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DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

W. C. MENDENHALL, DIRECTOR

GEOLOGIC ATLAS

OF THE

UNITED STATES

MONTEVALLO–COLUMBIANA FOLIO

ALABAMA

BY

CHARLES BUTTS

WASHINGTON, D. C.

ENGRAVED AND PRINTED BY THE GEOLOGICAL SURVEY

GEORGE W. STOSE, EDITOR OF GEOLOGIC MAPS. CLAUDE H. BIRDSEYE, CHIEF, DIVISION OF ENGRAVING AND PRINTING

1940

GEOLOGIC ATLAS OF THE UNITED STATES.

UNITS OF SURVEY AND OF PUBLICATION.

The Geological Survey is making a topographic and a geologic atlas of the United States. The topographic atlas will consist of maps called *atlas sheets*, and the geologic atlas will consist of parts called *folios*. Each folio includes topographic and geologic maps of a certain four-sided area, called a *quadrangle*, or of more than one such area, and a text describing its topographic and geologic features. A quadrangle is limited by parallels and meridians, not by political boundary lines, such as those of States, counties, and townships. Each quadrangle is named from a town or a natural feature within it, and at the sides and corners of each map are printed the names of adjacent quadrangles.

SCALES OF THE MAPS.

On a map drawn to the scale of 1 inch to the mile a linear mile on the ground would be represented by a linear inch on the map, and each square mile of the ground would be represented by a square inch of the map. The scale may be expressed also by a fraction, of which the numerator represents a unit of linear measure on the map and the denominator the corresponding number of like units on the ground. Thus, as there are 63,360 inches in a mile, the scale 1 inch to the mile is expressed by the fraction $\frac{1}{63,360}$, or the ratio 1:63,360.

The three scales most commonly used on the standard maps of the Geological Survey are 1:31,680, 1:62,500, and 1:125,000, 1 inch on the map corresponding approximately to one-half mile, 1 mile, and 2 miles on the ground. On the scale of 1:31,680 a square inch of map surface represents about one-fourth of a square mile of earth surface; on the scale of 1:62,500, about 1 square mile; and on the scale of 1:125,000, about 4 square miles. In general a standard map on the scale of 1:125,000 represents one-fourth of a "square degree"—that is, one-fourth of an area measuring 1 degree of latitude by 1 degree of longitude; one on the scale of 1:62,500 represents one-sixteenth of a "square degree"; and one on the scale of 1:31,680 represents one-sixty-fourth of a "square degree." The areas of the corresponding quadrangles are about 1,000, 250, and 60 square miles, though they differ with the latitude, a "square degree" in the latitude of Boston, for example, being only 3,525 square miles and one in the latitude of Galveston being 4,150 square miles.

FEATURES SHOWN ON THE TOPOGRAPHIC MAPS.

The features represented on the topographic maps comprise three general classes—(1) inequalities of surface, such as plains, plateaus, valleys, hills, and mountains, which collectively make up the *relief* of the area; (2) bodies of water, such as streams, lakes, swamps, tidal flats, and the sea, which collectively make up the *drainage*; (3) such works of man as roads, railroads, buildings, villages, and cities, which collectively are known as *culture*.

Relief.—All altitudes are measured from mean sea level. The heights of many points have been accurately determined, and those of some are given on the map in figures. It is desirable, however, to show the altitude of all parts of the area mapped, the form of the surface, and the grade of all slopes. This is done by contour lines, printed in brown, each representing a certain height above sea level. A contour on the ground passes through points that have the same altitude. One who follows a contour will go neither uphill nor downhill but on a level. The manner in which contour lines express altitude, form, and slope is shown in figure 1.

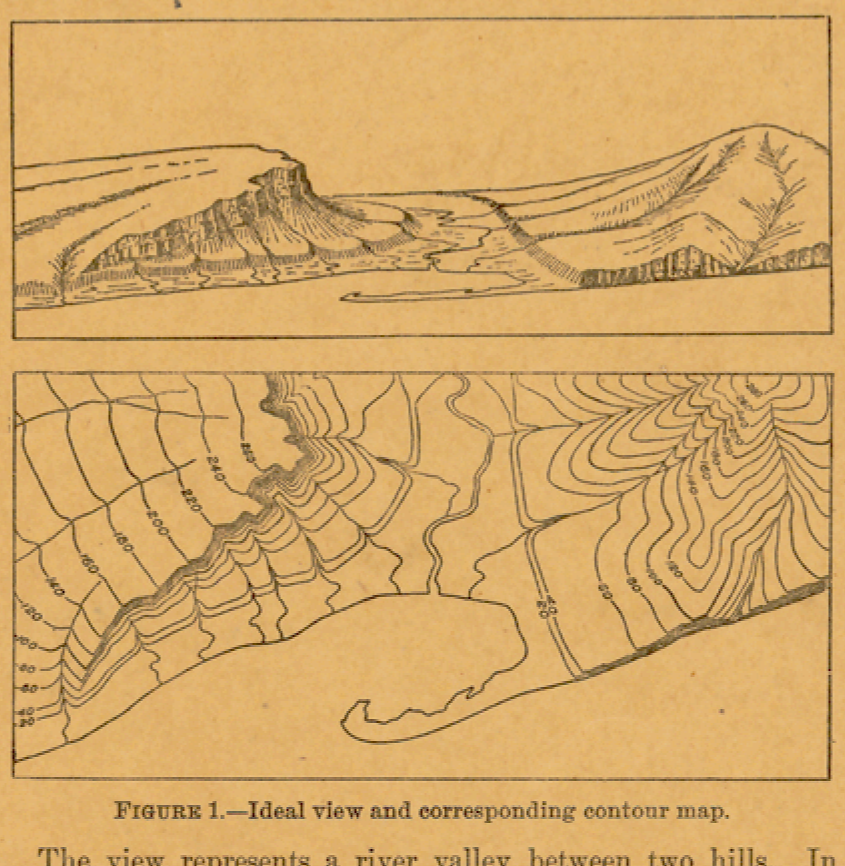

FIGURE 1.—Ideal view and corresponding contour map.

The view represents a river valley between two hills. In the foreground is the sea, with a bay that is partly inclosed by a hooked sand bar. On each side of the valley is a terrace. The terrace on the right merges into a gentle upward slope; that on the left merges into a steep slope that passes upward to a cliff, or scarp, which contrasts with the gradual slope back from its crest. In the map each of these features is indicated, directly beneath its position in the view, by contour lines. This map does not include the distant part of the view.

As contours are continuous horizontal lines they wind smoothly about smooth surfaces, recede into ravines, and project around spurs or prominences. The relations of contour curves and angles to the form of the land can be seen from the map and sketch. The contour lines show not only the shape of the hills and valleys but their altitude, as well as the steepness or grade of all slopes.

The vertical distance represented by the space between two successive contour lines—the contour interval—is the same, whether the contours lie along a cliff or on a gentle slope; but to reach a given height on a gentle slope one must go farther than on a steep slope, and therefore contours are far apart on gentle slopes and near together on steep slopes.

The contour interval is generally uniform throughout a single map. The relief of a flat or gently undulating country can be adequately represented only by the use of a small contour interval; that of a steep or mountainous country can generally be adequately represented on the same scale by the use of a larger interval. The smallest interval commonly used on the atlas sheets of the Geological Survey is 5 feet, which is used for regions like the Mississippi Delta and the Dismal Swamp. An interval of 1 foot has been used on some large-scale maps of very flat areas. On maps of more rugged country contour intervals of 10, 20, 25, 50, and 100 feet are used, and on maps of great mountain masses like those in Colorado the interval may be 250 feet.

In figure 1 the contour interval is 20 feet, and the contour lines therefore represent contours at 20, 40, 60, and 80 feet, and so on, above mean sea level. Along the contour at 200 feet lie all points that are 200 feet above the sea—that is, this contour would be the shore line if the sea were to rise 200 feet; along the contour at 100 feet are all points that are 100 feet above the sea; and so on. In the space between any two contours are all points whose altitudes are above the lower and below the higher contour. Thus the contour at 40 feet falls just below the edge of the terrace, and that at 60 feet lies above the terrace; therefore all points on the terrace are shown to be more than 40 but less than 60 feet above the sea. In this illustration all the contour lines are numbered, but on most of the Geological Survey's maps only certain contour lines—say every fifth one, which is made slightly heavier—are numbered, for the heights shown by the others may be learned by counting up or down from these. More exact altitudes for many points are given in bulletins published by the Geological Survey.

Drainage.—Watercourses are indicated by blue lines. The line for a perennial stream is unbroken; that for an intermittent stream is dotted; and that for a stream which sinks and reappears is broken. Lakes and other bodies of water and the several types of marshy areas are also shown in blue.

Culture.—Symbols for the cultural features and for public-land land lines and other boundary lines, as well as all the lettering and the map projection, are printed in black.

FEATURES SHOWN ON THE GEOLOGIC MAPS.

The maps representing the geology show, by colors and conventional signs printed on the topographic map as a base, the distribution of rock masses on the surface of the land and, by means of structure sections, their underground relations so far as known, in such detail as the scale permits.

KINDS OF ROCKS.

Rocks are of many kinds. On the geologic map they are distinguished as igneous, sedimentary, and metamorphic.

Igneous rocks.—Rocks that have cooled and consolidated from a state of fusion are known as *igneous*. Molten material has from time to time been forced upward in fissures or channels of various shapes and sizes through rocks of all ages to or nearly to the surface. Rocks formed by the consolidation of molten material, or *magma*, within these channels—that is, below the surface—are called *intrusive*. An intrusive mass that occupies a nearly vertical fissure which has approximately parallel walls is called a *dike*; one that fills a large and irregular conduit is termed a *stock*. Molten material that traverses stratified rocks may be intruded along bedding planes, forming masses called *sills* or *sheets* if they are relatively thin and *laccoliths* if they are large lenticular bodies. Molten material that is inclosed by rock cools slowly, and its component minerals crystallize when they solidify, so that intrusive rocks are generally crystalline. Molten material that is poured out through channels that reach the surface is called *lava*, and lava may build up volcanic mountains. Igneous rocks that have solidified at the surface are called *extrusive* or *effusive*. Lavas generally cool more rapidly than intrusive rocks and contain, especially in their outer parts, more or less volcanic glass, produced by rapid chilling. The outer parts of lava flows are also usually made porous by the expansion of the gases in the magma. Explosions due to these gases may accompany volcanic eruptions, causing the ejection of dust, ash, lapilli, and larger fragments. These materials, when consolidated, constitute breccias, agglomerates, and tuffs.

Sedimentary rocks.—Rocks composed of the transported fragments or particles of older rocks that have undergone disintegration, of volcanic material deposited in lakes and seas, or of material deposited in such bodies of water by chemical precipitation or by organic action are termed *sedimentary*.

The chief agent in the transportation of rock débris is water in motion, including rain, streams, and the water of lakes and of the sea. The materials are in large part carried as solid particles, and the deposits they form are called mechanical. Such deposits are gravel, sand, and clay, which are later consolidated into conglomerate, sandstone, and shale. Some of the materials are carried in solution, and deposits composed of these materials are called organic if formed with the aid of life or chemical if formed without the aid of life. The more common rocks of chemical and organic origin are limestone, chert, gypsum, salt, certain iron ores, peat, lignite, and coal. Any one of the kinds of deposits named may be formed separately, or the different materials may be intermingled in many ways, producing a great variety of rocks.

Another transporting agent is air in motion, or wind, and a third is ice in motion, or glaciers. The most characteristic of the wind-borne or eolian deposits is *loess*, a fine-grained earth; the most characteristic of the glacial deposits is *till*, a heterogeneous mixture of boulders and pebbles with clay or sand.

Most sedimentary rocks are made up of layers or beds that can be easily separated. These layers are called *strata*, and rocks deposited in such layers are said to be *stratified*.

The surface of the earth is not immovable; over wide regions it very slowly rises or sinks with reference to the sea, and shore lines are thus changed. As a result of upward movement marine sedimentary rocks may become part of the land, and most of our land surface is in fact composed of rocks that were originally deposited as sediments in the sea.

Rocks exposed at the surface of the land are acted on by air, water, ice, animals, and plants, especially the low organisms known as bacteria. They gradually disintegrate, and their more soluble parts are leached out, the less soluble material being left as a *residual* layer. Water washes this material down the slopes, and it is eventually carried by rivers to the ocean or other bodies of water. Usually its journey is not continuous, but it is temporarily built into river bars and flood plains, where it forms *alluvium*. Alluvial deposits, glacial deposits (collectively known as *drift*), and eolian deposits belong to the *surficial* class, and the residual layer is commonly included with them. The upper parts of these deposits, which are occupied by the roots of plants, constitute soils and subsoils, the soils being usually distinguished by a considerable admixture of organic matter.

Metamorphic rocks.—In the course of time and by various processes rocks may become greatly changed in composition and texture. If the new characteristics are more pronounced than the old the rocks are called *metamorphic*. In the process of metamorphism the chemical constituents of a rock may enter into new combinations and certain substances may be lost or new ones added. A complete gradation from the primary to the metamorphic form may exist within a single rock mass. Such changes transform sandstone into quartzite and limestone into marble and modify other rocks in various ways.

From time to time during geologic ages rocks that have been deeply buried and have been subjected to enormous pressure, to slow movement, and to igneous intrusion have been afterward raised and later exposed by erosion. In such rocks the original structural features may have been lost entirely and new ones substituted. A system of parallel planes along which the rock can be split most readily may have been developed. This acquired quality gives rise to *cleavage*, and the cleavage planes may cross the original bedding planes at any angle. Rocks characterized by cleavage are called *slates*. Crystals of mica or other minerals may have grown in a rock in parallel arrangement, causing lamination or foliation and producing what is known as *schistosity*. Rocks that show schistosity are called *schists*.

As a rule, the older rocks are most altered and the younger are least altered, but to this rule there are many exceptions, especially in regions of igneous activity and complex structure.

GEOLOGIC FORMATIONS.

For purposes of geologic mapping the rocks of all the kinds above described are divided into *formations*. A sedimentary formation contains between its upper and lower limits either rocks of uniform character or rocks more or less uniformly varied in character, as, for example, an alternation of shale and limestone. If the passage from one kind of rocks to another is gradual it may be necessary to separate two contiguous formations by an arbitrary line, and the distinction between some such formations depends almost entirely on the fossils they contain. An igneous formation contains one or more bodies of one kind of rock of similar occurrence or of like origin. A metamorphic formation may consist of one kind of rock or of several kinds of rock having common characteristics or origin.

[Continued on inside back cover.]

DESCRIPTION OF THE MONTEVALLO AND COLUMBIANA QUADRANGLES

By Charles Butts[1]

INTRODUCTION

LOCATION AND EXTENT

As shown by the key map (fig. 1) the Montevallo and Columbiana quadrangles are in the north-central part of Alabama, mainly in Shelby, Bibb, and Chilton Counties. The northwest corner of the Montevallo quadrangle includes a small area of Jefferson County, and the eastern part of the

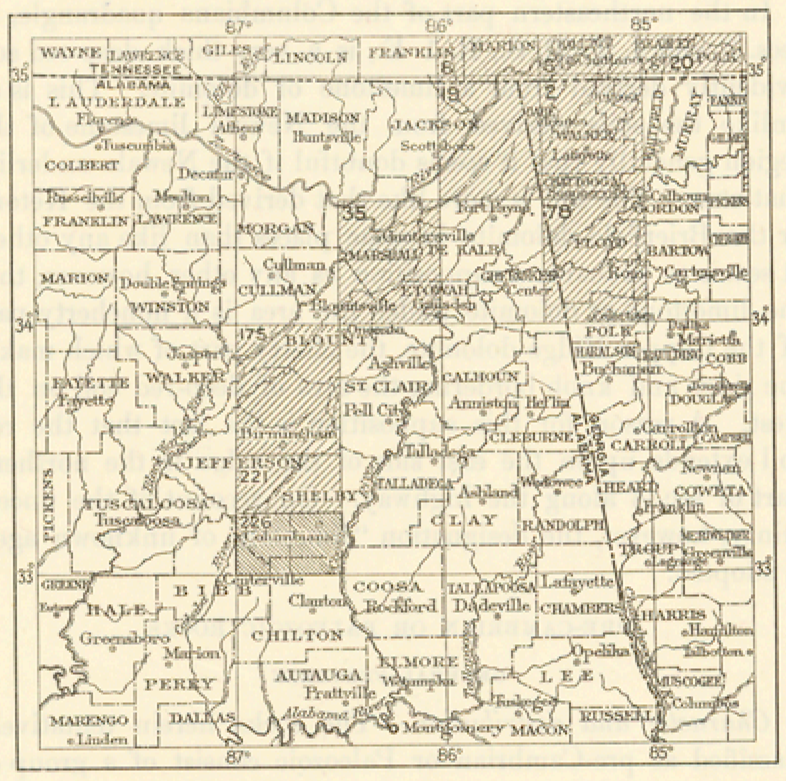

FIGURE 1.—Index map of northeastern Alabama and portions of adjacent States

The location of the Montevallo and Columbiana quadrangles, covered by Folio 226, is shown by the darker ruling. Published folios describing other quadrangles, indicated by lighter ruling, are the following: Nos. 2, Ringgold; 6, Chattanooga; 8, Sewanee; 19, Stevenson; 20, Cleveland; 35, Gadsden; 78, Rome; 175, Birmingham; 221, Bessemer-Vandiver

Columbiana quadrangle includes small areas of Coosa and Talladega Counties. The quadrangles are bounded by parallels 33° and 33°15′ and meridians 86°30′ and 87°. Each quadrangle covers one-sixteenth of a "square degree" and has an area of 250 square miles.

GENERAL RELATIONS

Northern Alabama is in the southern part of the Appalachian Highlands.[2] This physiographic division of the United States extends from the Atlantic Plain on the east to the

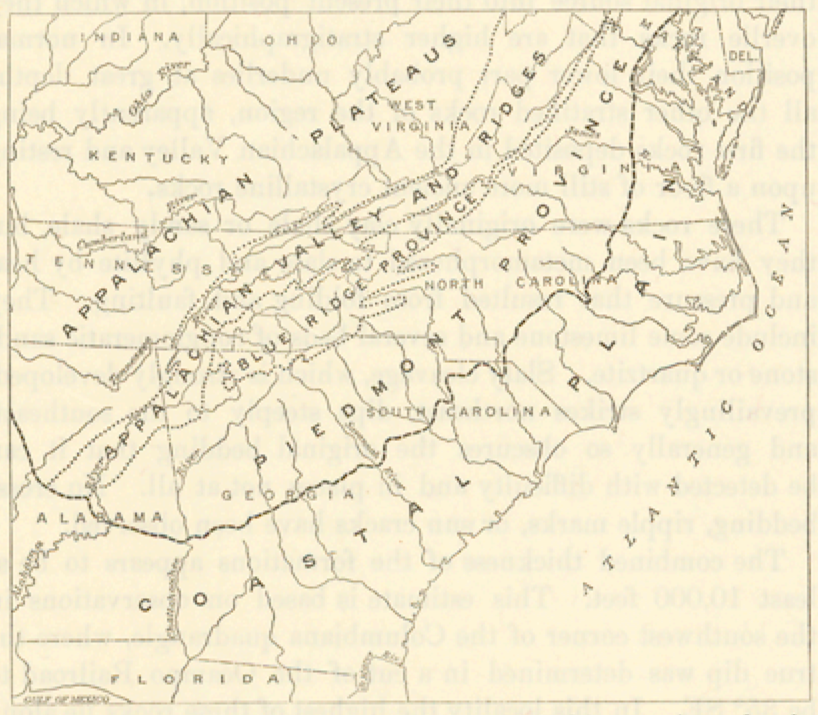

FIGURE 2.—Map of the southern part of the Appalachian province, showing its physiographic divisions and its relation to the Coastal Plain

Interior Plains on the west and from Canada and Lake Erie on the northeast into Alabama and Georgia on the southwest. The boundaries of the Appalachian Highlands and of the larger subdivisions are shown on the sketch map (fig. 2).

APPALACHIAN HIGHLANDS

SUBDIVISIONS

On the grounds of differences in topography, rocks, and geologic structure the portion of the Appalachian Highlands south of New England is divisible into four parts called provinces. These are, from southeast to northwest, the Piedmont province, the Blue Ridge province, the Valley and Ridge province, and the Appalachian Plateaus. West of the Appalachian Plateaus are the Interior Low Plateaus, which are included in the Interior Plains by the Association of American Geographers but which in the opinion of some, including the writer, should be regarded as part of the Appalachian Highlands.

The dividing line between the Piedmont province and the Blue Ridge province is the eastern foot of the Blue Ridge and the foot of the high but irregular eastern scarp of the mountains that form the southern extension of the Blue Ridge in western North Carolina and northern Georgia. The boundary between the Blue Ridge province and the Valley and Ridge province is the western base of the Blue Ridge of Virginia and of the high mountains of eastern Tennessee. This boundary continues into northwestern Georgia, to its intersection with the boundary between the Piedmont and Blue Ridge provinces, about 15 miles southeast of Dalton. The Blue Ridge province thus terminates in northwestern Georgia. Thence the indefinite boundary between the Piedmont and Valley and Ridge provinces runs southwestward through Sylacauga to the Coastal Plain in Chilton County, Ala. The boundary between the Valley and Ridge province and the Appalachian Plateaus is, in Pennsylvania, the escarpment known as the Allegheny Front or Allegheny Mountains; in southwestern Virginia and through Tennessee, the Cumberland escarpment or Cumberland Mountain; and in Alabama, the eastern scarp of Lookout Mountain and the eastern boundary of the Warrior coal field. The western boundary of the Appalachian Plateaus through Tennessee, lying midway between Knoxville and Nashville, is a broken escarpment 800 to 1,000 feet high, separating the Cumberland Plateau from the Highland Rim. This boundary is extended northeastward through eastern Kentucky and central Ohio to the vicinity of Cleveland, although it is not sharply defined in those States.

PIEDMONT PROVINCE

The Piedmont province is a rolling upland 1,100 feet above sea level at the foot of the Blue Ridge and 500 feet or less along the "fall line." Its generally flat surface has been deeply trenched by the streams that flow across it. It is underlain by very ancient and crumpled crystalline rocks, both igneous and metamorphic. A small area in the southeast corner of the Columbiana quadrangle lies in the Piedmont province.

BLUE RIDGE PROVINCE

The Blue Ridge province is narrow at its north end in Pennsylvania but more than 60 miles wide in North Carolina. It is a rugged region of hills and ridges and deep, narrow valleys. The altitude of the higher summits in Virginia is 3,000 to 5,719 feet above sea level, and in western North Carolina Mount Mitchell, 6,711 feet high, is the highest point east of Mississippi River. Throughout its extent this province stands up conspicuously above the adjoining provinces, from each of which it is separated by a steep, broken, rugged front from 1,000 to 3,000 feet high. The rocks of this province comprise closely folded quartzite, slate, schist, gneiss, granite, and greenstone.

VALLEY AND RIDGE PROVINCE

GENERAL FEATURES

The Valley and Ridge province, in which the Montevallo and Columbiana quadrangles are mainly situated, is a belt 50 to 80 miles wide, extending from Canada into Alabama, which is on the whole lower than the Blue Ridge province on the east and the Appalachian Plateaus on the west. Near Big Stone Gap, Va., the crest of the Big Black Mountains is 3,000 feet above the valley on its northwest side, and in northern Tennessee Holston Mountain, near the northwest front of the Blue Ridge province, rises nearly 3,000 feet above the valley on its southeast side.

In other places, as in the Birmingham district, the valley is not so distinctly defined by high escarpments. Nevertheless the altitude of the limestone and shale valleys that constitute the larger part of the Valley and Ridge province in the Birmingham district is considerably lower than that of the adjacent provinces.

The rocks of this province are not crystalline, like those of the Piedmont and Blue Ridge provinces, but are all sedimentary. They include limestone, dolomite, conglomerate, sandstone, and shale, which have been greatly disturbed by folding and faulting.

CAHABA RIDGES

The Valley and Ridge province in Alabama is divided into the Cahaba Ridges, Birmingham Valley, and Coosa Valley. Although in general a valley, this province contains many high ridges extending parallel to its general direction, of which Red Mountain is a good example. Most of these ridges lie along the west side of the valley from Pennsylvania to Alabama. In Alabama the ridge section includes all the valley west of the east boundary of the Coosa coal field and west of a line in continuation of that boundary southwest to Calera, thence northwest to Maylene by way of Montevallo, thence southwest through the middle of the southern part of the Cahaba coal field. The north end of the ridge area curves eastward and narrows to a point a few miles southeast of Gadsden. It includes Blount and Chandler Mountains. The name Cahaba Ridges is here applied to this part of the Valley and Ridge province in Alabama.

BIRMINGHAM VALLEY

The belt of relatively low land lying between Shades Mountain on the southeast and Sand Mountain on the northwest and extending the full length of the Cahaba coal field is commonly called Birmingham Valley. It includes Shades, Jones, and Opossum Valleys, Red Mountain, and Enon or Flint Ridge.

COOSA VALLEY

East of the Cahaba Ridges is the Coosa Valley, which is the broad, generally flat, low country occupied by Coosa River and its tributaries and farther southwest by Cahaba River and its eastern tributaries. The lower part of the Coosa Valley lies in the Piedmont province.

APPALACHIAN PLATEAUS

The subdivision of the Appalachian Highlands known as the Appalachian Plateaus is practically coextensive with the Appalachian coal fields. It is relatively high, ranging from 500 feet above sea level in the Warrior coal field to more than 4,500 feet in Pocahontas County, W. Va., and about 2,000 feet in western New York. In Tennessee it slopes somewhat westward, from about 2,000 feet above sea level on the east to about 1,800 feet on the west, where it terminates in the steep scarp 800 to 1,000 feet high, descending to the Highland Rim of middle Tennessee. As a whole this province may be regarded as a series of plateaus extending from New York to Alabama, which have been more or less separated into parts or, in large areas, nearly obliterated by erosion. Because they have been so much eroded they are called dissected plateaus. The separated parts have received names, and one of them, the Cumberland Plateau in Tennessee, is the part of the province that most nearly embodies the conception of a plateau.

The rocks of the Appalachian Plateaus are mostly sandstone, conglomerate, shale, and coal. In contrast with those of the Valley and Ridge province the strata of the plateaus have been but slightly disturbed.

TOPOGRAPHY OF THE QUADRANGLES

GENERAL FEATURES

The south half of the Montevallo quadrangle and nearly all of the Columbiana quadrangle lie in the Coosa Valley; the rest of the area lies in the Cahaba Ridges. A line drawn from Calera to Montevallo, passing 1 mile south of Hardys, thence north to Lacy, thence due southwest to Garnsey would approximately mark the boundary between the two subdivisions.

The region is one of late mature topography. The streams are approximately graded and reach all parts of the area, so that no extensive undrained surface remains. The upland surfaces probably nearly coincide with an ancient peneplain below which the larger streams have intrenched their valleys to a depth of about 200 feet. (See pl. 1.)

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[1] Surveyed in cooperation with the Geological Survey of Alabama. Text submitted in August 1924.

[2] Assoc. Am. Geographers Annals, vol. 6, pp. 19-98, 1917.

RELIEF

The altitude of the quadrangles ranges from 300 feet above sea level on Cahaba River at the west line of the Montevallo quadrangle and on Coosa River at the south line of the Columbiana quadrangle to 950 feet above sea level on Columbiana Mountain, in the northeastern part of the Columbiana quadrangle, making the extreme relief about 650 feet. Throughout nearly the whole of both quadrangles the relief does not exceed 250 feet. In the northwest corner of the Montevallo quadrangle Pine Mountain, the next mountain west of Turner, 750 feet above sea level, rises 350 feet above the valley at its east foot. In the northeast corner of the Montevallo quadrangle Double Mountain and Locust Ridge raise their crests about 300 feet above the low ground at their base.

There are two distinct types of topographic features in the quadrangles, which may be designated the linear and diffuse types. The linear type is characterized by parallel ridges and valleys having a northeast trend and the diffuse type by an irregular arrangement of hills and valleys. The linear type distinguishes the part of the quadrangles in the Cahaba Ridges; the diffuse type prevails in the Coosa Valley.

The two types of topography are the result of differences in the character and attitude of the strata. In the Cahaba Ridges the rocks, generally inclined at high angles and striking northeast, have determined the trend of the valleys and ridges; the valleys follow the belts of limestone and shale, which are easily eroded, and the ridges coincide with belts of more resistant sandstone and conglomerate. Noteworthy examples of such ridges occur in the northeast corner of the Montevallo quadrangle and northwest corner of the Columbiana quadrangle, where they are formed by the vertical or highly inclined basal sandstones of the Pottsville formation ("Coal measures") of the Coosa coal field. (See section B–B′ of the Columbiana quadrangle and section C–C′ of the Montevallo quadrangle, on structure-section sheets.) The broad limestone valleys are nearly level, as shown in Plate 2.

The rocks of the southeastern part of the Cahaba coal field, in the Montevallo quadrangle, are shale, sandstone, and conglomerate, which over large areas lie nearly flat. On account of their flatness, their resistance to erosive forces has been practically equal in all lateral directions, so that the arrangement of the valleys and ridges is irregular. The ridges extend in many directions, they vary greatly in breadth from point to point, and no two are alike in length. They are generally separated by deep, crooked valleys and send off innumerable short, narrow spurs that are separated by narrow ravines. The topography of Coosa Valley is characterized by low relief and irregularly arranged ridges and spurs. Although the rocks in the greater part of this area are steeply inclined and intensely plicated, they are fairly uniform in hardness, and the general result is much the same as it would be if the rocks were flat.

DRAINAGE

About 30 square miles in the northeast corner and an equal area in the southeast corner of the Montevallo quadrangle are drained by tributaries of Coosa River; the remainder of the quadrangle is drained by Cahaba River and its tributaries. All of the Columbiana quadrangle is drained by Coosa River and its tributaries.

The principal streams within the Cahaba River basin are Cahaba River, Piney Woods Creek, Savage Creek, and Little Cahaba River, which is formed by the junction of Shoal and Mahan Creeks about 3 miles west of Brierfield.

The chief streams of the Coosa River basin within the quadrangles are Coosa River and Bulley, Beeswax, Spring, and Waxahatchee Creeks. Wolf Creek, Camp Branch, Buxahatchee Creek, and Mill Creek are tributary to Waxahatchee Creek.

Except the Coosa, which has long navigable reaches, separated by rapids, none of the streams are of navigable size. The dam of the Alabama Power Co. several miles south of the Columbiana quadrangle has flooded The Narrows of the Coosa and raised the level of the river considerably. Some of the streams, including Shoal, Spring, and Mahan Creeks and Little Cahaba River, occupy limestone valleys and are fed by many large springs issuing from the rock. Most of the streams are permanent and afford even in seasons of drought sufficient water for stock, small powers, coal washing, and irrigation. The grades are fairly uniform, though the streams have not yet cut away all the hard-rock ledges from their beds and are still characterized by reaches of quiet and comparatively deep water alternating with stretches where the water riffles over bedrock.

In a distance of 70 miles north of the mouth of Little Cahaba River, Cahaba River falls 270 feet, or nearly 3.9 feet to the mile. At two places it falls at the rate of 22.9 and 28.6 feet to the mile for a distance of 0.7 mile. Little Cahaba River falls 270 feet in a distance of 28 miles above its mouth, or about 9.5 feet to the mile. Mahan Creek falls at the rate of about 14 feet to the mile. Waxahatchee Creek has a total fall in the 22.4 miles above its mouth of 6.8 feet to the mile. The profiles of these streams represent the streams of the quadrangles generally.

CULTURE

These quadrangles are moderately populated, and most of the arable land is cleared and cultivated. The rougher parts, as a large part of the Cahaba coal field and the area underlain by slate in the southeastern part of the Columbiana quadrangle, are nearly in a state of nature, except that the best of the timber has been cut. The region is served by branches of the Southern Railway and the Louisville & Nashville Railroad, and little of it is more than 10 miles from a railroad station. The main roads are in a fair to good condition, and some of the more important are metaled. Both town and country are well provided with schools and churches. The principal towns are Montevallo, the county seat of Shelby County, population 1,245 in 1930; Columbiana, population 1,180; and Calera, population 975. Aldrich, Straven, and Marvel are the principal coal-mining towns. Siluria has cotton factories, and Newala, Saginaw, Longview, and Varnons are the sites of the lime manufacturing of the region.

DESCRIPTIVE GEOLOGY

GENERAL FEATURES

The geology of this region has been described and has been mapped, on a smaller scale than that used in this folio, by the Alabama Geological Survey. In this as in other folios many new formations and new members in old formations are recognized and mapped, and a few different formation names have been substituted for those of the Alabama Geological Survey in order to avoid confusion or to bring the nomenclature into harmony with the prevailing usage.

General character of the rocks.—The rocks of the quadrangles are all sedimentary and range in age from pre-Cambrian to Cretaceous, all the Paleozoic systems but the Silurian and Devonian being well represented. The maximum thickness of rocks cropping out is about 20,000 feet exclusive of the overthrust masses of the Weisner formation and the underlying Wash Creek, Brewer, and Waxahatchee slates. In small parts of the quadrangles the original horizontal attitude has been fairly well preserved, but generally the strata have been so much folded and faulted that the original attitude and to a considerable extent the original relations have been destroyed. There are local superficial deposits of clay, sand, and gravel of Cretaceous age, of gravel of possible Tertiary age, and of alluvium of Recent age, but the last two are of little stratigraphic importance. The columnar section in the back of this folio shows the stratigraphic succession.

Proposed Ozarkian system of Ulrich.—Besides a shale and a limestone of unknown age, described under "Stratigraphy," there are in these quadrangles a number of dolomite formations, the stratigraphic position of which is of peculiar importance. These formations, known, in ascending order, as Brierfield dolomite, Ketona dolomite, Bibb dolomite, Copper Ridge dolomite, and Chepultepec dolomite, are in part the basis of a geologic system proposed by Ulrich[3] and named by him the Ozarkian system. The name was taken from the Ozark region of Missouri, from a study of which the idea of a distinct system arose. Ulrich[4] describes the proposed system thus:

> Under the term Ozarkian I include all the formations of the Appalachian Valley that can be shown to be younger than (1) the top of the Upper Cambrian Nolichucky shale in northeastern Tennessee and (2) the top of the Conasauga shale in southeastern Tennessee, northwestern Georgia, and northeastern Alabama, and which are older than the base of the Stonehenge limestone of the Canadian system [Beekmantown group] in southern and central Pennsylvania.

Pending the presentation of all the evidence in support of the adoption of this proposed system, in a paper now in preparation by Mr. Ulrich, the United States Geological Survey will continue to classify these formations as Cambrian or Ordovician. The present author, however, believes that the Ozarkian system of Ulrich should be adopted here, for it is in the part of Alabama described in this folio that it reaches its maximum known thickness of about 5,500 feet.

The position of the proposed system in the general stratigraphic succession, its relations to the Knox dolomite of earlier Tennessee and Alabama reports, the general relations of the lower Paleozoic formations of Alabama to those of other regions, and the various classifications followed by the Alabama and United States Geological Surveys are exhibited in the table on page 20.

STRATIGRAPHY

SHALE OF UNKNOWN AGE

In the northeast corner of the Columbiana quadrangle are several small detached areas of red shale and soft yellow, greenish, or grayish shale or rotten slate that have been thrust into their present position from an original source lying apparently 12 miles or more to the southeast. These rocks are much older than the limestone that they overlie, and their parent formations are supposed to underlie the limestone at a great depth.

The red shale is pretty certainly of Rome age, but the age of the yellow-green shale is uncertain. It is in contact with different formations on different sides—on the west with a heavy cherty formation supposed to be Copper Ridge dolomite; on the north, in the southeast corner of the Vandiver quadrangle, with Newala limestone; and on the east with the Rome formation. There seems to be no possibility of determining its age from its stratigraphic relations, nor have any fossils been found to reveal its age. Lithologically the shale resembles shale of the Conasauga and Weisner formations and the Waxahatchee, Brewer, and Wash Creek slates. In view of the uncertainty as to the age and relations of these rocks it is believed to be most expedient not to assign them to any definite place in the geologic column.

LIMESTONE OF UNKNOWN AGE

In the northeastern part of the Columbiana quadrangle, in secs. 3 and 4, T. 21 S., R. 1 E., is a very thick deep-red soil evidently derived from a limestone or dolomite. This is so unlike the soils derived from the Newala limestone of the region generally that it seems doubtful if the Newala underlies that area. The soil is more like that derived from the Ketona or the Brierfield dolomite in some places than like any other. It seems as probable a supposition as any other, however, that the limestone or dolomite under the area is a noncherty part of the Copper Ridge dolomite, the cherty part of which makes the ridge and knob bordering the area of deep-red soil on the west. A reason for this supposition is the fact that the red soil extends up on the east side of the ridge in the northern part of sec. 4 along the highway. On account of the uncertainty, however, the designation "limestone of unknown age" is adopted.

PRE-CAMBRIAN OR PALEOZOIC ROCKS

GENERAL FEATURES

Character and distribution.—The rocks herein tentatively classified as pre-Cambrian or Paleozoic consist of a group of slates and phyllite, divided, in ascending order, into the Waxahatchee slate, the Brewer phyllite, and the Wash Creek slate. They comprise the lower part of the Talladega slate of early Alabama reports and appear to be equivalent in part to the Ocoee group of Safford in Tennessee.

In the region covered by this folio these rocks occupy an area extending from Columbiana Mountain, where their breadth is about 2 miles, southwestward across the Columbiana quadrangle. Just south of the latitude of Columbiana they cover an area 6 miles wide, thence southward they widen gradually to a line about 4 miles north of the south edge of the quadrangle and then expand to a belt 15 miles wide extending clear across the Columbiana quadrangle and into the southeast corner of the Montevallo quadrangle.

In these quadrangles they have been thrust westward from their original source into their present position, in which they overlie rocks that are higher stratigraphically. In normal position their lower part probably underlies at great depths all the other stratified rocks of the region, apparently being the first rocks deposited in the Appalachian Valley and resting upon a floor of still more ancient crystalline rocks.

These rocks were originally clay shale or sandy shale, but they have been metamorphosed to slate and phyllite by heat and pressure that resulted from folding and faulting. They include some limestone and several beds of conglomeratic sandstone or quartzite. Slaty cleavage, which is strongly developed, prevailingly strikes northeast, dips steeply to the southeast, and generally so obscures the original bedding that it can be detected with difficulty and in places not at all. No cross-bedding, ripple marks, or sun cracks have been observed.

The combined thickness of the formations appears to be at least 10,000 feet. This estimate is based on observations in the southwest corner of the Columbiana quadrangle, where the true dip was determined in a cut of the Ocampo Railroad to be 35° SE. In this locality the highest of these rocks lie along the axis of the Columbiana syncline near Cobb Creek, at the south edge of the quadrangle. From this locality northwestward across the strike to the northwest edge of these rocks, where the lowest beds are reached, is a distance of 4 miles. The generally high dip indicated along this line by the dip symbols is probably in large part the dip of the slaty cleavage, but at an average east dip of 35° the entire thickness within the limits taken is 12,000 feet. There is obviously a possibility of duplication of beds, as a result of the minor folds that would probably be produced in the course of their overthrusting through a distance of 15 miles. This thickness agrees rather closely, however, with that of supposed equivalent rocks in the Great Smoky Mountains of Tennessee.

The persistent purplish-gray phyllite (the Brewer phyllite) near the middle of this slaty mass permits the division of the

[3] Ulrich, E. O., Revision of the Paleozoic systems: Geol. Soc. America Bull., vol. 22, pp. 281–680, 1911.

[4] Idem, p. 627.

mass into the three formations named. Lithologically, there is little difference between the Waxahatchee and Wash Creek slates. Even the Brewer phyllite differs from the slates little except in color, but it is the key to the structure and the stratigraphic relations of the mass. The area underlain by these rocks is one of low, rolling topography known as the Stump Hills. (See pl. 3.)

Age and correlation.—It is believed, as a result of fairly continuous tracing, that the lower part of the Talladega slate of the Alabama Survey is the approximate equivalent of the Ocoee group of Safford in Tennessee, the Waxahatchee slate especially resembling the phase or division of that group which was named by Keith Hiwassee slate, because of its excellent display in the gorge of Hiwassee River, in the southwestern part of the Murphy quadrangle, Tenn. Keith shows, in several folios covering quadrangles in Tennessee, that in sections exposing a complete sequence of "Ocoee" and overlying Lower Cambrian formations the Hiwassee slate underlies the Cochran conglomerate, which in turn underlies the Nichols slate. Now the Nichols slate has yielded *Olenellus*, regarded as a diagnostic Lower Cambrian trilobite, so that its Lower Cambrian age is established; hence the Hiwassee slate is either Cambrian or pre-Cambrian. Keith believes that it is Cambrian, because of its general resemblance to the overlying Cambrian slate and because of the lack of any structural discordance between the Hiwassee and Cochran that would indicate an unconformity.

Another view is that these rocks are of late pre-Cambrian age. This view is based upon their normal position, inferior to known Cambrian rocks, and upon their greater degree of metamorphism, in Alabama at least, than that of the known Cambrian rocks. Up to 1922 no organic remains had been found in unquestionable Talladega rocks. In that year the writer found in the Sawyer limestone fossils of the *Cryptozoon* type which in size, manner of growth, and internal structure closely resemble *Graysonia*, from the Belt series of Montana, described by Walcott. In view of these facts the writer is inclined to regard at least part of these rocks as pre-Cambrian. Because of the uncertainty regarding their age, however, the three formations are herein classified as pre-Cambrian or Paleozoic.

Another view definitely accepted by Prouty and favorably entertained by Ulrich and White is that the Talladega rocks are of Carboniferous age. This view is based mainly on the occurrence of *Lepidodendron* and other Carboniferous fossil plants in a black slate high in the Talladega in the vicinity of Erin, Clay County. As it is now known, however, that beds of Lower Devonian age occur high in the Talladega in the vicinity of Jemison, Chilton County, the belief that more than a small part of the Talladega is Carboniferous is untenable. (For further discussion of the age of the Talladega see "Structure," p. 12.)

WAXAHATCHEE SLATE

Name.—The name Waxahatchee slate is here introduced for the basal slate formation of these quadrangles. It is taken from a creek, most of whose course lies upon the outcrop of the formation in the Columbiana quadrangle.

