DESCRIPTION OF THE GADSDEN QUADRANGLE.

GEOGRAPHY.

General relations.—The Gadsden quadrangle is bounded by the parallels of latitude 34° and 34° 30′ and the meridians of longitude 86° and 86° 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 28.6 miles from east to west, and it contains 986.29 square miles. The adjacent quadrangles are: on the north, Scottsboro; on the east, Fort Payne; on the south, Springville; and on the west, Cullman. The Gadsden quadrangle lies wholly within the State of Alabama, containing portions of Marshall, Dekalb, Etowah, Cullman, and Morgan counties.

In its geographic and geologic relations this quadrangle forms a part of the Appalachian province, which extends from the Atlantic coastal plain on the east to the Mississippi lowlands on the west, and from central Alabama to southern New York. All parts of the region thus defined have a common history, recorded in its rocks, its geologic structure, and its topographic features. Only a part of this history can be read from an area so small as a single quadrangle; hence it is necessary to consider the latter in its relations to the entire province.

Subdivisions of the Appalachian province.—The Appalachian province may be subdivided into three well-marked physiographic divisions, throughout each of which certain forces have produced similar results in sedimentation, in geologic structure, and in topography. These divisions extend the entire length of the province, from northeast to southwest.

The central division is the Appalachian Valley. It is the best defined and most uniform of the three. In its southern part it coincides with the belt of folded rocks which forms the Coosa Valley of Georgia and Alabama and the Great Valley of East Tennessee and Virginia. Throughout the central and northern portions the eastern side only is marked by great valleys—such as the Shenandoah Valley of Virginia, the Cumberland Valley of Maryland and Pennsylvania, and the Lebanon Valley of northeastern Pennsylvania—the western side being a succession of ridges alternating with narrow valleys. This division varies in width from 40 to 125 miles. It is sharply outlined on the southeast by the Appalachian Mountains and on the northwest by the Cumberland Plateau and the Allegheny Mountains. Its rocks are almost wholly sedimentary and in large measure calcareous. The strata, which must originally have been nearly horizontal, now intersect the surface at various angles and in narrow belts. The surface differs with the outcrop of different kinds of rock, so that sharp ridges and narrow valleys of great length follow the narrow belts of hard and soft rock. Owing to the large amount of calcareous rock brought up on the steep folds of this district its surface is more readily worn down by streams and is lower and less broken than the divisions on either side.

The eastern division of the province embraces the Appalachian Mountains, a system which is made up of many minor ranges and which, under various local names, extends from southern New York to central Alabama. Some of its prominent parts are the South Mountain of Pennsylvania, the Blue Ridge and Catoctin Mountain of Maryland and Virginia, the Great Smoky Mountains of Tennessee and North Carolina, and the Cohutta Mountains of Georgia. Many of the rocks of this division are more or less crystalline, being either sediments which have been changed to slates and schists by varying degrees of metamorphism, or igneous rocks, such as granite and diabase, which have solidified from a molten condition.

The western division of the Appalachian province embraces the Cumberland Plateau and the Allegheny Mountains, also extending from New York to Alabama, and the lowlands of Tennessee, Kentucky, and Ohio. Its northwestern boundary is indefinite, but may be regarded as a somewhat arbitrary line coinciding with the Tennessee River from the northeastern corner of Mississippi to its mouth and thence crossing the States of Indiana and Ohio to western New York. Its eastern boundary is sharply defined along the Appalachian Valley by the Allegheny front, the Cumberland escarpment, and Lookout Mountain. The rocks of this division are almost entirely of sedimentary origin and remain very nearly horizontal. The character of the surface, which is dependent on the character and attitude of the rocks, is that of a plateau more or less completely dissected, or, elsewhere, of a lowland. In the southern half of the province the surface of the plateau is sometimes extensive and perfectly flat, but oftener it is much cut by stream channels into large or small flat-topped hills. In West Virginia and portions of Pennsylvania the plateau is sharply cut by its streams, which have left in relief irregularly rounded knobs and ridges bearing but little resemblance to the original surface. The western portion of the plateau has been completely removed by erosion and the surface is now comparatively low and level or rolling.

Altitude of the Appalachian province.—The Appalachian province as a whole is broadly dome-shaped, its surface rising from an altitude of about 500 feet above sea-level along the eastern margin to the crest of the Appalachian Mountains, and thence descending westward to about the same altitude on the Ohio and Mississippi rivers.

Each division of the province shows one or more culminating points. Thus the Appalachian Mountains rise gradually from less than 1000 feet in Alabama to more than 6600 feet in western North Carolina. From this culminating point their altitude decreases to 3000 feet in southern Virginia, then rises to 4000 feet in central Virginia, and finally descends to 2000 or 1500 feet on the Maryland-Pennsylvania line.

