DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY
GEORGE OTIS SMITH, DIRECTOR

GEOLOGIC ATLAS
OF THE
UNITED STATES

ELLIJAY FOLIO

GEORGIA–NORTH CAROLINA–TENNESSEE

BY

LAURENCE LA FORGE AND W. C. PHALEN

WASHINGTON, D. C.
ENGRAVED AND PRINTED BY THE U. S. GEOLOGICAL SURVEY
GEORGE W. STOSE, EDITOR OF GEOLOGIC MAPS S. J. KUBEL, CHIEF ENGRAVER
1913

GEOLOGIC ATLAS OF THE UNITED STATES.

The Geological Survey is making a geologic atlas of the United States, which is being issued in parts, called folios. Each folio includes topographic and geologic maps of a certain area, together with descriptive text.

THE TOPOGRAPHIC MAP.

The features represented on the topographic map are of three distinct kinds—(1) inequalities of surface, called *relief*, as plains, plateaus, valleys, hills, and mountains; (2) distribution of water, called *drainage*, as streams, lakes, and swamps; (3) the works of man, called *culture*, as roads, railroads, boundaries, villages, and cities.

Relief.—All elevations are measured from mean sea level. The heights of many points are accurately determined, and those of the most important ones are given on the map in figures. It is desirable, however, to give the elevation of all parts of the area mapped, to delineate the outline or form of all slopes, and to indicate their grade or steepness. This is done by lines each of which is drawn through points of equal elevation above mean sea level, the vertical interval represented by each space between lines being the same throughout each map. These lines are called *contour lines* or, more briefly, *contours*, and the uniform vertical distance between each two contours is called the *contour interval*. Contour lines and elevations are printed in brown. The manner in which contour lines express altitude, form, and grade is shown in figure 1.

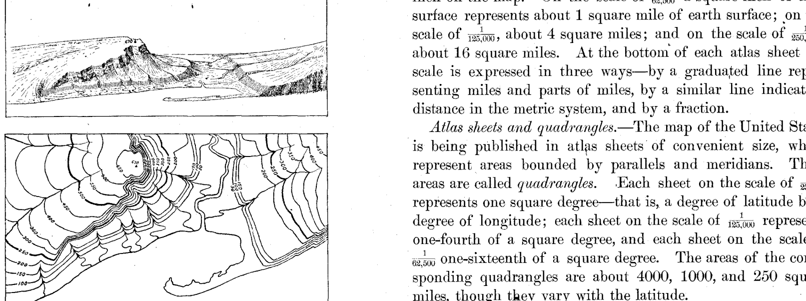


FIGURE 1.—Ideal view and corresponding contour map.

The sketch represents a river valley between two hills. In the foreground is the sea, with a bay that is partly closed by a hooked sand bar. On each side of the valley is a terrace. The terrace on the right merges into a gentle hill slope; that on the left is backed by a steep ascent to a cliff, or scarp, which contrasts with the gradual slope away from its crest. In the map each of these features is indicated, directly beneath its position in the sketch, by contour lines. The map does not include the distant portion of the view. The following notes may help to explain the use of contour lines:

1. A contour line represents a certain height above sea level. In this illustration the contour interval is 50 feet; therefore the contour lines are drawn at 50, 100, 150, and 200 feet, and so on, above mean sea level. Along the contour at 250 feet lie all points of the surface that are 250 feet above the sea—that is, this contour would be the shore line if the sea were to rise 250 feet; along the contour at 200 feet are all points that are 200 feet above the sea; and so on. In the space between any two contours are all points whose elevations are above the lower and below the higher contour. Thus the contour at 150 feet falls just below the edge of the terrace, and that at 200 feet lies above the terrace; therefore all points on the terrace are shown to be more than 150 but less than 200 feet above the sea. The summit of the higher hill is marked 670 (feet above sea level); accordingly the contour at 650 feet surrounds it. In this illustration all the contour lines are numbered, and those for 250 and 500 feet are accentuated by being made heavier. Usually it is not desirable to number all the contour lines. The accentuating and numbering of certain of them—say every fifth one—suffices and the heights of the others may be ascertained by counting up or down from these.

