into the Bangor limestone, but east of Taylor ridge another formation, the Floyd shale, comes in between them. This consists of from 850 to 1,350 feet of variable sediments, for the most part carbonaceous shales, containing local beds of coarse white sandstone, and of fine grained, flaggy sandstone, and some of blue limestone with nodules of chert. The sandstones are mostly confined to the synclinal basin east of White Oak mountain, between Ringgold and Parker gaps. In Armuchee valley and in the regions east of John and Horn mountains the formation is made up of black carbonaceous shales, which approach limestones in character in the western part of the area. These calcareous portions are highly fossiliferous, though the black shales are generally quite barren of organic remains.

Bangor limestone.—The Bangor limestone is 750 feet thick in the western part of the sheet, where it forms the lower portion of the mountain slopes. East of Taylor ridge it is about 500 feet thick, and only two small areas have escaped erosion, though it doubtless formed a continuous sheet over the whole of this region, and may have extended some distance farther eastward. The limestone shows with unmistakable clearness the mode of its formation. It is often 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. 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 and Pigeon mountains. The formation occurs in but three small areas east of Taylor ridge and apparently has a thickness of only about 200 feet, though the upper part may have been removed by erosion.

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, and its greatest thickness of 930 feet is found in the deeper portions of the Lookout mountain syncline.

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 at various angles with the surface. 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 which runs lengthwise of the synclinal trough, at every point occupying its lowest part, and 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 six 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 strata observed at the surface. On the scale of the map they cannot 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.

Anticlinal and synclinal folds.—It will be seen from the sections that the strata form a series of nearly parallel folds which trend about N. 15° E. In the western part of the sheet the folds are open and the beds generally dip at low angles, though in a few cases they approach the vertical. East of Taylor ridge they are often vertical or overturned, and in many places their normal relations are disturbed by faults. Thus, from the western to the eastern sides of the sheet, there is a progressive increase in the degree of disturbance which the rocks have suffered.

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.

In Lookout valley the strata dip away from the middle at low angles, though somewhat more steeply toward the west than the east. The same is true in McLamore cove, and also in the broad valley extending through the center of the sheet where the difference in dip on opposite sides of the axis is much greater. A short distance west of Lookout valley the rocks become practically horizontal, forming the broad plateau of Sand mountain. The axis of the Lookout mountain syncline forks at the head of Johnson crook, the western limb passing off the sheet, and the eastern uniting toward the south with the axis of the Pigeon mountain syncline. The syncline whose western edge forms Taylor ridge is not a simple trough, like those to the west, but is broken up into isolated basins by a number of transverse anticlines. One of the latter is represented in section EE, separating the basin which forms West Armuchee valley from Dirt Town valley on the south. The ridges from John mountain to Rocky Face are formed by a number of overlapping synclines whose axes pitch rapidly toward the south. The valleys on the northwest of this series of ridges are deeply eroded anticlines, while those on the southeast are synclines, which carry the ridge-forming stratum below the general valley level.

Faults.—Excepting a small area on the north edge of the sheet, just east of Lookout mountain, the faults are confined to the region east of Taylor ridge. They 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.

The eastern side of the Taylor ridge syncline, except for a short distance where it appears as Dick ridge, is sheared off by a fault which extends for many miles north and south beyond the limits of the sheet. This fault brings the oldest rocks of the region in contact at different places with all the overlying formations up to the Bangor limestone. Several faults of lesser importance occur north and east of Tunnel Hill, and one of even greater extent follows the eastern side of Chattoogata mountain and crosses the southeastern corner of the sheet. The latter is shown in section EE, and it has the peculiarity that the plane on which the older rocks were thrust over from the east was nearly horizontal and has been folded with the underlying strata.

MINERAL RESOURCES.

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

Coal.—The productive coal-bearing formations are the Lookout and Walden sandstones, which have already been described. They occupy, on this sheet, the surface of Lookout and Pigeon mountains and a small portion of Sand mountain, a total area of 116 square miles.

The accompanying columnar sections 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, though it is probable that in some of the sections by no means all of the beds are shown. 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 plane exactly, so that some uncertainty is thus introduced into the correlation of coal beds in 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—is from 450 to 550 feet. West of Lookout valley this division of the coal measures contains from three to five beds of coal, varying in thickness from a few inches to four feet. These beds are worked at Cole city and Castle rock, just west of the Ringgold sheet. They appear to thin out toward the east and only one is definitely located in Lookout mountain, though several thin beds probably exist below the conglomerate. This is shown in the section at the head of Johnson crook where its thickness, which may be only local, is five feet. On the western side of Lookout mountain, a few miles south, two beds, both of which have been worked, occur at about the same position as the one represented in the section.

In Sand mountain several beds of coal occur within less than 300 feet above the conglomerate, one of which is worked at the Ætna mines, ten miles west of Chattanooga. These beds are also represented in the southern portion of Lookout mountain, but, so far as known, they do not occur on the Ringgold sheet. At 540 and 615 feet above the conglomerate are beds of coal which are worked at the Durham mines on Lookout mountain. They very nearly correspond in position with the coal which is worked farther north in the Walden, at the Dayton and Rockwood mines. They lie in the center of the Lookout mountain syncline, and have been protected from erosion by the rim of heavy conglomerate which surrounds the basin. This rim has been cut through at McCallie gap and the higher rocks have been removed from the northern part of the basin by Rock creek and Long branch, so that only the southern portion contains coal.