The Appalachian Valley shows a uniform increase in altitude from 500 feet or less in Alabama to 900 feet in the vicinity of Chattanooga, 2000 feet at the Tennessee-Virginia line, and 2600 or 2700 feet at its culminating point, on the divide between the New and Tennessee rivers. From this point it descends to 2200 feet in the valley of New River, 1500 to 1000 feet in the James River Basin, and 1000 to 500 feet in the Potomac Basin, remaining about the same through Pennsylvania. These figures represent the average elevation of the valley surface, below which the stream channels are sunk from 50 to 250 feet, and above which the valley ridges rise from 500 to 2000 feet.

The altitude of the plateau, or western, division increases from 500 feet at the southern border of the province to 1500 feet in northern Alabama, 2000 feet in central Tennessee, and 3500 feet in southeastern Kentucky. It is between 3000 and 4000 feet in West Virginia, and decreases to about 2000 feet in Pennsylvania. From its greatest altitude, along the eastern border, the plateau slopes gradually westward, although it is generally separated from the interior lowlands by an abrupt escarpment.

Drainage of the Appalachian province.—The drainage of the province is in part eastward into the Atlantic, in part southward into the Gulf, and in part westward into the Mississippi. All of the western, or plateau, division of the province, except a small portion in Pennsylvania and another in Alabama, is drained by streams flowing westward to the Ohio. The northern portion of the eastern, or Appalachian Mountain, division is drained eastward to the Atlantic, while south of the New River all except the eastern slope is drained westward by tributaries of the Tennessee or southward by tributaries of the Coosa.

The position of the streams in the Appalachian Valley is dependent upon the geologic structure. In general they flow in courses which for long distances are parallel to the sides of the Great Valley, following the lesser valleys along the outcrops of the softer rocks. These longitudinal streams empty into a number of larger, transverse rivers, which cross one or the other of the barriers limiting the valley. In the northern portion of the province they form the Delaware, Susquehanna, Potomac, James, and Roanoke rivers, each of which passes through the Appalachian Mountains in a narrow gap and flows eastward to the sea. In the central portion of the province, in Kentucky and Virginia, these longitudinal streams form the New (or Kanawha) River, which flows westward in a deep, narrow gorge through the Cumberland Plateau into the Ohio River. From New River southward to northern Georgia the Great Valley is drained by tributaries of the Tennessee River, which at Chattanooga leaves the broad valley and, entering a gorge through the plateau, runs westward to the Ohio. Southward from an irregular line crossing northern Georgia and Alabama the streams flow directly to the Gulf of Mexico.

Topography of the Gadsden quadrangle.—This quadrangle lies for the most part in the western, or plateau, division of the Appalachian province as defined above. Its surface consists of broad, level plateaus alternating with narrow valleys. The character and position of both plateaus and valleys are closely connected with the character of the underlying rocks and with the geologic structure, or the relation of the strata to the surface.

The northwestern portion of the quadrangle is occupied by the Cumberland Plateau. This is cut through by the Tennessee River, and the portion north of the river is much dissected by the smaller streams, leaving a number of isolated remnants of the plateau, or mesas. They have an altitude of 1100 or 1200 feet, with smooth, level summits and steep slopes to the surrounding valleys. The central portion of the quadrangle is occupied by Sand or Raccoon Mountain, which has much the same character as the Cumberland Plateau. Its western edge forms a bold escarpment facing Browns Valley. The escarpment increases in height toward the north and is broken by a number of deep notches cut by the streams flowing westward from the plateau. As far back as the streams have cut down to the limestone they flow in narrow canyons, while their upper courses are in rather shallow channels upon the sandstone. Its surface is not so deeply cut by stream channels as the Cumberland Plateau, and there are many large areas almost perfectly smooth and so densely wooded that one may travel many miles without intimation that it is not a low as well as level country. Its altitude is a little over 1100 feet in the northern part of the area and about 1000 feet in the southern part. The southern extremity of Lookout Mountain occupies a small tract in the southeastern part of the quadrangle. Although essentially a plateau, its surface is not level, but is highest at the edges, sloping gradually toward the center and forming a broad, gentle trough.

All these plateaus are limited by steep escarpments from 600 to 1000 feet in height. The form of the escarpments is due to the relation of hard and soft rocks in the plateaus. By the terms "hard" and "soft" in this connection is meant greater or less capacity for resisting erosion, both corrasion by streams and solution by percolating waters. At the surface of the plateaus are hard sandstones, which resist erosion, while below are shales and limestones, which are readily worn down by the streams or removed by solution. The hard sandstone capping is constantly undermined and breaks off, forming cliffs. Thus the upper part of the escarpment is usually very steep and is frequently composed of vertical cliffs, while the lower portion has gentler slopes covered with fragments of sandstone from the cliffs above. This is the character not only of the escarpment which borders the outer portions of the plateaus, but also of that surrounding the numerous coves which penetrate the plateau from the sides.