2. Contour lines show or express the forms of slopes. As contours are continuous horizontal lines, they wind smoothly about smooth surfaces, recede into all reentrant angles of ravines, and project in passing around spurs or prominences. These relations of contour curves and angles to forms of the landscape can be seen from the map and sketch.

3. Contour lines show the approximate grade of any slope. The vertical interval between two contours is the same, whether they lie along a cliff or on a gentle slope; but to attain 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 ones.

A small contour interval is necessary to express the relief of a flat or gently undulating country; a steep or mountainous country can, as a rule, be adequately represented on the same scale by the use of a larger interval. The smallest interval used on the atlas sheets of the Geological Survey is 5 feet. This is in regions like the Mississippi Delta and the Dismal Swamp. For great mountain masses, like those in Colorado, the interval may be 250 feet and for less rugged country contour intervals of 10, 20, 25, 50, and 100 feet are used.

Drainage.—Watercourses are indicated by blue lines. For a perennial stream the line is unbroken, but for an intermittent stream it is broken or dotted. Where a stream sinks and reappears the probable underground course is shown by a broken blue line. Lakes, marshes, and other bodies of water are represented by appropriate conventional signs in blue.

Culture.—The symbols for the works of man and all lettering are printed in black.

Scales.—The area of the United States (exclusive of Alaska and island possessions) is about 3,027,000 square miles. A map of this area, drawn to the scale of 1 mile to the inch would cover 3,027,000 square inches of paper and measure about 240 by 180 feet. Each square mile of ground surface would be represented by a square inch of map surface, and a linear mile on the ground by a linear inch on the map. The scale may be expressed also by a fraction, of which the numerator is a length on the map and the denominator the corresponding length in nature expressed in the same unit. Thus, as there are 63,360 inches in a mile, the scale "1 mile to the inch" is expressed by the fraction $\frac{1}{63,360}$.

Three scales are used on the atlas sheets of the Geological Survey; they are $\frac{1}{250,000}$, $\frac{1}{125,000}$, and $\frac{1}{62,500}$, corresponding approximately to 4 miles, 2 miles, and 1 mile on the ground to an inch on the map. On the scale of $\frac{1}{62,500}$ a square inch of map surface represents about 1 square mile of earth surface; on the scale of $\frac{1}{125,000}$, about 4 square miles; and on the scale of $\frac{1}{250,000}$, about 16 square miles. At the bottom of each atlas sheet the scale is expressed in three ways—by a graduated line representing miles and parts of miles, by a similar line indicating distance in the metric system, and by a fraction.

Atlas sheets and quadrangles.—The map of the United States is being published in atlas sheets of convenient size, which represent areas bounded by parallels and meridians. These areas are called *quadrangles*. Each sheet on the scale of $\frac{1}{250,000}$ represents one square degree—that is, a degree of latitude by a degree of longitude; each sheet on the scale of $\frac{1}{125,000}$ represents one-fourth of a square degree, and each sheet on the scale of $\frac{1}{62,500}$ one-sixteenth of a square degree. The areas of the corresponding quadrangles are about 4000, 1000, and 250 square miles, though they vary with the latitude.

The atlas sheets, being only parts of one map of the United States, are not limited by political boundary lines, such as those of States, counties, and townships. Many of the maps represent areas lying in two or even three States. To each sheet, and to the quadrangle it represents, is given the name of some well-known town or natural feature within its limits, and at the sides and corners of each sheet are printed the names of adjacent quadrangles, if the maps are published.

THE GEOLOGIC MAPS.

The maps representing the geology show, by colors and conventional signs printed on the topographic base map, the distribution of rock masses on the surface of the land and, by means of structure sections, their underground relations, so far as known and 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*. Where the intrusive rock occupies a fissure with approximately parallel walls it is called a *dike;* where it fills a large and irregular conduit the mass is termed a *stock*. Where molten magma traverses stratified rocks it may be intruded along bedding planes; such masses are called *sills* or *sheets* if comparatively thin, and *laccoliths* if they occupy larger chambers produced by the pressure of the magma. Where inclosed by rock molten material cools slowly, with the result that intrusive rocks are generally of crystalline texture. Where the channels reach the surface the molten material poured out through them is called *lava*, and lavas often 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 as a rule contain, especially in their superficial parts, more or less volcanic glass, produced by rapid chilling. The outer parts of lava flows also are usually porous, owing to the expansion of the gases originally present in the magma. Explosive action, due to these gases, often accompanies volcanic eruptions, causing ejections 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 ejecta deposited in lakes and seas, or of materials deposited in such water bodies by chemical precipitation 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 are then said to be mechanical. Such are gravel, sand, and clay, which are later consolidated into conglomerate, sandstone, and shale. Some of the materials are carried in solution, and deposits of these are called organic if formed with the aid of life, or chemical if formed without the aid of life. The more important rocks of chemical and organic origin are limestone, chert, gypsum, salt, iron ore, peat, lignite, and coal. Any one of the kinds of deposit named may be separately formed, 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 glacial deposits is till, a heterogeneous mixture of bowlders and pebbles with clay or sand.