In the broader portion of the syncline, where Pigeon and Lookout mountains unite, it is altogether probable that workable coal will be found either in the beds worked in the northern basin or in those nearer the conglomerate which are mined farther south at Fort Payne and Gadsden.

Iron ore.—Two varieties of iron ore, which differ widely in appearance and in their mode of occurrence, are found on the Ringgold sheet. They are the hematite, or red fossil ore, and the limonite, or brown ore. The former is limited to the western and the latter to the eastern part of the sheet.

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 other rock strata, however, it is not absolutely constant, so that, while the map indicates closely the areas within which the ore may occur, careful examination is required at any particular locality to determine whether its quantity and quality are such as to make it commercially valuable.

The proportion of iron in the ore usually decreases with the distance below 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 even when the bed is not of sufficient thickness to make deep mining profitable at present.

The upper part of the Rockwood formation, which carries the ore, occurs in a narrow strip on either side of Lookout valley, the strata dipping gently away from the middle of the valley. In Johnson crook the strata dip at a very low angle toward the north and east, and over a considerable area the ore bed is so near the surface that it is extensively mined by removing the few feet of overlying rock. A narrow strip of Rockwood shale follows the eastern base of Lookout mountain around the head of McLamore cove and the point of Pigeon mountain. A workable bed of ore occurs throughout nearly the whole of this strip, though at some points it is broken up into a number of thin beds by shale partings, so that it cannot be mined economically. It is worked at various points where proximity to the Chattanooga Southern railroad affords easy transportation.

The Rockwood formation in the eastern part of the sheet consists largely of hard brown sandstones and sandy shales, and the conditions which prevailed during their deposition were apparently not favorable to the formation of iron ore. On the same belt some miles toward the north there is a heavy bed of ore in the upper part of the formation, which decreases in thickness toward the south. In White Oak mountain it probably does not occur in workable quantities south of the Tennessee-Georgia line.

Mineral paint.—A subordinate though locally important use of the red hematite is as mineral paint. Only the purer grades of soft ore, from which the lime has been thoroughly leached, are employed for this purpose. Considerable quantities are mined in Lookout valley and ground on the spot. Mills in Chattanooga are also supplied from the same locality.

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 cannot be indicated with the same certainty as in the case of red ore. These deposits, however, are found to be associated with certain groups of strata, so that in a general way their position may be indicated. 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 iron ore.

In the southeastern portion of the sheet, conditions were favorable for this accumulation at certain points in the Carboniferous rocks, generally near the contact between the Fort Payne chert and the Floyd shale. Three areas are indicated on the map in which extensive deposits of limonite are known to occur, but these probably do not include all such deposits. The area west of Sugar valley has been extensively worked and the ore deposits have been generally exhausted. Three small areas in the vicinity of Tunnel Hill are indicated as containing deposits of limonite, but in these the iron ore is subordinate in importance to the manganese ore.

Manganese ore.—Oxide of manganese is accumulated under the same conditions and by the same agency as is oxide of iron, but it is much less widely distributed than the latter. The deposits at Tunnel Hill are along a fault line at the contact of Knox dolomite with Cambrian shales. The faulting seems in some way to have assisted in the accumulation of the ore, probably by affording an easy passage to the percolating waters, which held the iron and manganese in solution after it was leached out of the surrounding rocks. The ore is found in nodules and irregular masses associated with chert and red clay which result from the decomposition of the Knox dolomite, and which are always specially abundant in the vicinity of faults. The ore has been mined somewhat extensively at Tunnel Hill.

Limestone.—The supply of limestone on the Ringgold sheet, suitable for blast-furnace flux and for lime, is abundant and convenient of access. The Bangor limestone is used at the Rising Fawn furnace in Johnson crook, on account of its freedom from earthy impurities and its close proximity to the furnace. It contains variable amounts of magnesium carbonate, sometimes as much as 35 per cent.

The Knox dolomite is quarried extensively at Graysville, near the Tennessee line, and burned for lime. The silica which this formation contains in large amount is generally segregated in layers of chert; these are easily removed in quarrying, and the layers of limestone produce an exceptionally high grade of lime.

It is probable that some of the earthy Chickamauga limestones may be suitable for the manufacture of hydraulic cement, but no analyses are available on which to base definite statements as to their value.

Building stone.—Stone adapted to architectural uses occurs in nearly every formation within the area, but none is quarried except in a small way for local use. A few miles north of the Tennessee line, on the Chattanooga sheet, are quarries of dove-colored earthy limestone at the base of the Chickamauga, and beds of the same character are widely distributed over the central and eastern part of the Ringgold sheet. The red and purple earthy limestones and sandstones in the valley west of Rocky Face would seem particularly adapted for the trimmings employed in brick buildings. Sandstones suitable for foundations occur in White Oak mountain and the ridges to the east, and also in Lookout and Pigeon mountains. These have as yet been quarried only for local use.