Cumberland Plateau and Sand Mountain are separated by Browns Valley, which is occupied in part by the Tennessee River and in part by small tributaries. The valley is almost perfectly straight throughout its whole length of 150 miles, and is bounded either by unbroken escarpments or by salient mesas which terminate upon a common line. This linear character is the most striking feature of the valley, and is due to the regularity of the fold on which it is located. The rocks once arched continuously across from the Cumberland Plateau to Sand Mountain, forming a ridge where the valley now is. The upper rocks composing the arch have been entirely removed, and the underlying easily erodible limestones, being brought higher in the arch than elsewhere, were earlier exposed to erosion. The valley, therefore, was excavated upon them. The rocks in the eastern escarpment dip a few degrees away from the valley, and in some places in the extreme edge of the Cumberland Plateau they are found also dipping away from the valley. The altitude of the valley is between 700 and 800 feet, with rounded hills rising from 100 to 150 feet higher, while the Tennessee River and its larger tributaries flow at a little over 600 feet. South of Guntersville the valley is separated into two narrow subordinate valleys by a ridge 300 or 400 feet high, lying parallel to the escarpments.

Murphree Valley is very similar to Browns Valley except that it is terminated toward the north, the escarpments passing continuously around its head and enclosing Bristow Cove, which is a part of the valley. It is also separated into two valleys by a low ridge parallel with the western escarpment.

Wills Valley is less smooth and regular than the valleys to the west, the difference being due to the character of the underlying rocks. From Atala northward the valley between the escarpments of Lookout and Sand mountains is separated into two distinct valleys by a ridge which is nearly as high as the escarpments.

The foregoing description and an examination of the topographic map show that in this region there are two plains whose surfaces are nearly parallel and are separated by a vertical distance of from 400 to 600 feet. The lower plain is apparent in the uniform altitude to which the hilltops in the valleys rise. The upper plain is the general surface of the plateau, below which the stream channels are deeply cut and above which rise a few hills and mesas.

Areas of these two plains have been recognized over nearly the entire Appalachian province, separated by a varying vertical distance, and their relations throw much light upon the history of the province during the later geologic ages. This region formerly stood much lower than now, so that the present plateau, the higher plain, was near sea-level. The land was worn down by streams flowing upon its surface till it was reduced to a nearly even plain, with only here and there a low hill remaining, where the rocks were unusually hard or where they were protected from erosion by their position. Since the surface was not perfectly reduced this is called a *peneplain*, and since it was formed near the lowest possible level of erosion it is called a *baselevel peneplain*. After the surface of the land had become reduced nearly to sea-level this region was elevated from 400 to 600 feet and at the same time tilted southward. The streams, which had become sluggish, were at once stimulated to renewed activity and began rapidly to sink their channels into the peneplain. Erosion progressed most rapidly upon soft rocks, so that in the western part of this district, where the sandstone capping was thin, and on the anticlines, where limestone formed the surface, the streams quickly sunk their channels down nearly to the new baselevel of erosion, and then, by broadening their valleys, began the formation of a new peneplain. The old peneplain was preserved at the higher level, where the hard rocks capped the plateau. After the formation of the second peneplain was well advanced upon areas of soft rock, the region was again lifted and the streams began cutting their present channels within the last-formed peneplain.

GEOLOGY.

STRATIGRAPHY.

The sedimentary record.—All the rocks appearing at the surface within the Gadsden quadrangle are of sedimentary origin; that is, they were deposited by water. They consist of sandstones, shales, and limestones, presenting great variety in composition and appearance. The materials of which they are composed were originally gravel, sand, and mud, derived from the waste of older rocks, 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 probably covered low, swampy shores.

These rocks afford a record of almost uninterrupted sedimentation from early Cambrian to late Carboniferous time. Their composition and appearance indicate at what distance from shore and in what depth of water they were deposited. Sandstones marked by ripples and cross-bedded by currents, and shales cracked by drying on mud flats, indicate shallow water; while limestones, especially by the fossils they contain, indicate greater depth of water and scarcity of sediment. The character of the adjacent land is shown by the character of the sediments derived from its waste. Coarse sandstones and conglomerates, such as are found in the Coal Measures, were derived from high land, on which stream grades were steep, or they may have resulted from wave action as the sea encroached upon a sinking coast. Red sandstones and shales, such as make up some of the Cambrian and Silurian formations, result from the revival of erosion on a land surface long exposed to rock decay and oxidation, and hence covered by a deep residual soil. Limestones, on the other hand, if deposited near the shore, indicate that the land was low and that its streams were too sluggish to carry off coarse sediment, the sea receiving only fine sediment and substances in solution.

The sea in which these sediments were laid down covered most of the Appalachian province and the Mississippi Basin. The Gadsden quadrangle was near its eastern margin at certain stages of sedimentation, and the materials of which its rocks are composed were probably derived largely from the land to the east. The exact position of the eastern shore-line of this ancient sea is not known, but it probably varied from time to time within rather wide limits.