Sedimentary rocks are usually made up of layers or beds which 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 thereby changed. As a result of upward movement marine sedimentary rocks may become part of the land, and most of our land areas are in fact occupied by rocks 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 the 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. Their upper parts, occupied by the roots of plants, constitute soils and subsoils, the soils being usually distinguished by a notable admixture of organic matter.

Metamorphic rocks.—In the course of time, and by various processes, rocks may become greatly changed in composition and in texture. If the new characteristics are more pronounced than the old such rocks are called *metamorphic*. In the process of metamorphism the constituents of a chemical 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 pressures, to slow movement, and to igneous intrusion have been afterward raised and later exposed by erosion. In such rocks the original structures may have been lost entirely and new ones substituted. A system of planes of division, along which the rock splits most readily, may have been developed. This structure is called *cleavage* and may cross the original bedding planes at any angle. The rocks characterized by it are *slates*. Crystals of mica or other minerals may have grown in the rock in such a way as to produce a laminated or foliated structure known as *schistosity*. The rocks characterized by this structure are *schists*.

As a rule, the oldest rocks are most altered and the younger formations have escaped metamorphism, but to this rule there are many important exceptions, especially in regions of igneous activity and complex structure.

FORMATIONS.

For purposes of geologic mapping 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. Where 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 in some cases the distinction depends almost entirely on the contained fossils. An igneous formation contains one or more bodies of one kind, of similar occurrence, or of like origin. A metamorphic formation may consist of rock of uniform character or of several rocks having common characteristics or origin.

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

AGES OF ROCKS.

Geologic time.—The time during which rocks were made is divided into *periods*. Smaller time divisions are called *epochs*, and still smaller ones *stages*. The age of a rock is expressed by the name of the time interval in which it was formed.

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

Inasmuch as sedimentary deposits accumulate successively the younger rest on those that are 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 superposed by faulting, so that it may be difficult to determine their relative ages from their present positions; under such conditions fossils, if present, may indicate which of two or more formations is the oldest.

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 called fossiliferous. By studying fossils it has been found that the life of each period of the earth's history was to a great extent different from that of other periods. Only the simpler kinds of marine life existed 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 peculiar forms, which 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. Where two sedimentary formations are remote from each other and it is impossible to observe their relative positions, the characteristic fossil types found in them may determine which was deposited first. Fossil remains in the strata of different areas, provinces, and continents afford the most important means for combining local histories into a general earth history.

It is 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 is deposited 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 known to be of sedimentary or of igneous origin. The patterns of each class are printed in various colors. With the patterns of parallel lines, colors are used to indicate age, a particular color being assigned to each system.

The symbols consist each of two or more letters. If the age of a formation is known the symbol includes the system symbol, which is a capital letter or monogram; otherwise the symbols are composed of small letters.

The names of the systems and of series that have been given distinctive names, in order from youngest to oldest, with the color and symbol assigned to each system, are given in the subjoined table.

Symbols and colors assigned to the rock systems.

	System.	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		₸	Peacock-blue.
Paleozoic	Carboniferous	Permian, Pennsylvanian, Mississippian	C	Blue.
	Devonian		D	Blue-gray.
	Silurian		S	Blue-purple.
	Ordovician		O	Red-purple.
	Cambrian		Є	Brick-red.
	Algonkian		A	Brownish red.
	Archean		Æ	Gray-brown.

SURFACE FORMS.