Road material.—The hard blue Bangor and Chickamauga limestones afford an abundant supply of macadam, and the residual chert of the Knox dolomite and of the Fort Payne formation is an ideal surfacing material. These formations are so widely distributed over the sheet that but little transportation would be required to build excellent roads, but unfortunately, except in the vicinity of Chattanooga, the abundant road material is as yet wholly unutilized.

Clays.—The residual deposits resulting from the weathering of the Bangor and Chickamauga limestones are red or blue clays, which are generally well adapted for making brick. They are also suitable for the manufacture of drain tile, and considerable quantities have been obtained for that purpose from Blowing Springs, near the southern edge of the sheet, and from a point about four miles south of Lafayette, where the clay is obtained from calcareous Cambrian shales. Some of the highly siliceous clays resulting from the decomposition of the Knox dolomite are probably well adapted for the manufacture of refractory fire brick, and the beds of fire clay which are usually associated with the coal may contain materials suited to the same purpose, but they are as yet wholly undeveloped.

SOILS.

Derivation and distribution.—Throughout the region covered by the Ringgold 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 of the mountains, 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 to soil by surface water. This process goes on more or less rapidly, according to the character of the cement which holds the particles together. Siliceous cement is nearly insoluble and rocks in which it is present, such as quartzite and some sandstones, are extremely durable. They produce but a scanty soil. Calcareous cement, on the other hand, is readily dissolved by water containing carbonic acid, and the clayey or sandy particles which it held together crumble down, forming an abundant soil. If the calcareous cement makes up but a small part of the stone it is often leached below the surface; the rock then becomes soft and porous while retaining its form; 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. The soil is generally quite thin where the limestone 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 sedentary. If the rock is a sandstone or sandy shale the soil is sandy, and if it is a clayey shale or limestone the soil is clay. As there are abrupt changes from bed to bed of sandstone, shale and limestone, 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. And as the attitude of the stratum determines the breadth of outcrop of each formation in any place, it also determines the area of the corresponding soil. Where a stratum is nearly horizontal, as the the Chickamauga limestone of West Chickamauga valley, the corresponding soil covers a broad area, but where one outcrops in a nearly vertical position, as the same formation does just east of Pigeon mountain, the resulting soil occupies only a narrow strip.

If the character of the soils derived from the various geological formations be known, 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 upon the steep slopes where soils derived from rocks higher up the slope have washed down and mingled with or covered the soils derived from those below. These are called overplaced 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 east of Chattooga river, and the Rome sandstone. (2) Clay soils; derived from the Bangor and Chickamauga limestones, the Rockwood formation west of Chattooga valley, 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.—Lookout and Pigeon 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 it contains sufficient clay to make the subsoil so coherent 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 the proximity to streams and the consequent activity of erosion. A large part of the plateau retains its original forest growth, generally 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 east of Chattooga river is made up of sandstones and sandy shales, and the extensive areas of its outcrops have sandy soils. They are agriculturally less important than 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 on most of the high ridges in the eastern portion of the sheet. Two strips of the Rome sandstone east of Taylor ridge yield sandy soil, and the surface is so rocky as to be scarcely tillable.

Since the sandstones of this region occupy the highest land, the overplaced soils, or those washed down to lower levels, are mostly sandy. These sandy soils are especially abundant at the foot of the escarpment surrounding the plateau, where the Bangor limestone and its clay soil are often wholly concealed.

Clay soils.—The valleys of this region are due to the presence of narrow belts of soluble limestone or easily eroded shale, and they are therefore always occupied by clay soils, except immediately along the larger streams. The most productive of these soils 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 have generally 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 in West Chickamauga valley where the largest area of the limestone occurs. 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 Pigeon mountain than on the broader belt of the same rocks in Chickamauga valley. The clay soils derived from the Cambrian shales are somewhat less productive. The Connasauga shales and those in the upper part of the Rome formation make stiff bluish gray soils which are usually thinner than those covering the limestones, the shaly structure of the rock 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.—Nearly half the area west of the plateau is underlain by the Knox dolomite. The soil derived from this formation consists of clay in which the 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 it becomes lighter with the increase in amount of chert, and in extreme cases is light gray or white. Even where the proportion of chert is very large this is a strong productive soil, especially adapted to fruit raising. The soil derived from the Fort Payne chert is similar to that from the Knox dolomite, but the areas of the Fort Payne are much smaller and usually occur on steep slopes, so that its soil is relatively unimportant.

Alluvial soils.—These are confined to small areas along the Chickamauga, Chattooga, and Oostanaula rivers. Although these streams flow in broad valleys they are rapidly cutting narrow channels below the general level of these valleys, and their flood plains, the bottom lands, are nowhere extensive. Most of the streams flow between high banks above which they rarely rise. Along the Oostanaula the soil is a rich sandy loam containing a considerable proportion of fine scales of mica derived from crystalline rocks which lie far to the east.

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