Two great cycles of sedimentation are recorded in the rocks of this region. Beginning with the first definite record, coarse sandstones and shales were deposited in early Cambrian time along the eastern border of the interior sea as it encroached upon the land. As the land was worn down, and perhaps still further depressed, the sediment became finer, until in the Knox dolomite and Chickamauga limestone of the Silurian period very little trace of shore material is seen. Following this long period of quiet was a slight elevation, producing coarser rocks. Following this elevation, which completed the first great cycle, came a second period, during which the land was low, probably worn down nearly to base-level, affording conditions for the accumulation of the Devonian black shale and Carboniferous limestone, which in general show very little trace of shore waste. A second great uplift brought these rocks into shoal water, and in some places above the sea, and upon them were deposited, in shallow water and swamps, the sandstones, shales, and coal beds of the Carboniferous. Finally, a further uplift at the close of the Carboniferous stopped the deposition of sediment in the Appalachian province, except along its borders in recent times.

CAMBRIAN ROCKS.

Conasauga shale.—The oldest rocks exposed within the boundaries of the quadrangle are found in the Coosa Valley south of Gadsden and Atala. They consist of greenish clay-shales with beds of blue, seamy limestone. The latter vary in thickness from a fraction of an inch to many feet, and their disposition in the shales is apparently quite irregular. The beds are usually bent and fractured and the fragments recemented by calcite, which forms a reticule of white veins in the blue limestone. The formation is separated from the other rocks of the region by a fault, so that its relations to the overlying formations do not appear on the Gadsden sheet. The rocks are so highly contorted that no measurement can be made of their thickness, but it may be at least several thousand feet.

SILURIAN ROCKS.

Knox dolomite.—The lowest division of the Silurian, the Knox dolomite, consists 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. Upon weathering, that part of the rock which consists of the carbonates of lime and magnesia is dissolved, leaving behind the insoluble chert imbedded in red clay. This residual material covers the surface to considerable depths, and the dolomite itself is seldom seen except in the stream channels. The whole thickness of the formation is not exposed at any point in the Gadsden quadrangle, but in the next one eastward it is seen to be between 3000 and 3500 feet.

Excepting a very small area in Browns Valley south of Warrenton, the Knox dolomite is confined to narrow strips in the valleys of the southeastern part of the quadrangle. In Murphree Valley and Bristow Cove the normal relations of the dolomite to the overlying formations are seen only on the northwestern side; on the southeast the dolomite is in contact with Carboniferous rocks along a fault, the intervening formations being entirely concealed. In Wills Valley the normal relations of the Knox are seen on the southeastern side, while on the northwest it is limited by a fault which brings it in contact at different points with all the higher formations.

Chickamauga limestone.—Next above the Knox dolomite is a formation named from its typical development in the Chickamauga Valley in Georgia. It is generally a fine-grained, blue limestone, separating into slabs a few inches in thickness, which are so hard as to ring when struck with a hammer. It is highly fossiliferous, and in this respect differs widely from the underlying Knox dolomite, which rarely contains any traces of organisms. The thickness of the formation varies from 700 to 1000 feet, increasing gradually to the eastward.

The most extensive exposure of Chickamauga limestone within the quadrangle is in Browns Valley, where the rocks have generally low dips. In Murphree and Wills valleys the dips are steeper and the width of the outcrops is consequently less. On the northwest side of Wills Valley the Chickamauga is not in a continuous belt, being partly concealed by the Knox dolomite along the fault already mentioned.

The passage from the dolomite upward into the Chickamauga limestone is usually rather abrupt, but shows no unconformity or break in the deposition. In the southern part of Wills Valley, however, there is a heavy bed of breccia or conglomerate at the bottom of the Chickamauga. It is composed of angular or slightly rounded fragments of chert imbedded in a limestone cement. In some places these chert pebbles are few and scattered, while in others they make up nearly the whole mass of the rock. This bed of breccia or conglomerate indicates a period of disturbance at the close of the Knox dolomite epoch, when the rocks already deposited were elevated above sea-level to the southward of this region, so that they suffered some local erosion, the more durable portions being redeposited on the adjacent sea-bottom.

Rockwood formation.—This, the upper, division of the Silurian rocks varies somewhat widely in character between its western and eastern exposures. In the northern part of the quadrangle, in Browns Valley, it consists of less than 200 feet of fine calcareous shales with some beds of blue limestone; farther south in Browns Valley, at Summit and in Bristow Cove, it is somewhat thicker, ranging from 300 to 500 feet, and contains some beds of brown, sandy shale along with the calcareous beds. In Wills Valley the formation shows a still further increase in thickness to 650 feet, of which a considerable portion is thin-bedded brown sandstone.

The formation takes its name from Rockwood, Tennessee (Kingston quadrangle). It is of great practical importance on account of the beds of red fossil iron ore which it generally contains. These are described under the heading Mineral Resources.

The formation occupies a continuous narrow strip near the center of Browns Valley and a narrower strip not entirely continuous along its northwestern side. In Murphree and Wills valleys also there is one continuous strip of the formation, and another at intervals along the faults.