Hills, valleys, and all other surface forms have been produced by geologic processes. For example, most valleys are the result of erosion by the streams that flow through them (see fig. 1), and the alluvial plains bordering many streams were built up by the streams; waves cut sea cliffs and, in cooperation with currents, build up sand spits and bars. Topographic 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 first built and afterward partly eroded away. The shaping of a marine or lacustrine plain is usually a double process, hills being worn away (*degraded*) and valleys being filled up (*aggraded*).

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

THE VARIOUS GEOLOGIC SHEETS.

Areal geology map.—The map showing the areas occupied by the various formations is called an *areal geology map*. On the margin is a *legend*, 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 legend, where he will find the name and description of the formation. If it is desired to find any particular formation, its name should be sought in the legend and its color and pattern noted; then the areas on the map corresponding in color and pattern may be traced out. The legend is also a partial statement of the geologic history. In it the names of formations are arranged in columnar form, grouped primarily according to origin—sedimentary, igneous, and crystalline of unknown origin—and within each group they are placed in the order of age, so far as known, 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*. The formations that appear on the areal geology map are usually shown on this map by fainter color patterns and 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 mined or stone quarried. If there are important mining industries or artesian basins in the area special maps to show these additional economic features are included in the folio.

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

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 and having traced out the relations among the beds on the surface, he can infer their relative positions after they pass beneath the surface and can draw sections representing the structure to a considerable depth. Such a section is illustrated in figure 2.

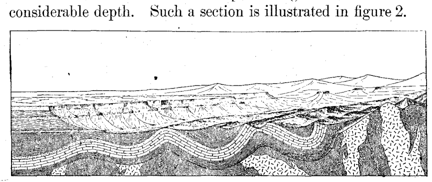


FIGURE 2.—Sketch showing a vertical section at the front and a landscape beyond.

The figure represents a landscape which 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.

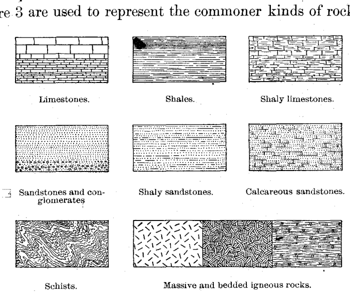


FIGURE 3.—Symbols used in sections to represent different kinds of rocks.

The plateau shown at the left of figure 2 presents toward the lower land an escarpment, or front, which is made up of sandstones, forming the cliffs, and shales, constituting the slopes. The broad belt of lower land is traversed by several ridges, which are seen in the section to correspond to the outcrops of a 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 strata appear at the surface their thickness can be measured and the angles at which they dip below the surface can be observed. Thus their positions underground can be inferred. The direction of the intersection of a bed with a horizontal plane is called the *strike*. The inclination of the bed to the horizontal plane, measured at right angles to the strike, is called the *dip*.

In many regions the strata are bent into troughs and arches, such as are seen in figure 2. The arches are called *anticlines* and the troughs *synclines*. As the sandstones, shales, and limestones were deposited beneath the sea in nearly flat sheets, the fact that they are now bent and folded is proof that forces have from time to time caused the earth's surface to wrinkle along certain zones. In places the strata 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.

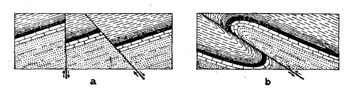


FIGURE 4.—Ideal sections of strata, showing (a) *normal* faults and (b) a *thrust* or *reverse* fault.

At the right of figure 2 the section shows schists that are traversed by igneous rocks. The schists are much contorted and their arrangement underground can not be inferred. Hence that portion of the section delineates what is probably true but is not known by observation or by well-founded inference.

The section also shows three sets of formations, distinguished by their underground relations. The uppermost set, seen at the left, is made up of sandstones and shales, which lie in a horizontal position. These strata were laid down under water but are now high above the sea, forming a plateau, and their change of elevation shows that a portion of the earth's mass has been uplifted. The strata of this set are parallel, a relation which is called *conformable*.

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

The horizontal strata of the plateau rest upon the upturned, eroded edges of the beds of the second set shown at the left of the section. The overlying deposits are, from their position, evidently younger than the underlying deposits, and the bending and eroding of the older beds must have occurred between their deposition and the accumulation of the younger beds. The younger rocks are *unconformable* to the older, and the surface of contact is an *unconformity*.