Distribution.—The Waxahatchee slate occupies a wide area southwest of Columbiana extending to the latitude of Shelby, where its area divides and one branch 2 miles wide passes southwestward into the southeast corner of the Montevallo quadrangle and the other swings southeastward and then eastward and continues into the main mass of the Talladega slate east of the Columbiana quadrangle, in Coosa and Talladega Counties. It is especially well displayed along Buxahatchee Creek immediately west of Sawyer Cove, where there is a nearly continuous exposure for a distance of 2 miles.

Character.—The Waxahatchee slate includes all the slate in this area below the Brewer phyllite. Near the top are the Sawyer limestone member and a stratum of sandstone, and apparently near the middle on Coosa River another stratum of sandstone. Thinner and less extensive layers of sandstone occur at other places.

The main body of the formation is composed of grayish, greenish, and bluish slate, which on weathering becomes soft and light gray, yellowish, or pale pink. South of Ocampo in the Montevallo quadrangle is a thinly fissile bluish slate that has been prospected for roofing slate. (See pl. 4.) A typical specimen is thus described by E. S. Larsen:[5]

Slate: Very fine textured rock with a slaty cleavage due to the parallel arrangement of the minute shreds of sericite, chlorite, kaolinite, etc. There are a very few small grains of quartz.

The formation contains much bluish, fine-grained slate described by Larsen from a thin section as follows:

Quartz-sericite schist: Resembles specimen No. 1 but has not so well developed a cleavage and has more small grains of quartz. Considerable organic pigment.

In the middle of the mass is a persistent stratum having a decidedly limy aspect on the weathered outcrop. This bed was noted at a number of places, beginning $1\frac{1}{2}$ miles south of Shelby and extending to a point $1\frac{1}{2}$ miles northwest of Shelby and thence southwest to Watson Creek, its outcrop paralleling that of the Brewer phyllite. A specimen of this bed, including a small pocket of calcareous material that effervesces freely when treated with acid, is thus described by Larsen:

Sericitic quartzite: Over one-half of this specimen consists of minute grains of quartz with a few of feldspar, embedded in a matrix of shreds of sericite, kaolinite, chlorite, etc. It differs from No. 1 in that it contains more grains of quartz and was apparently derived from a sandy shale.

The sandstones near the middle and top of the formation are very massively bedded and quartzitic. They are in places finely conglomeratic, most of the quartz pebbles being one-eighth of an inch or less in diameter. The beds have been greatly fractured and recemented with silica and as a result are shot through with thin veins which make a network on the surface. None of the beds appear to be more than 100 feet thick. Between the Sawyer limestone member and the Brewer phyllite is a soft, lumpy clay rock of brownish, greenish, or pinkish tint banded with thin yellowish, pinkish, or grayish laminae. This rock is prominently developed and displayed in the area between Sawyer Cove and the outcrop of the Brewer phyllite on the south.

Thickness.—As the Waxahatchee occupies about one-half of the outcrop of the three slate formations it is assumed to be about 5,000 feet thick. Where continuously exposed along Buxahatchee Creek for a distance of 2 miles directly across the strike, the dip apparently of both bedding and cleavage is 60°–80° E. The bedding is indicated by the presence at two points of sandstone layers 1 to 2 feet thick, which are parallel with well-developed planes of division that may be all bedding or partly cleavage planes. In view of the probable thickness of 5,000 feet for the Waxahatchee, it is evident that there is repetition of strata here by close folds, whether one or several it seems impossible to determine, else the thickness would be at least 10,000 feet.

Sawyer limestone member.—The Sawyer limestone member of the Waxahatchee slate was named from Sawyer Cove, in the southern part of the Columbiana quadrangle. It is a stratum of varied character. In places, as in the northern part of sec. 8, T. 24 N., R. 14 E., and at the junction of Camp Branch and Waxahatchee Creek 2 miles southwest of Shelby, the exposed parts are variegated pink, red, gray, and yellowish and veined with white calcite. The variegated rock is very fine grained, takes a high polish, and is an ornamental marble. Layers of black limestone occur in places. On the north side of Sawyer Cove the rock is a thick-bedded, highly siliceous gray limestone, weathering to a brown rock that looks like a sandstone. At this point it is also conglomeratic in part, some layers being filled with well-rounded quartz pebbles three-twentieths of an inch or less in diameter.

It is well displayed, having the characters just described, on the low knob north of Sawyer Cove in the southeast corner of sec. 13, T. 24 N., R. 14 E., also along Waxahatchee Creek and on the knoll where the creek leaves the cove in the NW. $\frac{1}{4}$ sec. 19, T. 24 N., R. 15 E. The pure limestone facies is best displayed on Buxahatchee Creek along the west side of Sawyer Cove, in the road and on the bluff just south of the southwest corner of the cove, and in the cove 3 miles west-southwest of Shelby, where it contains the fossils of *Cryptozoon* type mentioned above. In these places it is thick bedded, very fine grained, gray or in some layers mottled with pale pink and in some solid pink or pale red. The bed shows in the bluff just south of Brewer School on Crawford Branch, on Aiken Run, and on the highway $1\frac{1}{2}$ miles to the east. A dark limestone, of which only a thin bed was seen, crossing Watson Creek in the SE. $\frac{1}{4}$ sec. 18, T. 24 N., R. 14 E., may be the Sawyer limestone, but it seems too close to the Brewer phyllite above to be the Sawyer. The limestone is also well exposed on Waxahatchee Creek 2 miles southwest of Shelby, in the SW. $\frac{1}{4}$ sec. 22, T. 22 S., R. 1 W., and a short distance south of Buxahatchee Creek on the Evans property, in the NW. $\frac{1}{4}$ NE. $\frac{1}{4}$ sec. 8, T. 24 N., R. 14 E. At these places its variegated character is well developed. The marble from this limestone is described in the section on economic geology.

Associated with the limestone in secs. 10 and 15, T. 24 N., R. 14 E., and for 2 miles or more southeast of Brewer School are highly ferruginous layers that have attracted some attention and have been prospected as a possible iron ore. Much of this material is scattered on the surface along the outcrop southeast of Brewer School. It is dark brown and rather heavy, and the pieces have oblique pitting on the surface, which gives them a highly characteristic appearance. The pits are probably due to solution of the more calcareous parts of the rock. None of the rock seems rich enough in iron to be considered an available ore under present conditions. It has been regarded in the region as equivalent to the gray ore of the Talladega region, but that is an error.

The Sawyer limestone appears to be very uneven in thickness. On the south side of Sawyer Cove at least 100 feet crops out, and the fact that it has had such an influence on the topography here, the existence of the cove probably being due to its presence, indicates a greater thickness here than elsewhere. Limestone of the same character as the Sawyer occurs in the Hiwassee slate of Tennessee.

BREWER PHYLLITE

Name.—Overlying the Waxahatchee slate is a persistent stratum of purplish-gray phyllite, which, being everywhere in these quadrangles certainly identifiable, proved to be the key to the structure of the slate mass and served also to connect the partly detached overthrust area of slates south of Columbiana, in the Columbiana quadrangle, with the main body of Talladega rocks farther east. The name Brewer phyllite has been adopted for this formation because its outcrop passes near Brewer School, 6 miles south of Shelby. Purplish crumpled and banded slate in the road at the schoolhouse and immediately north of it is not regarded as belonging to the Brewer phyllite, the main body of which, strongly and characteristically purple, passes a quarter of a mile west of the schoolhouse. The Brewer was originally treated as a member of the Talladega slate but is here raised to the rank of a formation.

Distribution.—As shown by the map the Brewer phyllite crops out in a sinuous belt extending across the southern third of the Columbiana quadrangle, trending northward around the southward-pitching synclines and southward around the southward-pitching anticlines.

Character.—Lithologically the Brewer phyllite is like the main body of the great slate mass to which it belongs except for its color, which is probably due to a small quantity of iron oxide. It is fissile and finely banded and has a silky sheen or luster. A thin section is thus described by Larsen:

Quartz sericite schist. A well-banded schist, mainly sericite, chlorite, quartz, and probably kaolinite. Much clouded by black opaque specks, which are probably of organic origin but possibly some are magnetite. Very little hematite.

Another specimen is described as containing mainly sericite with the shreds oriented normal to the banding, also some small grains of quartz, and showing in alternate bands a concentration of the organic pigment.

Here and there green phyllite apparently replaces a part of the purple, particularly on the east side of the quadrangle, and this change may account for the apparent thinning of the purple rock in that direction. In other places, as near Sawyer Cove, there is close to the bottom of the formation a highly ferruginous portion or a lean iron ore much coarser grained than the main body. In the vicinity of Brewer School and eastward to the east side of the quadrangle the phyllite is crumpled; in places strongly so.

Thickness.—The thickness of the Brewer phyllite ranges from 500 feet on the west side of its area to 200 feet on the east edge of the Columbiana quadrangle.

WASH CREEK SLATE

Name.—The name Wash Creek slate is here introduced for the great body of slate overlying the Brewer phyllite in these quadrangles. The name is taken from Wash Creek, south of Sawyer Cove, in the Columbiana quadrangle.

Distribution.—The Wash Creek slate crops out across the southern part of the Columbiana quadrangle and extends about 1 mile into the Montevallo quadrangle. It extends north along the Columbiana syncline to a point 6 miles north of the south line of the quadrangle. Rocks that underlie the Weisner formation in Columbiana Mountain should possibly be assigned to this formation.

Character.—The Wash Creek slate is very much like the Waxahatchee slate. A considerable thickness at the bottom, lying between the Brewer phyllite and the ferruginous sandstone member described below and extending for some distance above that member, is rather more sandy than most of the slates of the region. It is extensively exposed, probably owing to its greater resistance to disintegration, and has the appearance of thin-bedded sandstone. It is probable that this division is sufficiently distinct to be generally recognizable. A thin section of a specimen collected 2 miles south of Sawyer Cove is thus described by Larsen:

Quartz-sericite schist: Rather abundant grains of quartz about 0.1 millimeter across, elongated in the direction of the banding (augen?), are embedded in a matrix of fine shreds of sericite. Clouded by submicroscopic dust, probably of organic origin. Derived from a fine-textured impure sandstone or siliceous shale.

Above this sandy part finely fissile greenish to gray slate prevails, generally crumpled in the southeastern part of the Columbiana quadrangle. (See pl. 5.) Most of the higher rocks of the formation in this quadrangle are of this character. At or near the top of the Wash Creek is a thick stratum of conglomeratic quartzite, which may belong to the Weisner formation. Not far below this quartzite is a considerable thickness of black slate that has been mistaken for an indication of coal. The Wash Creek slate generally, especially in the area extending for $1\frac{1}{2}$ miles north of the south line of the Columbiana quadrangle, contains many quartz veins, some of which must reach a thickness of 2 feet, to judge from the size of the quartz boulders that thickly strew the ground in many

[5] Personal communication.

places. It is probable that these veins carry small quantities of gold, for the sands along the streams contain a little gold dust.

Thickness.—The formation makes up about half of the great mass of slates in these quadrangles. It is probably at least 5,000 feet thick and may be thicker, as its top has not certainly been identified.

Ferruginous sandstone member.—About 1,000 feet above the Brewer phyllite is a persistent stratum of fine-grained sandstone with a little sandy slate, which includes layers of the same materials rather highly impregnated with hematite and constituting a lean ore. The member is well exposed in the bed of Wash Creek $1\frac{1}{2}$ miles south of Sawyer Cove and on the ridge half a mile west of the creek.

Section of ferruginous sandstone member of Wash Creek slate exposed on Ocampo Railroad in the NW. $\frac{1}{4}$ sec. 34, T. 24 N., R. 14 E.

	Feet
Sandstone, heavy bedded, fine grained, green	100
Sandstone, highly ferruginous; lean ore	3
Sandstone, heavy bedded, fine grained, green	20
Sandstone, highly ferruginous; lean ore	$5\frac{1}{4}$
Sandstone, heavy bedded, fine grained, green.	
	$128\frac{1}{4}$

This member is persistent and can be traced by the fragments of lean ore almost continuously across the Columbiana quadrangle and into the Montevallo quadrangle. In places the ore does not show, either because locally it was not deposited or because it has been displaced by faults. In these places the tracing is less certain and the outcrop is mapped by a broken band. The thickness of the ferruginous sandstone member is 100 to 129 feet. A specimen of the ore from a prospect pit in the SW. $\frac{1}{4}$ sec. 16, T. 24 N., R. 14 E., is thus described by Larsen, who examined a thin section:

Sandy hematite: The section consists of about half and half by volume of fragments of quartz and chlorite aggregates with some feldspar in a matrix of nearly opaque reddish-brown hematite.

This description will answer for all the lean ore of the slates of the region.

In sec. 16 the sandstone has been prospected for ore and is said to contain as high as 27 per cent of metallic iron.

The outcrop of this ferruginous member parallels rather closely that of the Brewer phyllite across the southern part of the Columbiana quadrangle. The bed was not observed east of the road leading south from Watson Ford on Waxahatchee Creek. The member is especially well developed in the southwestern part of sec. 16, T. 24 N., R. 14 E., in the adjoining parts of secs. 20 and 21, and along the strip from the northern part of sec. 32 to the SE. $\frac{1}{4}$ sec. 36.

CAMBRIAN SYSTEM

The rocks of unquestioned Cambrian age in these quadrangles include, in ascending order, the Weisner formation, the Shady limestone, the Rome ("Montevallo") formation, and the Conasauga ("Coosa") limestone. Lower, Middle, and Upper Cambrian time are all represented in these formations.

WEISNER FORMATION

Name.—The name Weisner quartzite was introduced in 1890, from Weisner Mountain, in Cherokee County, Ala., and has since been used by the Alabama Geological Survey in a number of publications.

Distribution.—There are two areas of Weisner rocks in the northeast corner of the Columbiana quadrangle, of which the larger is the horseshoe-shaped area of Columbiana Mountain. Within the sides of Columbiana Mountain is a second and smaller roughly triangular area. As more fully described in the section on structure (p. 12), the smaller area is an overthrust mass of Weisner rock lying on Conasauga limestone. The main area on Columbiana Mountain is apparently in unconformable relations to the Waxahatchee slate below and conformably underlies the Shady limestone and other rocks above. It belongs to the main and supposedly original overthrust mass mentioned on page 12.

Character.—The Weisner formation is composed of shale or slate inclosing five or more quartzite members, 3 to 100 feet thick. A section of the formation, compiled from the exposures on Beeswax Creek above Leeper's mill, half a mile northwest of Kingdon Church, and on the Mardis Ferry road on the east slope of Columbiana Mountain, is given below:

Section of Weisner formation in Columbiana Mountain

	Feet
12. Quartzite	10
11. Shale or slate, stiff, bluish, siliceous (and calcareous?); ore at base	180
10. Quartzite	5
9. Shale or slate, stiff, bluish, calcareous and siliceous; layers of sericitic quartzite; ore at bottom on Columbiana Mountain	618
8. Quartzite, thin bedded (shows at Leeper's mill)	75
7. Quartzite, thick bedded, conglomeratic (shows at Leeper's mill)	25
6. Shale or slate, mainly greenish	85
5. Ore and shale	11
4. Shale or slate with few thin quartzitic layers	300
3. Quartzite	3
2. Not exposed, a little slate or shaly sandstone at top	250
1. Quartzite, conglomeratic (crest of mountain)	30
	1,592

The part of the section on Beeswax Creek (Nos. 7 to 12) was measured by the writer; the part on the Mardis Ferry road was also measured in part by the writer, but some gaps were filled in from the section by P. S. Smith.[6]

Probably there are beds above the highest quartzite (No. 12) that should be included in this formation, but they are not exposed and probably do not exceed 100 feet in thickness. The lowest quartzite bed, assumed to be the base of the Weisner, is underlain by a great thickness of slate exposed along the road between Columbiana and Columbiana Mountain and weathered to a soft yellowish or yellowish-green shale. This slate is assumed to be the upper part of the Wash Creek slate, upon which the Weisner may normally rest. It is possible, however, that this slate is the Waxahatchee slate, upon which the Weisner was deposited unconformably.

The thin-layered rocks of the Weisner which include the quartzite beds are probably more properly classed as shale than as slate, although they cannot be distinguished in their weathered state from the underlying Wash Creek slate. When fresh they are bluish gray, but they weather to pale pinkish, yellowish gray, or yellowish green. They contain a considerable proportion of thin layers, which, are shown in thin sections to be sericitic quartzite. This rock is thus described by Larsen, who examined a thin section from a specimen collected just above Leeper's mill on Beeswax Creek, half a mile northwest of Kingdon Church:

Sericitic quartzite: Some bands consist largely of small grains of quartz with some feldspar, etc., in a matrix of sericite. Some bands are mainly sericite, chlorite, kaolinite, etc. Evidently derived from a thin-bedded fine-grained sandstone with some shale. The metamorphism is not intense.

The outward aspect of this shale or slate suggests that the differences found in it are due to a greater or less proportion of quartz grains.

The quartzite beds of the formation are hard, gray, medium thick bedded, and conglomeratic. The pebbles are neither abundant nor large as a rule, though some layers are fairly well filled with pebbles, a few of which may be as big as peas.

Ore beds that occur in the formation probably represent the gray ores of the Talladega region. A number of these beds have been definitely located in the section, and the occurrence of others of probably small extent is indicated by float ore present for short distances along the strike of the rocks at several horizons. The ore is a sandy hematite, part of which may carry from 40 to 54 per cent of metallic iron. It occurs as layers, some of them $3\frac{1}{2}$ feet thick, alternating with layers of shale as shown by the following section, which is one of the best seen in the formation.

Section of ore bed in a pit on Columbiana Mountain in the western part of sec. 8, T. 21 S., R. 1 E., one-sixth of a mile southeast of Nelson station

	Ft.	in.
12. Shale (or slate)	12	
11. Shale, ferruginous, lean ore, worthless		$8\frac{1}{2}$
10. Ore, probably low grade, worthless		7
9. Shale, ferruginous		2
8. Ore, low grade, probably worthless	1	1
7. Shale, more or less ferruginous		$8\frac{1}{2}$
6. Ore, low grade, probably worthless		7
5. Ore, apparently fair grade		5
4. Shale, ferruginous	2	4
3. Ore, apparently high grade	3	6
2. Shale?	10	
1. Quartzite, conglomeratic, supposed to be beds 7 and 8 of the section in the preceding column.		

The ore beds appear to be generally rather closely associated with the quartzite beds. Specimens of the ore are thus described by Larsen:

Sandy hematite: Rather abundant grains of quartz and some of feldspar, chloritic material, zircon, etc., in a reddish-brown, nearly opaque matrix of hematite. Quartz grains show strain.

Sandy hematite Similar to that just described but composed over half by volume of grains of quartz as much as 0.5 millimeter in diameter. The grains are rounded and show strain.

Thickness.—The thickness of the Weisner formation in this region, allowing 100 feet for the unexposed rocks at the top, as mentioned above, is in round numbers 1,700 feet. As the dip is regular and the sequence apparently undisturbed this determination seems reliable.

Age and correlation.—No fossils have been found by the writer in the Weisner rocks of Alabama or reported by others, and fossils are exceedingly rare in the rocks of this age in the southern Appalachian region. Species of *Hyolithes* and *Olenellus* have been found, however, at two localities in Tennessee in the upper part of the corresponding Cambrian quartzites (Chilhowee group of Safford) and *Olenellus* and several species of Lower Cambrian brachiopods have been obtained by S. W. McCallie from Weisner rocks in Bartow County, Ga. On this evidence the age of the Weisner is regarded as Lower Cambrian. The fossils from Bartow County, Ga., were identified by Walcott[7] as follows:

Obolella cf. O. atlantica Walcott.
Obolella cf. O. crassa (Hall).
Archaeocyathus?
Stenotheca cf. S. rugosa (Hall).
Olenellus thompsoni (Hall).

[6] The gray iron ores of Talladega County, Ala.: U. S. Geol. Survey Bull. 315, pp. 161-184, 1907.

[7] Walcott, C. D., Cambrian Brachiopoda: U. S. Geol. Survey Mon. 51, pt. 1, p. 211, 1912.

SHADY LIMESTONE

Name.—The name Shady was introduced by Keith[8] from Shady, Johnson County, Tenn., for a limestone between the Erwin quartzite and the Watauga shale. The name "Beaver" was also earlier applied by Hayes to this limestone, through a mistaken identification of it with the younger limestone of Beaver Ridge, northwest of Knoxville, Tenn. The name "Aldrich (Beaver)" has been used by the Alabama Geological Survey, from Aldrich, in the Montevallo quadrangle, but as the limestone at Aldrich is of Conasauga age, the name Aldrich is inapplicable to the limestone here called Shady.

Distribution.—The Shady limestone is best displayed in the bed of Beeswax Creek just east of the gap through the Weisner quartzite ridge half a mile east of Nelson. It was seen also in the SE. $\frac{1}{4}$ SE. $\frac{1}{4}$ sec. 20, T. 21 S., R. 1 E., where it shows for several hundred feet in the bed of Beeswax Creek, and in the SE. $\frac{1}{4}$ NW. $\frac{1}{4}$ sec. 21, where one or two exposures about a foot square were seen. The low ground and the character of the soil indicate that limestone underlies an area bordering the inner foot of Columbiana Mountain.

Character.—So far as seen the Shady limestone is in part thick bedded, coarse grained, and pale yellowish gray to nearly white and in part fine grained and bluish gray. The coarse-grained rock is a fair grade of marble. In the SW. $\frac{1}{4}$ sec. 17, T. 21 S., R. 1 E., barytes is scattered over a small area on the outcrop of the limestone, and in the northern part of sec. 21 a good deal of yellowish or black waxy chert occurs near the contact of the limestone and the overlying Rome formation.

Thickness.—The thickness of the limestone can not be determined exactly because neither of its limits has been definitely ascertained, but the width of its outcrop seems to be about 1,000 feet, and the dip to be about 30°, which is also that of the rocks above and below, and this would make the thickness 500 feet.

Age and correlation. — At its type locality in Johnson County, Tenn., the Shady limestone is between the Chilhowee group below and the Watauga shale above. The Chilhowee corresponds in age to the Weisner formation, which underlies the limestone in the area here described. Above this limestone in Columbiana Mountain is a formation of the same character as the Watauga of Tennessee. The limestone is therefore proved by its stratigraphic relations to be the same as the Shady. The Shady is also correlated with the Tomstown limestone of Pennsylvania and Maryland. Fossils found by Keith in the base of the Shady in Tennessee were identified by Walcott as of Lower Cambrian age. No fossils were found in the limestone in this area.

ROME ("MONTEVALLO") FORMATION

Name and limits.—The name Rome formation, from Rome, Ga., was introduced by Hayes in 1890. At about the same time the name "Choccolocco or Montevallo shales" was introduced by Smith for rocks in central Alabama now known to be equivalent to the Rome. The equivalency of the Rome and Montevallo was not, however, satisfactorily established until 1908. In the meantime the name Rome had been given wide currency by use in eleven folios of the Geologic Atlas, and it seems best to retain that name, although the name Montevallo has slight priority of publication.

Except in the Columbiana Mountain area, the base of the Rome formation is nowhere exposed in these quadrangles, but it is exposed in the southwestern part of the Rome quadrangle, in Georgia and Alabama where, as in the Columbiana Mountain area it is underlain by the Shady ("Beaver") limestone. The top of the Rome is fixed at the upper limit of red shale and of the peculiar hard, rusty-weathering calcareous sandstone or siliceous limestone characteristic of the Rome. This is a definite and easily recognized lithologic boundary. Above it is everywhere the olive-green shale or blue oolitic limestone of the Conasauga or equivalent formations.

Distribution.—The Rome formation crops out in a band half a mile wide that lies along the southeast edge of the Cahaba coal field in Opossum Valley north of Maylene. There is an isolated, apparently anticlinal area 2 miles northeast of Montevallo, and a large, very closely plicated, and apparently anticlinal area north of Montevallo, from which a belt three-quarters of a mile wide extends southwestward to the edge of the quadrangle. The sandstone at the top of the formation here makes several knobs or low ridges, the most conspicuous of which is that lying mainly in the NE. $\frac{1}{4}$ sec. 21, T. 21 S., R. 1 E.

The best exhibitions of the Rome are to be seen along the highway from Montevallo to Maylene, between Montevallo and Aldrich, west of Wilton, and on Sixmile Creek a few miles west of the Montevallo quadrangle. The formation is also present in the Columbiana quadrangle in the overthrust mass of Columbiana Mountain and in a few small detached areas in the northeast corner of the quadrangle. It crops out in a curving belt one-third of a mile or more wide on the inner side of the curve of Columbiana Mountain.

[8] U. S. Geol. Survey Geol. Atlas, Cranberry folio (No. 90), p. 5, 1903.

Thickness.—The thickness of the Rome in the Columbiana Mountain area seems to be 300 feet, but owing to the fact that elsewhere in the quadrangles the bottom of the Rome is not exposed, the formation being in faulted contact with higher formations, and owing also to its crumpled condition, no reliable determination of its thickness seems possible. Its exposed part can hardly be less than 1,000 feet thick.

Age and correlation.—Small collections of fossils have been obtained from the Rome in the Bessemer quadrangle, from which the following forms have been identified by C. D. Walcott except the *Olenellus*, which was identified by the writer.

Micromitra (Paterina) major Walcott.
Micomitra (Paterina) williardi Walcott.
Micromitra (Iphidella) pannula White.
Obolus smithi Walcott.
Wimanella shelbyensis Walcott.
Olenellus thompsoni Hall.
Paedumias transitans Walcott.
Wanneria halli?

The fossils of this list were obtained from two localities, one a quarter of a mile north and the other 4 miles south of Helena, from a bed that seems to be about 500 feet below the top of the Rome. In the vicinity of Montevallo, about 200 feet below the top of the Rome as delimited in that locality, *Olenellus thompsoni* is abundant. *Micromitra* (*Paterina*) *williardi*, *Obolus smithi*, and *Wimanella shelbyensis* are known only from the Rome of Cahaba Valley. *Micromitra* (*Iphidella*) *pannula* is recorded by Walcott from Lower, Middle, and Upper Cambrian rocks, but the greater number of occurrences are Middle Cambrian. The *Paedumias* and *Wanneria* are in some regions, as York County, Pa., associated with *Olenellus*, which is accepted as a Lower Cambrian genus. The paleontologic evidence, as generally interpreted, indicates the Lower Cambrian age of most of the Rome of this region. Ulrich, however, regards all or most of the Rome as Middle Cambrian.

CONASAUGA ("COOSA") LIMESTONE

Name.—The name Conasauga, from Conasauga River in northwestern Georgia, was introduced by Hayes in December, 1890, and appeared in print in February, 1891. The name Coosa, from Coosa Valley, was introduced by Smith in January, 1891, for the same rocks. For the reasons stated for adopting the name of the Rome formation, the name Conasauga is used in this folio rather than Coosa.

The boundary between the Rome and Conasauga is placed at the upper limit of red shale and sandstone and characteristic associated calcareous sandstone of the Rome and at the horizon of the introduction of limestone of Conasauga type. At Rome, Ga., this boundary is very definite, the Rome sediments being immediately succeeded by 150 feet of limestone, largely oolitic and fairly fossiliferous. Near Montevallo, however, the lowest limestone of Conasauga type is only a few feet thick close above beds of distinctly red shale and 200 feet above a bed of yellow-weathering clay shale containing *Olenellus thompsoni*. This basal Conasauga limestone is overlain by about 200 feet of sandy and clay shale, and this is succeeded by the main body of Conasauga limestone.

The Conasauga limestone at Aldrich was interpreted by the Alabama Geological Survey as underlying the "Montevallo shale" normally and therefore in the position of the Shady limestone, which was called "Beaver limestone" by Hayes. (See description of Shady limestone.) The Conasauga at Aldrich was accordingly named "Aldrich limestone" and in Alabama Survey reports is designated "Aldrich (Beaver) limestone." Although the Conasauga is indeed overlain by Rome shale near Aldrich, its position is due to the fact that it is in a closely folded syncline overturned to the west, so that the beds dip east at the low angle of about 25° or 30°. That it is really Conasauga is demonstrated by continuous tracing north to Dogwood, where it is in its normal relations between the Brierfield dolomite and the Rome formation. It is also proved to be Conasauga by its fossils, which are the same species as those collected from the limestone just west of Montevallo, especially from bed 4 of the section below. The new species of *Dorypyge* and other trilobites were also obtained from the limestone at Aldrich.

Distribution.—The Conasauga has a comparatively narrow band of outcrop extending from a point near the southwest corner of the Montevallo quadrangle northeastward, passing just west of Montevallo, and 2 miles northeast of that town being divided into two bands by an anticlinal area of the Rome formation. These bands reunite 2 miles farther northeast and possibly underlie a rather wide area in the flat, deeply soil-covered valley north of the anticlinal area. West of the fault at this locality is a narrow strip of Conasauga extending to the vicinity of Dogwood and thence in a narrow band to Shoal Creek 2 miles south of Aldrich. At Dogwood and farther north the Conasauga is absent, the Rome formation so far as known, being succeeded either by the Brierfield dolomite, as at Dogwood, or by the Ketona dolomite, as north of Maylene in Cahaba Valley. The best exposure of the Conasauga in this region is on the Birmingham road, beginning at the foot of the hill 1 mile northeast of Montevallo and extending 3 miles northeastward. The limestone is particularly well exposed, and the presence of the interbedded strata of yellow-green flaky shale is clearly apparent, although the shale does not crop out conspicuously.

Character.—In these areas the Conasauga is composed of limestone and shale. The following section will give a fair idea of its general character in the Montevallo quadrangle:

Section along Aldrich road immediately west of Montevallo

	Feet
Brierfield dolomite:	
23. Dolomite, cavernous, typical Brierfield	2
22. Not exposed	55
Conasauga limestone:	
21. Limestone, blue, thin clay bands; trilobites	2
20. Not exposed	150
19. Limestone	15
18. Shale, soft clay; weathers yellow; trilobites abundant	25
17. Limestone	15
16. Not exposed along road. Estimated 100 feet of limestone about in middle of this space exposed in field 800 feet northeast of road. Limestone dark blue, fine to coarse grained, some oolitic; trilobites, *Dorypyge aldrichensis*	200
15. Limestone	10
14. Not exposed	20
13. Shale, soft clay, weathering yellow; trilobites abundant	65
12. Not exposed	225±
11 Shale, sandy, micaceous, greenish (mudrock?)	120
10. Shale, green	5
9. Sandstone, ferruginous on weathering, probably calcareous	5
8. Shale or sandy mudrock, reddish	2
7. Shale or mudrock, sandy, greenish	25
6. Limestone, dark blue, fine grained to medium grained; trilobites	2
Total Conasauga	888
(Or, including the 55 feet not exposed at top, 943 feet.)	
Rome formation:	
5. Shale; weathers yellow; three bands of red shale about 5 feet thick about 30 feet apart, thin layers of friable micaceous sandstone	80
4. Shale, like No. 5, but no red shale	60
3. Not exposed; some reddish soil	100
2. Shale, clay, soft; weathers yellow; *Olenellus thompsoni* abundant, oboloid branchiopod	40±
1. Not exposed; débris of red sandstone and green shale weathering yellow	165
Shale, red and greenish, weathering yellow, and sandstone, more or less calcareous; several hundred feet.	

The intermixture of shale and limestone beds is characteristic of the Conasauga. In the Montevallo quadrangle the two seem to be about equal components of the formation. In other areas either the one or the other may compose nearly all of the mass. The section along the Birmingham road north of Montevallo gives a good exhibition of the alternation of shale and limestone. In that section the limestone is medium thick bedded, medium grained, and blue. Many of the beds have thin argillaceous layers from which the calcium carbonate is leached on weathering, leaving the clay as a narrow gray band parallel to the bedding and giving the weathered edges of the beds a characteristic ribboned appearance. The formation includes, perhaps only locally, considerable dolomite or rock of dolomitic appearance, as on the Birmingham road just southwest of the crossing of Shoal Creek, where it is apparently 100 feet thick, and in the overturned syncline on Davis Creek for about a quarter of a mile southeast of the railroad bridge just north of Aldrich. Much of the limestone is oolitic or perhaps pisolitic, some of the grains being a quarter of an inch or more in diameter. In the 150 feet of Conasauga at Rome, Ga., immediately overlying the Rome formation, oolite is common, also clay bands giving the ribboned surface of weathered layers. The rock on Beeswax Creek in the Columbiana quadrangle is, so far as seen, a thick-bedded blue limestone without shale beds. Some large masses of chert in this area near the contact with the Rome appear to be derived from the Conasauga, and, if they are, it is an unusual feature of the formation.

The shale is either sandy and micaceous, like Nos. 7, 8, and 11 of the Montevallo section, or, more generally, a clayey rock that is rather fissile and weathers down to thin yellow flakes.

No analyses of the limestone in this region have been made, but samples from the vicinity of Wheeling, in the Bessemer quadrangle, were composed of 89 per cent of calcium carbonate, 8 per cent of magnesium carbonate, 1.2 per cent of silica, and small quantities of iron oxide, alumina, and sulphur dioxide. Although much of the limestone in this region is undoubtedly higher in aluminous and siliceous impurities, there is probably rock as pure as that shown by these analyses.

Thickness.—As calculated from the dip and the width of outcrop the Conasauga just west of Montevallo is about 900 feet thick. It gradually thins northwestward toward the area in which it is absent. In the Columbiana Mountain area the thickness exposed is about 1,000 feet, and the whole thickness of the formation is probably at least 1,500 feet.

Age.—The Conasauga of these quadrangles is fossiliferous from bottom to top. Collections have been obtained from good exposures on Sixmile Creek 1½ miles northwest of Sixmile, Bibb County, and half a mile west of Montevallo, at Aldrich. These collections have not been fully identified, but from incomplete studies the following forms have been recognized. At the Sixmile locality were found trilobites of the genera *Amecephalus, Dorypyge, Zacanthoides* (*Z. orientalis*), and *Dolichometopus*, probably all undescribed species, although the *Dolichometopus* may be *D. productus;* at Aldrich *Dolichometopus productus* and another species of *Dorypyge* (*D. aldrichensis*), which was found also half a mile west of Montevallo.

Some of these fossils have been figured by the Geological Survey of Alabama.[9] At most localities these forms occur in the shale and limestone immediately above the Rome formation, but the horizon of the collection half a mile west of Montevallo is about at the base of the upper third of the formation.

Every one of the fossils named belongs in an assemblage of genera elsewhere occurring, so far as known, only in formations of Middle Cambrian age. As representatives of this assemblage are now known to range through the lower two-thirds of the Conasauga in the vicinity of Montevallo, and as no distinctly Upper Cambrian fossils are known from any part of the formation in these quadrangles, it may be that the entire formation in the area is of Middle Cambrian age, though it is possible that the Upper Cambrian is represented in the upper third.

Zacanthoides is represented in the Rutledge limestone of Tennessee perhaps by the same species as in Alabama. A species of *Dolichometopus* occurs in the base of the Elbrook limestone at Waynesboro, Pa., and has been figured by Bassler in the volume on the Cambrian and Ordovician of Maryland. *Dorypyge* ranges throughout the Appalachian Valley into Canada and to northern Greenland and, in association with *Amecephalus* and *Zacanthoides*, occurs also in the Middle Cambrian of the northwestern United States and British Columbia. On the basis of the fossil evidence, therefore, the lower two-thirds of the Conasauga of the southeastern belts in Alabama—that is, in Cahaba Valley and farther southeast—is correlated with the Rutledge limestone of Tennessee and with the lower part of the Elbrook limestone of Pennsylvania.

Ulrich, who has recently studied the distribution of this fauna, concludes that it is of Arctic origin and migrated southward along comparatively narrow seaways into eastern Alabama on the east and into British Columbia and waters farther south on the west.

So far as at present known an entirely different assemblage of fossils occurs in the Conasauga of Birmingham Valley and in Cherokee County. In the shale and limestone at Cedar Bluff, Cherokee County, trilobites are also especially abundant; nine species of them have been described by Walcott, and many species are still undescribed. A considerable number of fossils, some of the same species as in Cherokee County, have been found at other localities in this belt, including Whitney, Ketona, Murphrees Valley, Birmingham, Bessemer, and Woodstock in Tuscaloosa County. Some of the more common species are *Dicellomus appalachia, Lingulella buttsi, Crepicephalus texanus*, with the long inward-curving tail spines, *Norwoodia* (3 species), *Asaphiscus* (*Blainia*) (3 species), *Neolenus* (*Olenoides*) *curticei, Olenus truncatus?, Calagnostus reticulatus?, Cedaria prolifica*, and *Dendrograptus halli.*

Some of the forms listed above—*Neolenus* (*Olenoides*) *curticei* and the species of *Asaphiscus* (*Blainia*)—stand apart from the others. These forms are found on siliceous nodules that apparently occur in ordinary green shale of the Conasauga in the vicinity of Blaine, 3 miles east of Center, the county seat of Cherokee County. These forms are especially important because of their manner of occurrence and because *Neolenus*, of which several species are known, mainly from the northwestern United States and British Columbia, is in those regions an exclusively Middle Cambrian genus associated with *Dorypyge* and the other members of the *Dorypyge* fauna. The forms identified as *Asaphiscus* (*Blainia*) are, according to Resser, probably not true *Asaphiscus* and, being unknown elsewhere, have no stratigraphic significance beyond the fact of their resemblance to true *Asaphiscus*, which, although in the main a Middle Cambrian genus, ranges into the Upper Cambrian also. On the evidence of *Neolenus*, therefore, it is thought probable that the Middle Cambrian is represented in the basal part of the Conasauga in Cherokee County.

All the other fossils listed above are well established Upper Cambrian forms. Some of these forms, as species of *Norwoodia* and *Crepicephalus*, occur at Fourth Street and Eleventh Avenue, Birmingham, in shale that from its occurrence on an anticline seems to be low in the Conasauga of Birmingham Valley. Nearly all these fossils, except the *Neolenus* and *Asaphiscus*, occur in close association in the part of the formation exposed at Cedar Bluff, Cherokee County.[10] As *Crepicephalus texanus* is known to occur high in the Conasauga elsewhere, as about half a mile west of Whitney, St. Clair County, and at the Ketona quarry, Jefferson County, the horizon of the Cedar Bluff occurrence is proved to be high in the Conasauga. It appears, therefore, that at least two-thirds of the Conasauga of the Montevallo and Columbiana quadrangles is of Middle Cambrian age, whereas the Conasauga of Birmingham Valley is mainly, so far as known, of

[9] Geology of Alabama: Alabama Geol. Survey Special Rept. 14, pls. 5, 68, 1926.

[10] Idem, pls. 8, 9.

Upper Cambrian age. If this apparent difference in age should be verified by future investigation, it may prove desirable to remove the beds of the southeastern belts from the Conasauga and give them a new formation name, leaving the present name to apply in the northwestern belts, which are physically continuous with the Conasauga of the type locality.

CAMBRIAN OR ORDOVICIAN SYSTEM

Pending a decision as to the adoption of Ulrich's proposed Ozarkian system, which would include in ascending order the Brierfield, Ketona, Bibb, Copper Ridge, and Chepultepec dolomites, these formations are classified by the United States Geological Survey as of Cambrian or Ordovician age. This great mass of dolomite, comprising most of the Knox dolomite of earlier reports on this region, is 5,000 to 5,500 feet thick and is lithologically absolutely distinct from the immediately underlying Upper Cambrian. Except for a rare occurrence of *Cryptozoon*, the lower half of this mass is nonfossiliferous so far as known, and the fossils contained in the upper half are unknown in any rocks of established Cambrian age. Except where the Brierfield dolomite is present and perhaps there also this dolomite mass is separated from the underlying Upper Cambrian by a strong unconformity.

BRIERFIELD DOLOMITE

Name.—The Brierfield dolomite was named by Ulrich from the town of Brierfield, in the Montevallo quadrangle, which is situated upon an area of its outcrop.

Distribution.—The Brierfield dolomite crops out in a broad belt from the southwest corner of the Montevallo quadrangle to Ebenezer Church, but the outcrop is offset by faults at Brierfield and Wilton. Its areas are either low ground or low rounded ridges such as that on which Montevallo is situated. It decomposes to a deep, rich red soil, and the subsoil, in places where it is exposed along roads and in washes, is full of chalky-weathering cavernous chert. It preserves these distinguishing characteristics throughout this area and can be identified with certainty. At Dogwood the characteristic weathering phenomena are well displayed in a cut on the Southern Railway, and fine chert and slaty blue dolomite were noted at a few points west and southwest of Dogwood. North of Dogwood the dolomite area on the west should fall into the Brierfield stratigraphically, and, although the dolomite in this area presents marked differences as to color and silica content from the typical Brierfield farther south, it is nevertheless regarded as the Brierfield with a modified aspect.

The best exposure of the Brierfield dolomite is on Sixmile Creek for a mile or more below Sixmile, where all aspects of the formation are displayed. Nearly as good an exposure is on Shoal Creek in Montevallo. In that town and on the ridges northeast of it many boulders of the chert from the lower part of the Brierfield lie on the surface. The contact of the Brierfield and Ketona and the upper 100 to 200 feet of the Brierfield are well shown on Mahan Creek three-quarters of a mile northwest of Brierfield.

Character.—The dolomite is a thick-bedded fine-grained steely-blue rock and is highly siliceous. Specimens collected at Brierfield contain 40 per cent of insoluble matter, mostly silica. Except for the silica the rock is composed almost wholly of calcium and magnesium carbonates nearly in the dolomite ratio, which is 54.3 per cent of calcium carbonate and 45.7 per cent of magnesium carbonate. Many of the layers of dolomite on weathering become very characteristically pitted. Thin sections show the silica in the form of quartz, which fills small cracks and apparently also replaces the dolomite. No clastic grains could be found, so it appears that the silica was precipitated from solution along with other minerals of the rock and subsequently concentrated in the cracks. In the lower fourth of the formation part of the silica takes the form of a dense chert, but throughout the rest of the mass it occurs disseminated. Upon the weathering of the dolomite the silica forms a cavernous crust or a fine lacework of ridges upon the surface of the rocks, and on complete solution of the carbonates the silica remains as larger or smaller rounded boulders with a highly characteristic cavernous structure. (See pls. 6 and 7.) These products of weathering are so distinctive as to render the identification of the formation practically certain, whether the rock is exposed or under a cover of soil. The siliceous crusts and boulders from the Brierfield ultimately weather down to a chalky powder, thus differing from the dense, tough chert of the Copper Ridge dolomite, which takes the form of angular masses and breaks down into fine angular fragments.