DEVONIAN ROCKS.

Chattanooga black shale.—Overlying the Rockwood formation is a thin stratum of shale, which appears to represent the whole of the deposition that 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 boundaries of this quadrangle and for a long distance on either side north and south. It varies in thickness from 20 to 40 feet. The upper portion of the shale, 2 or 3 feet thick, is usually dark greenish-gray in color, and often carries near its top a layer of round phosphatic 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 resembling that of petroleum. In most cases the beds appear to be parallel and perfectly conformable with the underlying formation, but at some points, as at Guntersville, there is evidence of unconformity between the Silurian and Devonian. Thin lenses of conglomerate with seams of blue clay and coal, the latter half an inch or less in thickness, indicate the presence here of a land surface during a part of Devonian time, with some erosion of the underlying Silurian rocks.

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 for various ores, especially silver and copper. Such exploitation, however, has always been attended by failure, since there is nothing of present economic importance in the shale. Although it contains a large proportion of carbonaceous matter, which burns when placed in a hot fire, the amount is not sufficient to constitute a fuel, and no true coal in beds sufficiently thick to have economic value 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 in the Gadsden area only as a starting-point in prospecting for the red fossil iron ore, which occurs below it at a uniform depth over considerable areas.

In western-middle Tennessee the Chattanooga formation is of economic importance, since it there contains a bed of phosphate rock, at places 3 feet thick. This bed, however, does not extend so far east as this quadrangle, at least not with sufficient thickness to be commercially valuable.

CARBONIFEROUS ROCKS.

Fort Payne chert.—This formation consists of from 200 to 300 feet of very siliceous limestone. At the base, resting on the Chattanooga black shale, are usually heavy beds of chert with a small amount of limestone or greenish calcareous shale. The proportion of chert decreases upward, being replaced by limestone or shale. The top of the formation is not sharply defined, and the line separating it from the formations above is somewhat arbitrary. The Fort Payne chert is readily distinguished from that of the Knox dolomite by the great numbers of fossils which it contains. The rock is often made up of a mass of crinoid stems imbedded in a siliceous cement, which on weathering remains as a porous chert filled with fossil impressions.

The formation occurs in narrow strips in the valleys, continuous along the normal side and interrupted along the faulted side; and with the underlying Chattanooga and Rockwood shales it forms the low ridges which extend parallel with the plateau escarpments. The name of the formation is taken from Fort Payne, Alabama (Fort Payne quadrangle).

Oxmoor sandstone.—The Fort Payne chert in the region to the north of this usually merges into the overlying Bangor limestone, but over most of the Gadsden quadrangle another formation intervenes. This consists of coarse, white, sugary sandstone, evidently quite calcareous when unweathered, but always appearing friable and porous at the surface. It is from 260 to 350 feet thick in the southern part of Browns Valley, and entirely disappears before reaching the northern border of the Gadsden quadrangle; it is 380 feet thick in Murphree Valley below Walnut Grove, and somewhat thicker at Atala, but thins northward and disappears within a few miles. The Oxmoor sandstone doubtless corresponds in time of deposition to some of the upper beds of shale or limestone in the Fort Payne formation, and represents a rapid local deposition of coarse material brought in from the south. Dark-colored, calcareous shales occur at Atala and Guntersville between the Oxmoor and the Fort Payne. These probably represent the thin western edge of a formation, the Floyd shale, which attains a very great thickness toward the east. In the Gadsden quadrangle they are always deeply covered by soil from formations on either side, and are seen only in deep wells or other artificial exposures, so that no attempt has been made to map their outcrops.

Bangor limestone.—The Bangor limestone is from 500 to 800 feet thick and everywhere forms the steep slopes of the plateau escarpments. It shows clearly the mode of its formation, being often composed almost entirely of fragments of crinoids together with the calcareous coverings of other sea animals which left their remains to accumulate on the sea-bottom. The limestone usually occurs in heavy beds, though the upper portion often weathers to brightly colored clay-shales. Nodules of chert are frequent in the limestone, and in the southern part of Browns Valley a heavy bed of white sandstone occurs near the middle of the formation.

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 a luxuriant vegetation, which formed beds of coal. The Lookout sandstone includes from 60 to 570 feet of conglomerate, thin-bedded sandstone, and sandy and clay shales between the top of the Bangor limestone and the top of a heavy bed of conglomerate. This conglomerate is not invariably present, being in some places replaced by a coarse sandstone. Wherever present it resists erosion more than the beds above or below, and so forms a cliff, usually the edge of the plateau escarpments. It is generally separated from the Bangor limestone by several hundred feet of sandstone and shale, which farther north contains two or three beds of coal. In the western side of Murphree Valley, however, the conglomerate is seen to rest directly upon the limestone. The Lookout sandstone forms the capping of the plateau remnants, or mesas, which occupy the northern part of the quadrangle. In Sand and Lookout mountains it is covered by another formation, and appears only as a narrow border about these plateaus.