The third 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 traversed by eruptions of molten rock. But the pressure and intrusion of igneous rocks have not affected the overlying strata of the second set. Thus it is evident that a considerable interval elapsed between the formation of the schists and the beginning of deposition of the strata of the second set. During this interval the schists were metamorphosed, they were disturbed by eruptive activity, and they were deeply eroded. The contact between the second and third sets is another unconformity; it marks a time interval between two periods of rock formation.

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 as the section in the figure is related to the landscape. The profile of the surface in the section corresponds to the actual slopes of the ground along the section line, and the depth from the surface of any mineral-producing or water-bearing stratum that appears in the section may be measured by using the scale of the map.

Columnar section.—The geologic maps are usually accompanied by a *columnar section*, which contains a concise description of the sedimentary formations that occur in the quadrangle. It presents a summary of the facts relating to the character of the rocks, the thickness of the formations, and the order of accumulation of successive deposits.

The rocks are briefly described, and their characters are indicated in the columnar diagram. The thicknesses of formations are given in figures that state the least and greatest measurements, and the average thickness of each formation is shown in the column, which is drawn to scale. The order of accumulation of the sediments is shown in the columnar arrangement—the oldest being at the bottom, the youngest at the top.

The intervals of time that correspond to events of uplift and degradation and constitute interruptions of deposition are indicated graphically and by the word "unconformity."

GEORGE OTIS SMITH,
Director.

May, 1909.

DESCRIPTION OF THE ELLIJAY QUADRANGLE.

By Laurence La Forge and W. C. Phalen.

INTRODUCTION.

LOCATION AND GENERAL RELATIONS.

The Ellijay quadrangle is bounded by parallels 34° 30′ and 35° and meridians 84° and 84° 30′ and includes one-fourth of a square degree of the earth's surface, an area, in that latitude, of about 980 square miles. It is almost wholly in Georgia and includes parts of Fannin, Gilmer, Union, Lumpkin, Dawson, and Pickens counties in that State. (See fig. 1.) Along its northern side the quadrangle includes a narrow strip of Polk County, Tenn., and Cherokee County, N. C.

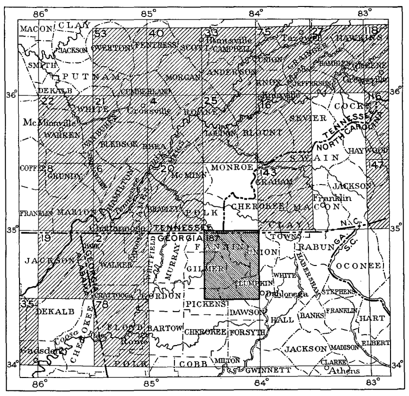


FIGURE 1.—Index map of the vicinity of the Ellijay quadrangle.

The location of the Ellijay quadrangle (No. 187) is shown by the darker ruling. Published folios describing other quadrangles, indicated by lighter ruling, are the following: Nos. 2, Ringgold; 4, Kingston; 6, Chattanooga; 8, Sewanee; 16, Knoxville; 19, Stevenson; 20, Cleveland; 21, Pikeville; 22, McMinnville; 25, Loudon; 27, Morristown; 33, Briceville; 35, Gadsden; 40, Wartburg; 53, Standingstone; 75, Maynardville; 78, Rome; 116, Asheville; 118, Greeneville; 143, Nantahala; 147, Pisgah.

The principal towns of the quadrangle are Copperhill, in Tennessee, and Blue Ridge, Mineral Bluff, and Ellijay, in Georgia. The quadrangle takes its name from the place last mentioned.

In its geographic and geologic relations the Ellijay quadrangle forms a part of the Appalachian province, which extends from the Atlantic Coastal Plain to the Mississippi lowland and from central Alabama northeastward into Canada. All parts of the province have had a common history, recorded in its rocks, its geologic structure, and its topographic features.

APPALACHIAN PROVINCE.

Subdivisions.—The Appalachian province comprises several well-marked physiographic divisions, shown in figure 2, throughout each of which certain forces have tended to produce similar results in sedimentation, in geologic structure, and

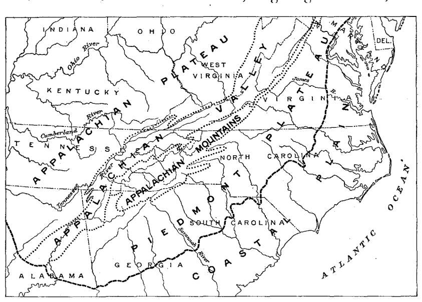


FIGURE 2.—Map of the southern part of the Appalachian province, showing its physiographic divisions and its relation to the Coastal Plain.