Thickness.—The thickness of the formation appears to be at least 1,250 feet on Sixmile Creek, where the conditions for measurement are favorable.

Age and correlation.—The only fossil seen in the Brierfield is a large compound cryptozoan, *Cryptozoon proliferum*, of which a number of coalesced heads 6 to 18 inches in diameter, forming a sort of reef, were seen on Sixmile Creek 1 mile west of the Montevallo quadrangle. The Brierfield is not known outside of the area mapped here. It is believed to be equivalent to part of the Gatesburg formation of central Pennsylvania, which is of very similar character and lies in the same stratigraphic position above the Upper Cambrian (Warrior) limestone. The Gatesburg is in part at least of the age of the Potsdam sandstone of New York, as shown by its fossils, from which it follows that the Brierfield is in part of the age of the Potsdam. The *Cryptozoon* mentioned above is abundant in the Hoyt limestone of New York, and this occurrence, so far as it goes, supports the correlation of the Brierfield with the Hoyt also.

UNCONFORMITY AT THE BASE OF THE KETONA DOLOMITE

In Birmingham Valley the Ketona dolomite succeeds the Conasauga limestone, the Brierfield dolomite being absent. In Cahaba Valley north of Maylene the Conasauga limestone and Brierfield dolomite are both absent, and the Ketona rests there upon the Rome formation. The Ketona has not been identified along the east side of Jones Valley south of the latitude of Cleveland, in the Bessemer quadrangle, and is almost certainly absent for a long distance north and south of Bessemer, where the Copper Ridge dolomite and Conasauga limestone are in contact. The stratigraphic gap in Cahaba Valley is measured by the thickness of the Conasauga and Brierfield formations, amounting to 3,000 feet, and the gap between the Conasauga and Copper Ridge in those parts of Birmingham Valley in which the Ketona is absent is measured by the thickness of the Brierfield, Ketona, and Bibb dolomites, amounting to about 2,500 feet in the Montevallo region. These stratigraphic gaps indicate considerable crustal oscillation between Conasauga time and Copper Ridge time in the Birmingham-Cahaba Valley region, with consequent erosion or nondeposition or both.

KETONA DOLOMITE

Name.—The Ketona dolomite was named for Ketona, 5 miles north of Birmingham, where there is a large quarry in the formation.

Distribution.—A small wedge-shaped area of Ketona extends west from the Montevallo quadrangle 1¼ miles north of McGuire Ford, and another such area, bounded on all three sides by faults, occurs a mile or so northwest of Fitch Bridge. Beginning near the southwest corner of the Montevallo quadrangle a narrow outcrop, offset in places by faults, extends northeastward near Brierfield, Wilton, and Montevallo and along Spring Creek to a point three-quarters of the distance across the quadrangle, where it is offset by a fault. The outcrop is shifted by this fault about 2½ miles south, and from this location it extends slightly west of north along the valleys of Shoal and Beaverdam Creeks to the north boundary of the quadrangle. The Ketona is unknown outside the Birmingham district. Farther southwest it is covered by Cretaceous deposits.

Character.—The Ketona dolomite is almost all thick bedded,[11] light gray, rather coarsely crystalline, and, unlike the Copper Ridge and Chepultepec dolomites, nearly free from silica. In this region the rock is rather soft, of saccharoidal texture, and generally light gray or white but to some extent blotched with pink. Chemically this rock is nearly pure dolomite, as shown by partial analyses of six samples collected by the writer every 40 feet through a thickness of about 200 feet on the Freeman farm, in the SW. ¼ NE. ¼ sec. 33, T. 21 S., R. 3 W., 5 miles north of Montevallo. These analyses, which were made by the United States Geological Survey, show an average of 0.64 per cent of insoluble matter, 54.30 per cent of calcium carbonate ($CaCO_3$), and 43.82 per cent of magnesium carbonate ($MgCO_3$). The amount necessary to make up 100 per cent is supposed to consist of a number of minor constituents, of which iron oxide is probably the chief. The insoluble matter is presumably silica and alumina. Recalculating the average percentages on the basis of 100 per cent of carbonates gives 44.65 per cent of magnesium carbonate and 55.35 per cent of calcium carbonate, or very nearly the dolomite ratio.

Thickness.—The Ketona is 275 feet thick at Sixmile, near the southwest corner of the Montevallo quadrangle, and apparently holds about the same thickness along the eastern strip of the outcrop. It seems to be much thicker in the Shoal Creek and Beaverdam Creek Valleys, perhaps as much as 800 or even 1,000 feet.

Age.—As no fossils have been found in the Ketona dolomite, its age is determined by its stratigraphic position and structural relations with other formations. There are no known formations elsewhere with which the Ketona can be correlated.

UNCONFORMITY AT TOP OF THE KETONA DOLOMITE

In the northern part of the Shoal Creek-Beaverdam Creek Valley the Bibb dolomite, which in the Montevallo region normally overlies the Ketona, is absent, and the Ketona is followed unconformably by the Copper Ridge dolomite. The Bibb is absent also from the section north of McGuire Ford, where the Copper Ridge and Ketona are in contact.

[11] For the character of the bedding see U. S. Geol. Survey Geol. Atlas, Birmingham folio (No. 175), pl. 2, 1910.

BIBB DOLOMITE

Name.—The Bibb dolomite was named by the writer from Bibb Furnace, in the Montevallo quadrangle, which is situated on or near the outcrop.

Distribution.—The Bibb crops out along a narrow strip, offset by faults near Wilton and Brierfield, that extends from the southwest corner of the Montevallo quadrangle northeastward to a point 1 mile southeast of Elliottsville Church, where its outcrop is offset 3 miles to the south by another fault. On the west side of this fault the Bibb is present at the base of Pine Ridge for 2 miles northward in Shoal Creek Valley, but no evidence of its presence was found farther north, and it is supposed to thin out and disappear east of Ryan, leaving the Ketona and Copper Ridge in unconformable contact north of that point. The formation is best exposed at Sixmile, in the vicinity of Brierfield, and along Spring Creek northeast of Montevallo. At Sixmile the exposure begins at the mill and extends down the creek for several hundred feet.

Character.—As shown in the Sixmile section, immediately west of the southwest corner of the Montevallo quadrangle, the Bibb is a very thick bedded, highly siliceous dolomite, in all respects similar to the Brierfield. Indeed, if it were not for the presence of the Ketona between them the Bibb and Brierfield could not be separated but would be treated as a single formation. On account of this likeness to the Brierfield further description of the Bibb will be omitted. The areas underlain by the Bibb, like those underlain by the Brierfield and Ketona, are prevailingly low and covered by a thick deep-red soil.

Thickness.—At Sixmile the Bibb is 275 feet thick, and in the vicinity of Brierfield it may be as much as 500 feet thick.

Age.—No fossils were found in the Bibb, and if there are any they are exceedingly scarce. In character and stratigraphic relations the Bibb is similar to the Potosi dolomite of Missouri, and it is therefore correlated with that formation.

COPPER RIDGE DOLOMITE

Name.—The name Copper Ridge dolomite, from a conspicuous ridge made by the formation passing 8 miles northwest of Knoxville, Tenn., as now used applies to all the rocks (chiefly dolomite) underlying the Chepultepec dolomite and overlying the Bibb dolomite. The Copper Ridge dolomite of Alabama is believed to be equivalent to the Copper Ridge chert of Tennessee, which, although so named, is not chert but dolomite.

Distribution.—The Copper Ridge dolomite crops out in four areas in the Montevallo quadrangle—in a small area on the west side 1 mile north of Little Cahaba River; in Pine Ridge, the southern continuation of Newhope Mountain, east of the Beaverdam Creek and Shoal Creek Valleys; in the long, low, sinuous ridge extending from Elliottsville Church to the southwest corner of the quadrangle; and in the low ridge beginning 2 miles southeast of Calera and extending southwestward to and beyond Concord Church. In the northeast corner of the Columbiana quadrangle is a narrow area doubtfully referred to the Copper Ridge on account of the abundance and character of the chert débris, which is of distinctly Copper Ridge type. The formation is almost certainly present under the coal fields and nearly all that part of the quadrangles east of Pine Ridge.

Character.—Only here and there is an exposure of the Copper Ridge dolomite seen in a wide expanse of territory, the surface of which is deeply covered with red, tawny, or gray soil full of chunks and boulders of chert. Fortunately, however, exposures on Alligator Creek, just west of the Montevallo quadrangle, have revealed the real nature of the Copper Ridge and Chepultepec dolomites. The section of these dolomites on Alligator Creek is followed upward in regular sequence by an almost complete section of the Longview and Newala limestones along Little Cahaba River east of Alligator Creek, within the Montevallo quadrangle. A compilation of the two sections is given on page 7.

The chert-yielding dolomite that constitutes the main mass of the Copper Ridge is prevailingly a thick-bedded, rather light gray, and rather coarse grained rock. On Alligator Creek, as shown in the above section, the lower part is very finely crystalline and light-gray. The appearance of the rock indicates calcium carbonate and magnesium carbonate nearly in the dolomite ratio. No analyses that surely represent the Copper Ridge dolomite are known to the writer.

The surfaces underlain by the Copper Ridge are thickly strewn with chert ranging from small pieces up to masses several feet in diameter. The larger masses are especially well displayed on Mahan Creek, in the Montevallo quadrangle a few miles south of Montevallo, where the creek cuts through the chert ridge 1 or 2 miles east of Brierfield. Notwithstanding the great quantities of chert on the surface little appears in the freshly exposed beds in creek sections and other places. The chert is evidently a secondary product developed in the process of weathering. Layers of dolomite or limestone at creek level may be followed to their outcrops higher up on the banks and be found to change entirely to massive chert.

The chert has been shown by Washburne[12] through microscopic examination to be crystalline quartz. It is very dense and tough, weathers with a jagged surface, and breaks down into small angular fragments, very little of it being mealy or chalky, like much of the chert of the other cherty formations of the region. A typical specimen is shown in Plate 3. The prevailing colors are white, yellowish, and pink.

Topographically the Copper Ridge dolomite generally expresses itself as a ridge, on account of the protecting mantle of chert which has accumulated on the surface. Pine Ridge is an example.

Section along Alligator Creek and Little Cahaba River in secs. 6 and 17, T. 24 N., R. 11 E.

	Feet
Newala and Longview limestones (on Little Cahaba River):	
21. Limestone, largely pearl-gray, noncrystalline or very finely crystalline, brittle, much heavy dolomite, and some chert below	1,000±
Chepultepec dolomite (on Alligator Creek):	
20. Dolomite, dark gray, coarsely crystalline, layers 6 inches to 1 foot thick	280
19. Not exposed	110
18. Dolomite with chert	80
17. Not exposed; much cavernous chert with gastropods	80
16. Dolomite like No. 20	200
15. Limestone, pearl-gray, very finely or not visibly crystalline; a few gastropods show in section on the weathered surface of a layer or two	350
	1,100
Copper Ridge dolomite (on Alligator Creek):	
14. Chert, solid	10
13. Dolomite, thick bedded, dark gray, coarsely crystalline, partly exposed; much chert débris with *Cryptozoon* common	75
12. Not exposed	130
11. Dolomite like No. 13	25
10. Not exposed	40
9. Chert, solid	20
8. Not exposed	80
7. Chert, solid	10
6. Dolomite like No. 13; not all exposed	250
5. Not exposed, dense chert with two or three species of *Cryptozoon* plentiful	360
4. Dolomite like No. 13; yields much dense jagged chert	375
3. Limestone, light gray, compact	10±
2. Dolomite, mostly light gray, finely crystalline; yields abundant heavy chert	375
	1,750
Ketona dolomite:	
1. Dolomite, light gray, coarse, some slightly magnesian limestone, no chert; exposed to fault	250±

Thickness.—The thickness of the Copper Ridge in the Alligator Creek section is 1,750 feet, which may be assumed as the thickness throughout these quadrangles.

Age and correlation.—Two types of *Cryptozoon* in the chert have been observed in or near the Montevallo and Columbiana quadrangles, and a few specimens of cephalopods (*Shelbyoceras*) and gastropods (*Scaevogyra*) in chert were collected in the southeastern part of the Columbiana quadrangle. The best collections were made about half a mile west of Chalkville, in the Birmingham quadrangle, and within a mile west of Springville, just east of the Birmingham quadrangle. According to Ulrich,[13] the Copper Ridge fossils, particularly the Chalkville collection, prove to be most closely related to those marking the Proctor dolomite and a considerable thickness of cherty and fossiliferous dolomite which was formerly included in the lower part of the Gasconade dolomite but which is treated as a separate unit under the name Van Buren formation in a report issued by the Missouri Bureau of Mines and Geology in March, 1930.

CHEPULTEPEC DOLOMITE

Name.—The Chepultepec dolomite was named by Ulrich[14] from the town of Chepultepec, in Murphrees Valley, 30 miles northeast of Birmingham, near which the formation is well developed and has yielded the most species and best preserved specimens of its characteristic fauna that have been found in Alabama. As now defined it overlies the Copper Ridge dolomite and is unconformably overlain by the Longview limestone.

Distribution.—In these quadrangles the Chepultepec occurs in Cahaba Valley, cropping out in a number of belts along the east flanks of the ridges of Copper Ridge dolomite. There is a large area of Chepultepec in Shelby Valley, and a belt of the same formation bordering the Copper Ridge area of Kelley Mountain about 6 miles east of Shelby. The cavernous mealy type of chert characteristic of the Chepultepec is especially abundant on the highway along the southeast base of Kelley Mountain, just east of the Columbiana quadrangle.

Character.—As shown in the section on Alligator Creek, the Chepultepec consists of limestone in its lower part and dolomite in its upper part. The dolomite appears to be somewhat thinner bedded than the Copper Ridge but of the same gray color and coarsely granular texture. The limestone at the bottom is light gray or pearl-gray and very finely crystalline or in part without visible crystalline texture. This limestone is possibly present at Chepultepec, where there is a valley, probably eroded upon it, between the Copper Ridge and Chepultepec formations, as noted by Ulrich in his original description. The Chepultepec differs from the Copper Ridge mainly in its limestone, its chert, and its fossils. Its chert, unlike that of the Copper Ridge, described above, is predominantly mealy, weathering to a chalky texture, much of it full of irregular cavities as if worm-eaten and but little of it sufficiently dense and resistant to form large boulders. Its character is shown in Plate 6 of the Bessemer-Vandiver folio (No. 221).

Thickness.—In the section on Alligator Creek the Chepultepec as delimited is about 1,100 feet thick. Its thickness may be different elsewhere, but under the conditions of exposure no reliable determination can be made.

Age and correlation.—The Chepultepec has yielded a considerable fauna, mainly gastropods, which generally occur in the cavernous mealy chert. The fossils are fairly common in the chert wherever the formation crops out in the region, but the most abundant and best fossils have been collected at the type locality near Chepultepec, in the Birmingham quadrangle. The following list, identified by Ulrich, includes most of these forms:

Archeocyathus? sp. undet.
Lophoconus sp.
Pelagiella expansa Ulrich.
Sinuopea humerosa Ulrich.
Sinuopea regalis Ulrich.
Sinuopea turgida (Hall).
Rhachopea grandis Ulrich.
Rhachopea strongi (Whitfield).
Ozarkotoma acuta Ulrich.
Euomphalopsis involuta Ulrich.
Helicotoma uniangulata (Hall).
Helicotoma discreta Ulrich.
Ozarkispira typica Ulrich.
Chepultepecia leiosomella (Sardeson).
Gasconadia putilla (Sardeson).
Gasconadia nitida Ulrich.
Ophileta, 4 unnamed species.
Cameroceras huzzahense Ulrich and Foerste.
Walcottoceras obliquum Ulrich and Foerste.
Levisoceras cf. L. mercurius (Billings).
Eremoceras gracile Ulrich and Foerste.
Eremoceras infundibulum Ulrich and Foerste.
Eremoceras major Ulrich and Foerste.
Buehleroceras sp.
Clarkoceras newton-winchelli (Clarke).
Clarkoceras conicum Ulrich and Foerste.
Clarkoceras curvatum Ulrich and Foerste.
Oneotoceras jasperense Ulrich and Foerste.
Hystricurus? n. sp.

A considerable number of these fossils have been found in the Chepultepec of the Montevallo and Columbiana quadrangles.

Ulrich states that 17 of these 31 species occur in Missouri in the chert of the Gasconade dolomite, about the same number in the Oneota dolomite in Wisconsin and Iowa, at least 3 in the small fauna found in the chert bed at the top of the Little Falls dolomite at Little Falls, N. Y., and 3 others in the same formation near Whitehall, N. Y. Evidently the deposits of this age transgressed very widely in northeasterly and northwesterly directions from central Alabama. In New York and the upper Mississippi Valley the stratigraphic sequence contains no beds corresponding to the Copper Ridge dolomite, and the beds of Gasconade (Chepultepec) age are much thinner than in Alabama and Tennessee.

UNCONFORMITY AT BASE OF LONGVIEW LIMESTONE

In Cahaba Valley there is an unconformity between the Chepultepec dolomite and the Longview limestone, owing to the absence of rocks equivalent to the Stonehenge limestone, 700 feet thick, of central Pennsylvania, which underlies the equivalent of the Longview and is above the horizon of the Chepultepec dolomite.

ORDOVICIAN SYSTEM

The rocks of unquestioned Ordovician age in these quadrangles include, in ascending order, the Longview limestone, Newala limestone, Odenville limestone, Mosheim limestone, Lenoir limestone, Athens shale, and Little Oak limestone. All these formations, except the Longview limestone, together with the contemporaneous Chickamauga limestone of Birmingham Valley, were included by the Alabama Geological Survey under the name "Pelham limestone." When this predominantly limestone mass was subdivided into the units recognized and mapped in this and other Alabama and Tennessee folios, it was decided that the name Pelham could not be applied to any one of them without confusion and misunderstanding, so new names were adopted, except for Mosheim, Lenoir, and Athens, which have long been in use in Tennessee for the respective units to which they are here applied. The table at the end of the text shows fully the equivalence of the "Pelham limestone" to the units here adopted.

LONGVIEW LIMESTONE

Name.—The Longview limestone was named from Longview, in the Montevallo quadrangle, which is situated upon the outcrop of the formation. At Longview the top and bottom of the limestone have not been precisely located, but farther north, in the Buck Creek section, in the Bessemer quadrangle, the bottom of the Longview is about 400 feet and the top about 1,500 feet southeast of the ford across Buck Creek on the road from Pelham to Helena.

Distribution.—The Longview limestone has been recognized only in the Cahaba Valley, where it crops out in a strip a quarter of a mile wide along the entire west side of the valley in the Bessemer quadrangle and continues southwestward in a wider belt of outcrop to the south side of the Montevallo quadrangle 2 miles west of the middle point. There is a narrow strip in the southwest quarter of the Montevallo quadrangle, in the vicinity of McGuire Ford, but the Longview has not been recognized in the eastern part of the Columbiana quadrangle, where its horizon is exposed only around the Chepultepec area in Shelby Valley and around the south end of the Kelley Mountain anticline in the vicinity of Mosteller, but it is probably present in those parts and included in the areas mapped as Newala and Chepultepec.

Character.—The Longview limestone is made up of alternating layers of limestone and dolomite or magnesian limestone. It seems to contain a greater proportion of dolomite than the overlying Newala limestone and is distinguished from the underlying Chepultepec by its limestone, of which the upper part of the Chepultepec is practically destitute. Another distinguishing feature of the Longview is its chert, which is compact and not cavernous and mealy as in the Chepultepec. It is also brittle and tender and tends to break down into small fragments. The overlying Newala limestone yields little chert.

Thickness.—The thickness of the Longview limestone west of Pelham, where its boundaries can be most nearly located, is about 400 feet.

Age and correlation.—The Longview is sparingly fossiliferous, but the few species of fossils are widely and apparently uniformly distributed, so that search seldom fails to be rewarded by a few specimens. The formation is characterized by several species of a genus of fossil gastropods, *Lecanospira*, of which *L. compacta*, long known as *Ophileta compacta*, is an example. There are other fossils, but the *Lecanospira* is the most common and is present at the Longview horizon all along the Valley and Ridge province through Tennessee and Virginia. It is also characteristic of the Nittany dolomite in central Pennsylvania and of a zone 350 to 430 feet above the bottom of the typical Beekmantown of New York, with which the Longview limestone is correlated. The *Lecanospira* and another gastropod, *Roubidouxia*, also correlate the Longview limestone with the Roubidoux formation of Missouri.

NEWALA LIMESTONE

Name.—The Newala limestone was named from Newala, a post office on the Southern Railway between Montevallo and Calera, near which it is fairly well exposed and is quarried for lime.

So far as known the chert-yielding Longview limestone passes into the pure Newala limestone by gradual change. Locally, as half a mile north of Alabaster, the top of the Newala is near a conglomerate or conglomeratic limestone that forms the bottom of the Lenoir limestone. (See Bessemer-Vandiver folio (No. 221), pl. 7.)

Distribution.—The Newala limestone is present in Cahaba Valley and throughout the region east of the valley. There is an area on Little Cahaba River near the west edge of the Montevallo quadrangle, a wide belt extending in general northward across the east half of the quadrangle, a belt of less length extending from Calera to the south boundary, and one large and four small areas in the east half of the Columbiana quadrangle.

The Newala is best displayed in the Little Cahaba section, in the southwestern part of the Montevallo quadrangle. It can also be seen in the quarries and adjacent ground in that part of its area lying approximately north of Varnons. In the southeastern part of the Columbiana quadrangle exposures are so few and incomplete that a satisfactory examination can not be made. The best exposures are along Beeswax and Bulley Creeks for a mile or so above their mouths, on Spring Creek at Kewahatchie, south of Mosteller, and just north of the highway along the south side of sec. 35, T. 20 S., R. 1 E. There are also excellent exposures in the area northeast of Columbiana west of Nelson, where the Newala has all the features characterizing it in Cahaba Valley.

Character.—The Newala is predominantly a limestone. Comparatively thick bedding is the rule. (See pl. 8.) Layers of dolomite a few feet thick occur here and there throughout the mass, more commonly in the lower part, but compose a small proportion of the whole. Strata of coarse dolomite, some of them 50 feet thick, occur in the upper part of the Newala just south of McGuire Ford, in the southwestern part of the Montevallo quadrangle. The dolomite is light gray and coarse grained and has a sandy appearance on the outside, so that it is called sandstone by the quarrymen. Thick layers, composed partly of limestone and partly of dolomite, are irregularly distributed. These are called mottled layers. The limestone varies in color and texture. In some beds it is dark gray and fine grained, in others dove-colored and fine grained or amorphous, and in still others a peculiar pearl-gray color, generally with nongranular or amorphous texture and very brittle, with a splintery or glassy fracture. Except for the clear calcite specks it has much the appearance of lithographic stone. Such layers are highly characteristic of the formation throughout a large area in the southern Appalachian region. This character

[12] Washburne, C. W., unpublished report.
[13] U. S. Geol. Survey Geol. Atlas, Bessemer-Vandiver folio (No. 221), p. 4, 1927; personal communication.
[14] Ulrich, E. O., Revision of the Paleozoic systems: Geol. Soc. America Bull., vol. 22, p. 638, 1911.

is less conspicuous in the northern part of Cahaba Valley and in the east side of the Columbiana quadrangle, where the more granular dove-colored layers predominate and there is a small proportion of dark granular beds. The upper part of the formation is of high purity and is extensively quarried for lime at a number of points between Keystone, 1$\frac{1}{2}$ miles north of this area, and Calera.

Thickness.—The thickness of the Newala in the Little Cahaba section, on the west side of the Montevallo quadrangle, is 800 feet; in the eastern outcrops it appears to be somewhat greater, perhaps 1,000 to 1,200 feet. In the eastern part of the Columbiana quadrangle the thickness seems to be much greater than elsewhere, but owing to uncertainty as to the geologic structure no estimate of the thickness is made.

Age and correlation.—Fossils are fairly common in the Newala but as a general rule are not liberated from the matrix on weathering and can not be extracted by breaking. They are generally revealed as sections of shells on limestone surfaces made smooth by weathering. From these sections their general character can be made out, but, except for one or two species, close specific distinctions can hardly be made. The fossils are nearly all gastropods. One of the most characteristic forms is *Ceratopea keithi*, a supposed operculum of an unknown gastropod. Another form that can be identified with reasonable assurance is *Hormotoma artemesia*, a slender high-spired gastropod of 10 or 12 whorls. Still another form of the same type is compared with *Coelocaulis* (*Murchisonia*) *linearis*.

These forms, especially the *Ceratopea* and *Hormotoma*, are common in limestone in the same general position as the Newala, overlying beds carrying *Lecanospira*, which extends the entire length of the Appalachian belt from Alabama to Pennsylvania. In Pennsylvania the Axemann limestone is a possible representative of part of the Newala.

ODENVILLE LIMESTONE

Name and definition.—The Odenville limestone was named from Odenville, St. Clair County, the limestone being partly exposed in the west end of a borrow pit of the Seaboard Air Line Railway a short distance east of Odenville. This formation includes 50 to 100 feet of rock, limestone so far as known, lying between the Newala limestone and the Mosheim limestone. So far as known the Odenville is conformable with the Newala limestone.

Distribution.—The Odenville is known only in Cahaba Valley from Odenville on the north to the vicinity of Saginaw on the south.

Character.—In a borrow pit by the railroad about a third of a mile east of Odenville the Odenville limestone shows layers of argillaceous, siliceous, cherty fossiliferous limestone distributed through a thickness of about 25 feet of rock otherwise not exposed. In Cahaba Valley in the Vandiver quadrangle, at Newhope Church and at a point in sec. 11, T. 18 S., R. 1 W., the presence of the formation is revealed by abundant fine chert with which silicified fossils are rather plentifully mingled. A few of its peculiar fossils were found about 1 mile west of Saginaw, in the Montevallo quadrangle.

Thickness.—Owing to lack of exposures the exact thickness of the Odenville limestone has not been determined, but its peculiar fossils occur on the surface at some localities in such a position relative to the Newala limestone where the dip is steep as to indicate a possible thickness of 50 to 100 feet. That it exceeds 100 feet is not probable.

Age and correlation.—The Odenville carries an undescribed fauna of trilobites, gastropods, brachiopods, cephalopods, and sponges. The brachiopods belong to two new genera of orthoids, which Ulrich has named *Taffia* and *Deltatreta* and which differ from true *Orthis* in possessing a deltidium. There are two genera of orthoceroids, a new species of *Maclurea* known only from abundant opercula, a *Calathium*-like sponge, a trilobite of the genus *Gonotelus* Ulrich (=*Goniurus* Raymond, preoccupied), and a fair abundance of rather massive plates of an undescribed *Chiton*. Several of these fossils are figured and named in the descriptive text accompanying the revised geologic map of Alabama published by the Geological Survey of Alabama in 1926. According to Ulrich, *Taffia* and *Deltatreta* are characteristic of beds of known Beekmantown age in the upper part of the Arbuckle limestone of Oklahoma, and a species of *Deltatreta* occurs in the late Beekmantown Powell limestone of Arkansas. According to Foerste, the orthoceroids possess features known only in that group of cephalopods which occur in formations of pre-St. Peter age. According to Ulrich, the same seems to be true of the genus *Gonotelus* and of the *Calathium*-like sponges. The Odenville is therefore classed as of very late Beekmantown age and tentatively correlated with the Black Rock limestone of northeastern Arkansas. It is included with the Newala limestone on the map.

UNCONFORMITY AT TOP OF THE ODENVILLE LIMESTONE

The Murfreesboro limestone of the Stones River group of middle Tennessee, the St. Peter sandstone and associated limestone of the Mississippi Valley section, and, according to Ulrich, about 500 feet of shale of Beekmantown age above the main body of the Arbuckle limestone of Oklahoma are unrepresented in Cahaba Valley, where the Mosheim limestone, next succeeding the Murfreesboro in age, immediately overlies the Odenville. Thus a stratigraphic hiatus amounting to 2,000 or 2,500 feet of limestone, sandstone, and shale exists between the Odenville and Mosheim limestones.

MOSHEIM LIMESTONE

Name and definition.—Throughout the Appalachian Valley in Tennessee and much of Virginia the limestone of Beekmantown age that corresponds, in part at least, to the Newala limestone and that forms the upper part of the Knox dolomite is overlain by the Mosheim limestone, named by Ulrich from Mosheim, on the Southern Railway, about 6 miles west of Greeneville, Tenn. This limestone is lithologically and faunally a well-defined unit, which in Tennessee is separated from the overlying Lenoir limestone by an erosional unconformity. In the northern part of Cahaba Valley the Odenville limestone comes between the Mosheim and the top of the Newala. The Odenville limestone, so far as known, is not present in Tennessee, the Mosheim there resting directly upon the Knox, the upper part of which is equivalent to some part of the Newala limestone.

Distribution.—In Alabama the Mosheim is exposed in a borrow pit on the Seaboard Air Line Railway east of Odenville, St. Clair County; in Cahaba Valley at Newhope Church, 7 miles northeast of Pelham; and in the Columbiana quadrangle in the road in the N. $\frac{1}{2}$ sec. 11, T. 24 N., R. 15 E. Doubtless it formerly extended over the northeastern part of the State, where it overlay the Odenville limestone, or the Newala limestone where the Odenville is absent, and was succeeded above by the Lenoir limestone. In these quadrangles the Mosheim is mapped with the Lenoir limestone.

Character.—The Mosheim is a pure thick-bedded blue or dove-colored limestone with conchoidal fracture, and it forms a white chalky crust on weathering. By these characteristics it is readily distinguishable from the Lenoir limestone, which is dark, finely crystalline, argillaceous, and contains layers that crumble to small nodules on weathering.

Thickness.—At Odenville the Mosheim is about 50 feet thick, and it probably holds about that thickness throughout its extent in the State.

Age and correlation.—The Mosheim is in places full of gastropods of Ordovician types, large, high-spired Lophospiras being prominent. At Odenville gastropods are plentiful as individuals, and there are perhaps a dozen species, several of which are figured in Plate 19 of the "Geology of Alabama." The Mosheim is clearly to be regarded as basal Chazyan in age and in southwestern Virginia has recently been found to occupy a position between the Lenoir limestone and the Murfreesboro limestone. So far as known it has no equivalent outside the Valley and Ridge province.

LENOIR LIMESTONE

Name.—The Lenoir limestone was named by Safford and Killebrew in 1876, from Lenoir City, Tenn., which is situated on the outcrop of the formation. The base of the Lenoir is defined by the lowest beds, in places conglomeratic, containing a fauna the most distinctive and striking member of which is the great flat-spired gastropod known as *Maclurea magna*, on account of which Safford originally called this formation the "*Maclurea* limestone." In Cahaba Valley south of Pelham the Lenoir is limited above by the persistent and easily recognized black shale known as the Athens shale.

Distribution.—Nearly all the outcrop of the Lenoir lies within the Montevallo quadrangle. There is a small area south of McGuire Ford, near the west side of the quadrangle, and a narrow, sinuous strip, offset by faults, extending across the east side of the Montevallo quadrangle and the west side of the Columbiana quadrangle.

Character.—The Lenoir is dominantly a very dark to black medium-grained thick-bedded limestone. Layers of dove-colored nongranular limestone occur in its middle part, and light-gray to nearly white layers near its base. Many of the limestone layers contain clayey material distributed in intersecting laminae throughout their thickness, and the edges of these laminae are narrow gray ridges that make a network of about 1-inch mesh on weathered surfaces. From Siluria north for about 5 miles pebbles of quartz, chert, and quartzite half an inch or less in diameter occur in the basal beds. About half a mile north of Alabaster the pebbles are most numerous and largest and occur through the maximum thickness of about 20 feet.[15] At this place, too, a mass of conglomerate containing quartzite pebbles as much as 3 inches in diameter occurs at the top of the Newala and about 50 feet below the basal pebbly Lenoir. This local coarse conglomerate may represent the Attalla chert conglomerate member of Birmingham Valley. At places north and south of this locality the basal pebbly beds of the Lenoir follow closely the light-gray limestone and dolomite of the Newala. The thickness of the pebbly beds and the size of the pebbles decreases northward and southward, and the beds were not seen north of Pelham nor south of Siluria. The contact between the Newala and Lenoir is exposed on Little Cahaba River half a mile or so south of McGuire Ford. At this place the basal layer of the Lenoir is impure and shaly and contains the characteristic *Maclurea magna*; the characteristic Newala fossils were found a few feet below. Several hundred feet of thick-bedded limestone lies next above, near the top of which, an eighth of a mile south of Rock School, are thinner beds containing *Maclurea magna*. Above this bed is apparently 100 to 200 feet of gray granular rock in medium thick beds, the upper part of which was once quarried for flux for the old Bibb furnace. At Pratts Ferry, on Cahaba River 5 miles southwest of McGuire Ford, the Lenoir limestone is excellently displayed. The formation here contains layers of light-gray, pink-mottled granular fossiliferous limestone that has a local repute as marble and has been used experimentally. The *Maclurea* is present in these layers and shows well on the polished surfaces of the rock. The top part of the limestone half a mile north of Calera, where the highest 25 feet or so is exposed, is thin bedded, blackish, and jointed into small blocks.

Thickness.—In the southwestern part of the Montevallo quadrangle the Lenoir appears to be 600 to 700 feet thick; in the eastern part it is 400 or 500 feet thick.

Age and correlation.—*Maclurea magna* is common in the basal beds and occurs throughout the formation. Specimens 4 to 6 inches across have been seen in the upper part in the area near the west side of the Montevallo quadrangle, and large individuals are abundant near Pratts Ferry. At and near Pratts Ferry *Christiania*, *Nidulites*, and a *Camarotoechia* occur. A species of *Christiania* and a large *Ormoceras*-like cephalopod occur near the top just north of Bowden's quarry, west of Saginaw. *Maclurea magna*, however, is most significant for correlation. It occurs along the Valley and Ridge province to northeastern New York and northwestern Vermont, where it seems to be confined to the middle part of the Chazy group, now known as the Crown Point limestone. This evidence seems sufficient for correlating the Lenoir with the middle Chazy. It is correlated also with the Pierce and Ridley limestones in the middle of the Stones River group of the Nashville Basin, Tenn., *Maclurea magna* having been found, according to Ulrich, in the Ridley.

UNCONFORMITY AT TOP OF LENOIR LIMESTONE

In Cahaba Valley there appears to be no representative of the Lebanon limestone, a formation of the Stones River group of Tennessee, which overlies the Ridley limestone and which, in a complete section, would intervene between the Lenoir limestone and the Athens shale. There is, therefore, between the Lenoir and Athens a hiatus represented by 200 feet or more of limestone that occurs in parts of Tennessee.

ATHENS SHALE

Name.—The Athens shale was named by Hayes[16] from Athens, Tenn., where it is strongly developed.

Distribution.—The Athens shale crops out in a narrow sinuous strip running across the east side of the Montevallo quadrangle and the west side of the Columbiana quadrangle. South of Calera no exposures of rock at its horizon were observed, but as it is not known to be absent it is assumed to be present and is so mapped. From scattered exposures in the eastern part of the Columbiana quadrangle its presence near the top of the limestone beds throughout this general region is somewhat doubtfully inferred, but it is not mapped as everywhere present. It was recognized by its graptolites on the Finley farm, in the SW. $\frac{1}{4}$ sec. 34, T. 21 S., R. 1 E., also at the highway crossing of the Louisville & Nashville Railroad a little more than half a mile southeast of Kewahatchie. In the road 1 mile west of Woods Ferry a wedge of Athens about 100 feet thick, with graptolites, is faulted in between highly fossiliferous Floyd shale on the west and what is apparently Fort Payne chert on the east. The extent of its outcrop along the strike in this locality is unknown and probably not determinable because of the lack of exposures.

The best exposure of the Athens is just west of Simpson Spring, 2$\frac{1}{2}$ miles northwest of Calera. Graptolites are plentiful in it there. The upper part is also well displayed in a cut on the Southern Railway half a mile east of Calera and at a cut a quarter of a mile east of Hardys station, between Calera and Montevallo. The exposure half a mile east of Calera is shown in Plate 9, and sections are given in the description of the Frog Mountain sandstone below.

Thickness.—The thickness of the Athens is very uneven. The greatest thickness determined is at Simpson Spring, 2 miles northwest of Calera. Here the exposed Athens is about 350 feet thick, and its full thickness may be somewhat greater, for the bottom could not be certainly located. Just east of Salem Church and three-quarters of a mile west of

[15] Butts, Charles, U. S. Geol. Survey Geol. Atlas, Bessemer-Vandiver folio (No. 221), pl. 7, 1927.

[16] Hayes, C. W., U. S. Geol. Survey Geol. Atlas, Kingston folio (No. 4), p. 2, 1894.

Calera it is more than 100 feet thick. Northeast of Calera it is 12 to 17 feet thick, as shown by the following section:

Section on knoll half a mile northeast of railroad station at Calera

	Feet
Chert (Fort Payne) on top of knoll.	
Concealed	15±
Sandstone, hard, well-rounded quartz grains (Frog Mountain)	2
Concealed, dark shaly débris (Athens?)	5
Shale, dark to brown, fissile; contains graptolites (Athens)	12
Soft obscurely layered bed (old soil?)	1
Limestone, dark, jointed, slivery (Lenoir)	5

On the Southern Railway half a mile east of Calera 33 feet or so of the Athens is exposed without showing the bottom. Knowledge of the Athens on the east side of the Columbiana quadrangle is too meager to permit any statement as to its thickness.

Basal limestone member of Athens shale.—At Pratts Ferry, a few miles west of the southwest corner of the Montevallo quadrangle, occurs a bed of thin-layered limestone about 10 feet thick between the Lenoir limestone and the main mass of the Athens shale. This bed is of great interest because it has been identified as far northeast in the Valley and Ridge province as Lexington, Va., and because of its many fossils. In collections made at Pratts Ferry Ulrich has identified about 75 species, and from the bed throughout its full extent he has obtained about 175 species. He regards it as an independent unit, which he has named the Whitesburg limestone from the town of Whitesburg, several miles northeast of Morristown, Tenn.

Age and correlation.—Considerable collections of graptolites have been made from the Athens shale of this region. Although these collections have not been thoroughly studied, the following species have been identified by Ruedemann and Ulrich:

Climacograptus cf. C. putilus (Hall).
*Cryptograptus tricornis (Carruthers).
Dicellograptus smithi Ruedemann.
Dicellograptus moffatensis var. alabamensis Ruedemann.
Dicellograptus mensurans Ruedemann.
*Dicranograptus nicholsoni var. parvangulatus Gurley.
Dicranograptus near D. contortus Ruedemann.
*Didymograptus sagitticaulis Hall.
*Diplograptus foliaceus var. alabamensis Ruedemann.
*Glossograptus ciliatus Emmons.
Leptograptus flaccidus (Hall).
Nemagraptus gracilis var. surcularis Hall.
Retiograptus geinitzianus Hall.

All these species occur in the Normanskill shale of New York, which proves that formation to be of the same age as the Athens shale. The five species prefixed by an asterisk (*) occur also in the Womble shale in Arkansas, with which the Athens is accordingly correlated.

Some of the species listed are of world-wide distribution, being found in the northwestern part of the United States, in England, in Scotland, and in Australia, thus proving that in Athens time these remote parts of the earth were connected by water under conditions favorable to the propagation and migration of graptolites.

Besides graptolites the Athens has yielded a considerable number of species of brachiopods and trilobites, which have not been carefully studied. Probably most of the species are undescribed.

LITTLE OAK LIMESTONE

Name.—The Little Oak limestone was named from Little Oak Ridge, north of Pelham, in the Bessemer quadrangle, on account of its good development and exposure along the west escarpment of the ridge.

Distribution.—In the quadrangles here described the Little Oak limestone crops out in a narrow band that runs along the chert ridge just east of Alabaster and Siluria to a point about three-quarters of a mile southeast of Siluria. This band continues the outcrop of the formation in the Bessemer quadrangle. It is exposed in the gap half a mile south of Alabaster and on the bluff half a mile east-southeast of Siluria. Several detached outcrops, known mainly from surficial chert carrying some of its characteristic fossils, lie along the east side of the Columbiana quadrangle.

Character.—In the band east of Siluria and Alabaster the Little Oak is a thin-bedded dark, somewhat argillaceous limestone. Weathered pieces of this limestone in the southern part of the Bessemer quadrangle show plainly the fine-grained argillaceous character of the limestone, which is rather shelly and is faintly banded with pink. Owing to the absence of exposures in the eastern part of the Columbiana quadrangle little could be learned of the character of the limestone. It yields in all the areas mapped much rather heavy, platy, pitted, sparingly fossiliferous chert, through which alone its presence below the soil is known.

At top in places it weathers to clay, as revealed in a railroad cut half a mile northwest of Mosteller (pl. 9).

Thickness.—The thickness of the Little Oak in these quadrangles is probably nowhere more than 100 feet, and it may not be more than 50 feet.

Age and correlation.—The Little Oak limestone has yielded a considerable number of fossils, and the general character of the fauna is indicated by the subjoined list.

The basal part of the formation is, locally at least, very fossiliferous, and the fossils occur in chert, which is derived perhaps from highly argillaceous or siliceous layers of limestone. The following fossils have been identified:

Nidulites sp.?
Receptaculites sp.?
Christiania near C. trentonensis Ruedemann.
Christiania, lamellose sp., probably new.
Orthis crassicosta Butts. Resembles O panderiana (Hall and Clarke) = O. orthambonites Billings.
Dalmanella fasciculata Butts.
Three genera of orthoids suggesting Dalmanella, Hebertella, and Pianodema.
Sowerbyella (Plectambonites) near P. pisum Ruedemann.
Rafinesquina sp.
Strophomena n. sp.?
Ambonychia sp.?
Maclurites sp.?
Tetranota cf. T. obsoleta Ulrich and Scofield.
Twenty or more species of gastropods, including species of Bucania and Trochonema.
Illaenus sp.?
Lichas?
Pterygometopus sp.?
Sphaerocoryphe sp.?
Leperditia ovalis Butts.