Walden sandstone.—This formation includes all the rocks of this region 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 underlying formation. The conditions, however, were probably more uniform and 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 originally formed an unbroken sheet over the whole of this region, and still occupies the surface of the plateaus, with a thickness of about 500 feet on some portions of Sand Mountain.

These two formations, the Lookout and Walden sandstones, constitute the coal measures. The coal will be described under the heading Mineral Resources.

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

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. When any particular bed is followed for a considerable distance it is often found forming 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.* The rocks are also altered by production of new minerals from the old, a change termed *metamorphism.*

Structure of the Appalachian province.—Three distinct types of structure occur in the Appalachian province, each one prevailing in a separate area corresponding to one of the three geographic divisions.

In the plateau region and westward the rocks are but little tilted from their original horizontal position and are almost entirely unchanged; in the valley the rocks have been steeply tilted, bent into folds, broken by faults, and to some extent altered into slates; in the mountain district faults and folds are prominent, but the rocks have been changed to a greater extent by the minute breaks of cleavage and by the growth of new minerals.

In the valley the folds and the faults developed from them are parallel among themselves and to the old land body, extending in a northeast-southwest direction for great distances. Some faults have been traced for 300 miles, and some folds have even greater length. The crests of the anticlines are very uniform in height, so that for long distances they contain the same formations. They are also approximately equal to one another in height, so that many parallel folds bring to the surface the same formations. Most of the rocks dip at angles greater than 10°, and frequently the sides of the folds are compressed till they are parallel. The folding is greatest in thin-bedded rocks, such as shale and shaly limestone, because the thin layers were most readily bent, and slipped along their bedding planes. Perhaps the most striking feature of the folds is the prevalence of southeastward dips. In some sections across the southern portion of the Appalachian Valley scarcely a bed can be found which dips toward the northwest.

Out of the close folds the faults were developed, and with extremely few exceptions the fault planes dip toward the southeast. The planes on which the rocks broke and moved are often parallel to the bedding planes, as the rocks slipped on the beds in folding. Along these planes of fracture the rocks moved to distances sometimes as great as 6 or 8 miles. There is a progressive increase in degree of deformation from northeast to southwest, resulting in different types in different places. In northern Pennsylvania folds are inconspicuous. Passing through Pennsylvania toward Virginia, they rapidly become more numerous and dips grow steeper. In southern Virginia the folds are closely compressed and often closed, while occasional faults appear. Passing through Virginia and into Tennessee, the folds are more and more broken by faults, until, half way through Tennessee, nearly every fold is broken and the strata form a series of narrow, overlapping blocks, all dipping eastward. This condition prevails southward into Alabama, but the faults become fewer in number and their horizontal displacement much greater, while the folds are somewhat more open.

In the Appalachian Mountains the structure is the same as that which marks the Great Valley; there are the eastward dips, the close folds, the thrust faults, etc. But in addition to these changes of form, which took place mainly by motion on the bedding planes, a series of minute breaks was developed across the strata, producing cleavage, or a tendency to split readily along these new planes. These planes dip to the east at from 20° to 90°, usually about 60°. This slaty cleavage was somewhat developed in the valley, but not to such an extent as in the mountains. As the breaks became more frequent and greater they were accompanied by growth of new minerals out of the fragments of the old. These consisted chiefly of mica and quartz and were crystallized parallel to the cleavage cracks. The final stage of the process resulted in the squeezing and stretching of hard minerals, like quartz, and complete recrystallization of the softer rock particles. All rocks, both those of sedimentary origin and those which were originally crystalline, were subjected to this process, and the final products from the metamorphism of very different rocks are often indistinguishable from one another. Rocks containing the most feldspar were most thoroughly altered, and those with most quartz were least changed. Throughout the greater part of the Appalachian Mountains there is a regular increase of metamorphism toward the southeast, so that a bed quite unaltered at the border of the Great Valley can sometimes be traced through greater and greater changes until it has lost every original character.

The structures above described are manifestly due chiefly to horizontal compression, which acted in a northwest-southeast direction, at right angles to the trend of the folds and cleavage planes. The compression apparently began in early Paleozoic time, and probably continued at intervals up to its culmination, shortly after the close of the Carboniferous, when the greater portion of the folding was effected.

In addition to the horizontal force of compression, the province has been subjected to other forces which have repeatedly elevated and depressed its surface. At least two periods of high land near the sea and two longer periods of low land are indicated by the character of the Paleozoic sediments. And in post-Paleozoic time there have been at least three, and probable more, periods of decided oscillation of the land due to the action of some vertical force. In every case the movements have resulted in the warping of the surface, and the greatest uplift has occurred nearly along the line of the Great Valley.

Structure sections.—The five 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 near the line of the section in a belt a few miles in width.

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.

Structure of the Gadsden quadrangle.—This quadrangle shows but little diversity in geologic structure. There are no crystalline rocks exposed and no traces of metamorphism. Over the greater portion the strata are nearly horizontal, dipping but a few feet to the mile, so that their inclination can be detected only by determining the altitude of some particular bed at several widely separated points.