The Ellijay quadrangle is situated in the Piedmont Plateau and Appalachian Mountains, in northern Georgia and adjacent portions of Tennessee and North Carolina.

in topography. Several of these divisions extend throughout the length of the province from northeast to southwest.

The central division, the Appalachian Valley, is the best defined and most uniform of these divisions. In its southern part it forms the Coosa Valley of Georgia and Alabama and the Great Valley of Virginia and east Tennessee. Throughout its central and northern portions its eastern side only is marked by great valleys—such as the Shenandoah Valley of Virginia, the Cumberland Valley of Maryland and Pennsylvania, the Lebanon Valley of eastern Pennsylvania, and the Kittatinny Valley of New Jersey—the western side being a succession of ridges alternating with narrow valleys. This division ranges in width from 40 to 125 miles. It is rather sharply outlined on the southeast by the Appalachian Mountains and on the northwest by the Cumberland and Allegheny plateaus. Its rocks are almost wholly sedimentary and are in large measure calcareous. The strata, originally nearly horizontal, now lie at various angles and crop out in narrow belts. The surface features differ with the outcrops of different sorts of rock, so that steep ridges and narrow valleys of great length follow narrow belts of more and less resistant rock respectively. Owing to the large amount of calcareous rock in this district its surface is more readily denuded and is lower and less broken than that of the divisions on either side.

The next division toward the east is the Appalachian Mountains, a system, made up of many minor ranges, which, bearing various local names, extends from southern New York to central Alabama. Some of its prominent parts are South Mountain, in Pennsylvania; the Blue Ridge, in Virginia; the Great Smoky Mountains, in Tennessee and North Carolina; and the Cohutta Mountains, in Georgia. Farther east is the Piedmont Plateau, a vast upland which, as its name implies, lies at the foot of the Appalachian Mountains. From New York to Alabama it stretches eastward and southward from the base of the mountains to the Coastal Plain, which borders the Atlantic. The mountains and the plateau are separated by no sharp boundary but merge into each other. The same rocks and the same structures occur in each, and the form of the surface differs from place to place, largely in accordance with the ability of the streams to wear down the rocks. Most of the rocks of this division are more or less crystalline, consisting of metamorphic rocks of both sedimentary and igneous origin.

The western part of the Appalachian province comprises the Cumberland, Allegheny, and other plateaus, which are grouped under the general head of the Appalachian Plateau, and the lower plains bordering the Mississippi lowland. The northwestern boundary of this part of the province is indefinite but may be regarded as coinciding with the eastern margin of the Mississippi embayment as far north as Cairo. From that point it runs in a general northeastward direction across Illinois, Indiana, Ohio, and Pennsylvania into western New York. The eastern boundary is for most of its length sharply defined by the Allegheny Front and the Cumberland escarpment. The rocks of this division are almost entirely of sedimentary origin and remain nearly horizontal. The surface is that of a more or less completely base-leveled plateau. In the southern half of the division the plateau is in places extensive and perfectly flat, but most of it is divided by streams into large or small areas having flat tops. In West Virginia and parts of Pennsylvania the plateau is sharply cut by streams, which have left in relief irregularly rounded knobs and ridges that bear but little resemblance to the original surface. The western part of the plateau has been completely removed by erosion, and its surface is now comparatively low and level or rolling.

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

Each division of the province contains one or more culminating points. Thus the Appalachian Mountains rise gradually from less than 1000 feet in Alabama to more than 6700 feet in western North Carolina. Thence they decrease to 4000 or 3000 feet in southern Virginia, rise to 4000 feet in central Virginia, and descend to 2000 or 1500 feet on the Maryland-Pennsylvania line.

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

The plateau or western division increases in altitude from 500 feet at the southern edge of the province to 1500 feet in northern Alabama, 2000 feet in central Tennessee, and 3500 feet in southeastern Kentucky. Its height ranges between 3000 and 4000 feet in West Virginia and decreases to 2500 or 2000 feet in Pennsylvania. From its greatest altitude, along its eastern edge, the plateau slopes gradually westward, although it is generally separated from the interior lowlands by an abrupt though low escarpment.