The fauna of the Little Oak limestone is unique and as yet has yielded but little information beyond the fact that it is probably of latest Lower Ordovician age. So far it has failed to reveal a single species that is certainly identical with any described form. Its affinities seem to be with European rather than with interior American faunas, a feature characterizing the more eastern trough of the Appalachian Valley. The *Christiania* and *Plectambonites* near *P. pisum* closely resemble *C. trentonensis* and *P. pisum*, respectively, from the Rysedorph conglomerate near Albany, N. Y., but until the Alabama specimens are critically compared with the type specimens and found to be the same it is unsafe to identify them with the species named. Both species have been identified by Ulrich from the Chambersburg limestone of Pennsylvania, but he is not certain that they are really those species or the same as the Alabama species. *Orthis crassicosta* agrees very closely with the figure and description of the form described by Billings under the name *Orthis orthambonites* (=*O. panderiana* Hall and Clarke), a Beekmantown species. A few of these fossils are figured in "Geology of Alabama," recently published by the Alabama Geological Survey.

The Little Oak limestone has been traced northeastward into northwestern Calhoun County, half a mile south of Reads, where it is overlain by red shale known from its fossils to be of Lowville age. This occurrence, in connection with its relations to the Lenoir limestone and Athens shale, definitely fixes its age as upper Chazy and younger than the typical Chazy of New York. As it lies within the same stratigraphic limits as the Tellico sandstone and Sevier shale of the Knoxville region, Tennessee, it is regarded as equivalent to some part of those formations, probably to part of the Sevier. Ulrich[17] makes it a new element of the general stratigraphic column next above the Sevier.

UNCONFORMITY AT TOP OF LITTLE OAK LIMESTONE

In parts of the quadrangles where the Athens is succeeded by the Frog Mountain sandstone (see pl. 10) there is a great stratigraphic gap caused by the absence of all the Ordovician above the Athens, the whole Silurian system, and the lowest Devonian (Helderbergian). In central Pennsylvania the thickness of the strata in this interval amounts to about 6,000 feet.

DEVONIAN SYSTEM

The Devonian system is represented in this part of Alabama by the Frog Mountain sandstone and possibly by the Chattanooga shale, but the age of the Chattanooga is in dispute.

FROG MOUNTAIN SANDSTONE

Name.—The Frog Mountain sandstone was named by Hayes from Frog Mountain, in Cherokee County, northeastern Alabama. As the sandstone here described is believed to represent the Frog Mountain, that name is applied to it.

Relations, distribution, and character.—The Frog Mountain sandstone overlies the Athens shale unconformably. Its relations and character are shown in the following sections:

Section at gap in ridge 1 mile northeast of Saginaw

	Ft.	in.
Carboniferous: Chert (Fort Payne)	50	
Devonian or Carboniferous: Clay, decomposed shale (Chattanooga), partly black, with yellow streaks	2	4
Devonian: Sandstone, coarse, friable, ferruginous, with well-rounded quartz grains (Frog Mountain)		6
Ordovician:		
Shale, pale green, soft, evenly laminated (Athens)		8
Shale, brown, soft, evenly laminated; contains graptolites (Athens)	2	

Section in cut on Southern Railway a quarter of a mile east of Hardys

	Feet
Carboniferous: Chert (Fort Payne)	50
Devonian or Carboniferous:	
Clay, stained black, with rotten brown sandstone layer 1 inch thick (Chattanooga)	2
Clay, yellow-green, sandy, with black streaks (Chattanooga)	3
Devonian: Sandstone, top 4 inches brown and rotten, rest coarse hard sandstone (Frog Mountain)	2
Ordovician:	
Shale, green (Athens)	1
Shale, black, fissile; graptolites abundant below and some within 1 foot of sandstone (Athens)	20

Section in cut on Southern Railway half a mile east of Calera

[See pl. 10]

	Ft.	in.
Carboniferous:		
Chert, irregularly thin bedded, with fossils abundant (seen)	40±	
Clay	2	
Chert with clay partings		2
Clay with thin chert layers		8
Chert		3
Clay, green and brown		8
Chert with brachiopods		4
Probably Devonian:		
Clay, sandy, with chert nodules and fossils	2	
Clay, sandy, crinoid stem plates abundant; Bryozoa and brachiopods	4	
Devonian: Sandstone, coarse, rounded, loosely cemented quartz grains (Frog Mountain)		4
Ordovician:		
Shale, green, fissile, with graptolites		8
Shale, brown, fissile		8
Sand (from sandstone layer?)		4
Shale, brown, fissile, with graptolites	33	
Ferruginous streak		1
Clay, sandy (from sandy limestone)	2	

These sections show the constant presence of the Frog Mountain sandstone from Calera northward. It is present and 2 feet thick in the gap through the chert ridge between Siluria and Alabaster, where, however, it overlies the thin basal part of the Little Oak limestone. It has not been observed south of Calera and Hardys in the Montevallo quadrangle, but that signifies nothing, for its horizon is not exposed at any point where it was traversed. The sandstone in the southeastern part of the Columbiana quadrangle identified and mapped as Frog Mountain is so regarded on account of its position between the Little Oak limestone below and the Fort Payne chert above, this position being the same as that of the Frog Mountain sandstone in Cahaba Valley. (See pl. 9.) The outcrop of the sandstone in that region is confined to the flanks of the Kelley Mountain anticline and to a small area in the northeast corner of sec. 18, T. 22 S., R. 1 E., which seems to be an inlier exposed on the summit of a small dome. The sandstone has not been observed to crop out at any place near the outside of the area of Floyd shale in the eastern part of the Columbiana quadrangle. Its absence from some parts of this border can be explained by faults but not from all. There is no evidence of faults in secs. 12 and 13, T. 24 N., R. 15 E.; in sec. 8, T. 24 N., R. 16 E.; or along the sinuous boundary between the Little Oak limestone and Floyd shale in Tps. 21 and 22 S., R. 1 E. If the sandstone were present along the border, it would necessarily, unless it has become very thin and soft, make its presence known. No trace of sandstone was observed, however, not even loose pieces. It seems that the sandstone must have been deposited in a narrow trough in the locality of the present Kelley Mountain anticline.

The Frog Mountain sandstone is everywhere rather coarse grained, firmly cemented, hard, quartzitic, and light or dark gray. At some exposures a few inches at the top is friable and ferruginous. At one place this top layer contains obscure markings resembling fossils but no undoubted fossils were discovered. The sandstone in the Kelley Mountain anticline is thick bedded, coarse, hard, and of a peculiar dark color quite different from that of the typical Frog Mountain sandstone.

Thickness.—The Frog Mountain is everywhere thin in the vicinity of Calera and north to Siluria, ranging from a few inches to a possible maximum of 3 feet. In the southeastern part of the Columbiana quadrangle it appears to be generally about 50 feet thick and locally may reach 100 feet.

Age and correlation.—It has been customary to apply the name Frog Mountain to any Devonian sandstone in northeastern Alabama and to regard it all as of Oriskany age. However, it has been learned through investigations of the last few years that the typical Frog Mountain sandstone of Frog Mountain, Cherokee County, is of Onondaga age; that sandstone in the same stratigraphic position in Red Mountain, near Bessemer and Birmingham, is of Oriskany age; and that sandstone near Odenville and near Ragland is of Hamilton age.[18] The name Frog Mountain has therefore been restricted to sandstone of Onondaga age in Alabama and Georgia.

As the sandstone in the Montevallo quadrangle is continuous with sandstone in Little Oak Mountain at Leeds, 10 miles to the north, which through its fossils appears to be of Onondaga age, all the Devonian sandstone of these quadrangles is believed to be of Onondaga age. The sandstone at Leeds is a peculiar speckled chalky-textured rock identical in character with sandstone at the base of the Frog Mountain sandstone at Frog Mountain and like that carries an abundance of a finely striated variety of *Chonetes mucronatus*. It is upon this evidence that the Devonian sandstone of the Montevallo and Columbiana quadrangles is believed to be of Onondaga age and therefore correctly named Frog Mountain sandstone. In the paper just cited the sandstone of Oriskany age in Red Mountain has been named Clear Branch sandstone and the sandstone of Hamilton age near Odenville and Ragland has been named Ragland sandstone.

[17] Ulrich, E. O., Ordovician trilobites of the family Telephidae and concerned stratigraphic correlations: U. S. Nat. Mus. Proc., vol. 76, art. 21, table on p. 73, 1930.

[18] For a full consideration of this subject see a recent paper by the writer (The Devonian of Alabama: Am. Jour. Sci., 5th ser., vol. 14, pp. 365-380, 1927).

UNCONFORMITY AT THE TOP OF THE FROG MOUNTAIN SANDSTONE

There is a stratigraphic break between the Frog Mountain sandstone and the Chattanooga shale, the extent of which depends on the age of the Chattanooga. If the Chattanooga is of Genesee age, as classified in the earlier reports, the break would represent no more than the Marcellus shale, Hamilton formation, and Tully limestone, but if the Chattanooga is of earlier Mississippian age, as advocated by Ulrich and accepted by the writer, then the break represents the formations named above and in addition all of the Upper Devonian rocks, the whole aggregating a thickness of 6,000 to 7,000 feet.

DEVONIAN OR CARBONIFEROUS SYSTEM

CHATTANOOGA SHALE

Name.—The Chattanooga shale was named from Chattanooga, Tenn. In this region it overlies the Frog Mountain sandstone and is overlain by the Fort Payne chert.

Character and distribution. — Throughout the Paleozoic regions of northeastern Alabama and south to the south end of Sequatchie (Browns) Valley and into Murphrees Valley the Chattanooga is a nearly homogeneous mass of densely black slaty shale 20 to 30 feet thick. Southward from the localities mentioned the formation gradually thins and is represented in outcrops by 18 inches to 5 feet of dark, yellowish-green and reddish clay. The undecomposed rock has not been seen in these quadrangles, but it may fairly be assumed to be black and green shale. All that is known of it in these quadrangles is shown in the sections on page 9. Just how much if any of the clay in the section half a mile east of Calera is Chattanooga is uncertain. Its aspect is different from that of the clay at the other points. In the eastern part of the Columbiana quadrangle the Chattanooga has not been recognized and is probably absent.

Age and correlation.—The Chattanooga has generally been classified as Devonian, but the correctness of that determination has been questioned, and some geologists regard the Chattanooga of Tennessee and Alabama as Mississippian. A fuller discussion is given on pages 10–11 of the Bessemer-Vandiver folio.

UNCONFORMITY AT THE TOP OF THE CHATTANOOGA SHALE

If the Chattanooga shale of this region is of Genesee age, as regarded by earlier workers, it is evident that there are no rocks above it corresponding to the Portage, Chemung, and Catskill formations, which together are 6,000 feet thick in central Pennsylvania. In addition the basal Mississippian rocks, corresponding to the Kinderhook, are probably absent. If these conclusions are correct, there is a stratigraphic gap above the Chattanooga shale of at least 6,000 feet. On the other hand, if the Chattanooga is basal Mississippian, then the unconformity at its top is of relatively minor importance, and that between its base and the top of the Frog Mountain sandstone is of great importance.

CARBONIFEROUS SYSTEM

MISSISSIPPIAN SERIES

FORT PAYNE CHERT

Name.—The Fort Payne chert was named from the town of Fort Payne, in De Kalb County, northeastern Alabama. The name was published almost simultaneously by C. W. Hayes, of the United States Geological Survey, and E. A. Smith, State geologist of Alabama.

Distribution.—The Fort Payne chert is present from Calera to Hardys, except where faulted out, and from Hardys northward across the Montevallo quadrangle. Along this line it makes a conspicuous ridge. From Calera southward the formation can not be followed continuously and was nowhere seen exposed, but its continuous presence is inferred from patches of chert débris at its horizon. It may, however, occur as detached lenses, and it is probably thin, whether continuous or lenticular. Indications of Fort Payne were seen in this line of outcrop on Sixmile Creek about 4 miles south of Erharkers. In the Columbiana quadrangle the only locality in which the Fort Payne seems to be undoubtedly present is in the strip at the base of the Floyd shale from Spring Creek Church northeastward to the west base of Kelley Mountain, and along this strip its occurrence is definitely known only south of the Louisville & Nashville Railroad and in secs. 11 and 14, T. 22 S., R. 1 E.

Like the Frog Mountain sandstone the Fort Payne is, except in one place, not known to be present at its horizon at the base of the exterior outcrop of the Floyd around the Kelley Mountain anticline. At a number of points along this outcrop, however, chert of different character and of Little Oak age, as described on page 9, occurs at the horizon of the Fort Payne and can easily be mistaken for it. Locally also pieces of fossiliferous chert in the lower part of the Floyd shale might be mistaken for Fort Payne, but the circumstances show clearly that these pieces have come from chert that is interbedded with sandstone and shale of typical Floyd character. The chert can not be regarded as Fort Payne unless the Fort Payne where the chert is found is passing into a clastic facies of Floyd character. It is more probable that the chert is derived from limestone layers such as are known to occur elsewhere in the lower part of the Floyd.

Character.—The Fort Payne is almost exclusively known from its chert. Like most other Mississippian cherts, it probably originated through the silicification of limestone. Primarily the Fort Payne as a formation is calcareous, as shown by specimens brought up from considerable depths as cores of diamond-drill borings. Some of the chert in such material appears as irregular inclusions in limestone, but this chert is full of calcite crystals. Coarse gray thick-bedded limestone is exposed at the Fort Payne horizon on Spring Creek about 1 mile west of Mosteller, in the Columbiana quadrangle. Elsewhere only fragments of crinoidal chert are seen, except at a few places along the chert ridges in the eastern and northeastern parts of the Montevallo quadrangle.

According to Washburne,[19] the chert is at present fine-grained crystalline quartz. It is generally yellow. Weathered pieces are commonly whitish with small red patches. It is brittle or finely jointed, so that it breaks easily, and usually the attempt to trim fossils out of it breaks them into small pieces. In some localities the beds are so much shattered that the chert can be blasted out to a depth of 100 feet in a condition to be used for road surfacing without other preparation than a few blows of a sledge on the larger pieces.

In places some beds of the chert yield on weathering a light, very fine grained, soft, porous rock suitable for use as polishing material.

Thickness.—The greatest thickness of the Fort Payne seen in these quadrangles is 60 feet, exposed at Saginaw. The formation probably nowhere exceeds 100 feet in thickness. It is thickest in the northern part of the Montevallo quadrangle and thins southward and southeastward. In the southern part of the Montevallo quadrangle it appears to be thin, and in the southeastern part of the Columbiana quadrangle it is probably not more than 50 feet thick.

Age.—The Fort Payne is known through its fossils and through tracing into northern middle Tennessee and southern Kentucky to be in the main of the age of the Keokuk limestone, although it also includes a representative of the older Burlington limestone.

UNCONFORMITY AT BASE OF FLOYD SHALE

In the Montevallo quadrangle and on the west side of the Columbiana quadrangle the Floyd shale is underlain by the Fort Payne chert and the Fort Payne in downward succession by the Little Oak limestone, the Athens shale, and the Lenoir limestone, which rests on either the Mosheim or the Newala limestone. In the oval area on Page Spring Creek in the southeast quarter of the Vandiver quadrangle, adjoining the Columbiana quadrangle on the north, only the Athens shale and Little Oak limestone intervene between the Fort Payne and Newala. The Warsaw, Spergen, St. Louis, and Ste. Genevieve limestones, which in a complete sequence in the Mississippi Valley intervene between the rocks equivalent to the Fort Payne chert and the Floyd shale, are everywhere absent in this region, so that there is an unconformity between the Fort Payne and Floyd. North of Columbiana and in the region immediately northeast of the Columbiana quadrangle the Fort Payne chert, Little Oak limestone, Athens shale, and Lenoir, Odenville, and Mosheim limestones are absent, and the Floyd shale in consequence rests unconformably upon the Newala limestone.

In the southern part of the Columbiana quadrangle there are in places between the Floyd shale and Newala limestone either darker shale with graptolites, supposed to be Athens, or limestone and chert, supposed to represent the Little Oak limestone. In places also a thin representative of the Fort Payne chert or an uneven thickness of Frog Mountain sandstone is present, and elsewhere both are present, apparently with or without the underlying Little Oak limestone or Athens shale. All the evidence obtained concerning these occurrences indicates that the formations named are thin and patchy, as if the beds were local deposits in lagoons and embayments. Such deposition would account for the fact that the Floyd in different places in this area rests on beds widely separated in age. The Floyd here was clearly a deposit in a sea transgressing on a long-standing land surface or a surface that had been recently fluctuating between a state of dry land and a state of partial submergence. The transgressive relation of the Floyd has a bearing on the age of the Waxahatchee, Brewer, and Wash Creek slates as mentioned on page 3.

FLOYD SHALE

Name.—The name Floyd was introduced by Hayes for a mass of predominantly black shale, with a little sandstone and limestone, in Floyd County, Ga. The shale of this mass is of the same character and part of it of the same age as the shale here described, for which the name Floyd is accordingly used. It has been discovered recently, however, that the typical Floyd is not strictly equivalent to the Floyd shale of these quadrangles, for in Floyd County, Ga., the Floyd, as actually mapped, includes beds at least as old as Ste. Genevieve limestone. In the reports of the Alabama Geological Survey the term "Oxmoor or shale and sandstone phase of the upper part of the lower Carboniferous rocks" has been applied to the Floyd shale and the overlying Parkwood formation. The stratigraphic equivalence and geographic relations of the formations are shown by Figure 4 of the Bessemer-Vandiver folio.

Distribution.—The Floyd shale occupies a wide area in the northwest quarter of the Columbiana quadrangle from which two belts extend southwestward on the sides of the Calera anticline, and a sinuous band extends northwestward around the south end of the Yellow Leaf trough in the northeast corner of the Montevallo quadrangle. In the eastern part of the Columbiana quadrangle is a belt, essentially synclinal and of roughly oval shape, extending around the south end of the Kelley Mountain anticline.

Character.—The Floyd shale is in these quadrangles a predominantly gray to olive-green thinly fissile to crumbly shale, with strata of black fissile shale making a subordinate though considerable proportion of the whole. Included in the shale is much hard fine-grained greenish to gray sandstone occurring as more or less persistent strata, some as much as 50 feet thick, or as lenses of comparatively small extent. The bedding planes of the sandstone layers are commonly coated with small quartz crystals of secondary formation, and these cause the pieces of sandstone scattered on the surface to glisten so that they are locally called "diamond rocks." An example of the lenticular character of much of this sandstone can be seen in any good exposure, as at the cut on the Southern Railway between Calera and Shelby Springs, where the observed facts furnished the basis for the sketch section of Figure 3.

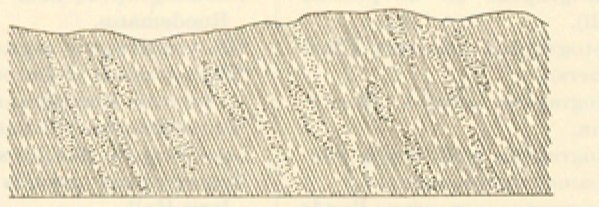


FIGURE 3.—Ideal section showing sandstone lenses in Floyd shale

The sandstone in the Floyd of these quadrangles is similar in external appearance to beds in the Floyd of Shades Valley, southeast of Bessemer, in the Bessemer quadrangle. A thin section from a specimen collected about 1 mile east of Readers Gap shows the rock to be composed of irregular quartz grains in a green matrix, some and perhaps all of which is green mica. Associated with the quartz is an opaque yellowish to white mineral, which may be kaolin from decomposed and iron-stained feldspar grains. In these quadrangles the shale is full of quartz veins a quarter of an inch to 2 inches thick. Being characteristic of the Floyd, quartz fragments from these veins lying on the surface, locally in rather thick accumulations, reveal the presence of that formation even where the soil is deep.

At many places in the narrow strip of flat land that extends along the east edge of the Floyd shale from the Cretaceous border at Providence Church, southwest of Calera, to Columbiana and in the cove 2 miles north of Columbiana along the Pumpkin Swamp road heavy dark crushed, sheared, and veined noncrystalline limestone occurs in dark shale of Floyd type. The limestone shows more commonly in and near Columbiana than elsewhere, and on the Southern Railway a short distance southwest of the station some poor specimens of Mississippian fossils, including *Fenestella*, were obtained from one of the protruding layers of limestone. No fossils were found elsewhere, although careful search was made wherever the limestone was seen. It is probable that the limestone of this strip is in the basal part of the Floyd. Limestone occurs also in the lower part of the formation on Beeswax Creek, near the line between secs. 26 and 27, T. 21 S., R. 1 E., and there is a stratum of considerable thickness that first appears in Spring Creek half a mile west of Mosteller and is rather extensively exposed near the contact of the Floyd shale and the Frog Mountain sandstone as far south as the road half a mile west-southwest of Spring Creek Church, in the NW. $\frac{1}{4}$ sec. 11, T. 22 S., R. 1 E. There is a small exposure of limestone in shale of Floyd type on the west bank of Coosa River at Woods Ferry. The great body of the limestone stratum extending from Spring Creek southwestward beyond Spring Creek Church is thin bedded and argillaceous and weathers to shale. Some thick coarsely crystalline layers occur at the base of the thin limestone half a mile northwest of Spring Creek Church. The thin argillaceous limestone is crowded with fossils, of which fenestellid Bryozoa are the most numerous and striking. Similar shale full of Bryozoa is exposed in the road about 1 mile west of Woods Ferry in faulted contact with Athens shale bearing graptolites.

Except in the highly fossiliferous limestone just described, the Floyd is extremely barren of fossils in these quadrangles. Fossils, mainly from these basal limestone layers in the Floyd shale, collected near the center of sec. 2, T. 24 N., R. 15 E., and identified by Girty, are listed on page 11.

[19] Washburne, C. W., unpublished report.

Cleiothyridina sublamellosa (Hall).
Composita subquadrata (Hall).
Leiorhynchus carboniferum Girty.
Productus arkansanus Girty.
Productus ovatus Hall.
Productus semireticulatus Martin?
Spirifer aff. S. increbescens Hall.
Spiriferina spinosa (Norwood and Pratten).
Spiriferina transversa (McChesney).
Eumetria marcyi (Shumard).
Griffithides mucronatus Girty.

A few fossils, including *Leiorhynchus carboniferum*, were collected on the Tuscaloosa road in sec. 35, T. 22 S., R. 2 W.

Large collections of fossils were made from the Bangor limestone and Floyd shale of Shades Valley, in the Bessemer quadrangle, north of the Montevallo quadrangle, and in the northeast corner of the Vandiver quadrangle, north of the Columbiana quadrangle. Lists of these fossils are published in the Bessemer-Vandiver folio.

Nearly all the species of the above list, as well as those listed in the Bessemer-Vandiver folio, would be expected in any considerable collection of Chester group fossils from the Mississippi or Ohio Valleys and are sufficient evidence of the Chester age of the Floyd.

Thickness.—The thickness of the Floyd is probably not more than 1,000 feet, although the generally steeply inclined attitude of the formation and its wide extent might give the impression that it is many thousand feet thick. The true thickness is best determined in the belt just north of Saginaw. Here the bottom of the Floyd is easily determined by the Fort Payne chert ridge, and the top of the Parkwood, overlying the Floyd, is fixed by the Shades sandstone member of the Pottsville formation. As the beds are approximately vertical, the thickness of the two formations can not exceed the distance between the limits stated, which is practically 2,000 feet. Of this thickness probably no more than half should be assigned to the Floyd. The delimitation of the Floyd and Parkwood is based on the presence or absence of black shale, which occurs only in the Floyd. It is not possible to locate exactly the plane of separation everywhere, but so far as observed the 1,000 feet here assigned to the Floyd includes all the black shale. The apparent great thickness of the Floyd in the wider areas is the result, therefore, of the plication of a comparatively weak mass of shale not more than 1,000 feet thick.

PARKWOOD FORMATION

Name.—In Shades and Cahaba Valleys, mainly north of these quadrangles, on the west side of the Cahaba and of the Coosa coal fields, are shales and sandstones named the Parkwood formation,[20] from the town of Parkwood, which is situated upon the formation. The Parkwood is defined as including the 1,500 to 2,200 feet of shale and sandstone lying above the base of the sandstone making Little Shades Mountain and Bald Ridge, half a mile west of Oxmoor, and below the Brock coal bed, which is taken as the base of the Pottsville formation.

Distribution.—The best exhibition of the Parkwood is in the vicinity of Oxmoor, where it is nearly all exposed, and along the Southern Railway west of Genery Gap, both places in the Bessemer quadrangle. In the Montevallo and Columbiana quadrangles the formation is nowhere well exposed. Its certain area of outcrop is a sinuous belt around the south point of the Yellow Leaf trough, in the northeast corner of the Montevallo quadrangle and northwest corner of the Columbiana quadrangle. It could not be satisfactorily identified along the east side of the Coosa coal field and is believed to be cut out by a fault that brings the Floyd shale into contact with the Pine sandstone member of the Pottsville. There is an elongated area along Shoal Creek west of Wilton, bounded on the south by the Helena fault, that is supposed to be Parkwood because a coal bed cropping out in that region is believed to be the Brock coal, which lies at the base of the Pottsville formation and immediately overlies the Parkwood. A little shale was seen in the bed of Shoal Creek in this area.

Character.—The Parkwood formation in these quadrangles is composed of gray shale and sandstone. The sandstone is generally in thick flags and makes strata as much as 100 feet thick. Some of the sandstone is hard and quartzose, but most of it is probably more or less feldspathic. A large part is somewhat ferruginous and weathers to a rusty color. No calcareous matter occurs in the formation, and at only one place was black shale noted. In these respects the Parkwood is entirely different from the underlying Bangor limestone or Floyd shale. In its eastern areas of outcrop, however, the Parkwood is scarcely distinguishable from the Floyd, and the basis of separation of the two is the presence or absence of the black shale that composes a large part of the Floyd, the rocks down to the upper limit of black shale being included in the Parkwood. The Parkwood bears a strong resemblance to the Pottsville also but contains no coal. In Shades Valley its top is marked by the base of the Brock coal, the lowest bed of the Cahaba coal field, lying 40 feet below the Shades sandstone. In these quadrangles the Brock coal is not known, except in a small area in the northwest corner of the Montevallo quadrangle, and the only practicable boundary between the Parkwood and Pottsville is therefore the bottom of the Shades sandstone.

Thickness.—In these quadrangles the Parkwood is about 1,000 feet thick, as indicated in the discussion of the thickness of the Floyd shale above.

Age and correlation.—In Shades Valley, in the Bessemer quadrangle, where the Parkwood is about 2,000 feet thick, a collection of fossils strongly indicating Pennsylvanian age was obtained from a sandstone about 500 feet below the top. In the southwest corner of the Bessemer quadrangle and apparently about 500 feet above the bottom of the Parkwood fossils of unmistakable Mississippian age are present. These fossils are listed in the Bessemer-Vandiver folio. It appears, therefore, that where the sediments of Parkwood type attain their maximum thickness they probably transgress the paleontologic and chronologic boundary between the Mississippian and Pennsylvanian series and that the upper 500 feet at least is probably of Pennsylvanian age. It is assumed that in the Montevallo and Columbiana quadrangles, where the thickness of the Parkwood is only about 1,000 feet, the upper part, including the probable Pennsylvanian beds, is missing, that the remaining lower part is Mississippian, and that the Pottsville lies unconformably upon it near its middle. The Mississippian part of the Parkwood is of Chester age, and its lower part probably corresponds to the upper part, possibly the upper two-thirds, of the typical Pennington formation of southwestern Virginia. In a personal communication Charles Schuchert expresses the opinion that the Pennsylvanian part is equivalent to the Morrow group of Arkansas and Oklahoma.

UNCONFORMITY AT THE TOP OF THE MISSISSIPPIAN

Where the Parkwood is thickest, in Shades Valley in the Bessemer quadrangle, sedimentation was apparently continuous into Pennsylvanian time, but in the Warrior field, where the Parkwood is absent, the Pennsylvanian rocks rest unconformably upon the Floyd. This relation is in harmony with the marked unconformity that has been long recognized by geologists as existing between the Mississippian and Pennsylvanian on the west side of the Valley and Ridge province from Alabama to Pennsylvania.

PENNSYLVANIAN SERIES

POTTSVILLE FORMATION

Name.—The Pottsville formation takes its name from Pottsville, in the anthracite coal field of Pennsylvania. It forms the lowest part of the Pennsylvanian series, and in the Warrior field, in the Birmingham and Bessemer quadrangles, it rests unconformably upon the eroded surface of the Mississippian rocks, but in Shades Valley sedimentation was apparently continuous and there is no break between the Parkwood and Pottsville formations. The base of the Brock coal bed is taken as the base of the formation on the northwest side of the Cahaba field, but in the Coosa field, where the Brock coal appears to be absent, the bottom of the Shades sandstone is taken as the base. The Pottsville forms the top part of the Paleozoic section in Alabama.

Distribution.—There are two areas of Pottsville rocks in these quadrangles, known as the Cahaba and Coosa coal fields. The Cahaba field occupies a quadrangular area in the northwestern part of the Montevallo quadrangle, and the south end of the Coosa field occupies a small area in the northeast corner of the Montevallo quadrangle and northwest corner of the Columbiana quadrangle.

Character.—The Pottsville rocks comprise sandstone, shale, and coal and form the coal measures of the State. The sandstone is usually in thick-bedded to massively bedded strata from a few feet to more than 100 feet thick. Except in the ridge-making members most of the sandstone is medium coarse grained and not so thoroughly cemented as to withstand weathering a long time, so the strata generally make low, rounded ridges and knolls. The shale is in beds of varying thickness and constitutes a minor proportion of the formation. It is either of purely argillaceous or of sandy composition and includes thin sandstone layers. The coal beds are associated with or included in the shale beds.

The upper 2,800 feet of the Pottsville in the Cahaba coal field, in the Montevallo quadrangle, beginning below with the Straven conglomerate member, is made up in large proportion of very coarse conglomerate in beds some of which are more than 100 feet thick, interbedded with sandstone and shale containing workable coal beds. The well-rounded pebbles of the conglomerate consist of chert and quartzite, most of which are 4 inches or less in diameter but a few as much as 8 inches. The chert is of the type of the Copper Ridge (see p. 6) and probably was derived from a land surface of Copper Ridge lying on the east. The quartzite pebbles also must have come from the east. Mineralogically the sandstones are made up almost wholly of quartz grains, though containing a little mica and feldspar and scattered crystals of magnetite and zircon. The shale consists largely of very fine quartz grains and mica shreds in about equal proportion, together with small quantities of the other minerals that occur in the sandstone. Both shale and sandstone are colored with carbon and iron oxide.

Although the rocks are probably for the most part of fresh-water origin, yet the presence of marine fossils at certain horizons from bottom to top of the formation in the Warrior and Cahaba fields shows that there were incursions of the sea in Pottsville time.

The basal part of the formation contains several beds of siliceous sandstone and conglomerate known collectively as the "Millstone grit." The presence of these hard, resistant beds, inclined 15° or more or even vertical for long distances, has been the controlling condition of the formation of the high ridges along the northwest sides of the Cahaba and Coosa coal fields, such as Shades and Pine Mountains of the Cahaba field and Backbone, Oak, and Double Oak Mountains of the Coosa field.

Thickness.—The Pottsville in the deepest part of the Cahaba coal field in the Maylene Basin is about 9,000 feet thick and in the part of the Coosa field in these quadrangles about 3,500 feet thick. The Maylene Basin probably holds the youngest Paleozoic rocks in Alabama.

Shades sandstone member.—The Brock coal, at the base of the Pottsville in the Birmingham quadrangle and elsewhere, is generally overlain by 40 feet or more of shale, above which is the Shades sandstone member, named from Shades Mountain, in the Bessemer quadrangle. In the area here described, however, the Brock coal is known only in the northwest corner of the Montevallo quadrangle, and the Shades sandstone is therefore elsewhere considered the basal member of the Pottsville. The Shades is thick bedded, rather coarse, and generally somewhat conglomeratic in the lower part. It is 200 feet thick. Its basal 40 feet or so crops out as a cliff along Shades Mountain almost the entire length of the Cahaba field. It crops out for about 1 mile across the northwest corner of the Montevallo quadrangle and makes the west ridge of Double Mountain, which extends around the south end of the Yellow Leaf trough in the northeast corner of the Montevallo quadrangle and into the northwest corner of the Columbiana quadrangle, where it is named Stony Ridge.

Pine sandstone member.—The Pine sandstone member, named from Pine Ridge, in the Bessemer quadrangle, is a gray siliceous rock, thick-bedded at the base but grading into thinner beds at the top. It is about 400 feet thick and makes by its outcrop a low ridge crossing the northwest corner of the Montevallo quadrangle and Locust Ridge, within Stony Ridge made by the Shades sandstone, around the southwest end of the Yellow Leaf trough, in the northeast corner of the Montevallo quadrangle.

Chestnut sandstone member.—Some 800 feet above the Pine sandstone member and separated from it by shale and sandstone with coal beds is the Chestnut sandstone member. This sandstone is gray and siliceous, rather flaggy in composition, and parted into three benches by shale in places 25 feet thick; the whole member is perhaps 200 feet thick. It is sufficiently resistant to make a conspicuous ridge nearly the whole length of the Cahaba coal field. In this area it can be recognized only in the northwestern part of the Montevallo quadrangle.

The Chestnut sandstone is the highest bed included in the "Millstone grit." The sandstones higher in the section are more feldspathic or argillaceous, finer grained, and less firmly cemented and hence less resistant. In fact, a progressive change can be noted from a fairly coarse siliceous, locally conglomeratic sandstone at the base of the Shades member through the Pine sandstone member to a somewhat argillaceous flaggy rock at the top of the Chestnut sandstone member.

Wolf Ridge sandstone member.—In the Bessemer and Vandiver quadrangles the Wolf Ridge sandstone makes Wolf Ridge, from which it is named. Its outcrop extends about 1 mile into the northeast corner of the Montevallo quadrangle. It is about 100 feet thick. It may represent the Chestnut sandstone of the Cahaba field.

Straight Ridge sandstone member.—The Straight Ridge sandstone is also well developed in the Vandiver quadrangle, where it is a hard thick-bedded sandstone 50 to 100 feet thick. It just enters the Montevallo quadrangle in the northeast corner, where it crops out in a small triangular area.

Straven conglomerate member.—In the northeastern part of the Cahaba field, in the Montevallo quadrangle, is the Straven conglomerate, named from the mining town near which it is well developed. The pebbles in it are of quartzite and well rounded; a large part of them are from 2 to 4 inches in diameter and here and there is a larger one. It is persistent around the Dry Creek basin and on the south flank of the Piney Woods Creek anticline and thence south perhaps to the vicinity of Savage Creek mine. Its thickness does not appear to exceed 50 feet, except perhaps locally.

General correlation of the coal beds.—The coal beds are described under the heading "Economic geology." Their names, sequence, and horizons are shown on the columnar-section sheet.

[20] Butts, Charles, U. S. Geol. Survey Geol. Atlas, Birmingham folio (No. 175), p. 8, 1910.

As there is no direct connection between the several coal fields, it is necessary to depend on fossil plants or stratigraphic relations for correlating the coal beds. From fossil plants David White makes the correlations between the Warrior and Cahaba fields indicated in Figure 5 of the Bessemer-Vandiver folio. As fossil plants are rare in the south end of the Coosa Basin, this means of correlation is not at present available there.

White divides the Pottsville formation into lower, middle, and upper Pottsville. The lower Pottsville extends from the bottom of the Pottsville to the top of the Lee formation of Virginia and Tennessee or to the top of the sandstone in east Tennessee named Emory by Safford and Killebrew and Rockcastle by Campbell. It includes the Pocahontas coals of Virginia and West Virginia. The middle Pottsville includes the beds that carry the Sewell and Quinnimont coals of West Virginia, and the upper Pottsville includes the Kanawha coals of West Virginia. The corresponding divisions in the Alabama coal field are indicated in Figure 5 of the Bessemer-Vandiver folio. Lists of the fossils occurring in the Pottsville of Alabama are published in the Bessemer-Vandiver folio.

UNCONFORMITY AT TOP OF POTTSVILLE FORMATION

In this part of Alabama there are no rocks corresponding to a great sequence found in other parts of the United States, including the upper part of the Pottsville and the Allegheny, Conemaugh, Monongahela, and Permian formations of the Carboniferous of the northern Appalachians, as well as the entire Triassic and Jurassic systems and the Lower Cretaceous of other parts of the world. There is thus a very great stratigraphic gap between the Cretaceous rocks of this region and the youngest rocks underlying them.

CRETACEOUS SYSTEM

In this region the Cretaceous system is represented by the Upper Cretaceous Tuscaloosa formation, which is present as outliers and scattered masses near the border of the main areas of the formation.

TUSCALOOSA FORMATION

Name and relations.—The Tuscaloosa formation was named from Tuscaloosa, Ala., where it is typically developed. It rests unconformably upon all the other formations of the region from the Rome, in the southwestern part of the Montevallo quadrangle, to the Pottsville, 2 or 3 miles west of the Montevallo quadrangle.

Distribution.—The Tuscaloosa formation is distributed irregularly in these quadrangles. Apparently the most extensive continuous area and the greatest thickness are on the ridge west of the Centerville road, in the southwest corner of the Montevallo quadrangle. In this general region the Tuscaloosa is extensively distributed but has knobs of dolomite and chert protruding through it, showing that it was laid down on a knobby surface. Isolated patches of sandy soil similar to that on the Tuscaloosa areas occur nearly as far north as Montevallo, as shown on the map. Some of these patches have been mapped with approximately located boundaries, but these boundaries indicate sufficiently the area within which isolated Tuscaloosa deposits occur. A few patches of coarse gravel in the southwestern part of the Columbiana quadrangle are supposed to be Tuscaloosa.

Character.—The Tuscaloosa is composed largely of clay, which is more or less variegated, with subordinate proportions of sand and gravel. Red, pink, yellow, and bluish bands alternate in the mass of clay. The sand occurs, partly at least, as thin layers in the clay. In the Shelby ore bank at Shelby is a 12-foot layer of pink, white, and orange-colored sand with quartz pebbles overlain by a 15-foot layer of red loam, as shown in Plate 11. From its resemblance to typical Tuscaloosa deposits the writer is disposed to regard the material at Shelby as Tuscaloosa, originally either a semidetached deposit in an old low valley or shallow embayment of the pre-Cretaceous surface or an outlier left in the course of erosion. The basal Tuscaloosa is in places, if not generally, a very coarse gravel. Such a deposit 30 feet thick directly overlies the Floyd shale in the southeast corner of T. 24 N., R. 12 E., and extends southwest to Mahan Creek in the northeastern part of T. 23 N., R. 12 E. Abundant loose gravel of the same kind occurs from this region eastward one-third of the distance across the southern part of the Columbiana quadrangle, nowhere reaching a mile north of the south line. East of this limit no gravel was seen, nor does gravel occur west of the ridge of Floyd shale about southwest of Providence Church. Detached patches of such gravel occur three-quarters of a mile west and the same distance northwest of Providence Church. All these gravel beds that appear to be nearly in place lie between altitudes of 600 and 700 feet. A plausible interpretation is that the coarse gravel is a local basal Tuscaloosa deposit. As such gravel has nowhere been seen to be overlain by unquestionable Tuscaloosa material, however, and as similar gravel that, owing to its high level, can hardly be regarded as Tuscaloosa occurs at other points, as on the top of Kelley Mountain, on the east edge of the Columbiana quadrangle, there is some doubt as to the correctness of the reference of any of the gravel to the Tuscaloosa.

Thickness.—The thickness of the Tuscaloosa may reach but probably does not exceed 100 feet. A water well 1 mile south of Concord Church, 6 miles southwest of Calera, penetrated 90 feet of unconsolidated material to reach the underlying Ordovician limestone, and this material is in part at least Tuscaloosa clay. Another well, on the Mapleville road 1 mile southwest of Providence Church, passed through 3 feet of sandy soil and 47 feet of clay into gravel, which is the water-bearing stratum. A well on the same road at the south edge of the quadrangle is reported 50 feet deep in sand and gravel. It could hardly be much deeper, for one-eighth of a mile southeast bedrock crops out scarcely more than 50 feet below the well head.

Age and correlation.—The scanty collections of fossil plants that have been obtained in other parts of Alabama indicate, according to E. W. Berry, that the basal Tuscaloosa, with which part only of the formation this folio is concerned, is probably of the same age as the upper part of the Raritan formation of Maryland and New Jersey, which is the lowest formation of the Upper Cretaceous in the eastern United States.

TERTIARY (?) SYSTEM

All around Kelley Mountain and extending up to the 600-foot level is abundant coarse quartzite gravel, and scattered pebbles of the same rock occur on the crest of the mountain at an altitude of 700 feet, or 350 feet above Coosa River. This gravel is well displayed along the road northeast of Pine Flat School. There is a small deposit of the same kind of gravel on a low knoll three-quarters of a mile west of Mosteller and a notable deposit along the road on the west side of the ridge 1 mile northeast of Bay Spring Church.

These pebbles were originally deposited at a level at least as high as the top of Kelley Mountain, on a flood plain of an old base-leveled valley. They have been redistributed down the slopes in the course of the degradation of the region, as it is impossible that they could have been originally deposited in their present positions, although some of the material on the slopes may have been deposited by the river at a later stage in its downcutting. From the depth of the erosion that has since occurred, it does not seem probable that this gravel is younger than late Tertiary.

QUATERNARY SYSTEM

The Quaternary system is represented in these quadrangles by the deposits of Recent alluvium laid down upon the flood plains of the present streams. Wells near Curry Ford show a thickness of 40 feet for the alluvium, which at that place consists of sand, clay, and gravel.

STRUCTURE

Method of representing structure.—The structure is shown on the map by structure sections, which show how the cut edges of the strata would appear in deep trenches extending across the region at right angles to the strike of the rocks. This method is very instructive, but it has the disadvantage of showing the structure only near the particular line of the section. It is the best method where the rocks are greatly folded and faulted.

The details of structure are shown on the maps by strike and dip symbols and by lines representing the position of the faults and of the folds.

General features of the structure.—In these quadrangles, as throughout the Valley and Ridge province, the rocks, originally horizontal, have been, through enormous pressure exerted from the southeast, intensely folded, crumpled, and faulted, so that they now lie in great arches (anticlines) and troughs (synclines) having a general northeasterly trend. There are several great faults along which the strata have been greatly dislocated, the major faults running along the southeast sides of the two coal fields.