The Sequatchie anticline, which crosses the western side of the quadrangle, is typical of the Appalachian folds. Its length is somewhat greater than that of the combined Sequatchie and Browns valleys, for at its ends the upper rocks have not been entirely removed by erosion, but remain arched across from side to side. On the southeastern side of the anticline the rocks dip at low angles, from 8° to 12°, while on the northwestern side they are much more steeply inclined, being in some places vertical or overturned. The same is true in Wills Valley and its southward continuation as Greasy Cove, but the difference in dip on opposite sides of the axis is greater than in Browns Valley. In Murphree Valley and Bristow Cove the strata also dip away from the center, but the low angles of dip are on the northwest side, while the steep dips are on the southeast side. This is one of the few exceptions to the general rule that the Appalachian folds have their steepest dips on the western side of the anticlinal axes. West of Browns Valley the strata dip steeply, but in the Cumberland Plateau a short distance beyond the escarpment they are nearly horizontal. Sand Mountain is a very broad syncline, and away from the immediate edges the strata are so nearly horizontal that the dip can scarcely be detected. In the southern part of the quadrangle this broad syncline is interrupted by the Murphree Valley anticline; and the two synclines thus formed are narrower and have steeper dips, as shown in sections D and E, than the single syncline farther north, shown in section B.

At intervals along the western side of Browns Valley, on the steep side of the anticline, some faulting has occurred, and one or more formations are concealed by others which have been thrust over them from the southeast. This fault is shown in only one of the sections, D. On the southeast side of Murphree Valley is a similar fault on the steep side of the anticline, but the displacement has been much greater, and several formations whose outcrops occur on the northwest side of the valley are concealed on the southeast side. The steep western side of the Wills Valley anticline is faulted at intervals, two or more parallel faults sometimes occurring, as shown in section C, in place of the single one shown in section D. The fault which cuts off the southern end of Lookout Mountain has a much greater displacement than any of those above mentioned, and brings the oldest rocks of the district in contact with the youngest. It differs materially from most other faults of this region in being for some distance transverse, instead of parallel, to the axes of the folds. Also the fault plane is more nearly vertical in this than in other faults of the region.

MINERAL RESOURCES.

The mineral resources of the Gadsden quadrangle consist of coal, iron ores, limestone, building and road stone, and brick and tile clay.

Coal.—The coal-bearing formations of this region are the Lookout and Walden sandstones, which have already been briefly described. They occupy the surface of the plateaus, forming 665 square miles, or about seven-tenths of the quadrangle. Probably a considerable portion of the area covered by these two formations contains workable coal, though more thorough prospecting will be required to determine the exact position and thickness of the coal beds at any particular locality.

Several beds of coal are found locally developed in the Lookout sandstone, but they are variable in position and thickness, and only one is important. This occurs almost immediately below the heavy stratum of conglomerate which forms the uppermost member of the formation.

About 6 miles east of Guntersville, on Dry Creek, this bed is exposed below the conglomerate and about 200 feet above the top of the Bangor limestone. It is from 1½ to 3 feet in thickness, and has been worked in a very small way, the coal being taken down to the Tennessee River on flatboats. A bed occupying a similar position below the conglomerate has also been opened in Polecat Cove, east of Guntersville. It shows a thickness of but 14 inches on the outcrop.

The sandstones and shales forming the lower members of the Lookout formation thin out from the center of the quadrangle southward, and probably contain but little coal in its southern half. A bed is reported to occur below the conglomerate at Gregory Gap and elsewhere along the western side of Straight Mountain, and it may attain a workable thickness in a small area here, and also possibly in Blount Mountain.

Several coal beds are found in the sandy shales of the Walden formation, and two of these are of workable thickness. They are probably confined to the southern third of the quadrangle. The lower of the two occurs about 180 feet above the top of the Lookout conglomerate, associated with grayish-black sandy shale. It has been most extensively worked along Black Creek in the southern end of Lookout Mountain, about 3 miles from Gadsden. The Lookout conglomerate, which forms the bed of Black Creek above the falls, pitches down toward the end of the mountain and then turns up vertically along the fault. It thus forms a small basin in which the higher members of the overlying Walden sandstone rest. The coal is from 18 to 24 inches in thickness. The basin to which the workable coal is confined is of limited extent, perhaps covering 2 or 3 square miles. The same bed is worked at the mines of the Alabama Coal and Coke Company on the Nashville, Chattanooga, and St. Louis Railway near Littleton. At this point the bed is from 20 to 30 inches thick. It has been opened and worked for local use at numerous points in the syncline between Blount and Straight mountains, and also in Sand Mountain south of the Black Warrior River. It decreases in thickness toward the north, as indicated by the shading on the economic map.