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

The position of the streams in the Appalachian Valley is dependent on the geologic structure. In general they flow in courses which for long distances are parallel to the sides of the Great Valley, following the subordinate valleys along the outcrops of the belts of less resistant rocks. These longitudinal streams flow into a number of larger, transverse rivers, which cross one or the other of the barriers limiting the valley. In the northern part of the province the Hudson, Delaware, Schuylkill, Susquehanna, Potomac, James, and Roanoke are such transverse streams, each of which passes through the Appalachian Mountains in a narrow gap and flows southward or southeastward to the sea. In the central part of the province, in Kentucky and Virginia, the longitudinal streams unite to form New (or Kanawha) River, which flows northwestward in a deep, narrow gorge through the Cumberland Plateau into the Ohio. From New River southward to northern Georgia the Great Valley is drained by tributaries of the Tennessee, which at Chattanooga leaves the broad valley and, entering a gorge through the plateau, runs westward to the Ohio. South of Chattanooga the streams flow directly to the Gulf of Mexico.

Climate and vegetation.—The climate is very humid, the southern Appalachian Mountains being one of the regions of heaviest precipitation in the United States. The rainfall reaches a maximum in late spring and early summer and falls to a minimum in the autumn. Erosion is therefore rapid, and the streams carry large quantities of detrital material. In consequence of the abundant rainfall and in spite of the rather poor quality of the soil as a whole, vegetation grows rapidly and much of the region is heavily forested. The greater part of the cultivated land is in the plateau areas and along some of the main valleys.

As the general altitude of the region is greater than that of the Piedmont Plateau, most of the forest growth consists of broad-leaved trees, of which there are a number of species, and the pines are confined largely to the lower areas. The mountain tops are as a rule wooded, some being covered with open parklike growths of oak, chestnut, locust, and other large trees, others with dense thickets of sassafras and sumac. There are but few "balds." In Georgia, however, even the loftiest summits do not reach the altitudes favorable for the growth of balsams and spruces such as are found on the high mountains of North Carolina. As a rule the best timber grows on the northern slopes and in the coves, and that on the summits and southern slopes of the ridges is not so good. The mountain ravines and smaller valleys are crowded with a heavy growth of timber of many species, and in the more open country and along the larger streams elms, birches, and gums are abundant. The greater part of the Ducktown mining district is bare of forest, the trees and undergrowth having been killed by the fumes from the copper-smelting furnaces.

Stratigraphy.—The rocks of the southern part of the Appalachian province are in part of sedimentary and in part of igneous origin and range in age from Archean to Carboniferous. In general the oldest rocks crop out toward the east side of the region and the youngest toward the west, but on account of the deformation of the rocks and the relief of the surface there is much alternation of older and younger beds in any section across the region.

The rocks of the Piedmont Plateau and Appalachian Mountains are largely of igneous origin and are almost wholly crystalline. The sedimentary rocks are chiefly of Archean and early Cambrian age but include a few small masses of Ordovician and later rocks. In Virginia and North Carolina there are several areas of Triassic strata. Except those of Triassic age the strata of this region are greatly altered. The igneous rocks are largely Archean, but a few small masses are of early Cambrian age and some large bodies are regarded as late Carboniferous. Many gabbro and diabase dikes are of Triassic or later age.

The rocks of the Appalachian Valley are mostly sedimentary and range in age from early Cambrian to early Carboniferous, but the Silurian and Devonian systems are not well represented. The strata comprise limestone, shale, sandstone, and conglomerate, but the calcareous beds predominate.

In the Cumberland Plateau and the region west of it the rocks are also almost wholly sedimentary and of the same general age as those of the Appalachian Valley, but the earliest Cambrian rocks are not exposed and on the other hand the surface of the plateau is formed by Carboniferous strata younger than those exposed in the valley. Their lithologic character is also different, as sandstone and conglomerate make up a greater part of their bulk, at least in the plateau, and beds of coal are interstratified here and there.