A few miles northwest of the northwest corner of the Montevallo quadrangle is the great Birmingham anticline. From the crest of this arch the strata dip southeastward into the great trough of the Cahaba coal field. The Shades sandstone, which rises toward the northwest and crops out on the southeast limb of this anticline in the northwest corner of the Montevallo quadrangle, is several thousand feet beneath the surface at the southeast edge of the Cahaba field. The general southeast dip on this limb of the anticline is interrupted by several minor folds, such as the Tacoa, Piney Woods Creek, and Dogwood-Mayberry anticlines, which produce corresponding minor synclines or basins—the Belle Ellen and Pea Ridge synclines and the Dry Creek basin. Steep dips prevail along the northwest side of the Cahaba field; on the southeast the rocks flatten out and are gently undulating over a large area northwest of Aldrich. They are sharply upturned to a vertical or even slightly overturned attitude along the axis of the Aldrich syncline and southwest of Aldrich. East of the Cahaba coal field is the east limb of another great anticline, the rocks of Cahaba Valley dipping in general eastward into the trough of the Coosa coal field and, south of the Coosa trough, as in most of the Montevallo and Columbiana quadrangles, into the Columbiana Mountain syncline. At the south end of the Coosa coal field are a number of minor folds that extend southwest to the Elliottsville fault. This fault has produced a peculiar offset in the outcrop of the formations and of the ridge of the Copper Ridge dolomite, probably as a result of the westward movement of the strata on the north, including those of the Coosa coal field, the movement pivoting around a point near the south end of the Elliottsville fault. If the segment of strata were swung back to its original position, the broken ends of the Copper Ridge outcrop would probably be brought together in the vicinity of sec. 30, T. 21 S., R. 2 W. North of Elliottsville the fault probably shifts into the midst of the Newala limestone, and the movement has followed the bedding planes of that formation and so has produced no displacement by which the movement would be revealed. This fault probably connects northeast of Newhope Church with the Cahaba Valley fault, in the Vandiver quadrangle.

The Columbiana syncline pitches southwest in the southern part of the Columbiana quadrangle and northeast in the northeastern part, in Columbiana Mountain. The Weisner formation in Columbiana Mountain appears to be in unconformable contact with the Waxahatchee slate, but as the rocks beneath the Weisner may be Wash Creek slate the relations are not known. If they are Wash Creek, then there is an east-west fault at the southwest base of Columbiana Mountain between the Wash Creek and Waxahatchee. The peculiar fact about this fault, if there is one, is that it is downthrown on the east, contrary to the rule in the Valley and Ridge province.

In a consideration of the Columbiana syncline as a whole, stratigraphically, areally, and structurally, the following interpretation is strongly suggested. In the Columbiana Mountain region the axis pitches to the northeast and the stratigraphic sequence in ascending order is as follows: Slate of the Talladega, Weisner quartzite, Shady limestone, Rome formation, and Conasauga limestone. In the southern part of the quadrangle the axis of the syncline pitches to the southwest and the succession upward is Waxahatchee slate, quartzite, Sawyer limestone with more slate above, Brewer phyllite, and Wash Creek slate.

There is a certain degree of similarity in the stratigraphic sequence in both of these areas. At the south end of Columbiana Mountain the Weisner quartzite is underlain by slate of Waxahatchee type, which is apparently continuous with the Waxahatchee to the southwest. On the southwest the discontinuous beds of quartzite underlying the Sawyer limestone may be modified Weisner, the Sawyer limestone may correspond to the Shady limestone, and the purplish Brewer phyllite may correspond to the Rome formation, strongly distinguished by its red shale. Here the correspondence ends. The Wash Creek slate bears no resemblance to the Conasauga limestone overlying the Rome formation in the Columbiana Mountain area. However, the Wash Creek could be a wholly clastic facies of the Conasauga, which in some other areas is predominantly shale. The interpretation suggested by these facts is that the Columbiana syncline is crossed by a low northwest-southeast anticline between Columbiana and Shelby, giving an opposing pitch to the axis as described, and that the stratigraphic succession is actually repeated on opposite sides of the cross anticline, as suggested by the facts. If this interpretation should prove to be the correct one it follows that the rocks next above the Waxahatchee slate in the southern part of the Columbiana quadrangle are of Lower Cambrian age with higher Cambrian formations succeeding them. This would leave only the age of the Waxahatchee undetermined.

The small area of Weisner rocks, mainly in secs. 9 and 16, T. 21 S., R. 1 E., in the syncline northeast of the area of the Rome and Conasauga formations is overthrust upon these younger formations. The depth of the Columbiana syncline in the southern part of the Columbiana quadrangle is unknown. The Waxahatchee, Brewer, and Wash Creek slates are overthrust upon the Newala limestone, and the attitude of the limestone is a matter of speculation. It may have been folded and eroded before the overthrusting of the slates. The alinement of the Columbiana syncline shows that folding took place after the overthrusting also. This fact is further attested by the general parallelism of the outcrops of the mapped slate formations with the outcrops of limestone formations around the south end of the Kelley Mountain anticline. The Kelley Mountain anticline is a definite arch pitching southwest. Between it and the Columbiana syncline are a low arch between Shelby and Kewahatchie and a low syncline, in which lies the Floyd shale of that region.

In the development of the folds through pressure from the southeast, which produced movement of the great body of rocks to the northwest, the crests of the major anticlines were naturally thrust farther northwest than the bottoms of the synclines, so that the common limbs, the northwest limbs of the anticlines or the southeast limbs of the synclines, having before the movement a northwest dip, became vertical, then overturned with a southeast dip, and finally, in some places, completely overfolded, so that the common limbs of the folds were upside down. These limbs, weakened by stretching and crushing, finally gave way, and overlying masses slid forward along the planes of the breaks so far that the older rocks, buried deep in the center of the overturned arches, were thrust upward stratigraphically into a position above the upper rocks involved in the folding. (See pl. 12.) In time the overturned and overthrust masses were eroded away, and the surface was reduced to the present condition, in which no trace of the faulting is preserved in the topography. Thus are explained the great faults bordering the coal fields, the Opossum Valley, Helena, and Coosa faults, and the disappearance of the common limbs of the folds. The total northwest movement along each of these faults was at least as much as the thickness of rocks displaced, which on the Opossum Valley fault is at least 2 miles and in places on the Helena fault at least 3 miles. The actual horizontal movement may have been much greater. The combined effect of all these faults is an overlapping structure for the whole area.

Dip of fault planes.—The dip of the fault planes is unknown for most of their length, but at Aldrich data obtained in mining show a dip of 35° E. for the Helena fault at that place. The great fault plane at the base of the Waxahatchee slate probably has low dips of varying direction from place to place.

Metamorphism.—Notwithstanding the great movement, with attendant friction and crushing near the fault planes, there has been very little metamorphism of the rocks. The Montevallo coal bed, which has been mined up to the fault, is said to show no change that indicates any difference from its ordinary chemical composition. The Waxahatchee, Brewer, and Wash Creek slates have been, however, slightly metamorphosed from their original condition of clay shale to their present condition of slate and phyllite, probably as a result of extreme compression involved in their overthrusting for 12 miles or more.

The Floyd shale and the Waxahatchee, Brewer, and Wash Creek slates are very minutely crumpled, and the beds everywhere dip steeply. They have also been fractured minutely, and the fractures have been filled with quartz, which forms veins, most of those in the Floyd from a quarter to half an inch thick and those in the slates as much as 2 feet. The slates have been so strongly compressed that slaty cleavage has been generally developed in them.

GEOLOGIC HISTORY

In the earliest time of which there is record in the sedimentary rocks of the Appalachian Highlands, perhaps a hundred million years ago, or according to more recent hypotheses, based on the rate of formation of lead from radioactive minerals, as much as five hundred million years ago, along the site of the Valley and Ridge province lay a strait between still more ancient lands on the east and on the west. This strait was on the eastern border of a great area, extending to the region of the present Great Lakes, that was slowly but intermittently subsiding during all of Paleozoic time. The Appalachian Strait widened into the Appalachian Gulf. The filling up of this subsiding earth basin by sediments derived from the bordering lands constitutes the part of this history which properly begins with the Paleozoic era. The vast lapse of time which had preceded the deposition of these sediments is recorded in the rocks of the Blue Ridge and Piedmont provinces. These rocks, which extend beneath the Valley and Ridge province and Appalachian Plateaus, are the foundation upon which the Paleozoic rocks rest.

PALEOZOIC ERA

CAMBRIAN PERIOD

From the bordering land areas great quantities of fine mud were discharged into the Appalachian Strait by the rivers of pre-Weisner (Waxahatchee, Brewer, Wash Creek) time (pre-Cambrian or Paleozoic). At intervals coarse sand mixed with small quartz pebbles was deposited, and this material became quartzite, a few thin beds of which are found in the slates. There was also a short period of limestone deposition, when the Sawyer limestone member of the Waxahatchee slate was laid down. Fine clayey material greatly predominated, however, indicating derivation from land of low relief or deposition in water distant from shore, so that only the finer sediment was transported to it.

As the pre-Weisner slates were originally finely stratified clay, they were evidently deposited in water. No organic remains except the Calcareous alga of *Cryptozoon* type in the Sawyer limestone member have ever been discovered in them or in their equivalent in Georgia and Tennessee, but they reveal no conditions unfavorable to Cambrian types of life. In their general lack of fossils they also accord with known pre-Cambrian rocks elsewhere. Although they are here classified as pre-Cambrian or Paleozoic, the weight of evidence seems to the writer to favor pre-Cambrian age for them.

In the succeeding Weisner epoch much coarse sand with fine gravel was deposited in alternation with fine material like that of the pre-Weisner slates. The Weisner epoch was certainly Cambrian, for Lower Cambrian fossils occur, though rarely, in the Weisner rocks.

The Weisner epoch was succeeded by that in which the Shady limestone was laid down. This indicates a great change in geographic or meteorologic conditions, for obviously pure limestone can not be deposited except in water free from earthy sediment. A few forms of life are known to have existed in the sea of the Appalachian region in Shady time, but so far as known life was scarce.

The deposition of earthy sediment was resumed in the succeeding Rome epoch, and a notable feature of the deposits then formed is the red shale, which denotes perhaps an accumulation of soil stained red by iron oxide on a tributary land during an arid time in which the Shady limestone was laid down, the lack of water for the transportation of sediment being the cause of the clear sea of Shady time. At rare intervals the Rome sea was invaded by swarms of trilobites and brachiopods whose remains are now entombed in the deposits laid down during the time of their invasion.

In the Conasauga epoch, which followed the Rome epoch, the conditions again favored the formation of limestone in Alabama. Probably in Conasauga time a persistent land barrier was raised between Cahaba and Birmingham Valleys, for, as shown under the heading "Descriptive geology," the Conasauga is absent along the eastern margin of the Cahaba coal field and probably was not deposited there because of an island in that part of the Conasauga sea. This Cahaba barrier marks an area in which there was a decided tendency to uplift, technically called a positive area, as shown below, and to this tendency is due the peculiarities of distribution of the Ordovician limestones in the two valleys. In Middle Cambrian time, the area southeast of this barrier was occupied by the sea, which seems to have withdrawn by Upper Cambrian time, for apparently no Upper Cambrian beds occur in that part of Alabama.

CAMBRIAN OR ORDOVICIAN PERIOD

The period succeeding the deposition of the Conasauga limestone and ending with the deposition of the Chepultepec dolomite was one of the most notable periods for the deposition of dolomite in the history of the earth. After the Conasauga limestone was laid down Birmingham Valley and Cahaba Valley were elevated above sea level, and the resulting erosion produced the unconformity described on page 6. After the deposition of the Brierfield dolomite in the Montevallo region there followed a resubmergence, including that of the Cahaba barrier, except south of Bessemer (p. 6), and the Ketona dolomite was laid down in both Birmingham and Cahaba Valleys. The deposition of the Ketona was succeeded by another uplift of about the same region as before while the Bibb dolomite of the Montevallo region was deposited, after which the sea spread over all of the southern Appalachian region and so remained while the great mass of the Copper Ridge dolomite was deposited, and in the Montevallo-Columbiana region submergence continued during Chepultepec time.

The seas of this dolomite period were nearly devoid of living organisms that possessed parts capable of fossilization except in Chepultepec time, when some forms, principally gastropods, were common but not abundant.

ORDOVICIAN PERIOD

The Ordovician period was one of notable oscillation in the Valley and Ridge province, leading to repeated emergence and submergence of certain areas and corresponding gaps in the sedimentary sequence.

The Cahaba barrier seems to have been continuously effective and part of the time to have extended over Cahaba Valley. After a short emergence during Stonehenge time (p. 7) the Cahaba Valley was resubmerged, and Ordovician deposition began with the Longview limestone and continued apparently without interruption through Newala and Odenville time, after which Cahaba Valley emerged during early Chazy time, in which the St. Peter sandstone and possibly limestone of early Stones River age were deposited elsewhere. In Cahaba Valley the deposition of limestone was resumed in Mosheim and Lenoir time, was interrupted while the Athens shale was being deposited in the south end of the valley, and then repeated with the deposition of the Little Oak limestone (late Chazyan). Afterward the valley area was elevated above sea and so remained until it was temporarily submerged again in early Frog Mountain (Onondaga) time. In Lenoir, Athens, and Little Oak time marine animals, brachiopods, gastropods, and graptolites, were fairly abundant in the seas of the region. In Athens time this Alabama region had connection through the ocean with all parts of the world, as testified by the world-wide distribution of the Athens graptolites (p. 9).

The great difference between the faunas of Birmingham and Cahaba Valleys during Ordovician time is due to the complete separation, by the Cahaba barrier, of the seas occupying the two valleys.

SILURIAN PERIOD

Crustal oscillation continued through the Silurian period. The elevation of the Cahaba Valley area above sea level prevented the deposition or resulted in the removal of any Silurian deposits that may have been laid down in that region. Birmingham Valley and the site of the Cahaba coal field, probably including the part of that field in the Montevallo quadrangle, on the other hand, were submerged at the beginning of the period and so remained while the Red Mountain formation was laid down. Beyond this there is no record of events during the Silurian period in these quadrangles.

DEVONIAN PERIOD

The unrecorded time of the Silurian period continued through the early part of the Devonian period. Then the western part of the Montevallo quadrangle may have been temporarily submerged in Oriskany time, but if so the record is buried beneath the rocks of the Cahaba coal field. In Onondaga time all the area east of the Cahaba coal field was probably submerged and the Frog Mountain sandstone was deposited. The remainder of the Devonian period, an immensely long time, is, however, a blank in this area, except in so far as the Chattanooga shale may constitute a meager record, but the range of possible interpretations of this record is so great that limits of space permit no further discussion here.

CARBONIFEROUS PERIOD

The events of the early part of Carboniferous (Mississippian) time (Burlington epoch) are scantily recorded in the Birmingham district in the basal beds of the Fort Payne chert. The region was entirely submerged, however, during Keokuk and Warsaw time but was raised again above sea level during all or parts of St. Louis and Ste. Genevieve time. Then it was resubmerged and so remained during succeeding Chester and early Pennsylvanian time while the prevailingly earthy sediment of the Floyd shale and Parkwood formations was deposited. The deposition of the Parkwood seems to have been followed by the deposition of the Brock coal and the basal sandstone of the Pottsville formation of the Cahaba and Coosa coal fields. The deposits of Pottsville time were the mud, clay, and sand that formed the Pottsville shales and sandstones. The pebbles of chert in the great masses of coarse conglomerate beginning with the Straven conglomerate member were doubtless derived from areas of Copper Ridge dolomite, and the pebbles of quartzite, and here and there one of conglomerate, were probably derived from the Weisner, Wash Creek, Brewer, and Waxahatchee formations, areas of all these formations east and southeast of the coal fields having been raised into land in Carboniferous time.

The most interesting and valuable deposit of the Pottsville is coal. Land vegetation became abundant and grew luxuriantly in swamps of vast extent near sea level, in which thick deposits of vegetal débris accumulated as in a modern peat bog. These deposits were covered by sediment and in time converted by pressure and loss of moisture and gaseous constituents into bituminous coal. The process was repeated many times, giving rise to many coal beds, thick and thin. That the coal swamps were near sea level is proved by the occurrence of marine fossils over extensive areas of the coal fields at several horizons from top to bottom of the Pottsville (p. 11). As the plants grew in the air and the animals lived only in the sea there must have been alternate emergence and submergence, such as would most likely take place if the land stood continuously near sea level, so that a slight sinking would permit flooding by the sea. As the Pottsville accumulated near sea level and is about 9,000 feet thick in the southern part of the Cahaba field, there must have been constant although, as shown by the coal beds, intermittent subsidence of the earth's crust during the long time of its accumulation. The luxuriant vegetation of the Carboniferous period consisted largely of great trees allied to modern club mosses and of smaller plants allied to modern ferns. No flowering plants had yet appeared.

As a bed of peat about 5 feet thick is necessary to make 1 foot of bituminous coal it is easily seen that at the highest imaginable rate of growth a very long time was required to accumulate the coal beds of Alabama, which in the Cahaba field, for example, aggregate not less than 100 feet in thickness and thus required an amount of vegetal matter equal to a bed of peat 500 feet thick.

No record of events during the rest of the Carboniferous period exists in Alabama. In this unrecorded time the Pennsylvanian coal measures of upper Pottsville, Allegheny, Conemaugh, and Monongahela age were laid down in western Pennsylvania, Ohio, Indiana, and Illinois, and above them the Permian series of the Carboniferous, the last of the deposits of the Paleozoic era.

APPALACHIAN REVOLUTION

The Paleozoic era was one of subsidence and deposition in the Appalachian Gulf region. It was a constructive era, in which rock formations were built up. At the end of the Paleozoic a reverse movement—uplift of the formerly subsiding area—began, and it has continued ever since. The region became dry land. As the land emerged from the water it was attacked by the agents of erosion, which have been active during all subsequent time. This great change in the operations of nature in this part of the earth is known as the Appalachian revolution. Besides the direct uplift that affected the region there was a lateral westward movement of the crust, the effects of which are most conspicuous in the Valley and Ridge province (pp. 12–13), where the strata were folded, crumpled, and faulted and changed from their original horizontal to their present inclined attitudes, as already described and as shown in the structure sections. Probably these movements were very slow and continued long into the Mesozoic era. They must have been accompanied by violent earthquakes, to judge from the earthquake results of such comparatively slight movements as that which produced the San Francisco earthquake and that on the Red Gap fault, which produced the earthquake in the Birmingham region a few years ago.

MESOZOIC AND CENOZOIC ERAS

Except in Tuscaloosa time, when there was a brief period of submergence and deposition, the Mesozoic and Cenozoic were eras of destruction in this area, and almost no records of them exist in the Birmingham district. Like all land areas the region was subjected to erosion during the whole of Mesozoic and Cenozoic time; a great thickness of solid rock has been removed—10,000 feet, for example, in the vicinity of Birmingham—and as a result the present hills, ridges, and valleys have been carved in the surface of the region.

Cumberland peneplain.—Although erosion has been constant, the upward movements of the crust in the Appalachian Highlands seem to have been intermittent. Some of the pauses were so long that extensive areas were worn down nearly to a plain (peneplain) near sea level. The peneplain of which there is the best evidence seems to have attained its complete development in early Cretaceous time, for its marginal parts, slightly submerged by a tilting movement, were covered by early Cretaceous deposits on the Coastal Plain. Farther north, however, the peneplain was more elevated, and in the Cumberland Plateau it is now represented by an extensive fairly even surface, approximately 2,000 feet above sea level. Thence it slopes southward, connecting approximately with the surface of Sand Mountain in northern Alabama and that of Blount Mountain, 1,300 feet high, farther south. Possibly the crest of Red Mountain and the higher summits of the Warrior and Cahaba coal fields nearly coincide with the old peneplain, but it is too obscurely preserved in these southern latitudes to be surely identified. Because this old peneplain of supposed Cretaceous age is excellently preserved in the Cumberland Plateau it is named the Cumberland peneplain. It may be the same as the Schooley peneplain of New Jersey, which is also thought to dip beneath the Cretaceous deposits of that area.

Peneplains of later date and lower altitude are preserved in the Highland Rim of middle Tennessee and in the Coosa Valley of Alabama. The Highland Rim and Cumberland peneplains probably converge southward and become indistinguishable in the Warrior coal field.

Life of the Mesozoic and Cenozoic eras in Alabama.—There can be no doubt that the land of the southern Appalachian region supported the succession of plant and animal life peculiar to each period of the Mesozoic and Cenozoic eras, although but scanty remains of this life have been preserved or yet discovered. The leaves of several modern genera of forest trees have been found in the Cretaceous deposits of Alabama, and the trees must have grown on the land bordering the Cretaceous sea. Among these genera are the fan palm, the sequoia ("big trees" of California), pine, tulip ("yellow poplar"), magnolia, sycamore, sassafras, holly, poplar, willow, cinnamon, fig, and walnut. The oak was living at this time in the Carolinas, but no specimens have been reported from Alabama. In Cenozoic time a number of other genera of trees, such as hickory, pawpaw, cassia (senna), redbud, dogwood, and ash, made their appearance, and their remains are preserved in the Eocene (lower Tertiary) deposits of Alabama. Two living genera of ferns, *Lygodium* (climbing fern) and *Asplenium* (spleenwort), are also recorded from the Alabama Eocene.

Among the animals modern types of clams and fishes probably inhabited the rivers of Alabama throughout the Mesozoic era and the Tertiary period of the Cenozoic era, as they did the rivers of other regions during those times. The great reptiles, the dinosaurs and others that inhabited the Rocky Mountain region, also probably roamed through the forests and over the plains of Alabama, although any morasses in which any of them may have been mired and preserved were removed in the general course of erosion. The strange mammals that are so well known from remains found in the Tertiary deposits of the West, also doubtless lived in Alabama, but like the dinosaurs and for the same reason they have left no traces. In early Quaternary time, while the northern part of North America was buried in the ice of the glacial epoch, the mastodon, megatherium, cave bear, saber-toothed tiger, and a host of other recently extinct animals inhabited the Alabama region, and we may believe that the first human being to tread the soil of Alabama was a contemporary of these extinct animals.

ECONOMIC GEOLOGY

The mineral resources of the Montevallo and Columbiana quadrangles consist of coal, iron, dolomite, limestone, marble, shale, clay, road metal, building stone, soil, and water. The most valuable of these resources are coal, iron, limestone, and dolomite.

COAL

The areas of the coal measures of Alabama (Pottsville formation) are naturally grouped in four separate fields—the Warrior, Plateau, Cahaba, and Coosa fields.[21] These quadrangles include part of the Cahaba field and of the Coosa field. The coal is high-grade bituminous. All of it is excellent for making steam and for domestic use and much of it for making coke and gas. The composition of the coal is shown in the table of analyses (p. 16).

COALS OF THE CAHABA FIELD

The coal beds that are workable in part or the whole of their extent in this area are as follows, named from below upward: Gould, one or more beds of the Nunnally coal group, Buck (Atkins), Youngblood (Black shale, Coke), Clark (Little Pittsburgh?, Woodstock, Blocton No. 1), Gholson, Thompson (Underwood), Helena, Yeshic, Montevallo, Lower Dogwood, Lower Maylene, and Upper Maylene.

Gould coal bed.—A bed apparently within the horizon of the Gould coal group has been opened in the NE. ¼ sec. 12, T. 24 N., R. 11 E. This is perhaps one of the Peter mines, operated many years ago. The bed at this place is overturned, dipping 45° SE. The character of the bed is shown in section 1, Figure 4.

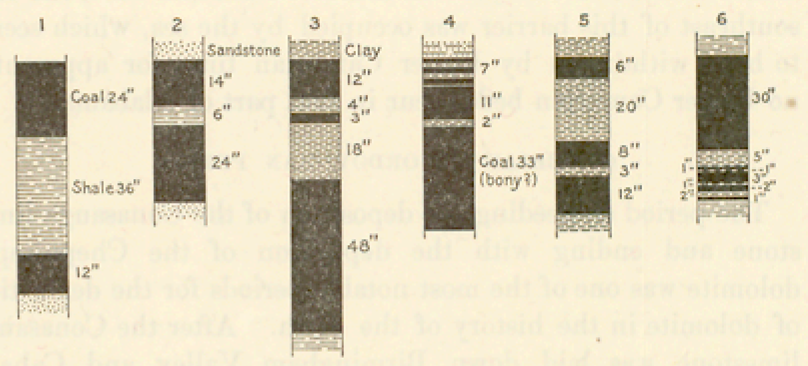


FIGURE 4.—Sections of Gould, Nunnally, Big Bone, and Buck coal beds

1. Gould (?) coal at Old Peter mine, in NE. ¼ sec. 12, T. 24 N., R. 11 E.
2. Nunnally coal, next to top bed (Cubical), in NE. ¼ sec. 12, T. 24 N., R. 11 E. (estimated)
3. Nunnally coal, top bed (Figh), in NE ¼ sec. 12, T. 24 N., R. 11 E. (estimated)
4. Coke Oven (Big Bone) coal on Southern Railway in SE. ¼ sec. 9, T. 20 S., R. 4 W.
5. Buck (Atkins) coal on Louisville & Nashville Railroad at Piney Woods
6. Buck (Atkins) coal on Southern Railway in NE. ¼ sec. 20, T. 21 S., R. 4 W.

What is supposed to be the same bed has been opened at the bend of Shoal Creek near the common corner of secs. 5, 6, 7, and 8, T. 24 N., R. 12 E. The coal was not open to inspection, but the extent of the working and the coal scattered about indicated a bed of considerable thickness. The Gould bed was not seen at its outcrop in the northwest corner of the Montevallo quadrangle, but at Bamford, 2 miles to the northeast, in the Bessemer quadrangle, it shows solid coal 18 inches to 2 feet thick, and there is little doubt that it carries workable coal in the northwestern part of the Montevallo quadrangle. Its probable outcrop is shown by the broken line between the outcrops of the Pine and Chestnut sandstones.

Nunnally coal group.—On the Southern Railway along the line between secs. 4 and 9, T. 21 S., R. 4 W., three beds of the Nunnally coal group are exposed. The lowest of these, seen in the southern part of sec. 4, shows only 8 inches of coal; 100 feet or so higher 18 inches is exposed in another bed; and 100 feet still higher, in the northern part of sec. 9, is a 2-foot bed that is possibly the top bed of the Nunnally group. The thicknesses may not be truly representative, for the rocks here are plicated, and the coal beds are probably somewhat thinned by squeezing. Just north of the Montevallo quadrangle, in secs. 34 and 35, T. 20 S., R. 4 W., are two coals, probably belonging to the Nunnally group, the lower of which is reported to be 2 feet and the upper 3½ feet thick. West of the Montevallo quadrangle, 3 to 4 miles due west of Gurnee Junction, at least two of these beds are 2 feet or more thick.

At the old Peter mines, in sec. 12, T. 24 N., R. 11 E., in the southern part of the Montevallo quadrangle, three beds were mined, named by Squire,[22] in ascending order, the B or Lemley, the C or Cubical, and the D or Figh "seams." Squire reports a bed 2½ feet thick between the Lemley and Cubical beds that was not mined, also a bed (the A bed) below the Lemley. These beds are identified as the Nunnally coal group. At this locality the rocks are slightly overturned and dip about 60° S. Only the Cubical and Figh beds could be seen, and as they were exposed in the walls of the steep slopes they were inaccessible and could not be accurately measured. The estimated thickness is given in sections 2 and 3, Figure 4.

The third bed from the top, the Lemley, was not open to examination, and no knowledge of its thickness was obtained. Squire[23] gives the following analysis, which is inserted here on account of the unusual character indicated for the coal. If the analysis is correct this is a cannel coal, but it seems more probable that the figures for volatile matter and fixed carbon were accidentally interchanged in Squire's table.

Analysis of coal from B or Lemley seam of the Brierfield Co., Bibb County, Ala.

[J. L. Beeson, analyst]

Moisture	2.265
Volatile matter	57.130
Fixed carbon	37.407
Ash	3.198
	100.000
Coke	40.605
Sulphur	1.158
Sulphur left in coke	.487
Per cent sulphur in coke	1.198

The occurrence of workable beds in this group on both the north and south outcrops may be regarded as indicating that they extend underneath the entire area and contain a great quantity of available coal.

Harkness coal bed.—The Harkness bed, which lies 400 to 500 feet above the Nunnally coal group, is apparently represented by a group of thin coals exposed on the Southern Railway in sec. 9, T. 20 S., R. 4 W. It is not known to be of minable thickness in this area.

Wadsworth coal bed.—A thin coal exposed on the Southern Railway in the SE. ¼ sec. 9, T. 21 S., R. 4 W., is apparently at the horizon of the Wadsworth coal. So far as known to the writer, it is not thick enough to be of value in this area.

Big Bone (Coke oven) coal bed.—From 350 to 400 feet above the Wadsworth is the Big Bone or Coke oven coal. The only places at which it was seen are one on the Southern Railway and another on the east bank of the river a quarter of a mile to the northeast, both in the SE. ¼ sec. 9, T. 2 S., R. 4 W. At the locality on the railroad the bed is 4 feet 5 inches thick and is made up as shown in section 4, Figure 4. At the river bank it is 3 feet 6 inches to 5 feet thick and bony; it is overlain by shale and underlain by conglomeratic sandstone. Southwest of this area, in the Brookwood quadrangle, the Big Bone is better known. It is a dirty, bony bed reaching a thickness of 12 to 16 feet but containing little good coal. Its bony character persists in the Montevallo quadrangle and it does not promise to be of much value.

Pump (Alice and Jones) coal beds.—At 400 feet above the Big Bone coal are the Pump coal beds. The beds are separated by 15 to 40 feet of shale and are both thin; the lower is generally the thicker. Their relation is shown by the following section:

Section on road a quarter of a mile southeast of Booth Ford

	Ft.	in.
Shale.		
Coal (Upper Pump)	1	6
Shale	25	
Coal (Lower Pump)	2	
Shale.		
	28	6

The same beds in the same relations are also exposed by prospect pits half a mile west of Glen Carbon, where the lower bed is 20 inches thick; the upper bed was not seen, as the pit was closed. Thin beds that crop out on Mayberry Creek near the north line of sec. 11, T. 24 N., R. 11 E., appear to be near the horizon of the Pump beds. The Pump coals are of very high grade, as shown by analyses by the Tennessee Coal, Iron & Railroad Co. of samples collected a few miles southwest of this area. These coals were given the field names Alice and Jones by the geologists and prospectors of the Tennessee Coal, Iron & Railroad Co. As they appear to lie at the horizon of the Pump coals of Squire, named from the pumping station of the Louisville & Nashville Railroad a mile or so west of Helena, the name Pump is used here.

Buck (Atkins) coal bed.—The Buck bed is 200 feet above the upper Pump bed. It is of good thickness south of Piney Woods Tank, in T. 21 S., R. 4 W., but at that locality it is much parted and worthless, as shown by section 5, Figure 4. It was not seen north of that place. On the Louisville & Nashville Railroad half a mile south of Piney Woods Tank the bed is 4 feet thick and apparently clear coal, and about 1 mile farther southwest, on the Southern Railway, it is 3 feet 10 inches thick with a clear bench 2 feet 6 inches thick at the top. (See section 6, fig. 4.) It is probably workable along its outcrop southwest of Piney Woods Tank. Indications of a bed identified as the Buck are to be seen on Mayberry Creek and half a mile east of the creek, where it comes up on the south side of the Aldrich syncline. It seems probable that it is the same bed as that called by Squire the "cannel bed," which he says is 3 feet thick and partly bony. Too little is known of the bed in this locality to warrant an estimate of its probable value. Analyses by the Tennessee Coal, Iron & Railroad Co. of samples taken southwest of this area show a most excellent quality.

[21] For a map of the coal fields of Alabama see U. S. Geol. Survey Geol. Atlas, Bessemer-Vandiver folio (No. 221), fig. 7, 1927; and for sections showing the coal beds of the different fields see same folio, fig. 5.

[22] Squire, Joseph, Report on the Cahaba coal field, pp. 99–102, Alabama Geol. Survey, 1891.

[23] Idem, p. 102.

Youngblood (Coke, Black shale) coal bed.—The Youngblood bed is 200 feet above the Buck. This bed has proved very persistent and uniform throughout the southern part of the Cahaba field and is believed to be about 3 feet thick throughout the part of the field in the Montevallo quadrangle. This bed was worked recently at the Daley mine, half a mile southwest of Aden and just beyond the west line of the quadrangle, where it is reported to range from 2 to 4½ feet in thickness without partings, with a measured thickness of 3½ feet, 300 feet from the mine mouth, as shown in section 1, Figure 5. An

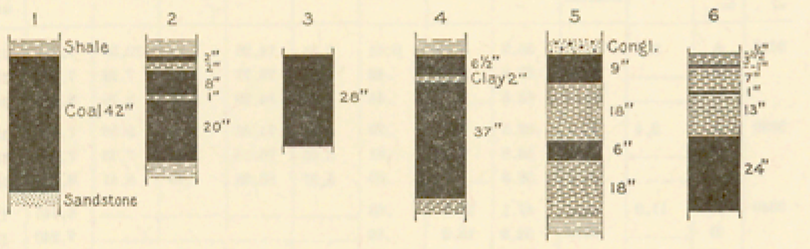


FIGURE 5.—Sections of Youngblood and Clark coal beds

1. Youngblood (Black Shale, Coke) coal in Daley mine, half a mile southwest of Aden
2. Youngblood coal on Louisville & Nashville Railroad three-fourths mile northeast of Piney Woods tank
3. Youngblood coal in Old Mossboro mine
4. Clark coal in Marvel No. 2 mine
5. Clark coal in Louisville & Nashville Railroad cut in SE. ¼ sec. 31, T. 21 S., R. 4 W.
6. Clark coal on Fourmile Creek in SW. ¼ sec. 3, T. 24 N., R 11 E.

analysis of the coal at this point is given as No. 9666 in the table of analyses. In a prospect pit just west of Glen Carbon the bed is 20 inches thick. On the Louisville & Nashville Railroad three-quarters of a mile northeast of Piney Woods Tank the bed is 2 feet 9 inches thick with partings, as shown in section 2, Figure 5. At the old Mossboro mine, on the north edge of the quadrangle, the bed is 2 feet 4 inches thick and clear coal (section 3, fig. 5). On the south side of the field the Youngblood appears to be the same as the bed named by Squire and Brewer the Shaft "seam," which was worked by a shaft at that locality many years ago. Old prospect pits on Little Mayberry Creek indicate three pairs of coal beds that are in the same relative positions and about the same distances apart as the Buck and Youngblood below, the Clark and Gholson in the middle, and the Thompson and Helena at the top. The Youngblood appears to be the upper bed of the lowest pair on which there are evidences of old workings in the Mayberry Creek region. This bed appears also to be the same as that called the Beebee by Squire and Brewer. At a closed pit on Mayberry Creek supposed to be on this bed 4 feet of coal is reported. At an old pit on Little Mayberry Creek about 275 feet above its sharp bend to the west, indications of 4 feet of coal were visible. One-third of a mile to the east is the apparent location of the old slope said by Squire to be on the Shaft bed. In the Blocton road 1 mile southwest of Aldrich the bed is 2 feet thick on its vertical outcrop.

Clark (Little Pittsburgh?) coal bed.—The Clark coal bed is 500 feet or more above the Coke bed. At least two thin beds occur about midway between these beds; they show on the railroad northeast of Piney Woods Tank. The Clark is a variable bed on its outcrop north of Savage Creek, but southwest of the Montevallo quadrangle it is a comparatively regular and valuable bed. At the Marvel mines, just west of the quadrangle, it is 3 feet 9 inches thick, with partings. (See section 4, fig. 5.) The composition of this coal is given in analysis 9253. About 1½ miles northeast of the Marvel mines the bed has degenerated to a worthless condition, as shown by section 5, Figure 5. At Glen Carbon the Clark bed was formerly mined, but the mine was abandoned on account of the irregularity of the bed, which ranges from a few inches to 7 feet in thickness and is overlain by conglomeratic sandstone. At this place the Clark and Gholson beds are separated by the unusual interval of 70 feet. Near Mossboro the Clark bed is 15 to 18 inches thick.

On the south side of the field two coals having about the relative positions of the Clark and Gholson beds have been located on most of the streams from Alligator Creek on the west to Little Mayberry Creek on the east. The old pits are closed, and the coal could not be seen except on Alligator and Fourmile Creeks. On Alligator Creek just west of the Montevallo quadrangle an old pit recently reopened discloses the following section:

Section in northeast corner of sec. 7, T. 24 N., R. 11 E.

	Ft.	in.
Coal, Gholson bed	10	2½
Sandstone, conglomeratic	30	
"Rash"		3
Shale	3	
"Rash"		4
Coal, Clark bed	1	6
"Rash"		1
Total Clark bed	1	11

The relations of these coal beds to one another and the intervening conglomerate, as well as the relation of this group to the beds above and below, give strong evidence of the correctness of the identification here made. On Fourmile Creek, in the SW. ¼ sec. 3, T. 24 N., R. 11 E., another pit was reopened, and the bed was found to be, with partings, 4 feet 1½ inches thick. (See section 6, fig. 5.)

Gholson coal bed.—The Gholson bed lies 30 to 70 feet above the Clark in this region, and between the two beds a conglomeratic sandstone occurs throughout large areas. The Gholson is persistent and uniform on its northwest outcrop from Marvel to Mossboro. Southwest of Marvel the bed is considerably broken by partings. This condition appears in the siding to the Garnsey mine, just west of the Montevallo quadrangle, as shown in section 1, Figure 6. At the Marvel No. 1 mine the bed is as shown in section 2, Figure 6, its total thickness, including clay partings, being 4 feet. (For the composition of this coal see analysis 9252.) The bed was formerly mined at Anita, Gurnee, and Glen Carbon, where it has an average thickness of 3 feet 6 inches and is of excellent quality. (See analysis 9667.) Just north of the Montevallo quadrangle the bed is 3 feet 2 inches thick.

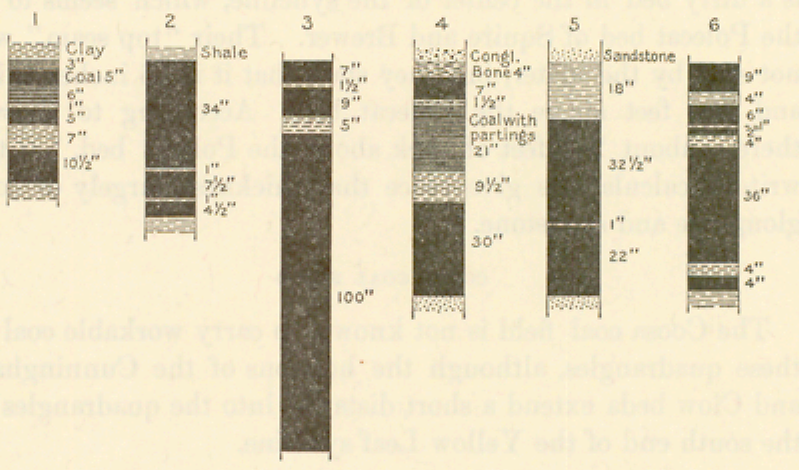


FIGURE 6.—Sections of Gholson and Thompson coal beds

1. Gholson coal at siding to Garnsey mine, Garnsey
2. Gholson coal in Marvel No. 1 mine
3. Gholson coal on Alligator Creek in NE ¼ sec. 7, T. 24 N., R. 11 E.
4. Thompson (upper) coal in Garnsey mine, entrance to ninth west heading
5. Thompson coal in Garnsey mine, face of ninth east heading
6. Thompson coal on Fourmile Creek in the western part of sec. 3, T. 24 N., R. 11 E.

A bed 2 feet thick in the vertical rocks near the axis of the Piney Woods Creek anticline, a quarter of a mile due south of Superior, is probably the Gholson, as is also the bed opened half a mile southeast of Straven, where it is 33 inches thick and has a 6-inch parting of clay near the middle.

On the south margin of the field the Clark and Gholson are believed to be represented by two beds close together. On Alligator Creek, in the NE. ¼ sec. 7, T. 24 N., R. 11 E., the supposed Gholson bed is 10 feet 2½ inches thick, with partings but with a bench of coal 8 feet 4 inches thick at the bottom. (See section 3, fig. 6.) One of two openings close together on Little Mayberry Creek is believed to be in this bed, the other in the Clark bed. Possibly, however, this bed is the Shaft "seam" of Squire, which he reports to be 4 feet thick.

Thompson (Underwood) coal bed.—The bed here called the Thompson (upper) was so named by the geologists of the Tennessee Coal, Iron & Railroad Co., who determined by prospecting that it is above the Straven conglomerate, whereas the Thompson or conglomerate bed farther north, as at Coalmont, in the southern part of the Bessemer quadrangle is below the Straven conglomerate and therefore is called the Thompson (lower). Both beds are exposed with conglomerate between them in cuts on the Southern Railway between Glen Carbon and Superior. (See section in next column.) The Thompson (upper) is the most valuable bed of the Cahaba field in and west of the Montevallo quadrangle. It is thick on Fourmile Creek, but in the Dry Creek syncline and immediately south of the Piney Woods anticline its condition is not so good, though even in these places it may be locally workable. The bed is 300 feet above the Gholson, and between the two are thin beds, showing best in the cuts along the siding to the Garnsey mine, that represent the Smith Shop, Quarry, and other beds of the section on the Louisville & Nashville Railroad west of Helena.

The Thompson bed was mined at the Garnsey mine. The opening to the mine is just west of the quadrangle, but most of the workings are in this area. At this mine the bed is uneven but has a persistent clay parting, in places 1 foot thick, that divides the bed into two benches, as shown in sections 4 and 5, Figure 6. The whole bed is mined. In the Garnsey mine a mile or more south of the mine mouth the character of the bed is reported to have become so poor that it was no longer minable with profit, and the mine was abandoned. The composition of the coal at this place is shown in the table. Analysis 9251 represents the whole bed, 9249 the lower bench, and 9250 the upper bench. At the Savage Creek mine this bed is reported to be made up of two benches, with a clay parting 3 feet thick. Only the top bench is mined; it is 3 feet 7 inches thick and free from the partings that impair the quality of the upper bench at Garnsey. North of the Savage Creek mine the bed was seen only at Straven and west of the Superior mine, in cuts of the Southern Railway. At Straven it is 3 feet thick and dirty, and its worthless character at a point 1 mile west of Superior is shown in the section in the next column.