The second workable seam in the Walden is about 400 feet above the Lookout conglomerate. It is confined to a few isolated areas where the rocks containing it have escaped erosion in the lower portions of the synclines. These are shown on the economic sheet, and have a total area of about 22 square miles. The bed is 3½ feet thick in the eastern syncline, and decreases westward to a little over 2 feet in Sand Mountain.

Iron ore.—The only iron ore sufficiently abundant to be commercially important is the red fossil ore of the Rockwood formation. This ore is very similar in appearance to that occurring at the same horizon in such widely separated localities as Wisconsin, New York, and Tennessee. It is a stratified bed of constant thickness having definite relations 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 the depth below the surface, and at considerable depths it becomes simply a more or less ferruginous limestone. This 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. Considerable quantities of this soft ore are frequently obtained by trenching along the outcrops of the bed where it is not of sufficient thickness to make mining profitable. The outcrops of the Rockwood shales which carry the iron ore occur in narrow strips in the valleys parallel with the base of the escarpments. The outcrops are always continuous on one side of the valley, but are interrupted by faulting on the other. This fact is of importance to the prospector, and a recognition of these faults would prevent much useless expenditure. The iron ore is worked on both sides of Lookout Mountain, at Gadsden and Atala. It is probably continuous in workable quantity from Atala northward in the ridge between Big Wills and Little Wills creeks. The ore dips toward the southeast at an angle of about 25°, and is mined by drifting in on the southeast side of the ridge. In Bristow Cove the ore has not been sufficiently prospected to determine its value. In Browns Valley it shows considerable variation in thickness and purity, and while it is probably not generally workable, there are doubtless some localities where it may be mined with profit. The base of the Rockwood is locally marked, as at Guntersville, by a bed of red calcareous sandstone from 4 to 10 feet thick. This is sometimes mistaken for iron ore, but it contains too large a proportion of sand and other impurity to be used as an ore.

Limestone.—Suitable stone for blast-furnace flux and for lime is abundant in several formations, notably the Bangor, Chickamauga, and Knox. The Chickamauga is quarried for lime and flux about a mile west of Atala.

Building stone.—Stone adapted to architectural uses occurs in nearly all the formations of this region. Sandstones especially well adapted for foundations occur in the Lookout and Walden formations, but these have as yet been quarried only in a small way for local use.

SOILS.

Derivation and distribution.—Throughout the Gadsden quadrangle 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.

Such sedimentary rocks as occur in this region are changed by surface waters more or less rapidly, the rapidity of the change 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 an abundant 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 was pure, but often very thick where it contained 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 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.

The character of the soils derived from the various geological formations being 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 covered or mingled with the soil 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 follows: (1) Sandy soils; derived from the Walden, Lookout, and Oxmoor sandstones and parts of the Rockwood formation. (2) Clay soils; derived from the Bangor and Chickamauga limestones and the Conasauga shale. (3) Cherty soils; derived from the Knox dolomite and the Fort Payne chert. (4) Alluvial soils; deposited by the larger streams upon their flood-plains.

Sandy soils.—The entire surface of the plateaus, and consequently more than two-thirds of the quadrangle, is covered by sandy soils, derived from sandstones and sandy shales of the coal measures. At the surface the soil is a gray sandy loam, while the subsoil is generally light-yellow, but varies to deep red. In some places it consists largely of white sand, but oftener it contains sufficient clay to give the subsoil considerable coherence, so that a cut bank will remain vertical for some years. The depth of the soil on the plateaus 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 surface 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. It also kills all except the coarser grasses, so that the pasturage is injured.

Since the sandstones occupy the highest land, the overplaced soils, or those washed down the steep slopes to lower levels, are mostly sandy. They are especially abundant along the plateau escarpments, where the Bangor limestone and its clay soils are often wholly concealed.

Clay soils.—Big Spring Valley, Browns Valley, and the coves among the mesas to the westward are underlain by limestone whose surface is covered by a thin mantle of clay soil composed of its insoluble portions. In some places the rock decay has gone to a considerable distance below the surface and the soil is deep and bright-red in color, but generally the limestone is covered by a thin layer of bluish-gray or black soil. The Bangor and Chickamauga outcrops in Bristow Cove and Wills Valley are generally covered by deep-red clay, while the Conasauga shale south of Gadsden and Atala forms a stiff bluish-gray clay. 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.—The soil derived from the Knox dolomite and Fort Payne chert consists of clay in which the chert is imbedded, with some admixture of sand. 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 considerable this is a strong productive soil.

Alluvial soils.—These are confined principally to the flood-plains or bottoms of the Tennessee River, which are a mile or more broad in Browns Valley, but become much narrower or are wholly wanting below Fort Deposit, where the river flows in a narrow channel between high limestone bluffs. The soil is a rich, sandy loam, containing a considerable proportion of fine mica scales, derived from the crystalline rocks far to the eastward. Narrow strips of bottom land occur along some of the creeks, but their alluvial soils have been transported only a short distance and are simply a mixture of local sedentary soils.

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