It is believed that the Thompson (upper) bed can be identified on its southern outcrop on Fourmile and Alligator Creeks. On Alligator Creek in the NE. ¼ sec. 7, T. 24 N., R. 11 E., it has an upper bench of 3 inches and a lower of 38 inches, separated by 7 inches of clay. The bed was once mined on a small scale at the old Morrill slope, near the west branch of Fourmile Creek, and in the western part of sec. 3, T. 24 N., R. 11 E., on the main stream. The old mine in sec. 3 has recently been reopened, and the rocks exposed are shown in section 6, Figure 6.

A prospect on Little Mayberry Creek is believed to mark the outcrop of this bed, which appears to be the same as the Cooper seam of Squire, reported by him to be 2½ feet thick.

Section of Thompson coal bed on the Southern Railway west of Superior

			Ft.	in.
Sandstone.				
Shale			40	
Sandstone			10	
Conglomerate			10	
Clay				6
Coal	Thompson (upper)			3
Clay	Thompson (upper)			2
Coal	Thompson (upper)			2
Coal, clean	Thompson (upper)			8
Clay			2	
Conglomerate, coarse (Straven)			30	
Clay			1	6
Coal, Thompson (lower)		3 in. to	1	6
Clay		2 in. to	3	
Conglomerate and sandstone			30	

Helena coal bed.—The Helena coal bed, which is about 160 feet above the Thompson, is of considerable value in the northern part of the Montevallo quadrangle but is little known in the southern part. In the vicinity of Coleanor and Piper, southwest of this quadrangle, extensive prospecting has failed to discover the bed, or if found it is too thin to be worth considering.

At the Savage Creek mine, where by mine levels it is 185 feet above the Thompson bed, it is of good thickness and condition. (See section 1, fig. 7.) At the Superior mine it shows a similar section, and although the coal and clay benches are here somewhat uneven, the bed as a whole appears to

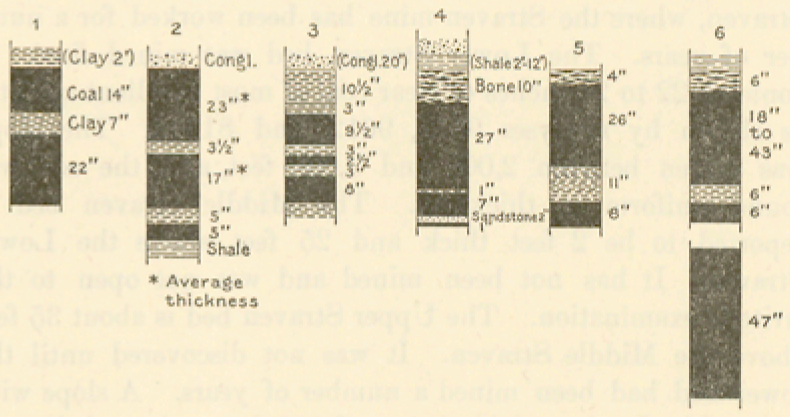


FIGURE 7.—Sections of Helena, Montevallo, and Maylene coal beds

1. Helena coal in Savage Creek mine
2. Helena coal in Superior mine
3. Montevallo coal in SW. ¼ sec. 18, T. 22 S., R. 4 W.
4. Montevallo coal in Aldrich mine, ninth west heading, near main slope
5. Montevallo coal in Aldrich mine, room 37 off west heading
6. Maylene coal in Climax mine, face of fourteenth west heading

maintain a good workable thickness. (See section 2, fig. 7.) The bed is believed to be workable throughout the Dry Creek basin and seems to be also in the Eureka Basin, on the north. About a mile southeast of Straven, at the north end of the Maylene Basin, the bed is of good thickness and quality, and a mine opened since the quadrangle was surveyed is now operating upon it. South of the Aldrich axis, on Little Mayberry Creek, Squire reported a bed 4 to 6 feet thick and regarded it as the Montevallo. It is structurally impossible for this bed to be the Montevallo, and the writer regards it as probably the Helena. Except this report of Squire nothing is known of the bed in this region.

Yeshic coal bed.—The Yeshic bed, about 165 feet above the Helena, is of doubtful value in this area. One-third of a mile east of the Garnsey mine is an opening on a bed identified as the Yeshic, which is 18 inches thick and 370 feet above the Thompson coal. Prospect pits in the N. ½ sec. 17, T. 21 S., R. 3 W., appear to be on this bed, but the identification can not be regarded as at all certain. At the opening nearest the west side of sec. 17 the bed is 2 feet 2 inches thick, of clear coal.

Montevallo coal bed.—According to calculations the Montevallo bed in the vicinity of Garnsey is about 800 feet above the Thompson bed and 430 feet above the Yeshic. This result is computed from the level of the Thompson bed at the end of the main slope of the Garnsey mine and the dip between the end of the slope and a point beneath the outcrop of the Montevallo coal, about half a mile in advance of the workings.

The Montevallo has long been mined at and near Aldrich and has always had a high reputation as a domestic coal. Along its northwest outcrop the bed is thin and parted but is to be regarded as workable ultimately, if not so under present conditions. In the SW. ¼ sec. 18, T. 22 S., R. 4 W., the bed is 2 feet 2 inches thick, with partings. (See section 3, fig. 7.) The coal in the thicker benches of this section is hard and bright and probably of good quality. In the southwest corner of sec. 24, T. 23 S., R. 4 W., 18 inches of coal was visible, and the bed may not have been fully exposed. Near the center of sec. 18, T. 21 S., R. 3 W., 18 inches of coal is reported, and the bed may be thicker.

On the outcrop at the southeast side of the field the bed is in the best condition. At the Aldrich mine the bed is made up practically as shown in sections 4 and 5, Figure 7, which represent the average composition of the bed. The following section is exceptional:

Section of Montevallo coal in Aldrich mine, room 19 off sixth east entry

	Ft.	in.
Bone or "rash"		5
Coal	4	2
Clay		1
Coal		1
	6	7

The chemical composition of the coal at the points where sections 4 and 5, Figure 10, were measured is given in analyses 9339 and 9340.

At the Little Gem mine, in the NW. ¼ sec. 5, T. 22 S., R. 3 W., the Montevallo bed has been brought up to outcrop by the Dogwood anticline, the mine being situated on the north limb. The following section is representative:

Section on main slope of Little Gem mine at seventh left heading

	Ft.	in.
Shale.		
"Rash"		2
Coal		7
"Rash"		½
Coal	2	2
"Rash"		1
Coal		11
Clay ("middleman")		5
Coal		5
Clay, "rash," and coal		3
Coal		4½
Clay, floor of mine.		

There can hardly be a doubt that the Montevallo is a valuable bed beneath an area 2 miles or so wide between the Aldrich and Little Gem mines immediately west of the boundary fault.

Straven coal group.—The Straven coals are best known at Straven, where the Straven mine has been worked for a number of years. The Lower Straven bed was mined first. It contains 22 to 24 inches of clear coal of most excellent quality, as shown by analyses 9611, 9612, and 81933. The slope was driven between 2,000 and 3,000 feet, and the coal was found uniform in thickness. The Middle Straven bed is reported to be 2 feet thick and 25 feet above the Lower Straven. It has not been mined and was not open to the writer's examination. The Upper Straven bed is about 35 feet above the Middle Straven. It was not discovered until the lower bed had been mined a number of years. A slope with side entries has been driven about 2,000 feet on it, and the coal was found of uniform thickness. The following section shows the usual make-up of the bed:

Section of upper Straven coal at Straven mine

	Ft.	in.
Coal, "rash," and shale; not mined		8
Coal, hard (analysis 14391)		10½
Parting, "rash" or soft coal .... Knife-edge to		4
Coal (analysis 14391)	2	2
Clay		8½
Coal, softer than upper benches (analysis 14392)	1	1½
Clay	5	6½

This bed is reported to persist in workable condition throughout its area of about 2½ square miles in the Dry Creek basin. The quality of the coal is shown by analyses 81928 and 81934–81938.

It is believed by the proprietors of the Montevallo-Straven mine that the coal worked in that mine is the Montevallo bed. In a preliminary report[24] the writer tentatively accepted this identification. On further examination, however, that view has been abandoned. The objections to regarding these coal beds as Montevallo are, first, they are too far above the Thompson coal, 1,100 feet or more, whereas the Montevallo is only about 800 feet above; second, there are three coals, whereas there is only one at the Montevallo horizon. It is much more probable that the Straven group is the same as the Dogwood group.[25]

Dogwood coal group.—The Dogwood coals include three or four thin beds, the lowest 500 feet and the highest 600 feet above the Montevallo bed, as determined at the Aldrich and Little Gem mines. The Lower Dogwood bed was once mined at the old Export slope, on the north limb of the Dogwood anticline, where it is about 500 feet above the Montevallo bed in the Little Gem mine. What appears to be the highest bed of the group was once mined on Davis Creek in the SW. ¼ sec. 18, T. 22 S., R. 12 E., where the distance between that bed and the Montevallo is 600 feet. The Dogwood coals have been thoroughly prospected by the Tennessee Coal, Iron & Railroad Co. from the north end of the Maylene Basin to the Tuscaloosa road in the northwest corner of sec. 3, T. 22 S., R. 11 E. There are three beds within a thickness of 100 feet or so. They are generally thin or so divided by partings as to be valueless, but one or another shows here and there a minable bench.

[24] Butts, Charles, The southern part of the Cahaba coal field, Ala.: U. S. Geol. Survey Bull. 431, pp. 89–146, 1911.

[25] A full discussion of this question has been published in a press memorandum of the Interior Department dated March 25, 1926.

Lower Maylene coal bed.—The horizon of the Lower Maylene bed is 1,300 to 1,400 feet above the Montevallo bed. Between the Lower Maylene bed and the Dogwood group are the Wooten, Lower Lovelady, and Upper Lovelady beds, which so far as known are thin and worthless. The Lower Maylene bed is 4 to 5 feet thick and considerably parted but of excellent quality. A representative section of this bed in the Climax mine is shown in section 6, Figure 7. A sample was taken from the bench 2 feet 5 inches thick, and the analysis of it is given as No. 9610. The coal having been worked out, the Climax mine has been abandoned.

Upper Maylene coal bed.—From 8 to 40 feet above the Lower Maylene coal, as reported, lies the Upper Maylene bed, which the writer did not see.

Polecat coal bed.—About 250 feet above the Lower Maylene is a dirty bed in the center of the syncline, which seems to be the Polecat bed of Squire and Brewer. Their "top seam" was not seen by the writer, but they state that it is 18 inches thick and 200 feet above the Polecat bed. According to Brewer there is about 245 feet of rock above the Polecat bed, but the writer's calculations give twice that thickness, largely of conglomerate and sandstone.

COOSA COAL FIELD

The Coosa coal field is not known to carry workable coal in these quadrangles, although the horizons of the Cunningham and Clow beds extend a short distance into the quadrangles in the south end of the Yellow Leaf syncline.

MINING DEVELOPMENTS

In this part of the Cahaba field there are nine active mines as listed on the economic-geology map. The total production in 1928 was 606,312 tons.

Mining conditions.—The coal beds of the Cahaba and Coosa fields are generally inclined at angles exceeding 20°. In some places the beds are vertical or nearly so; in others, however, low dip prevails or the beds are practically flat. They have little or no dip in the area included in the Pea Ridge syncline, about 50 square miles in extent, where the strata are flat or broadly rolling. The general topographic conditions are illustrated in Plate 13. No faults of consequence have been detected, nor have any been encountered in mining. Adequate data for determining the approximate position of the beds at any point are given by sections and dip symbols on the maps. The rocks adjacent to the coal beds are generally stable and give no unusual trouble in mining; at least the writer has heard very few complaints of trouble. Neither is any particular trouble from water or gas reported. The construction of railroads to the mines presents no great difficulties. At present abundant timber and water are obtainable close to the mines. The dip of most of the rocks and the small thickness of the coal beds make it necessary to drive the cross entries near together, as the rooms must be driven up the rise from the lower entry, and it is not practicable to push the empty cars more than 250 to 300 feet up the inclined floors. The cross entries are therefore about twice as many and their aggregate cost is about twice as much as in mining flat beds of good thickness.

Character and composition of the coal.—All the coal of this region is bituminous, has a fuel ratio just below 2, and makes good coke. It is also a steam and domestic coal of high grade. In efficiency it ranks below the Pocahontas and New River coals of West Virginia, being comparable to the highest-grade Kanawha coals of that State. The amount of impurities, clay as partings and sulphur or iron pyrites in some beds, makes washing necessary if the coal is to be coked. The composition of the coal is shown by the subjoined table of analyses. These analyses were made at the fuel-testing plant of the United States Geological Survey and its successor, the laboratory of the Bureau of Mines at Pittsburgh, on samples collected by the standard method, as follows: A channel of uniform depth and width was cut from top to bottom of the bed, and such partings were rejected as are rejected in mining. The coal thus obtained, 25 to 50 pounds, was pulverized and quartered down in the mine to about 2 quarts, which was sent in a sealed galvanized-iron can to the chemical laboratory. It was there transferred to a glass jar and kept sealed until analyzed. The samples thus fairly represent the composition of the bed at the place of sampling.

In the table, the analyses are given in three forms, marked A, B, and C. Analysis A represents the sample as it comes from the mine. Analysis B represents the theoretical condition of the coal after all moisture has been eliminated. Analysis C represents the coal after all moisture and ash have been theoretically removed. This form is supposed to represent the true coal substance, free from the most significant impurities. Forms B and C should not be used in comparison, for they represent theoretical substances that do not exist.

In the analytical work it is not possible to determine the proximate constituents of coal or lignite with the same degree of accuracy as the ultimate constituents. Therefore the moisture, volatile matter, fixed carbon, and ash are given to one decimal place only; whereas the ash (in the ultimate analysis), sulphur, hydrogen, carbon, nitrogen, and oxygen are given to two decimal places. The determination of the calorific value to individual units is not reliable, hence in the column headed "British thermal units" the values are given to the nearest tens.

Analyses of coal from the southern part of the Cahaba coal field, Montevallo and Columbiana quadrangles, Ala.

[A. C. Fieldner, chemist in charge]

Laboratory No.	Form of analysis	Proximate				Ultimate					Heat value	
		Moisture	Volatile matter	Fixed carbon	Ash	Sulphur	Hydrogen	Carbon	Nitrogen	Oxygen	Calories	British thermal units
9610	A	3.3	32.2	55.9	8.63	0.41	5.01	74.25	1.12	10.58	7,315	13,170
	B		33.3	57.8	8.92	.42	4.81	76.77	1.16	7.92	7,565	13,610
	C		36.5	63.5		.46	5.28	84.29	1.27	8.70	8,305	14,950
9339	A	2.4	36.0	52.5	9.10	.79	5.20	74.33	1.02	9.56	7,415	13,350
	B		36.9	53.8	9.32	.81	5.05	76.15	1.04	7.63	7,600	13,680
	C		40.7	59.3		.89	5.57	83.98	1.15	8.41	8,380	15,080
9340	A	11.0	30.2	47.1	11.7	.68					6,445	11,600
	B		33.9	52.9	13.2	.76					7,240	13,030
	C		39.0	61.0		.88					8,340	15,020
9611	A	3.8	32.0	58.7	5.48	.97	5.29	77.26	1.25	9.75	7,665	13,800
	B		33.3	61.0	5.70	1.01	5.05	80.33	1.30	6.61	7,970	14,350
	C		35.3	64.7		1.07	5.36	85.18	1.39	7.00	8,455	15,210
9612	A	3.8	31.3	54.3	10.6	.67					7,160	12,890
	B		32.6	56.4	11.0	.70					7,445	13,400
	C		36.6	63.4		.78					8,360	15,050
81928	A	4.7	33.4	53.5	8.40	.65	5.51	73.68	1.29	10.47		13,170
	B		35.0	56.2	8.82	.68	5.23	77.34	1.35	6.58		13,820
	C		38.4	61.6		.75	5.74	84.82	1.48	7.21		15,160
81933	A	3.1	34.8	54.3	7.8	.77						13,320
	B		35.9	56.0	8.1	.79						13,750
	C		39.1	60.9		.86						14,950
81934	A	2.3	35.0	53.0	9.7	.96						13,220
	B		35.8	54.2	10.0	.98						13,530
	C		39.8	60.2		1.09						15,030
81935	A	2.6	35.6	54.9	6.9	.76						13,890
	B		36.6	56.3	7.1	78						13,950
	C		39.4	60.6		.84						15,020
81936	A	2.8	35.6	55.9	5.7	.96						13,790
	B		36.6	57.5	5.9	.99						14,190
	C		38.9	61.1		1.05						15,070
81937	A	2.8	35.1	53.7	8.4	.89						13,330
	B		36.1	55.3	8.6	.92						13,720
	C		39.5	60.5		1.01						15,010
81938	A	2.7	35.0	54.6	7.74	.90	5.27	75.75	1.32	9.02		13,470
	B		35.9	56.1	7.96	.93	5.11	77.87	1.36	6.77		13,850
	C		39.1	60.9		1.01	5.55	84.61	1.48	7.35		15,050
14391	A	3.1	35.6	53.3	8.0	.59					7,320	13,170
	B		36.8	55.0	8.2	.61					7,550	13,590
	C		40.1	59.9		.66					8,225	14,810
14392	A	3.6	36.8	53.2	6.4	1.10					7,505	13,510
	B		38.2	55.1	6.7	1.14					7,785	14,010
	C		40.9	59.1		1.22					8,340	15,010
9249	A	3.4	31.7	55.0	9.89	.65	4.99	72.72	1.15	10.60	7,245	13,040
	B		32.8	57.0	10.24	.67	4.78	75.32	1.19	7.80	7,505	13,510
	C		36.6	63.4		.75	5.33	83.91	1.33	8.68	8,360	15,050
9250	A	3.6	29.2	53.7	13.51	.61	4.87	70.56	1.11	9.34	6,915	12,440
	B		30.3	55.7	14.01	.63	4.64	73.16	1.15	6.41	7,165	12,900
	C		35.3	64.7		.73	5.40	85.08	1.34	7.45	8,335	15,000
9251	A	3.7	27.4	49.9	19.0	.57					6,485	11,680
	B		28.4	51.8	19.8	.59					6,735	12,120
	C		35.4	64.6		.74					8,390	15,100
9252	A	6.6	28.9	46.9	17.60	1.28	4.89	63.37	1.10	11.76	6,375	11,480
	B		30.9	50.2	18.85	1.37	4.44	67.86	1.18	6.30	6,830	12,290
	C		38.1	61.9		1.69	5.47	83.62	1.45	7.77	8,415	15,150
9667	A	3.1	32.5	61.1	3.30	.61	5.48	80.69	1.25	8.67	8,030	14,560
	B		33.5	63.1	3.41	.63	5.29	83.28	1.29	6.10	8,290	14,920
	C		34.7	65.3		.65	5.48	86.22	1.34	6.31	8,580	15,450
9253	A	4.6	33.2	55.1	7.09	.69	5.03	74.85	1.18	11.16	7,435	13,390
	B		34.8	57.8	7.44	.72	4.73	78.50	1.24	7.37	7,800	14,040
	C		37.6	62.4		.78	5.11	84.81	1.34	7.96	8,425	15,170
9666	A	4.8	31.4	52.4	11.37	.74	5.26	71.61	1.23	9.79	7,100	12,780
	B		33.0	55.0	11.95	.78	4.96	75.25	1.29	5.77	7,460	13,430
	C		37.5	62.5		.89	5.63	85.46	1.47	6.55	8,475	15,250

9610. Climax mine, 1½ miles southwest of Maylene, face of west entry 14. 2,000 feet in mine. Lower Maylene bed.

9339. Aldrich mine, Aldrich, west entry 9, just off main slope, 31-inch cut. Montevallo bed.

9340. Same, room 37 off west entry 6, 34-inch cut. Montevallo bed.

9611. Straven mine, Straven, room 5 off west entry 5, 900 feet in mine, 2-foot cut. Lower Straven bed.

9612. Straven mine, Straven, room 15 off east entry 5, 900 feet in mine. Lower Straven bed.

81928. Straven mine of Helena Straven Coal Co. Straven bed.

81933–81938. Straven mine of Montevallo-Straven Coal Co. (81933, Lower Straven bed; 81934–81938, Straven bed).

14391. Montevallo-Shelby mine, Straven, upper bench of bed, 36½-inch cut. Upper Straven bed.

14392. Same, lower bench, 13½-inch cut. Upper Straven bed.

9249. Garnsey No. 1 mine, sec. 7, T. 22 S., R. 4 W., east entry 9, 66½-inch bed, 22-inch cut. Thompson bed.

9250. Same, east entry 9, 66½-inch bed, 32½-inch cut. Thompson bed.

9251. Same, entrance to west entry, 73-inch bed, 63½-inch cut. Thompson bed.

9252. Marvel mine, Marvel, slope No. 1, first right entry, 200 feet south of mine mouth, 46-inch cut. Gholson bed.

9667. Glen Carbon mine, Glen Carbon, room 15 off east entry 12, 3,000 feet in mine. Gholson bed.

9253. Marvel mine No. 2, Marvel, left entry 1, 37-inch cut. Clark bed.

9666. Daley mine, near Marvel, sec. 6, T. 22 S., R. 4 W., 100 feet north of main slope, 300 feet from mouth, 3½-foot cut. Youngblood bed.

IRON ORE

Deposits of iron ore in the form of limonite and hematite occur in this region. Limonite occurs at Shelby, at the old pits that supplied ore to the Bibb furnace, southwest of Montevallo, and in small deposits at other points. The hematite ore exists as stratified beds in the Weisner formation and underlying slates. The most valuable of these deposits have been described by McCalley,[26] Smith,[27] Grasty,[28] and Butts.[29]

[26] McCalley, Henry, Report on the valley regions of Alabama, pt. 2, pp. 494–495, 510–512, 518–519, Alabama Geol. Survey, 1897.

[27] Smith, P. S., The gray iron ores of Talladega County, Ala.: U. S. Geol. Survey Bull. 315, pp. 173–174, 1907.

[28] Grasty, J. S., Cambrian gray and red hematites of east Alabama: Manufacturers Record, Sept. 17, 1908.

[29] Butts, Charles, Iron ores in the Montevallo-Columbiana region, Ala.: U. S. Geol. Survey Bull. 470, pp. 215–230, 1911.

LIMONITE

Limonite at Shelby.—The limonite deposit at Shelby was the largest in the area, but as operations have been abandoned there it possesses now only a scientific and historic interest. Operations were begun in 1844 to 1846, and work was practically continuous until about 1920. The iron made here early acquired a high reputation. A rolling mill was completed in 1860, at which armor plates were made for the Confederate Government. The *Merrimac* was armored with these plates.

The workings at Shelby have been confined to an area of about 160 acres. The ore deposit occurs in and beneath a mound, the top of which was originally 100 feet above the surrounding surface.

The eastern two-thirds of the ore-bearing area is underlain by Newala limestone, and the western third possibly by shale, the limestone and shale being separated by a fault. The thickness of the deposit has never been determined, but it is known by test pits in the bottom of the deepest workings to be more than 100 feet thick and to contain ore to the greatest depths explored. Probably the deposit accumulated in an old sink hole.

The ore was in two quite different kinds of material sharply separated from each other. Over most of the ore-bearing area was a layer of compact red loam about 15 feet thick, called the "blanket." Underlying the "blanket" in most of the area was a heterogeneous mass of more or less iron-stained clay, sand, and rock fragments. (See pl. 15.) On the south edge of the workings, and apparently only there, a white and orange-colored sand lay between the "blanket" and the clay, as shown in the following section:

Section at south edge of Shelby workings

[See pl. 11]

	Feet
Loam, red, compact, with lump ore ("blanket")	15
Sand, pink and white, slightly clayey, with quartz pebbles abundant	6
Sand like above, but orange-colored, with abundant quartz pebbles	6
Clay, tawny, with ore powder and streaks of slabby ore, with chert inclusions, probably residual from limestone	20
	47

The red loam of the "blanket" resembles the red loam that has been called "Lafayette" in other parts of the State. The 12 feet or so of sand and pebbles has all the appearance of Cretaceous material and probably is such. Test pits south of the workings have encountered this sand and gravel. It was impracticable to utilize the ore where the gravel and sand occur, on account of the difficulty of separating the pebbles. The clayey material below, composing the great bulk of the deposit, appears to be residual from the underlying limestone and shale. In places pinnacles of limestone project up into the clay to a height of 25 feet or so. (See pl. 14.)

The ore in the "blanket" is designated lump ore. It was scattered rather irregularly through the red loam or to some extent aggregated into richer bodies having the form of thin lenses. Generally it was in small pieces 2 inches or less in diameter, compact and pure, reported to average 52 per cent of metallic iron and to yield a ton of ore to 3 or 4 cubic yards of material. The ore in the underlying clayey material was of all forms occurring in such deposits—small spongy lumps, slabby, wavy layers, and concretionary masses. Much of this ore contained more or less of impurities, such as inclusions of chert, clay, and sand. Some large masses were too sandy for use. All gradations occur, down to sandstone composed of detrital sand and fine chert fragments, originally occurring loose in the deposit, with just enough iron oxide for cement. According to a report of the former superintendent, W. H. Walker, the ore in this part of the deposit averaged 45 per cent of iron, and the yield was a ton of ore to 10 cubic yards of material.

The following analyses, made in January, 1911, have been supplied by the company.

Analyses of limonite from Shelby ore bank

	1	2	3	4	5	6
Iron (Fe)	51.02	54.19	51.09	54.46	48.70	48.99
Silica (SiO_2)	12.88	12.92	11.95	7.30	11.35	12.27
Alumina (Al_2O_3)	2.19	------	1.55	3.55	2.39	6.20
Phosphorus (P)	.22	.16	.09	.10	.12	------
Manganese (Mn)	.90	.88	.53	.45	.81	.60
Sulphur (S)	------	------	------	------	.026	.033

These analyses show a somewhat higher percentage of iron and less silica and phosphorus than the brown ores of the Woodstock district, Bibb County. The manganese is about the same.

The character of the pig iron is shown by the analyses given in the next column.

The iron contains enough manganese to give it toughness, and it was all used in car wheels, chilled rolls, and special castings.

Charcoal, obtained mostly from the surrounding country, was the fuel used. The average consumption was 106.21 bushels of charcoal to a ton of iron. The flux was obtained from the marble quarries near Sylacauga.

Analyses of pig iron from Shelby furnace

Grade of iron	Silicon	Sulphur	Phosphorus	Manganese
1	1.91	0.016	0.35	0.61
1	2.05	.018	.34	.85
2	1.28	.019	.34	.76
2	1.25	.017	.36	.61
3	.70	.021	.38	.47
3	.77	.022	.40	.46
4	.49	.018	.39	.56
4	.65	.021	.42	.58
5	.28	.022	.48	.45
5	.36	.022	.47	.52

Limonite west of Brierfield.—About 3 miles west of Brierfield is a deposit of brown ore from which ore was obtained for the Bibb furnace from the time of its establishment in 1862 until its abandonment about 1895. The furnace was half a mile east of the ore bank and was connected by railroad with the bank and with the Southern Railway at Brierfield. The old stack is still standing, but the railroad has been torn up. It is said that iron smelted at the Bibb furnace was manufactured into cannon at Selma for use by the Confederate army during the Civil War.

The old ore diggings are in the southern part of sec. 22 and the northern part of sec. 27, T. 24 N., R. 11 E. They extended over an area of about 10 acres and reached a depth estimated at 60 feet. The ore occurs in red or orange-colored sand or sandy clay, containing also many chert boulders and much smaller chert débris. The deposit is underlain by Ketona and Brierfield dolomites. At one point in the bottom of the ore pit is a projecting mass of dolomite, and not more than 200 feet distant on the same level is an exposure of variegated crumpled clay that seems clearly of Cretaceous age. Apparently in Cretaceous time clay was deposited in the hollows in the dolomite and subsequently covered by sand and clay, probably derived for the most part from the adjacent ridges, which also furnished the intermixed chert débris. In this heterogeneous mass of material the ore was segregated. According to report, no ore occurs in the variegated clay at the bottom.

The ore appears to be of the same types as in the Shelby bank, being in compact lumps near the top and of platy and concretionary character below. So far as could be judged from the walls of the old diggings, most of the ore occurs in the top 20 feet. The lump ore is aggregated in more or less distinct bands in the face of the workings, the bands being probably cross sections of lenticular aggregates of ore. As usual with ore of this class, it occurs in irregular pockets, and excavation might continue for several days without encountering much ore.

A large area in this locality is covered with Cretaceous or later deposits, apparently identical in character with that at the Bibb furnace banks and presumably carrying workable ore, evidences of which may be seen here and there on the surface. There are reports of ore in the region immediately southeast of the Bibb furnace in the area underlain by Copper Ridge dolomite, and some ore from this locality was supplied to the furnace by individuals who hauled it in wagons.

The ore from the Bibb bank is reported to have yielded about 40 per cent of iron. Analyses of the ore are given below.

Analyses of iron ore from Bibb furnace bank in secs. 22 and 27, T. 24 N., R. 11 E.[a]

	1	2	3	4
Ferric oxide (Fe_2O_3)	74.540	81.421	78.945	57.459
Silica (SiO_2)	7.442	1.133	3.043	34.423
Phosphoric acid (P_2O_5)	1.389	.863	2.3+	------
Oxide of manganese (MnO)	------	------	------	.278
Metallic iron (Fe)	52.19	57.00	55.27	40.22

[a] McCalley, Henry, Report on the valley regions of Alabama, pt. 2, p. 494, Alabama Geol. Survey, 1897.

1. An average sample of the ore of the banks in the SW. ¼ sec. 27, T. 24 N., R. 11 E.
2. A compact ore with a slight metallic appearance and with irregular velvety-looking seams. Locality, Mechanics bank. Collected by T. J. Peter, Brierfield.
3. Labeled "From hill opposite Bibb furnace." Collected by T. J. Peter.
4. A concretionary limonite with the cavities lined with a fibrous limonite and holding a well-bleached white siliceous or cherty rocky material, carrying over 97 per cent of silica.

West and northwest of the Bibb bank for 4 miles a number of other ore-bearing areas have long been known. They are described by E. A. Smith,[30] and his account is republished by McCalley.[31] One locality in the NW. ¼ sec. 13, T. 24 N., R. 10 E., was visited by the writer. Ore taken out of a number of test pits in Cretaceous material appeared to be of about the usual grade. Apparently there is much ore in this general region, but probably the deposits are not rich enough to compete with such deposits as those in the Woodstock district and in other localities in the State where brown ores are being mined.

The region here described has been fully explored for ore deposits, and nothing of importance has been discovered in addition to the occurrences at Shelby and near the Bibb furnace. It seems a safe conclusion that no other limonite deposits of economic importance occur in the region.

HEMATITE

Ore deposits of Columbiana Mountain.—Hematite ore of possible value occurs in the Weisner rocks of Columbiana Mountain east of Columbiana, in association with the quartzite beds to which the ridge owes its existence. Ore occurs at a number of points in both Columbiana Mountain and the ridge on the northeast partly inclosed by its sides, but the only bed that shows any promise of economic importance lies close above the quartzite given as Nos. 5 and 6 of the section on page 4 (middle column). The ore bed is known only north of the Mardis Ferry road. It has been thoroughly prospected for about 2 miles along its outcrop in secs. 7, 8, and 18, T. 21 S., R. 1 E. The ore consists of layers in shale, as shown in the following section:

Section of ore in pit on knoll half a mile northeast of Nelson, in the SE. ¼ NW. ¼ sec. 8, T. 21 S., R. 1 E.

	Feet
Shale, pale gray, fissile, soft	10
Ore, apparently of good grade	7
Ore, low grade	3
Sandstone	2
Shale, pale gray, fissile, soft	15
Sandstone?	

Another pit, 50 feet farther north, showed about 8 feet of ore. At these pits the beds are vertical and strike N. 50° E. On the crest of the ridge one-sixth of a mile southeast of Nelson station is a pit at which the following section was measured:

Section of ore in pit one-sixth of a mile southeast of Nelson station, in western part of sec. 8, T. 21 S., R. 1 E.

	Ft.	in.
Shale	12	
Shale, ferruginous, lean ore, worthless		8½
Ore, probably low grade and worthless		7
Shale, ferruginous		2
Ore(?), low grade, probably worthless		11
Shale, more or less ferruginous		8½
Ore, low grade, probably worthless		7
Ore, apparently fair grade		5
Shale, ferruginous	2	4
Ore, apparently high grade	3	6
Shale(?)	10	
Quartzite, conglomeratic.		

At this pit the strike is N. 20° E. and the dip 30° E. A little more than a mile southwest of this pit, in the NW. ¼ SE. ¼ sec. 18, T. 21 S., R. 1 E., the following measurement was obtained:

Section of ore bed at pit in the NW. ¼ SE. ¼ sec. 18, T. 21 S., R. 1 E.

	Ft.	in.
Shale.		
Ore, fair grade	1	
Shale, with ore streaks 2 inches or less thick	5	
Ore, fair grade (?)	2	6
Shale		10
Ore; bottom not certainly seen		2
Shale, ferruginous.		

The strike here is N. 10° E. and the dip 30° E. On the Mardis Ferry road, east of Columbiana, according to Smith,[32] this ore bed is made up of a number of thin layers of hematite separated by shale, and the ore is somewhat quartzose, as shown in the following section:

Section of ore bed on Mardis Ferry road 1¼ miles east of Columbiana

	Ft.	in.
Shale.		
Ore	2	
Shale (?)	4	6
Ore		6
Shale (?)		1
Ore		3

The dip at this point is 27° E. The extent of this bed south of the road is unknown. At Leeper's mill, on Beeswax Creek in sec. 21, T. 21 S., R. 1 E., where the exposure of the rocks is unbroken, it is not present. All the ore of the shale and quartzite formations in this region is hematite, whether in the better grades or in the ferruginous sandstones, some of which may rank as lean ore. They are all stratified deposits and in that respect resemble Clinton ore. The layers of the better ore of Columbiana Mountain are intersected by joints and bedding planes which divide the ore into smooth-faced rhombohedral pieces generally less than 6 inches in diameter. In the lean ores and ferruginous sandstones this manner of jointing is less conspicuous.

The areal extent of any of the ore beds is not known, but as their outcrops die out, as shown by the disappearance of their float or débris, it is a reasonable assumption that the beds die out underground also. In other words, the ore beds are lenticular deposits, probably of small extent.

The only facts bearing on the underground extent of the ores are reported by W. H. Walker, former superintendent of

[30] Smith, E. A., Report of progress for 1875, pp. 86-95, Montgomery, 1876.

[31] McCalley, Henry, Report on the valley regions of Alabama; Part 2, On the Coosa Valley region, pp. 488-495, Alabama Geol. Survey, 1897.

[32] Smith, P. S., op. cit., p. 174.

the Shelby iron works, who says that in a prospect pit driven in for about 30 feet the ore layers passed into shale. This might be due either to the replacement of shale by ore near the surface or to the accidental circumstance that the pit was near the margin of a lens of ore that feathered out at the depth reached. It was not stated whether the ore layers thinned out or passed into shale without thinning.

Microscopic examinations of thin sections of the ore show it to be composed of quartz grains, minute pebbles of the size of clover seed, fragments of feldspar, particles of a green mineral that may be chlorite, and probably other minerals, all cemented by red iron oxide. The sections examined do not show whether the iron oxide replaces other minerals originally present or whether it was of sedimentary origin like the inclosing slates. These slates are commonly calcareous, and the ore layers may have been originally highly calcareous and the calcareous matter may have been later replaced by the iron oxide.

No recent analyses of the ores from Columbiana Mountain are at hand. It is stated by Mr. Walker that analyses by the Shelby Iron Co. showed 42 to 43 per cent of metallic iron.

A furnace test on a carload of this ore was made at the Shelby iron works. According to Mr. Walker the ore was found to be very refractory, its fusion requiring a very high heat.

The ore of the Weisner formation is probably representative of the ores of the Talladega slate in the Talladega region. Other iron-bearing deposits, of no value so far as known, are described in the publications cited in footnotes 26 to 29.

MARBLE

About 3½ miles a little south of east from Calera, in the NW. ¼ NE. ¼ sec. 8, T. 24 N., R. 14 E., on property belonging to J. S. Evans, of Calera, the Sawyer limestone member of the Waxahatchee slate consists in part at least of marble. Below is a section showing the stratigraphic relations; the thicknesses are all approximate.

Section 3½ miles east-southeast of Calera

	Feet
Sandstone, highly ferruginous (lean ore?)	20
Shale; weathers yellowish green	20
Marble, thick bedded, fine grained, variegated	25
Sandstone (quartzite?) coarse, with quartz veins	50

The dip in this locality is 20°–60° E. The layers of the marble are 3 to 4 feet thick. They are cut by joints that divide them into blocks of considerable size, and it seems probable that under good cover even larger blocks would be found. The rock is very fine grained and takes a high polish. Parts of the layers are gray, and parts are variegated with deep red and pale pink, the whole stratum being perhaps half gray and half variegated. The rock is traversed by many white calcite veins, which contribute to the beauty that the red and pink rock has when polished.

There is another exposure of this marble about 1¼ miles northeast of the one just described, in the NE. ¼ NW. ¼ sec. 4, T. 24 N., R. 14 E., on land owned by J. W. Miller. For data concerning the marble at this place, the writer is indebted to E. A. Smith, who says: "It shows a thickness of some 20 feet or more of varying shades of pink, chocolate, and red colors alternating with white, sometimes in distinct bands, in some parts of rather uniform pink shade."

The Shady limestone contains layers of fine-grained rock that is a marble of good grade. A slightly yellowish mottled specimen took a fair polish, and a very uniformly bluish-gray specimen took a very high polish. The latter specimen contains fine cracks along which oxidation has taken place, and if that feature is prevalent it would impair the value of the rock as marble. The specimen was taken on the outcrop, however, and the rock under cover is probably less affected by this defect. The Shady limestone is thick bedded, and probably blocks of satisfactory size could be quarried from it. The formation crops out on valley flats along Beeswax Creek within the arms of Columbiana Mountain near water level and dips about 30° E.

LIMESTONE AND DOLOMITE

Limestone and dolomite of excellent quality for all purposes are present in these quadrangles in abundance.

Ketona dolomite.—The Ketona is economically important as the source of most of the flux rock used in the Birmingham blast furnaces. It is remarkably pure in the area lying along Shoal Creek between Montevallo and Maylene and extending northward. Six samples, representing a thickness of 200 feet, from the SW. ¼ NE. ¼ sec. 33, T. 21 S., R. 3 W., about half a mile a little south of east from Ryan station, were analyzed in the laboratory of the United States Geological Survey and were found to have the following average composition:

Analysis of dolomite from point half a mile east-southeast of Ryan station

Calcium carbonate ($CaCO_3$)	54.295
Magnesium carbonate ($MgCO_3$)	43.82
Insoluble matter	.64
	98.775

This dolomite underlies the low ground between the coal measures on the west and the chert ridge (Pine Ridge) east of Maylene. How much of this mass is of the grade shown by the analyses is unknown; there is at least 200 feet of pure rock in the section studied. In the vicinity of Montevallo there are other bands of dolomite of the Ketona type disconnected by faults. The outcrop of these bands is much narrower because they are thinner and the dip is steeper.

Newala limestone.—The Newala limestone is extensively exploited in Cahaba Valley for burning lime. The Newala, Saginaw, Longview, and Varnons quarries and lime works are in this area. The limestone has probably a thickness of 1,000 feet and extends the full length of Cahaba Valley in these quadrangles. The quantity of the rock is therefore practically inexhaustible. The beds dip eastward, generally 30° to 40°, and crop out on the level valley floor. This attitude necessitates open-pit quarrying, the hoisting of the rock, and continual pumping of water. Successful operations, therefore, demand a rather expensive equipment. Except for layers and thicker beds of dolomite here and there, called sandstone by the quarrymen (see analyses 4 and 6), the limestone is very pure. These beds of dolomite are an obstacle to quarrying where pure limestone is needed for chemical uses. The dolomite can not be cheaply separated, and a face of rock free from it of sufficient height for economical quarrying seems hard if not impossible to find. In the following tables are given analyses of the Newala limestone and of lime made from it. The Keystone quarry is in the Bessemer quadrangle; the other quarries are in the Montevallo quadrangle.

Analyses of Newala limestone

[R. S. Hodges, chemist, Alabama Geological Survey, analyst]

	1	2	3	4	5	6	7
Silica (SiO_2)	0.53	0.45	0.29	0.23	0.17	0.45	0.74
Alumina (Al_2O_3)	.11	.17	.19	.15	.11	.21	.36
Iron oxide (Fe_2O_3)	.21	.25			.06		.12
Calcium carbonate ($CaCO_3$)	96.13	96.10	98.56	77.66	99.13	57.64	97.77
Magnesium carbonate ($MgCO_3$)	3.00	3.05	.78	22.01	.23	41.50	.69
	99.98	100.2	99.94	100.05	99.70	99.93	99.69

1. Quarry of Keystone Lime Co., Keystone, Ala. Average sample.
2, 3, 4. Quarry of Longview Lime Co., Longview, Ala. 2, Average sample; 3, selected sample; and 4, coarse grained rock.
5, 6. Quarry of Newala Lime Works, Newala, Ala. 5, Close-grained rock; and 6, coarse-grained rock.
7. Quarry of Shelby Lime Works. Average sample.

Analyses of lime from Newala limestone

	1	2	3	4
Silica (SiO_2)	0.34	0.57	0.514	0.82
Alumina (Al_2O_3)	.12	.23	.05	.12
Ferric oxide (Fe_2O_3)	.10		.04	.26
Calcium oxide (CaO)	97.20	69.60	98.28	98.05
Magnesium oxide (MgO)	1.81	6.48	1.42	.62
Carbon dioxide (CO_2)	.11	.83		
Moisture	.30	22.45		
	99.98	100.16	99.93	99.87

1. From Keystone Lime Co.
2. Hydrated lime from Longview Lime Co.
3. From Newala Lime Co.
4. From Shelby Lime Co.

The samples for the general average analyses were taken by clipping from the face of the quarry pieces amounting in weight to about 40 pounds and representing from 200 to 300 feet in thickness of rock. As shown by analysis 5 the best grade of stone contains more than 99 per cent of calcium carbonate. The granular layers are highly magnesian. The most highly magnesian stone approaches closely the composition of dolomite, as shown by analysis 6, but the high content of calcium carbonate in the average samples indicates only a small proportion of the high-magnesium rock. For a series of analyses representing so great a thickness of rock along an outcrop of 10 miles or more, the content of insoluble impurities is very low.

Lime and cement.—The Newala limestone burns to lime of high grade, as shown by the analyses in the table above, and lime burning is an important industry between Siluria and Calera. The Lenoir limestone is utilized for cement manufacture at the cement mill at Leeds, Ala. Probably shale suitable for cement could be obtained from the Floyd, Parkwood, and Pottsville formations. The shale used at Leeds is obtained from the Floyd. The proximity to supplies of fuel is also favorable for the manufacture of cement.

CLAY AND SHALE

Residual clay from the limestone and dolomite formations of the region occurs in places as the subsoil and together with the topsoil affords material suitable for brick, as near Birmingham. Such material has been utilized at Ashby for refractory brick. At this place the material is derived from the Copper Ridge dolomite and apparently consists largely of the disintegrated chert that occurs in the formation, which has weathered down to a highly siliceous clay and includes a considerable proportion of chert fragments and boulders. There may be also an admixture of Cretaceous clay. Below is a section of the material that is used.

Section of clay at Ashby clay pit

	Feet
Earth, brown: apparently utilized	2
Clay, gray, sandy, much fine chert	3–5
Clay, iron stained, full of chert fragments	1
Clay, gray, with considerable fine chert	5
	11–13

Residual clay of this class has not been utilized elsewhere in this area, and definite knowledge as to the occurrence, extent, and depth of workable bodies has not been obtained. A stratum of such material seems to cover a large part of the limestone and dolomite areas of the Birmingham district, however, and bodies of sufficient size for exploitation probably could be found in these quadrangles, if the demand should warrant it.

The shales of the Pottsville formation, the Floyd shale, and the Waxahatchee, Brewer, and Wash Creek slates are probably suitable for shale brick and for tile, but they have not been thus utilized.

ROOFING SLATE

In the Waxahatchee slate are beds possibly suitable for roofing slates. The slate in these beds is a true mica slate, the mica being very fine. It has a cleavage parallel with the bedding. Texturally it seems suited for roofing slates, but so far as explored the jointing appears to be so close that blocks of the requisite size for splitting into slates can not be obtained. The close jointing can be seen in railroad cuts and in a test pit that has been opened about 1 mile south of Ocampo. (See pl. 4.) If roofing slates of satisfactory grade are present in this region in commercial quantities and under conditions for profitable quarrying they will be found in the belt of Waxahatchee slate that extends from Shelby Springs southwestward by Ocampo to the south boundary of the area.

ROAD METAL

In this region abundant road metal can be obtained from limestone and chert. The Fort Payne chert is extensively utilized for this purpose in the vicinity of Birmingham and Bessemer. It is so minutely fractured and jointed in the beds that when blasted most of it breaks down into fragments suitable for the road. It makes a very clean, smooth, compact, durable surface. Doubtless equally suitable material could be obtained from the formation along the ridge below Hardys and Siluria. The chert from the Copper Ridge and Chepultepec dolomites, great quantities of which can be obtained on the surface along the outcrop of those formations, is harder than the Fort Payne and would be somewhat expensive to crush. It probably would make a very durable top dressing if crushed fine enough and mixed with fine limestone screenings or earthy material to act as a bond. Here and there bodies of rather small chert fragments mixed with earth and clay, suitable for road metal without special preparation except the removal of the larger chunks, are present in the areas of the Copper Ridge and Chepultepec dolomites and the Longview and Newala limestones.

A probably rather small source of most excellent material is the residual earth full of fine quartz fragments from thin veins, which in places overlies the Floyd shale and the Waxahatchee, Brewer, and Wash Creek slates. Short pieces of natural road on such areas, which were as hard and smooth as a metaled roadway, were noted by the writer. An example is the half-mile stretch of road running north to Waxahatchee Creek in the E. ½ sec. 20, T. 23 S., R. 1 W., 3 miles west of Columbiana; and another is a short piece on the Montgomery road 3 miles south of Shelby, west of Mill Creek, near the boundary between secs. 20 and 21, T. 24 N., R. 15 E., half a mile north of Waxahatchee Creek. Accumulations of such material that would afford a large supply for local use can doubtless be found throughout the areas of Floyd shale and Waxahatchee, Brewer, and Wash Creek slates in these quadrangles.

SOILS

These quadrangles have a variety of soils. The shales and sandstones of the coal measures yield a soil ranging from a sandy to a clay loam, depending on whether sandstone or shale predominates in the underlying rocks, from the disintegration of which the soil is derived. These types of soil are blended and modified by admixture with each other as a result of the creep of the soil down the slopes. The soils are 8 to 10 inches thick and are underlain by about 3 feet of sandy clay subsoil. The soils and the subsoil contain a considerable percentage of fragments of rock, but as a rule the fragments are fine and are no obstacle to cultivation. The soils are moderately fertile.

The limestone and dolomite valleys have some of the best soil. The areas of Copper Ridge dolomite and those of the Fort Payne chert carry a stony loam which is comparatively unfertile on the hills and ridges but of good fertility in the valleys and low-lying flat lands among the hills, where it has accumulated by transportation from the higher ground. On the slopes and hilltops the soil is full of chert boulders, which are an impediment to cultivation, but on the lower grounds the chert fragments, though plentiful, are finer and less troublesome. The areas of Conasauga limestone have a reddish, yellowish, or black clay loam of good fertility. The same statements apply to the Newala and Lenoir limestone areas of Cahaba Valley.

The areas of Floyd shale and Waxahatchee, Brewer, and Wash Creek slates are likely to have a clay soil, not thick except in places, and of fairly good quality, especially over the more calcareous parts of the slates. This soil produces good crops of corn, cotton, and vegetables, and with intelligent treatment should hold its productivity well. The small species of *Lespedeza* (Japan clover) and native grasses thrive fairly well on this soil, and large areas that are now waste lands could profitably be utilized for stock raising.

The alluvium along the streams and in the coves is the best soil of the quadrangles, but it is of small extent.

WATER RESOURCES

Surface water.—The average annual precipitation in these quadrangles ranges from 48 inches in the southern part to 50 inches in the northern part. This precipitation is usually so uniformly distributed throughout the year that the surface water supply is ample for all needs, including potable water, water for stock, and water for industrial establishments requiring large quantities, as for making steam, washing coal, or smelting.

Ground water.—There are many springs in the limestone belts, and one, Bay Spring, 4 miles south of Shelby, has a flow sufficient to run a sawmill. This spring is probably the outlet of an underground stream. At Shelby Springs are a number of sulphur and chalybeate springs whose waters are supposed to have medicinal value, but no analyses of them are available. These are near the fault separating the Floyd shale and the Waxahatchee, Brewer, and Wash Creek slates. In general, however, outside the limestone areas springs are neither many nor large. Where good surface water is not available sufficient supplies of water can be had by sinking wells to a depth of 50 feet at most places in the Pottsville and the Waxahatchee, Brewer, and Wash Creek areas and not more than 100 feet in the areas of Cretaceous sand or gravel. The range in quality and composition of this water is shown in the accompanying table of analyses. The water from the limestone areas is hard, as shown by samples 42 to 44. The water from the Cretaceous, being from sand and gravel, is remarkably free from lime and consequently of very low hardness.

Little is known regarding the deep waters of these quadrangles. The Shades and Pine sandstones seem to be good water-bearing strata, and flowing wells might be obtained by drilling to them in the Belle Ellen syncline and possibly also in the Yellow Leaf syncline. Elsewhere the structural conditions do not appear to be favorable for artesian wells.

Water power.—No regular gaging stations have been maintained on streams in the Montevallo and Columbiana quadrangles, and no miscellaneous discharge measurements have been made.

Cahaba River and the larger creeks are capable of developing considerable power for gristmills, sawmills, small electric plants, and other industrial works. Cahaba River near Blocton, several miles west of this region, is capable of developing, with a 34-foot dam and an 80 per cent turbine, 500 net horsepower at ordinary low water. In these quadrangles the flow of the Cahaba is smaller, but the potential power is still considerable. Coosa River is the largest stream traversing any part of the quadrangles, and its power is developed by the Alabama Power Co. with a dam and power plant about 12 miles south of the Columbiana quadrangle, the slack water extending into the quadrangle.

Within these quadrangles minor power could be utilized on Shoal, Mahan, Buxahatchee, Waxahatchee, and other creeks and on Cahaba and Little Cahaba Rivers. On Mahan Creek near Brierfield 35 horsepower has been developed at one mill and 40 horsepower at another. The flow from Bay Spring, about 3½ miles south of Shelby, on the fault line between the Newala limestone and the Waxahatchee, Brewer, and Wash Creek slates, is sufficient to supply power for a gristmill and sawmill near the mouth of Mill Creek.

August, 1924.

Approximate analyses of waters of the Montevallo and Columbiana quadrangles, Ala.

[In parts per million. R. S. Hodges, chemist, Alabama Geological Survey, analyst]

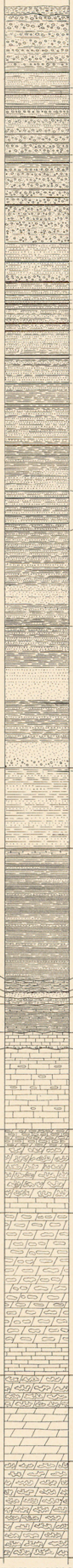
No.	Description of sample	Date of collection	Formation	Total hardness	Alkalinity	Sodium and potassium	Magnesium	Calcium	Iron	Chlorine	Sulphate radicle	Bicarbonate radicle	Total
33	Well of J. B. Cook, 2 miles southwest of Calera, depth 45 feet	May 27, 1912	Cretaceous	34	21	1	1	11	Trace.	11	Trace.	25	49
34	Well of Theodore Sneas, 3 miles southwest of Calera, depth 30 or 40 feet	May 27, 1912	do	6	6	5	Trace.	2	Trace.	7	1	7	22
35	Well of D. W. Killingsworth, 6 miles southeast of Montevallo, depth 33 feet	May 27, 1912	do	40	71	22	Trace.	16	0 5	3	12	86	139. 5
36	Well of Jesse Shaw, 6 miles southeast of Montevallo and 1¼ miles southwest of Killingsworth's, depth 35 feet	May 27, 1912	do	5	4	2	Trace.	1. 5	. 5	2. 5	2	5	13. 5
37	Well of Olive Watson, on Maplesville road about 9 miles southwest of Calera	May 27, 1912	do	2	2	2. 5	Trace.	1	. 5	2. 5	2	2. 5	11
38	Well of J. A. Lowry, on Maplesville road 7 or 8 miles southwest of Calera	May 27, 1912	do	5	2	5	Trace.	1	. 5	8	3	2. 5	20
39	Spring 2 miles southwest of Shelby Springs	May 28, 1912	do	50	54	9	3	15	. 5	4	11	66	108. 5
40	Dean Farm Spring	May 28, 1912	Waxahatchee, Brewer, or Wash Creek.	128	128	6	6	41	Trace.	2. 5	10	156	221. 5
41	Spring in highway 1 mile northeast of Calera	May 28, 1912	Fort Payne chert.	66	66	4	2	23	Trace.	3	4	80	116
42	Public well at Calera near livery stable, depth 20 to 25 feet	May 28, 1912	Newala limestone.	222	174	10	16	61	. 5	21. 5	38	212	359
43	Calera Waterworks well, depth 30 feet	May 28, 1912	do	276	189	6	14	86	Trace.	33. 5	52	230	421. 5
44	J. Holcomb, at Calera, depth 20 to 25 feet	May 28, 1912	do	234	135	3	25	52	Trace.	41	44	164	329

Ordovician and Cambrian formations of central Alabama, showing different usages and equivalents

System and series	Alabama: Montevallo-Columbiana folio	Alabama: Bessemer-Vandiver folio: Cahaba Valley	Alabama: Bessemer-Vandiver folio: Birmingham Valley	Alabama: Birmingham folio: Birmingham Valley	Alabama: Birmingham folio: Cahaba Valley	Alabama: Alabama Geological Survey reports	Tennessee (U. S. Geological Survey reports): Central basin	Tennessee: Valley and Ridge province: Western areas	Tennessee: Valley and Ridge province: Eastern areas: Knoxville folio	Tennessee: Valley and Ridge province: Eastern areas: Morristown folio	New York (New York State Survey reports)
Ordovician. Middle Ordovician.			Chickamauga limestone. Basal Trenton represented.	Chickamauga ("Pelham") limestone. [Represented.]		Pelham limestone.	Trenton fully represented.	Chickamauga limestone. [Represented]	[Absent.]	[Sevier shale northwest of Clinch Mountain=Martinsburg shale. Lower part=Trenton.]	Trenton limestone.
	Absent.	Absent.	Represented.	[Represented.]	[Absent.]		[Not represented.]	[Represented?]		[Represented?]	Black River group. Amsterdam limestone. Watertown limestone.
			Represented.	[Represented.]			Carters limestone.	[Represented.]	Bays sandstone.	Moccasin limestone. Northwest of Clinch Mountain. Bays sandstone [typical]. Southeast of Clinch Mountain.	Leray limestone. Lowville limestone.
Lower Ordovician.	? Little Oak limestone.	Little Oak limestone.	Not represented.	[Not represented.]	Chickamauga ("Pelham") limestone.		[Not represented.]	[Probably not represented.]	Sevier shale [typical: Ottosee shale of Ulrich].	Sevier shale southeast of Clinch Mountain.	Chazy group.
	Tellico sandstone not represented.	Not represented.							Tellico sandstone.	[Not represented.]	
	Athens shale.	Athens shale.							Athens shale.	Athens shale.	Normanskill shale and Valcour limestone.
	Absent.	Absent.							Holston marble member of Chickamauga limestone.	Chickamauga limestone northwest of Clinch Mountain.	
	Absent.	Absent.					Stones River group. Lebanon limestone.		Chickamauga limestone.	Chickamauga limestone southeast of Clinch Mountain.	Pamelia limestone.
	Lenoir limestone.	Lenoir limestone.	Stones River group represented. Attalla chert conglomerate member at base.	[Stones River group represented] Attalla conglomerate member at base.			Ridley limestone. Pierce limestone.	[Stones River limestone represented.]			Crown Point limestone.
	Absent.	Absent.					Murfreesboro limestone. Bottom not exposed.			?	Day Point limestone.
	Mosheim limestone.	Mosheim limestone.	Absent.	[Absent.]			No lower rocks cropping out or exposed.				
	Odenville limestone.	Odenville limestone.									
	Newala limestone.	Newala limestone.			?	?					Beekmantown limestone.
	Longview limestone.	Longview limestone.	Absent.	[Absent.]				Knox dolomite.	Knox dolomite.	Knox dolomite.	
Cambrian or Ordovician (Ozarkian system of Ulrich).	Chepultepec dolomite	Chepultepec dolomite.	Absent.	Knox dolomite. [Absent except in Murphrees Valley.]	Knox dolomite. [Chepultepec dolomite present.]	Knox dolomite.					Chert bed at top of Little Falls dolomite.
	Copper Ridge dolomite.	Copper Ridge dolomite.	Copper Ridge dolomite.	[Copper Ridge dolomite present.]	[Copper Ridge dolomite present.]						
	Bibb dolomite.	Bibb dolomite.	Absent.	[Absent.]	[Absent.]					?	
	Ketona dolomite.	Ketona dolomite.	Ketona dolomite.	Ketona dolomite member.	Ketona dolomite member.			[Absent.]	[Absent.]	[Absent.]	
	Brierfield dolomite.	Brierfield dolomite.	Absent.	[Absent]	[Absent.]						Hoyt limestone. Theresa dolomite. Potsdam sandstone.
Cambrian. Upper Cambrian.	Conasauga ("Coosa") limestone.	Absent.	Conasauga ("Coosa") limestone.	Conasauga ("Coosa") limestone.	[Absent.]	Coosa (Flatwoods) shale.		Conasauga shale.	Nolichucky shale. Maryville limestone. Rogersville shale. Rutledge limestone.	Nolichucky shale. Maryville limestone. Rogersville shale. Rutledge limestone.	
Middle Cambrian.	Rome ("Montevallo") formation.	Rome ("Montevallo") formation.	Horizon not exposed.	[Horizon not exposed]	Rome ("Montevallo") formation.	Montevallo variegated shales and sandstones.		Rome formation.	Rome formation.	Rome formation.	
Lower Cambrian.	Absent (?); may be represented in Rome formation.	[No lower rocks cropping out or exposed.]				[Absent.]		Not exposed.	Beaver limestone. Apison shale.	[Not exposed.]	Lower Cambrian slates, quartzites, and limestones with Poughquag quartzite at base.
	Shady limestone.					Aldrich limestone.			[Not represented.]		
	Weisner quartzite.					Weisner sandstone and shale.			Hesse sandstone [or quartzite]. Murray shale. Nebo sandstone. Nichols shale. Cochran conglomerate.		

GENERALIZED COLUMNAR SECTION OF THE SEDIMENTARY ROCKS OF THE MONTEVALLO AND COLUMBIANA QUADRANGLES

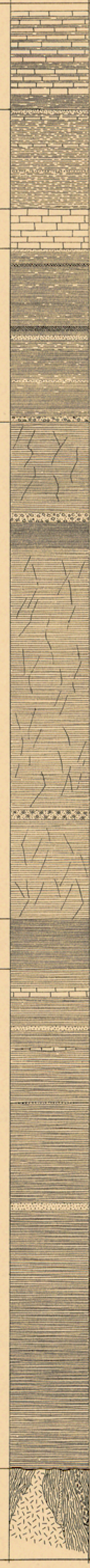
SCALE: 1 INCH=1,000 FEET

System	Series	Formation	Symbol	Section	Thickness in Feet	Minor Divisions	Character of Rocks and Topography
CARBONIFEROUS	PENNSYLVANIAN	Pottsville formation.	Cpv		9180	Upper Maylena coal. Lower Maylena coal. Upper Dogwood coal. Lower Dogwood coal. Montevallo coal. Yeshic coal. Helena coal. Straven conglomerate member. Thompson coal. Smithshop coal. Quarry coal. Gholson ? coal. Clark ? coal. Moyer coal. Youngblood coal. Buck coal. Pump coal. Aiken coal. Wadsworth coals. Harkness (Big Bone) coal. Nunnally coal group. Chestnut sandstone member. Gould coal. Pine sandstone member. Shades sandstone member. Brock coal.	Shale, sandstone, conglomerate, and coal beds. Sandstone, siliceous and feldspathic (arkosic), thick-bedded, and flaggy. The Shades, Pine, and Chestnut sandstone members, which are hard ridge makers, compose the "Millstone Grit" of Alabama. The shale is generally of clayey composition and of dark color, but some is siliceous. This formation contains nearly all the coals of Alabama, except the lignite of the southern part of the State.
	?	Parkwood formation.	Cpw		1000±		Shale and sandstone, predominantly gray, much like the Pottsville formation but without coal. Carries a sparse Mississippian fauna in the lower part and a sparse fauna of Pennsylvanian aspect in the upper part. Generally unfossiliferous.
	MISSISSIPPIAN	Floyd shale.	Cf		1200–2000±		Mainly dark to black clay-shale including thin layers of argillaceous limestone and a considerable proportion of fine-grained greenish sandstone, apparently in lenticular layers of no great extent. Some gray and finely conglomeratic sandstone.
		UNCONFORMITY					
		Fort Payne chert.	Cfp		150±		Gray thick and thin-bedded fossiliferous chert.
		UNCONFORMITY					
DEV.	L. D.	Frog Mountain sandstone.	Dfm		0–100		Rusty and dark sandstone.
ORDOVICIAN	LOWER ORDOVICIAN	Little Oak limestone.	Olo		0–100		Thick-bedded dark partly cherty, fossiliferous limestone.
		UNCONFORMITY					
		Athens shale.	Os		200–500		Black fissile graptolitic shale with layers of black argillaceous limestone.
		UNCONFORMITY					
		Lenoir and Mosheim (?) limestones.	Ol		0–400		Thick-bedded dark medium-grained limestone with clay veins that make a residual network on the weathered surface. Mosheim limestone is compact, dove-colored, pure, and fossiliferous.
		UNCONFORMITY					
		Newala and Odenville limestones.	On		800–1200		Thick-bedded, compact, light bluish-gray limestone with layers of dolomite and magnesian limestone. Yields very little or no chert. Sparingly fossiliferous. Extensively burned for lime. Odenville limestone, at top argillaceous and fossiliferous.
		Longview limestone.	Olv		0–400		Thick-bedded, partly magnesian limestone yielding much rather brittle chert which commonly contains fossils, especially gastropods of the characteristic genus *Lecanospira*.
CAMBRIAN OR ORDOVICIAN		Chepultepec dolomite.	€Oc		600–1000±		Medium thick-bedded, rather coarse-grained dark bluish-gray dolomite which yields cavernous fossiliferous chert. Locally a considerable thickness of thick-bedded light bluish-gray compact limestone in basal part.
		Copper Ridge dolomite.	€Ocr		2000±		Thick-bedded, mainly dark bluish-gray dolomite; some light-gray fine-grained dolomite. Yields many large masses of dense jagged chert, much more than any other formation in Alabama. Chert very sparingly fossiliferous.
		Bibb dolomite.	€Ob		275–500		Thick-bedded bluish-gray finely crystalline dolomite, highly siliceous, with silica incrustations or network of silica ridges on weathered surfaces of cavernous layers.
		Ketona dolomite.	€Ok		275–1000		Thick-bedded dark-gray dolomite, which is an almost pure carbonate rock of dolomite composition. To a large extent contains not over 2 percent of insoluble matter. Extensively used in blast furnaces.
		Brierfield dolomite.	€Obf		1250±		Thick-bedded bluish-gray finely crystalline dolomite, highly siliceous, with silica incrustations or network of silica ridges on weathered surfaces of cavernous layers.

SECTION CONTINUED ON BACK OF THIS SHEET

COLUMNAR SECTION—Continued

SCALE: 1 INCH=1,000 FEET



System	Series	Formation	Symbol	Section	Thickness in Feet	Minor Divisions	Character of Rocks and Topography
CAMBRIAN	MIDDLE CAMBRIAN	Conasauga ("Coosa") limestone.	€c		0-1500		Mainly thin-bedded limestone with intercalated shale which aggregates a considerable proportion of the whole. Limestone is somewhat impure with argillaceous and siliceous matter and also somewhat magnesian. Makes low, flat, poorly drained land, called "flatwoods."
	? LOWER CAMBRIAN	Rome ("Montevallo") formation.	€r		1000±		Red shale, fine-grained calcareous sandstone weathering rusty, and a small amount of limestone, some layers of which appear to be fairly pure. Generally makes rough land of low hills. Sparingly fossiliferous.
		Shady dolomite.	€s		400±		Thick-bedded light-gray to white coarse-grained limestone. Makes valley.
		Weisner formation.	€w		1700-1800	Hematite ore. Hematite ore (good grade).	Clay and siliceous slate or sericitic schist with finely conglomeratic quartzite lentils 3 to 125 feet thick. Hematite lenses. Makes the high ridges of the Columbiana Mountain region.
PRE-CAMBRIAN OR PALEOZOIC	TALLADEGA SLATE OF ALABAMA REPORTS	Wash Creek slate.	wc		5000±	Massive sandstone. Black slate. Ferruginous sandstone member, containing lean ore.	Sericitic phyllite, greenish and grayish when weathered. Some crumpled quartz veins that contain a little gold present in places. Sandy in lower part. Occasional small lentil of conglomeratic sandstone or quartzite. In upper part, heavy bed of conglomeratic sandstone, with black slate or schist beneath. Low rounded hills and ridges.
		Brewer phyllite.	bw		500±		Sericitic phyllite, predominantly purplish gray, some of it having green silty luster. Locally ferruginous at bottom (lean ore). Easily recognizable and important as key to structure and stratigraphy of Talladega slate.
		Waxahatchee slate.	wx		5000±	Sawyer limestone member (50-200 feet). Sandstone (50-100 feet). Limestone (10-20 feet). Sandstone (100± feet).	Variegated fine-grained limestone or ornamental marble; dark and light-gray rather coarse limestone; sandy and pebbly limestone, locally ferruginous and making a lean ore. Dark bluish shale and schist weathering pink, yellow, and gray. Conglomeratic sandstone in quartzite lentils. Limestone beds in the upper part. Low rounded hills and ridges.
PRE-CAMBRIAN		Crystalline schists, gneisses, and granite.					

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

TOPOGRAPHY

ALABAMA
MONTEVALLO QUADRANGLE

EXPLANATION

RELIEF (printed in brown)

Altitude (above mean sea level instrumentally determined)

Contours (showing height above sea, horizontal form, and steepness of slope of the surface)

Depression contours

DRAINAGE (printed in blue)

Streams

Intermittent streams

Pond

Marsh

CULTURE (printed in black)

Roads and buildings

Church or schoolhouse and cemetery

Private or poor roads

Trails

Railroad

Bridge

U. S. township and section lines

County line

City, village, or borough line

Triangulation or primary traverse monument

Bench mark giving precise altitude

R.B. Marshall, Chief Geographer.
Frank Sutton, Geographer in charge.
Topography by R.W. Berry.
Control by C.B. Kendall, E.A. Stearns, A.D. Cameron, and A.K. Gilman.
Surveyed in 1907-1908.

Scale 1/62500

Contour interval 50 feet.
Datum is mean sea level.

1940

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

TOPOGRAPHY

ALABAMA
COLUMBIANA QUADRANGLE

EXPLANATION

RELIEF
(printed in brown)

Altitude
(above mean sea level instrumentally determined)

Contours
(showing height above sea, horizontal form, and steepness of slope of the surface)

Stream wash

DRAINAGE
(printed in blue)

Streams

Intermittent streams

Lake or pond

CULTURE
(printed in black)

Roads and buildings

Church or schoolhouse and cemetery

Private or poor roads

Railroad

U. S. township and section lines

County line

City, village, or borough line

Bench mark giving precise altitude

R.B. Marshall, Chief Geographer.
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Topography by W.J. Lloyd and F.E. Hale.
Control by Coast and Geodetic Survey,
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Surveyed in 1909.

TRUE NORTH
MAGNETIC NORTH
APPROXIMATE MEAN DECLINATION 1940

Scale $\frac{1}{62500}$

1 ½ 0 1 2 3 4 Miles

1 ½ 0 1 2 3 4 5 Kilometers

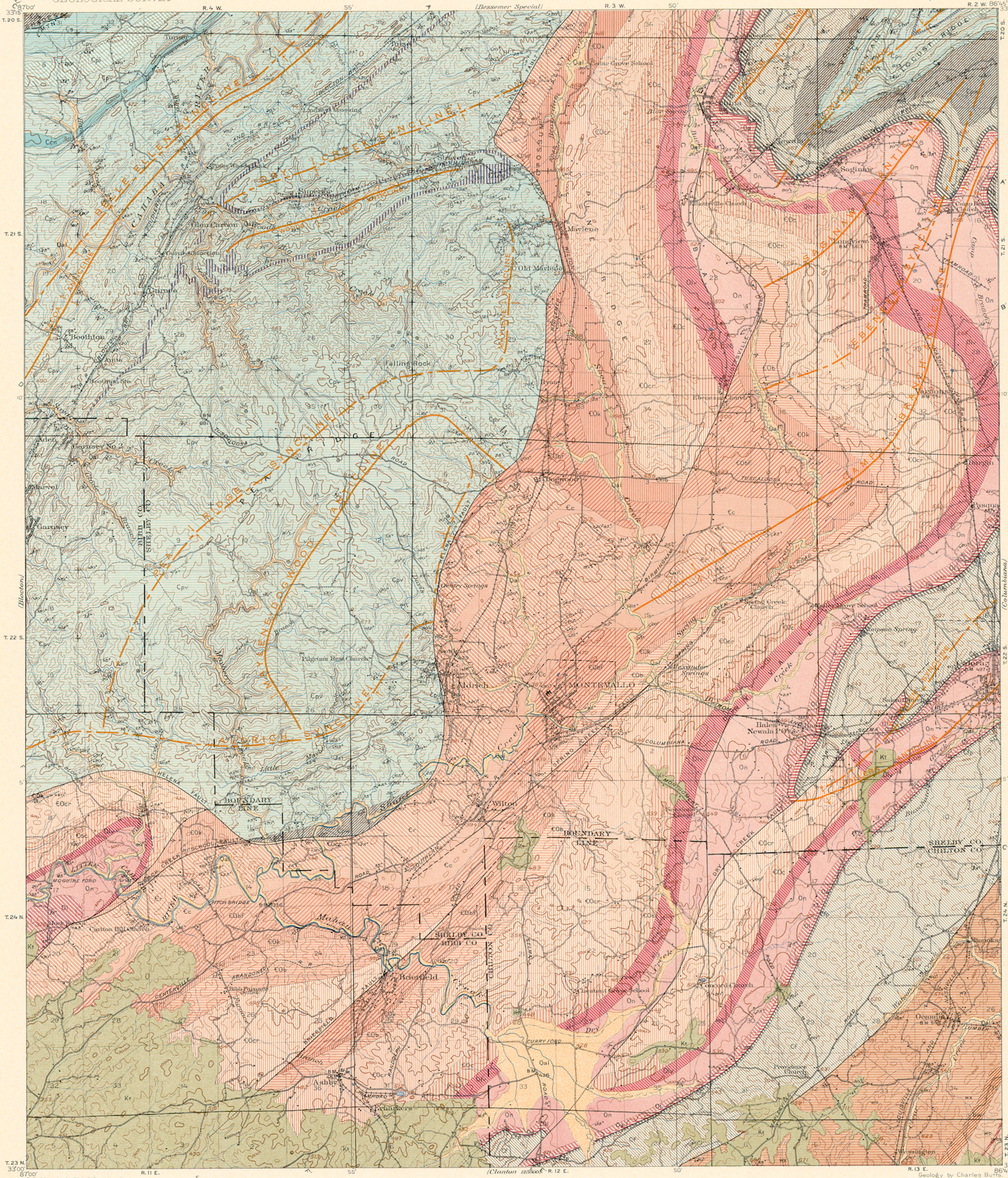
Contour interval 50 feet.
Datum is mean sea level.

1940

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

AREAL GEOLOGY

ALABAMA
MONTEVALLO QUADRANGLE



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TRUE NORTH
MAGNETIC NORTH
APPROXIMATE MEAN DECLINATION 1908.

Scale $\frac{1}{62500}$

1 ½ 0 1 2 3 4 Miles

1 ½ 0 1 2 3 4 5 Kilometers

Contour interval 50 feet.
Datum is mean sea level.
Edition of October 1940

Geology by Charles Butts.
Surveyed in 1908-1910.

EXPLANATION

SEDIMENTARY ROCKS

(Subaqueous deposits are shown by patterns of parallel lines; subaerial deposits by patterns of dots and circles)

QUATERNARY — *Recent*

Qal — **Alluvium**
(flood-plain deposits of present streams)

CRETACEOUS — *Upper Cretaceous*

Kt — **Tuscaloosa formation**
(varicolored sand, clay, and gravel)

UNCONFORMITY

CARBONIFEROUS — *Pennsylvanian*

Cahaba field / *Coosa field*: Cpv, Ccn, Cpi, Cs; Csr, Cpv, Csn, Csl, Cs

Pottsville formation
(sandstone, conglomerate, shale, and coal beds; sandstone members—Shades, Cs, Pine, Cpi, Chestnut, Ccn, Wolf Ridge, Cwr, and Straight Ridge, Csr; Straven conglomerate member, Csn)

CARBONIFEROUS — *Mississippian*

Cpw — **Parkwood formation**
(gray shale and sandstone)

Cf — **Floyd shale**
(black or gray shale, some gray granular and impure shaly limestone, and much fine-grained gray and green sandstone)

UNCONFORMITY

Cfp — **Fort Payne chert**
(chert and limestone)

UNCONFORMITY

DEVONIAN AND POSSIBLY CARBONIFEROUS — *Middle to Upper Devonian and possibly Mississippian*

DCc — **Chattanooga shale and Frog Mountain sandstone**
(Chattanooga shale, black shale of Upper Devonian or Mississippian age, unconformable on Frog Mountain sandstone, soft gray sandstone of Onondaga (Middle Devonian) age)

UNCONFORMITY

ORDOVICIAN — *Lower Ordovician*

Olo — **Little Oak limestone**
(thick-bedded argillaceous cherty limestone, with irregular nodular chert layers; weathers to earthy network; late Chazy age)

UNCONFORMITY

Oa — **Athens shale**
(dark to black calcareous shale with thin limestone layers; late Chazy age)

UNCONFORMITY

Ol — **Lenoir limestone**
(dark-gray crystalline limestone with a little chert locally; Chazy age; conglomerate locally at bottom; in Cahaba Valley only, where underlying Mosheim limestone is possibly also present)

UNCONFORMITY

On — **Odenville and Newala limestones**
(thick-bedded gray limestone and some dolomite; very pure in upper part; Beekmantown age; absent in Birmingham Valley; Newala burned for lime)

Olv — **Longview limestone**
(cherty limestone and dolomite; some layers with fairly abundant quartz grains; Beekmantown fauna)

UNCONFORMITY

CAMBRIAN OR ORDOVICIAN *

€Oc — **Chepultepec dolomite**
(dolomite with mealy, cavernous, fossiliferous chert)

€Ocr — **Copper Ridge dolomite**
(gray crystalline dolomite with much very dense, tough, angular chert at base; pure limestone may represent pre-Copper Ridge rocks in Tennessee)

€Ob — **Bibb dolomite**
(thick-bedded blue fine-grained highly siliceous dolomite, weathering to cavernous boulders)

€Ok — **Ketona dolomite**
(thick-bedded light-gray coarse-grained dolomite of great purity; extensively used for flux)

€Obf — **Brierfield dolomite**
(thick-bedded siliceous dolomite)

CAMBRIAN — *Middle Cambrian*

€c — **Conasauga ("Coosa") limestone**
(medium thick-bedded dark fine-grained limestone, some dolomite, and yellowish-green shale)

CAMBRIAN — *Lower Cambrian*

€r — **Rome ("Montevallo") formation**
(purple, red, greenish, and grayish shale, calcareous gray sandstone, and a little limestone)

RELATION UNDETERMINED

PRE-CAMBRIAN OR PALEOZOIC — *Equivalent to lower part of Talladega slate of Alabama reports*

wc, wcs — **Wash Creek slate**
(sericitic slate, weathering green and gray, and black slate; conglomeratic in upper part; contains quartz veins, probably gold bearing; ferruginous sandstone member, wcs, in lower part)

bw — **Brewer phyllite**
(purplish-gray sericitic schist with silky luster and some green schist)

wx — **Waxahatchee slate**
(bluish sericitic slate, weathering pink, yellowish, and gray)

Known fault

Probable fault

Concealed fault
(covered by younger deposits)

T. *Overthrust side of thrust fault*

Strike and dip of stratified rocks

Strike of vertical beds

Horizontal beds

Axis of anticline

Axis of syncline

* Ozarkian of E. O. Ulrich

UNITED STATES
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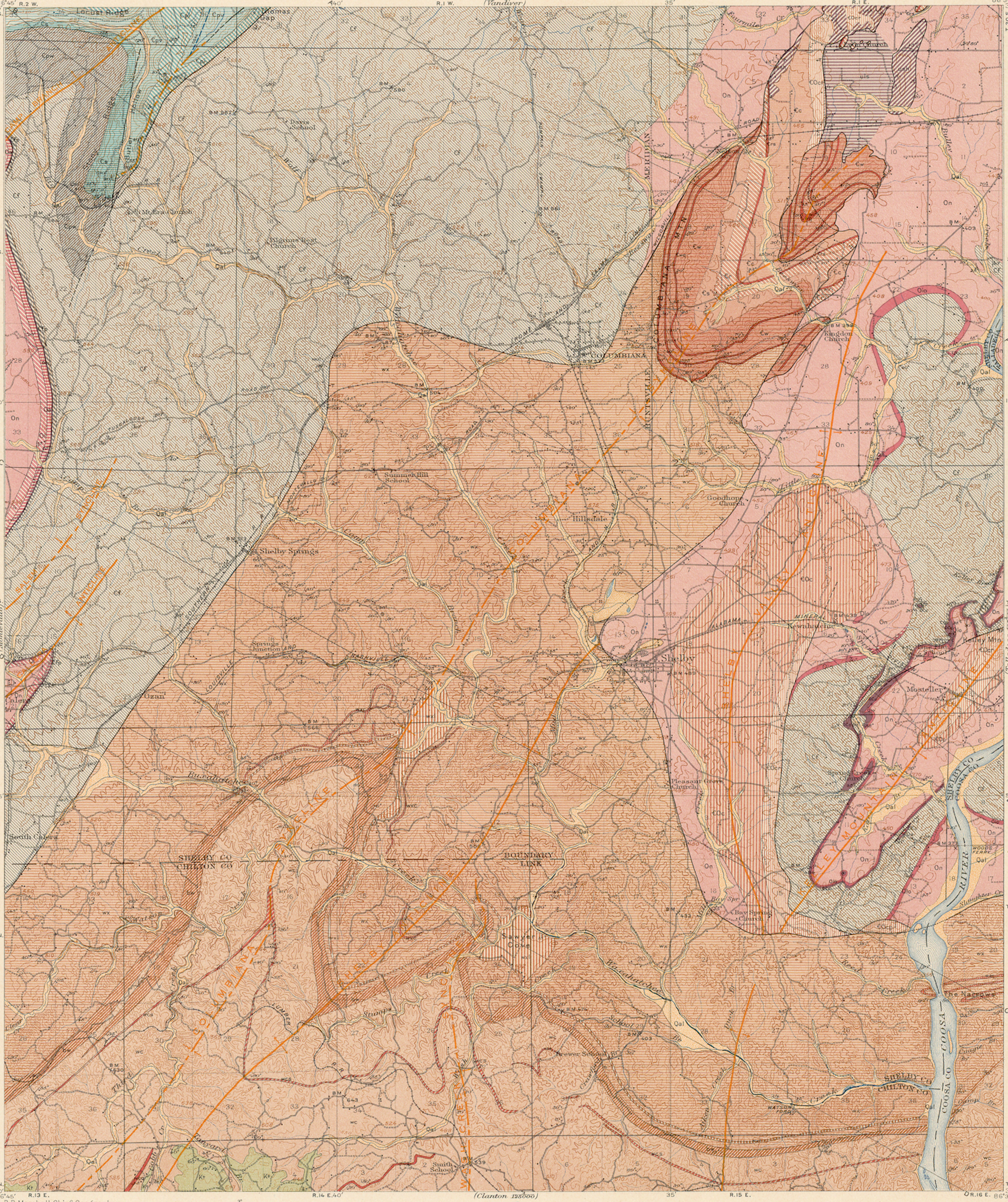
GEOLOGICAL SURVEY

AREAL GEOLOGY

ALABAMA
COLUMBIANA QUADRANGLE



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Contour interval 50 feet.
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(flood-plain deposits of present streams)

CRETACEOUS — Upper Cretaceous

Kt — Tuscaloosa formation
(varicolored sand, clay, and gravel)
UNCONFORMITY

CARBONIFEROUS — Pennsylvanian

Cpv, Cpi, Cs — Pottsville formation
(sandstone, conglomerate, shale, and a coal bed; sandstone members, Shades, Cs, Pine, Cpi)

CARBONIFEROUS — Mississippian

Cpw — Parkwood formation
(gray shale and sandstone)

Cf — Floyd shale
(black or gray shale, some gray granular and impure shaly limestone, and much fine-grained gray and green sandstone)
UNCONFORMITY

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(Chattanooga shale, black shale of Upper Devonian or Mississippian age, unconformable on Frog Mountain sandstone, soft gray sandstone of Onondaga (Middle Devonian) age)
UNCONFORMITY

ORDOVICIAN — Lower Ordovician

Olo — Little Oak limestone
(thick-bedded argillaceous cherty limestone, with irregular nodular chert layers; weathers to earthy network; late Chazy age)
UNCONFORMITY

Oa — Athens shale
(dark to black calcareous shale with thin limestone layers; late Chazy age)
UNCONFORMITY

Ol — Lenoir limestone
(dark-gray crystalline limestone with a little chert locally; Chazy age; conglomerate locally at bottom; in Cahaba Valley only, where underlying Mosheim limestone is possibly also present)
UNCONFORMITY

On — Odenville and Newala limestones
(thick-bedded gray limestone and some dolomite; very pure in upper part; of Beekmantown age)
UNCONFORMITY

CAMBRIAN OR ORDOVICIAN *

€Oc — Chepultepec dolomite
(dolomite with mealy, cavernous, fossiliferous chert)

€Ocr — Copper Ridge dolomite
(gray crystalline dolomite with much very dense, tough, angular chert at base; pure limestone may represent pre-Copper Ridge rocks in Tennessee)

CAMBRIAN — Middle Cambrian

€c — Conasauga ("Coosa") limestone
(medium thick-bedded dark fine-grained limestone, some dolomite, and yellowish-green shale)

CAMBRIAN — Lower Cambrian

€rs, €r — Rome ("Montevallo") formation
(purple, red, green, and grayish shale, calcareous gray sandstone, and a little limestone; yellowish to purplish sandstone lentil, €rs, at top)

€s — Shady limestone
(thick-bedded coarse and fine grained light-gray limestone)

€wq, €w — Weisner formation
(dark-gray or greenish shale or slate; quartzitic lenses, €wq, more or less conglomeratic, and beds of siliceous pebbly iron ore)
RELATION UNDETERMINED

PRE-CAMBRIAN OR PALEOZOIC — Equivalent to lower part of Talladega slate of Alabama reports

wcq, wc, wcs — Wash Creek slate
(sericitic slate, weathering green and gray, and black slate, conglomeratic in upper part; contains quartz veins, probably gold bearing; ferruginous sandstone member, wcs, in lower part; heavy conglomeratic sandstone member, wcq, in upper part)

bw — Brewer phyllite
(purplish-gray sericitic schist with silky luster and some green schist)

wxl, wxc, wx — Waxahatchee slate
(bluish sericitic slate, weathering pink, yellowish, and gray; Sawyer limestone member, wxl, and conglomeratic sandstone member, wxc, in upper part)

uls — Limestone of unknown age
(in northeast corner of quadrangle; yields deep-red soil; may be of Ordovician or Cambrian age)

ush — Shale of unknown age
(yellowish-green shale in northeast corner of quadrangle; may be of Talladega, Weisner, or Conasauga age)

Known fault

Probable fault

Concealed fault
(covered by younger deposits)

Klippe
(erosion remnant of overthrust mass)

Overthrust side of thrust fault

Direction of thrust in overthrust mass

Strike and dip of stratified rocks

Strike of vertical beds

Horizontal beds

Axis of anticline

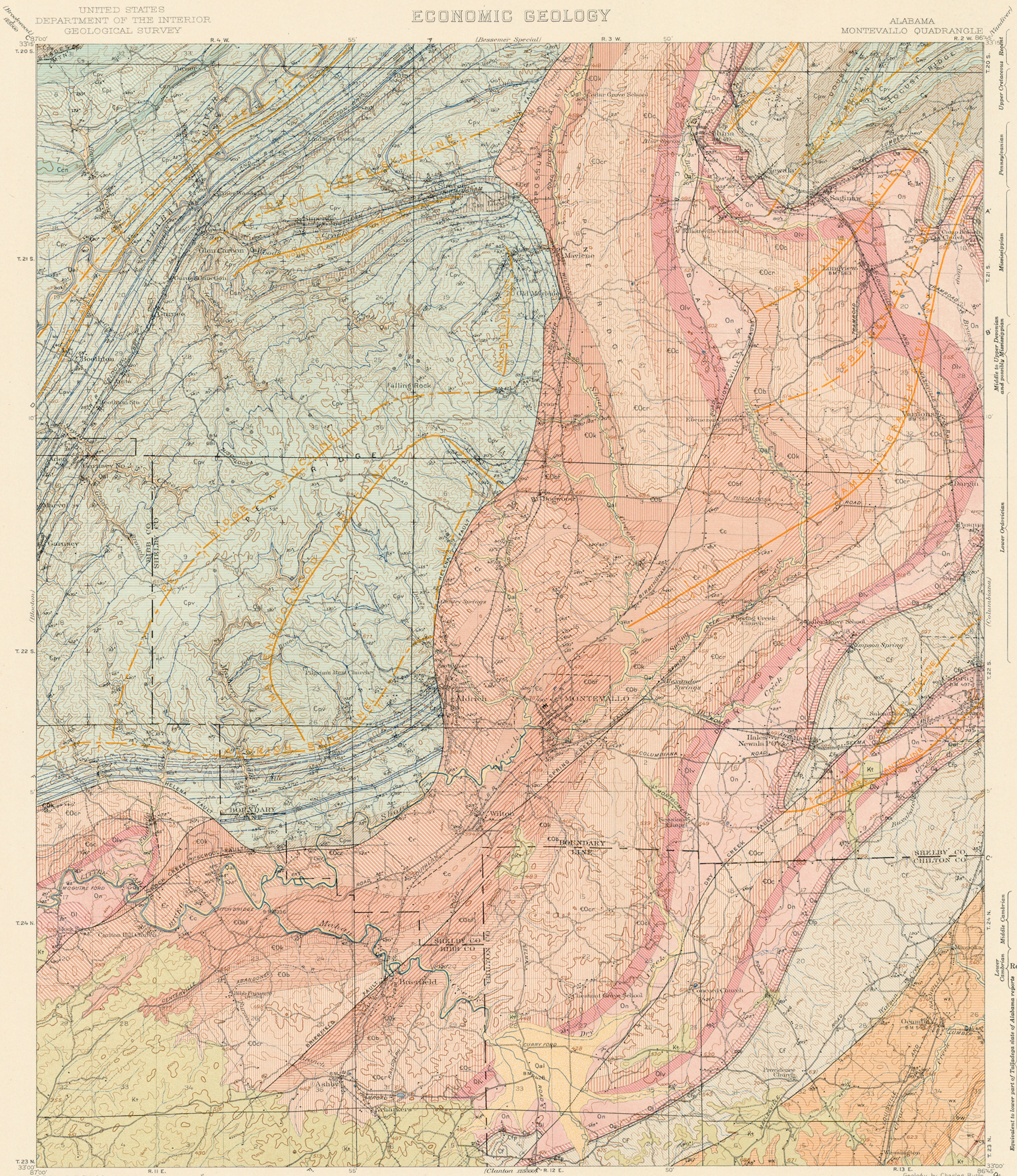
Axis of syncline

* Ozarkian of E. O. Ulrich

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

ECONOMIC GEOLOGY

ALABAMA
MONTEVALLO QUADRANGLE



R. B. Marshall, Chief Geographer.
Frank Sutton, Geographer in charge.
Topography by R. W. Berry.
Control by C. B. Kendall, E. A. Stearns, A. D. Cameron, and A. K. Gilman.
Surveyed in 1907-1908.

APPROXIMATE MEAN DECLINATION 1908.

Scale 1/62500

Contour interval 50 feet.
Datum is mean sea level.
Edition of October 1940

Geology by Charles Butts.
Surveyed in 1908-1910.

ECONOMIC DATA

⚒ *Coal mines*
A. Abandoned

x *Coal prospects and country banks*

LIST OF ACTIVE MINES IN 1930

1. Boothton, No. 1
2. Boothton, No. 2
3. Boothton, No. 3
4. Sicard
5. Straven
6. Peerless
7. Dogwood, No. 1
8. Dogwood, No. 2
9. Aldrich

CAHABA COAL FIELD

pc, Polecat
my, Maylene
s, Straven
m, Montevallo
ys, Yeshic
h, Helena
t, Thompson
gs, Gholson
cl, Clark (Little Pittsburgh?)
y, Youngblood (Black shale, Coke)
b, Buck
p, Pump (Alice and Jones)
bb, Big Bone (Coke Oven)
w, Wadsworth
hn, Harkness
nu, Nunnally, Upper
nm, Nunnally, Middle
nl, Nunnally, Lower
g, Gould

COOSA COAL FIELD

n, Nivens

Coal outcrops
(dashed lines indicate uncertainty as to position or thickness of beds)

EXPLANATION

SEDIMENTARY ROCKS

(Subaqueous deposits are shown by patterns of parallel lines; subaerial deposits by patterns of dots and circles)

QUATERNARY — Recent

Qal — **Alluvium** (flood-plain deposits of present streams)

CRETACEOUS — Upper Cretaceous

Kt — **Tuscaloosa formation** (varicolored sand, clay, and gravel)

UNCONFORMITY

CARBONIFEROUS — Pennsylvanian

Cahaba field / Coosa field

Cpv — **Pottsville formation** (sandstone, conglomerate, shale, and coal beds; sandstone members—Shades, Cs, Pine, Cpi, Chestnut, Ccn, Wolf Ridge, Cwr, and Straight Ridge, Csr; Straven conglomerate member, Csn)

CARBONIFEROUS — Mississippian

Cpw — **Parkwood formation** (gray shale and sandstone)

Cf — **Floyd shale** (black or gray shale, some gray granular and impure shaly limestone, and much fine-grained gray and green sandstone)

UNCONFORMITY

Cfp — **Fort Payne chert** (chert and limestone)

UNCONFORMITY

DEVONIAN AND POSSIBLY CARBONIFEROUS — Middle to Upper Devonian and possibly Mississippian

DCc — **Chattanooga shale and Frog Mountain sandstone** (Chattanooga shale, black shale of Upper Devonian or Mississippian age, unconformable on Frog Mountain sandstone, soft gray sandstone of Onondaga (Middle Devonian) age)

UNCONFORMITY

ORDOVICIAN — Lower Ordovician

Olo — **Little Oak limestone** (thick-bedded argillaceous cherty limestone, with irregular nodular chert layers; weathers to earthy network; late Chazy age)

UNCONFORMITY

Oa — **Athens shale** (dark to black calcareous shale with thin limestone layers; late Chazy age)

UNCONFORMITY

Ol — **Lenoir limestone** (dark-gray crystalline limestone with a little chert locally; Chazy age; conglomerate locally at bottom; in Cahaba Valley only, where underlying Mosheim limestone is possibly also present)

UNCONFORMITY

On — **Odenville and Newala limestones** (thick-bedded gray limestone and some dolomite; very pure in upper part; Beekmantown age; absent in Birmingham Valley; Newala burned for lime)

Olv — **Longview limestone** (cherty limestone and dolomite; some layers with fairly abundant quartz grains; Beekmantown fauna)

UNCONFORMITY

CAMBRIAN OR ORDOVICIAN *

€Oc — **Chepultepec dolomite** (dolomite with mealy, cavernous, fossiliferous chert)

€Ocr — **Copper Ridge dolomite** (gray crystalline dolomite with much very dense, tough, angular chert at base; pure limestone may represent pre-Copper Ridge rocks in Tennessee)

€Ob — **Bibb dolomite** (thick-bedded blue fine-grained highly siliceous dolomite, weathering to cavernous boulders)

€Ok — **Ketona dolomite** (thick-bedded light-gray coarse-grained dolomite of great purity; extensively used for flux)

€Obf — **Brierfield dolomite** (thick-bedded siliceous dolomite)

CAMBRIAN — Middle Cambrian

€c — **Conasauga ("Coosa") limestone** (medium thick-bedded dark fine-grained limestone, some dolomite, and yellowish-green shale)

CAMBRIAN — Lower Cambrian

€r — **Rome ("Montevallo") formation** (purple, red, greenish, and grayish shale, calcareous gray sandstone, and a little limestone)

RELATION UNDETERMINED

PRE-CAMBRIAN OR PALEOZOIC — Equivalent to lower part of Talladega slate of Alabama reports

wc — **Wash Creek slate** (sericitic slate, weathering green and gray, and black slate; conglomeratic in upper part; contains quartz veins, probably gold bearing; ferruginous sandstone member, wcs, in lower part)

bw — **Brewer phyllite** (purplish-gray sericitic schist with silky luster and some green schist)

wx — **Waxahatchee slate** (bluish sericitic slate, weathering pink, yellowish, and gray)

Known fault

Probable fault

Concealed fault (covered by younger deposits)

T, Overthrust side of thrust fault

Strike and dip of stratified rocks

Strike of vertical beds

Horizontal beds

Axis of anticline

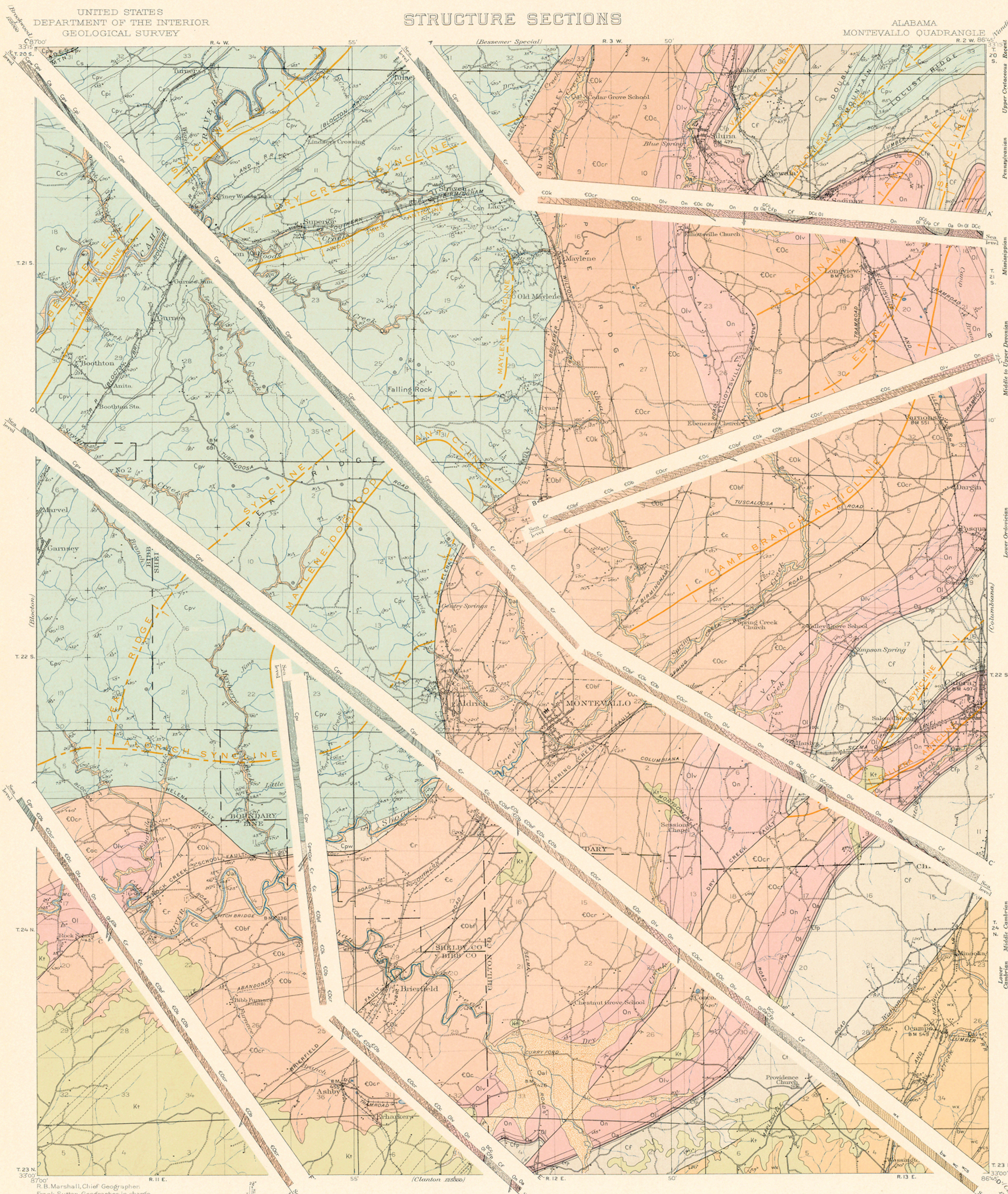
Axis of syncline

* Ozarkian of E. O. Ulrich

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

STRUCTURE SECTIONS

ALABAMA
MONTEVALLO QUADRANGLE



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Scale $\frac{1}{62500}$

1 ½ 0 1 2 3 4 Miles

1 ½ 0 1 2 3 4 5 Kilometers

Edition of October 1940

Geology by Charles Butts.
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EXPLANATION

SEDIMENTARY ROCKS

SHEET SYMBOL | SECTION SYMBOL

QUATERNARY — Recent

Qal — Alluvium
(flood-plain deposits of present streams)

CRETACEOUS — Upper Cretaceous

Kt — Tuscaloosa formation
(varicolored sand, clay, and gravel)

UNCONFORMITY

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Pottsville formation (Cpv, Csr, Csn, Cwr, Ccn, Cpi, Cs)
(sandstone, conglomerate, shale, and coal beds; sandstone members—Shades, Cs, Pine, Cpi, Chestnut, Ccn, Wolf Ridge, Cwr, and Straight Ridge, Csr; Straven conglomerate member, Csn)

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Probable fault

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(covered by younger deposits)

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Strike of vertical beds

Horizontal beds

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Axis of syncline

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UNITED STATES
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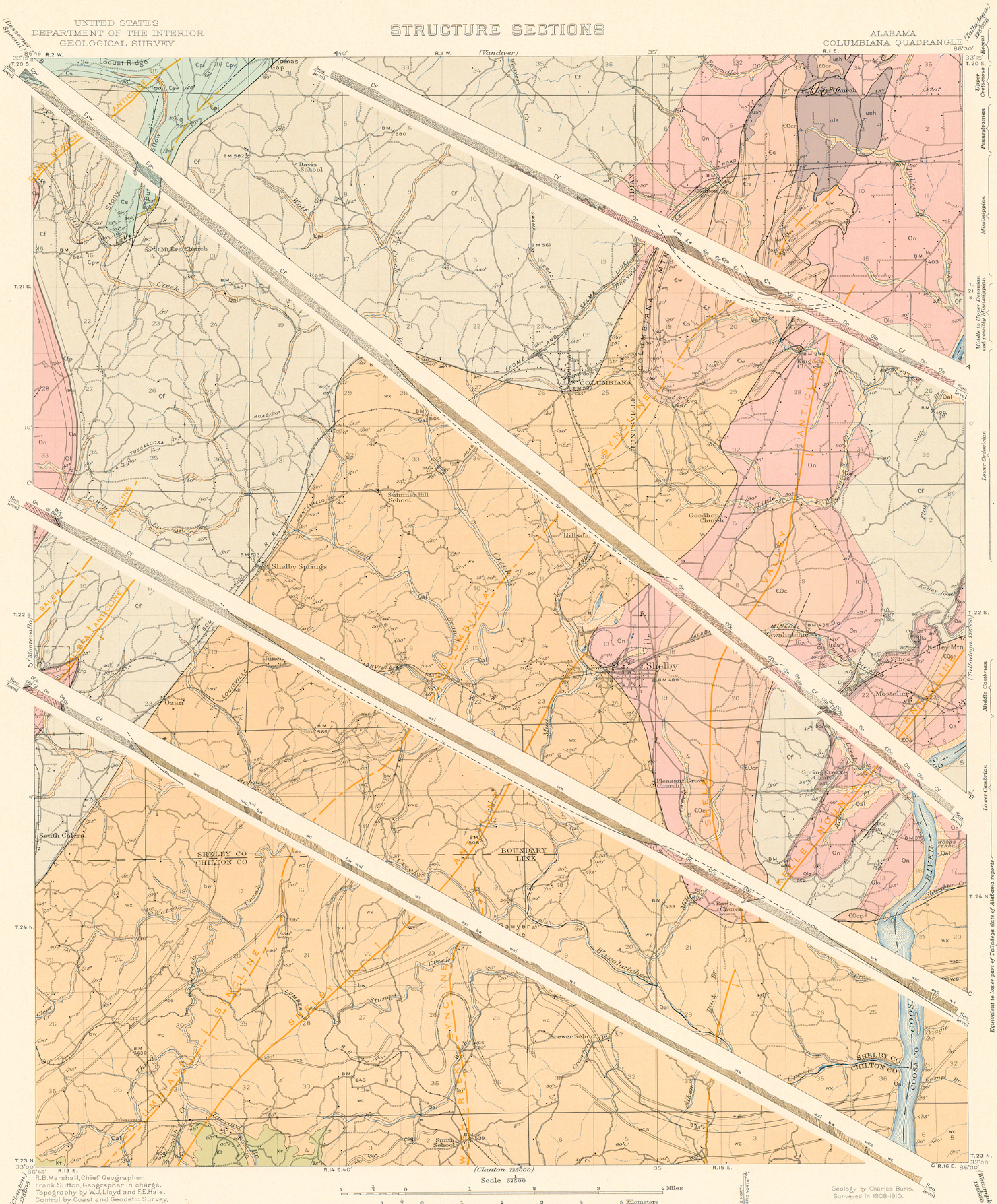
GEOLOGICAL SURVEY

STRUCTURE SECTIONS

ALABAMA
COLUMBIANA QUADRANGLE



R.B.Marshall, Chief Geographer.
Frank Sutton, Geographer in charge.
Topography by W.J.Lloyd and F.E.Hale.
Control by Coast and Geodetic Survey,
C.B.Kendall, and E.A.Stearns.
Surveyed in 1909.

Scale $\frac{1}{62500}$

1 ½ 0 1 2 3 4 Miles

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Edition of October 1940

TRUE NORTH
MAGNETIC NORTH
2½°
APPROXIMATE MEAN DECLINATION 1940

Geology by Charles Butts.
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UNCONFORMITY

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CAMBRIAN — Middle Cambrian

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(medium thick-bedded dark fine-grained limestone, some dolomite, and yellowish-green shale)

CAMBRIAN — Lower Cambrian

€rs, €r — **Rome ("Montevallo") formation**
(purple, red, green, and grayish shale, calcareous gray sandstone, and a little limestone; yellowish to purplish sandstone lentil, €rs, at top)

€s — **Shady limestone**
(thick-bedded coarse and fine grained light-gray limestone)

€wq, €w — **Weisner formation**
(dark-gray or greenish shale or slate; quartzitic lenses, €wq, more or less conglomeratic, and beds of siliceous pebbly iron ore)

RELATION UNDETERMINED

PRE-CAMBRIAN OR PALEOZOIC — Equivalent to lower part of Talladega slate of Alabama reports

wcq, wc, wcs — **Wash Creek slate**
(sericitic slate, weathering green and gray, and black slate, conglomeratic in upper part; contains quartz veins, probably gold bearing; ferruginous sandstone member, wcs, in lower part; heavy conglomeratic sandstone member, wcq, in upper part)

bw — **Brewer phyllite**
(purplish-gray sericitic schist with silky luster and some green schist)

wxl, wxc, wx — **Waxahatchee slate**
(bluish sericitic slate, weathering pink, yellowish, and gray; Sawyer limestone member, wxl, and conglomeratic sandstone member, wxc, in upper part)

uls — **Limestone of unknown age**
(in northeast corner of quadrangle; yields deep-red soil; may be of Ordovician or Cambrian age)

ush — **Shale of unknown age**
(yellowish-green shale in northeast corner of quadrangle; may be of Talladega, Weisner, or Conasauga age)

Known fault

Probable fault

Concealed fault
(covered by younger deposits)

Klippe
(erosion remnant of overthrust mass)

T Overthrust side of thrust fault

T Direction of thrust in overthrust mass

30° Strike and dip of stratified rocks

Strike of vertical beds

Horizontal beds

Axis of anticline

Axis of syncline

* Ozarkian of E. O. Ulrich

PLATE 1.—COOSA RIVER IN THE SOUTHEAST CORNER OF THE COLUMBIANA QUADRANGLE

Looking south from the Narrows. Shows upland surface or old peneplain with intrenched river valley.

PLATE 2.—VIEW LOOKING NORTHWEST ACROSS SHELBY VALLEY

Valley eroded mainly on the Newala limestone. Columbiana Mountain in the distance.

PLATE 3.—ROUNDED HILLS CHARACTERISTIC OF AREAS UNDERLAIN BY WAXAHATCHEE SLATE

About 2 miles south of Shelby. Looking east.

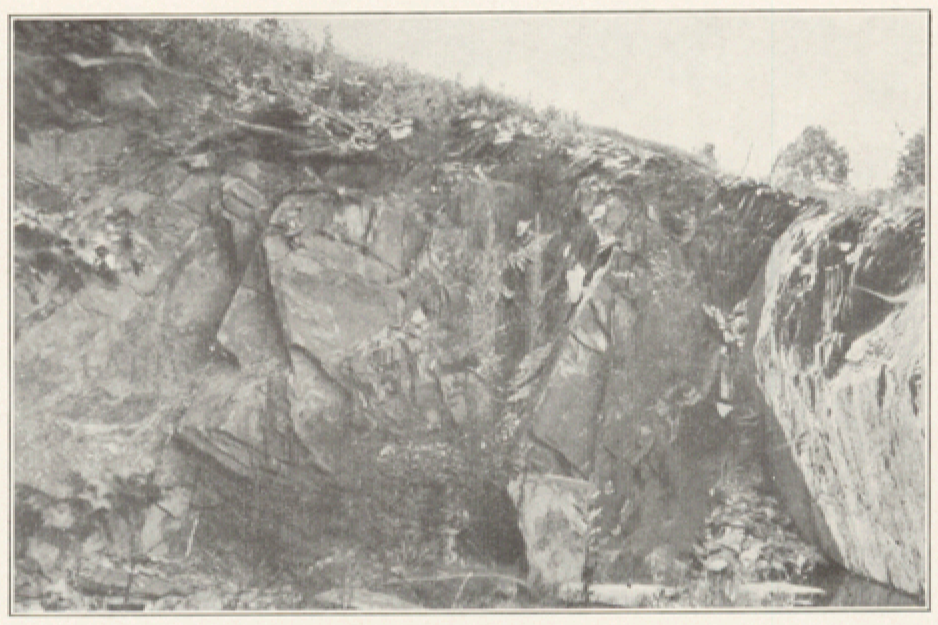

PLATE 4.—PROSPECT FOR ROOFING SLATE IN WAXAHATCHEE SLATE

Three-fourths of a mile south of Ocampo. Looking north.

PLATE 5.—CRUMPLED WASH CREEK SLATE 8 MILES SOUTH OF SHELBY

PLATE 6.—BRIERFIELD DOLOMITE INCRUSTED WITH CHARACTERISTIC FRETWORK OF RESIDUAL SILICA

Sixmile Creek, about 1 mile northwest of the southwest corner of the Montevallo quadrangle.

PLATE 7.—CAVERNOUS SILICA FROM BIBB DOLOMITE

Characteristic weathering product from the Brierfield and Bibb dolomites.

PLATE 8.—NEWALA LIMESTONE IN BOWDEN'S QUARRY

About half a mile south of Newala, in the northeastern part of the Montevallo quadrangle. Looking east.

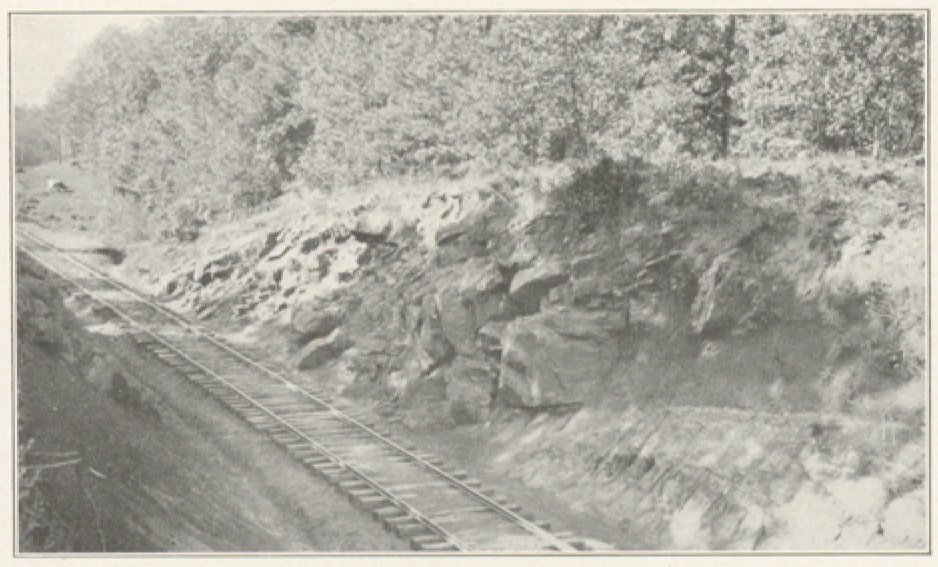

PLATE 9.—FROG MOUNTAIN SANDSTONE (DEVONIAN) LYING ON FOSSILIFEROUS CLAY WHICH IS DECOMPOSED LITTLE OAK LIMESTONE (ORDOVICIAN)

Cut on railroad 1 mile northwest of Mosteller, in the eastern part of the Columbiana quadrangle. Between the clay and sandstone is a stratigraphic gap representing the upper part of the Ordovician system, the entire Silurian system, and the lower part of the Devonian system.

PLATE 10.—CARBONIFEROUS AND ORDOVICIAN ROCKS IN CUT ON SOUTHERN RAILWAY HALF A MILE EAST OF CALERA

The Athens shale (Ordovician) is overlain by the Frog Mountain sandstone (Devonian), 4 inches thick; clay that may be of Devonian age in the middle; and Fort Payne chert (Mississippian) at the right. There is a great stratigraphic break between the Frog Mountain sandstone and Athens shale. Looking northeast.

PLATE 11.—SHELBY IRON ORE DIGGINGS

At top there is 15 feet of red loam carrying best quality of lump ore, underlain by light-colored sand and quartz gravel, possibly of Cretaceous age.

PLATE 12.—CONASAUGA LIMESTONE OVERTHRUST ON A COAL BED IN THE POTTSVILLE FORMATION

Shoal Creek, 1.5 miles southwest of Aldrich, in the Cahaba coal field.

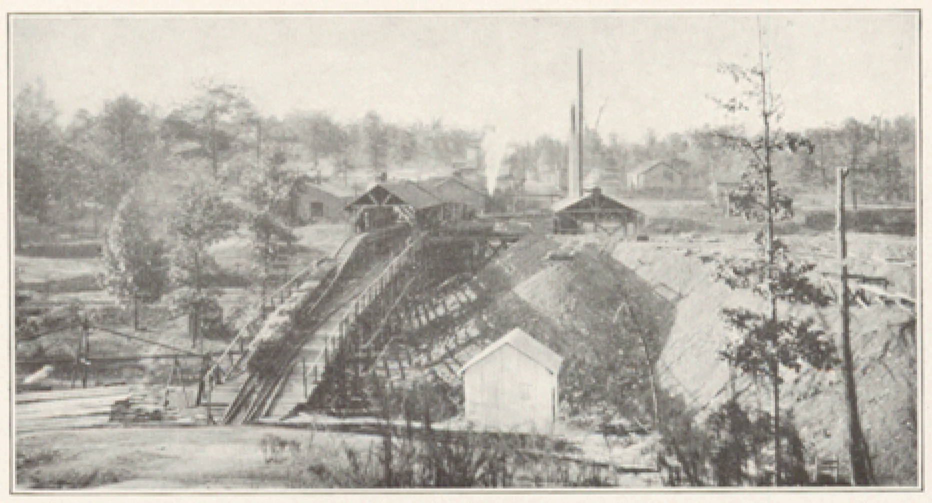

PLATE 13.—TYPICAL COAL MINE IN THE CAHABA COAL FIELD

Coleanor mine, about 2 miles west of the Montevallo quadrangle. Looking west.

PLATE 14.—RESIDUAL PINNACLE OF CONTORTED NEWALA LIMESTONE EXPOSED IN ORE BANK AT SHELBY

PLATE 15.—IRON ORE DIGGINGS AT SHELBY

Ore is in pockets in decayed rock, which is reported to extend nearly 100 feet below the bottom of the pit. The clay seems to fill an ancient sink hole.

When it is desirable to recognize and map one or more specially developed parts of a formation the parts are called *members* or by some other appropriate term, such as *lentils*.

AGE OF THE FORMATIONS.

Geologic time.—The largest divisions of geologic time are called *eras*, the next smaller are called *periods*, and the still smaller divisions are called *epochs*. Subdivisions of the Pleistocene epoch are called *stages*. The age of a rock is expressed by the name of the time division in which it was formed.

The sedimentary formations deposited during a geologic period are called a *system*. The principal divisions of a system are called *series*. Any aggregate of formations less than a series is called a *group*.

As sedimentary deposits accumulate successively the younger rest on the older, and their relative ages may be determined by observing their positions. In many regions of intense disturbance, however, the beds have been overturned by folding or their relations to adjacent beds have been changed by faulting, so that it may be difficult to determine their relative ages from their present positions at the surface.

Many stratified rocks contain *fossils*, the remains or imprints of plants and animals which, at the time the strata were deposited, lived in bodies of water or were washed into them or were buried in surficial deposits on the land. Such rocks are said to be fossiliferous. A study of these fossils has shown that the forms of life at each period of the earth's history were to a great extent different from the forms at other periods. Only the simpler kinds of marine plants and animals lived when the oldest fossiliferous rocks were deposited. From time to time more complex kinds developed, and as the simpler ones lived on in modified forms life became more varied. But during each period there lived forms that did not exist in earlier times and have not existed since; these are *characteristic types*, and they define the age of any bed of rock in which they are found. Other types passed on from period to period and thus linked the systems together, forming a chain of life from the time of the oldest fossiliferous rocks to the present. If two sedimentary formations are geographically so far apart that it is impossible to determine their relative positions the characteristic fossils found in them may determine which was deposited first. Fossils are also of value in determining the age of formations in the regions of intense disturbance mentioned above. The fossils found in the strata of different areas, provinces, and continents afford the most effective means of combining local histories into a general earth history.

It is in many places difficult or impossible to determine the age of an igneous formation, but the relative age of such a formation can in general be ascertained by observing whether an associated sedimentary formation of known age is cut by the igneous mass or lies upon it. Similarly, the time at which metamorphic rocks were formed from the original masses may be shown by their relations to adjacent formations of known age; but the age recorded on the map is that of the original masses and not that of their metamorphism.

Symbols, colors, and patterns.—Each formation is shown on the map by a distinctive combination of color and pattern and is labeled by a special letter symbol.

Patterns composed of parallel straight lines are used to represent sedimentary formations deposited in the sea, in lakes, or in other bodies of standing water. Patterns of dots and circles represent alluvial, glacial, and eolian formations. Patterns of triangles and rhombs are used for igneous formations. Metamorphic rocks of unknown origin are represented by short dashes irregularly placed; if the rock is schist the dashes may be arranged in wavy lines parallel to the structure planes. Suitable combination patterns are used for metamorphic formations that are known to be of sedimentary or of igneous origin. The patterns of each class are printed in various colors. The colors in which the patterns of parallel lines are printed indicate age, a particular color being assigned to each system.

Each symbol consists of two or more letters. The symbol for a formation whose age is known includes the system symbol, which is a capital letter or monogram; the symbols for other formations are composed of small letters.

The names of the geologic time divisions, arranged in order from youngest to oldest, and the color and symbol assigned to each system are given in the subjoined table.

Geologic time divisions and symbols and colors assigned to the rock systems.

Era.	Period or system.	Epoch or series.	Symbol.	Color for sedimentary rocks.
Cenozoic	Quaternary	Recent Pleistocene	Q	Brownish yellow.
	Tertiary	Pliocene Miocene Oligocene Eocene	T	Yellow ocher.
Mesozoic	Cretaceous		K	Olive-green.
	Jurassic		J	Blue-green.
	Triassic		Ꞧ	Peacock-blue.
Paleozoic	Carboniferous	Permian Pennsylvanian Mississippian	C	Blue.
	Devonian		D	Blue-gray.
	Silurian		S	Blue-purple.
	Ordovician		O	Red-purple.
	Cambrian		Ꞓ	Brick-red.
Proterozoic	Pre-Cambrian		pꞒ	Brownish red and gray-brown.

DEVELOPMENT AND SIGNIFICANCE OF SURFACE FORMS.

Hills, valleys, and all other surface forms have been produced by geologic processes. Most valleys are the result of erosion by the streams that flow through them (see fig. 1), and the alluvial plains that border many streams were built up by the streams; waves cut sea cliffs, and waves and currents build up sand spits and bars. Surface forms thus constitute part of the record of the history of the earth.

Some forms are inseparably connected with deposition. The hooked spit shown in figure 1 is an illustration. To this class belong beaches, alluvial plains, lava streams, drumlins (smooth oval hills composed of till), and moraines (ridges of drift made at the edges of glaciers). Other forms are produced by erosion. The sea cliff is an illustration; it may be carved from any rock. To this class belong abandoned river channels, glacial furrows, and peneplains. In the making of a stream terrace an alluvial plain is built and afterward partly eroded away. The shaping of a plain along a shore is usually a double process, hills being worn away (*degraded*) and valleys filled up (*aggraded*).

All parts of the land surface are subject to the action of air, water, and ice, which slowly wears them down, producing material that is carried by streams toward the sea. As this wearing down depends on the flow of water to the sea it can not be carried below sea-level, which is therefore called the *base-level* of erosion. Lakes or large rivers may determine base-levels for certain regions. A large tract that is long undisturbed by uplift or subsidence is worn down nearly to base-level, and the fairly even surface thus produced is called a *peneplain*. If the tract is afterward uplifted it becomes a record of its former close relation to base-level.

THE GEOLOGIC MAPS AND SHEETS IN THE FOLIO.

Areal-geology map.—The map showing the surface areas occupied by the several formations is called an *areal-geology map*. On the margin is an explanation, which is the key to the map. To ascertain the meaning of any color or pattern and its letter symbol the reader should look for that color, pattern, and symbol in the explanation, where he will find the name and description of the formation. If he desires to find any particular formation he should examine the explanation and find its name, color, and pattern and then trace out the areas on the map corresponding in color and pattern. The explanation shows also parts of the geologic history. The names of formations are arranged in columnar form, grouped primarily according to origin—sedimentary, igneous, and metamorphic rocks of unknown origin—and those within each group are placed in the order of age, the youngest at the top.

Economic-geology map.—The map representing the distribution of useful minerals and rocks and showing their relations to the topographic features and to the geologic formations is termed the *economic-geology map*. Most of the formations indicated on the areal-geology map are shown on the economic-geology map by patterns in fainter colors, but the areas of productive formations are emphasized by strong colors. A mine symbol shows the location of each mine or quarry and is accompanied by the name of the principal mineral product mined or quarried. If there are important mining industries or artesian basins in the area the folio includes special maps showing these additional economic features.

Structure-section sheet.—The relations of different beds to one another may be seen in cliffs, canyons, shafts, and other natural and artificial cuttings. Any cutting that exhibits these relations is called a *section*, and the same term is applied to a diagram representing the relations. The arrangement of the beds or masses of rock in the earth is called *structure*, and a section showing this arrangement is called a *structure section*.

FIGURE 2.—Sketch showing a vertical section below the surface at the front and a view beyond.

The geologist is not limited, however, to natural and artificial cuttings for his information concerning the earth's structure. Knowing the manner of formation of rocks, after tracing out the relations of the beds on the surface he can infer their relative positions beneath the surface and can draw sections representing the probable structure to a considerable depth. Such a section is illustrated in figure 2.

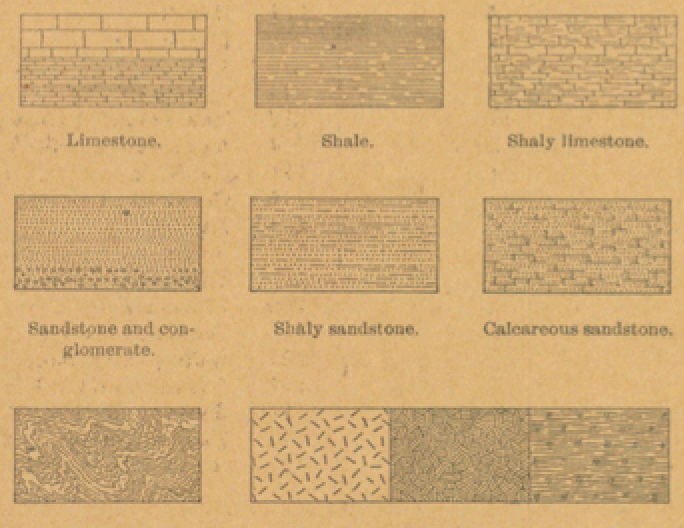

FIGURE 3.—Symbols used in sections to represent different kinds of rock.

The figure represents a landscape that is cut off sharply in the foreground on a vertical plane so as to show the underground relations of the rocks. The kinds of rock are indicated by appropriate patterns of lines, dots, and dashes. These patterns admit of much variation, but those shown in figure 3 are used to represent the commoner kinds of rock.

The plateau shown at the left of figure 2 presents toward the lower land an escarpment, or front, made up of sandstone, which forms the cliffs, and shale, which forms the slopes. The broad belt of lower land is traversed by several ridges, which, as shown in the section, correspond to the outcrops of a folded bed of sandstone that rises to the surface. The upturned edges of this bed form the ridges, and the intermediate valleys follow the outcrops of limestone and calcareous shale.

Where the edges of the beds appear at the surface their thickness can be measured and the angles at which they dip below the surface can be observed, and by means of these observations their positions underground are inferred. The direction of the intersection of the surface of a dipping bed with a horizontal plane is called its *strike*. The inclination of the bed to the horizontal plane, measured at right angles to the strike, is called its *dip*.

In many regions the beds are bent into troughs and arches, such as are seen in figure 2. The arches are called *anticlines* and the troughs *synclines*. As the materials that formed the sandstone, shale, and limestone were deposited beneath the sea in nearly flat layers the fact that the beds are now bent and folded shows that forces have from time to time caused the earth's crust to wrinkle along certain zones. In places the beds are broken across and the parts have slipped past each other. Such breaks are termed *faults*. Two kinds of faults are shown in figure 4.

FIGURE 4.—Ideal sections of broken and bent strata, showing (a) *normal* faults and (b) a *thrust or reverse* fault.

At the right of figure 2 the section shows schists that are traversed by igneous rocks. The schists are much contorted, and the form or arrangement of their masses underground can not be inferred. Hence that part of the section shows only what is probable, not what is known by observation.

The section also shows three sets of formations, distinguished by their underground relations. The uppermost set, seen at the left, is made up of beds of sandstone and shale, which lie in a horizontal position. These beds were laid down under water but are now high above the sea, forming a plateau, and their change of altitude shows that this part of the earth's surface has been uplifted. The beds of this set are *conformable*—that is, they are parallel and show no break in sedimentation.

The next lower set of formations consists of beds that are folded into arches and troughs. The beds were once continuous, but the crests of the arches have been removed by erosion. These beds, like those of the upper set, are conformable.

The horizontal beds of the plateau rest upon the upturned, eroded edges of the beds of the middle set, as shown at the left of the section. The beds of the upper set are evidently younger than those of the middle set, which must have been folded and eroded between the time of their deposition and that of the deposition of the upper beds. The upper beds are *unconformable* to the middle beds, and the surface of contact is an *unconformity*.

The lowest set of formations consists of crystalline schists and igneous rocks. At some period of their history the schists were folded or plicated by pressure and intruded by masses of molten rock. The overlying beds of the middle set have not been traversed by these intrusive rocks nor have they been affected by the pressure of the intrusion. It is evident that considerable time elapsed between the formation of the schists and the beginning of the deposition of the beds of the middle set, and during this time the schists were metamorphosed, disturbed by the intrusion of igneous masses, and deeply eroded. The contact between the middle and lowest sets is another unconformity; it marks a period of erosion between two periods of deposition.

The section and landscape in figure 2 are ideal, but they illustrate actual relations. The sections on the structure-section sheet are related to the maps in much the same way that the section in the figure is related to the landscape. The profile of the surface in each structure section corresponds to the actual slopes of the ground along the section line, and the depth to any mineral-producing or water-bearing bed shown may be measured by using the scale given on the map.

Columnar section.—Many folios include a *columnar section*, which contains brief descriptions of the sedimentary formations in the quadrangle. It shows the character of the rocks as well as the thickness of the formations and the order of their accumulation, the oldest at the bottom, the youngest at the top. It also indicates intervals of time that correspond to events of uplift and degradation and constitute interruptions of deposition.

THE TEXT OF THE FOLIO.

The text of the folio states briefly the relation of the area mapped to the general region in which it is situated; points out the salient natural features of the geography of the area and indicates their significance and their history; considers the cities, towns, roads, railroads, and other human features; describes the geology and the geologic history; and shows the character and the location of the valuable mineral deposits.

W. C. MENDENHALL,
Director.

December, 1934.

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