Structure.—Three distinct kinds of structure occur in the Appalachian province, each prevailing in a separate area. In the Cumberland Plateau and the region lying farther west the strata are generally level and retain their original composition. In the valley the beds have been steeply tilted, bent into folds, broken by faults, and to some extent altered into slates. In the mountain and piedmont districts faults and folds are important features of the structure, but cleavage and metamorphism are equally conspicuous.

The folds and faults of the valley region are about parallel to one another and to the northwest shore of the ancient continent. They extend from northeast to southwest, and some are very long. Faults 300 miles long are known, and folds of even greater length occur. The crests of most of the folds continue at the same height for great distances, so that they present the same formations. Not uncommonly adjacent folds are nearly equal in height, and the same beds appear and reappear at the surface. Most of the beds dip at angles greater than 10°; in many places the sides of the folds are compressed until they are parallel. Generally the folds are smallest, most numerous, and most closely squeezed in thin-bedded rocks, such as shale and shaly limestone. Perhaps the most striking feature of the folding is the prevalence of southeastward dips. In some sections across the southern portion of the Appalachian Valley scarcely a bed can be found which dips northwestward.

Faults appear on the northwest sides of anticlines, differing in extent and abundance with the differences in the strata. Almost every fault plane dips southeastward and is about parallel to the beds of the upthrust mass. The fractures extend across beds many thousand feet thick, and in places the upper strata are pushed as far as 10 or 15 miles over the lower. In the central part of the valley of east Tennessee folds are generally so obscured by faults that the strata form a series of narrow overlapping blocks of beds dipping southeastward.

In the Appalachian Mountains the southeastward dips, close folds, and faults that characterize the Great Valley are repeated. The strata are also traversed by the minute breaks of cleavage and are metamorphosed by the growth of new minerals. The cleavage planes dip eastward at angles ranging from 20° to 90°, commonly about 60°. This phase of alteration is somewhat developed in the valley as slaty cleavage, but in the mountain region it is important and in many places obscures all other structures. All the rocks were subjected to this process, and the final products of the metamorphism of very different rocks may be indistinguishable from one another. Throughout the southern part of the Appalachian province there is a great increase of metamorphism toward the southeast, where the resultant schistosity is the most prominent of the secondary structures. Formations in that region whose original condition is unchanged are extremely rare, and in many rocks the alteration has obliterated all the original characters. Many beds that are scarcely altered at the border of the valley can be traced southeastward through greater and greater changes until every original feature is lost.

In most of the sedimentary rocks the bedding planes have been destroyed by metamorphic action, and even where they are distinct they are generally less prominent than the schistosity. In the igneous rocks planes of fracture and motion were developed, which, in a measure, made deformation easier. Along these planes or zones of localized motion the original texture of the rock was largely destroyed by the fractures and by the growth of new minerals, in many places this alteration extending through the entire mass of the rock.

General geologic record.—The rocks of the southeastern part of the Appalachian province—the general region in which the Ellijay quadrangle is situated—are in part of igneous and in part of sedimentary origin. With a few unimportant exceptions they fall into two fairly distinct groups—(1) igneous and metamorphic rocks, including gneiss, schist, granite, diorite, and similar formations; and (2) sedimentary strata of Paleozoic age. The former group is of greater areal extent and is in general the older. Some of the metamorphic rocks are very ancient, dating from the earliest known period, but it is thought that a part of the igneous rocks were formed after the sedimentary strata were deposited. The greater part of the rocks have been more or less metamorphosed, some of the older gneisses and schists having been so completely altered that their original character has been quite obscured.

From the relations of the formations and their internal structures much of their history can be deduced. Whether the igneous rocks were solidified within the earth's mass or upon its surface is shown by their structures and by their relations to the inclosing rocks. From the composition, texture, and structures of the sedimentary rocks much can be learned regarding the conditions of their deposition, as well as the conditions that existed on the land surface from which their constituents were derived. The attitude of the rocks indicates the extent and character of the deformation which they have undergone since their formation. Their metamorphism throws light on the magnitude and kind of the deforming stress, as well as on the other agencies, where there have been any, which have altered the original characters of the rocks.

The rocks themselves thus yield records covering a long time, beginning with the earliest geologic period and lasting until nearly the close of the Paleozoic era. In like manner much of the later history of the region can be deduced from its topography; the character of the surface, the distribution of the various forms of relief, the courses of the streams, and the nature of the surficial deposits are among the things that throw light upon the physiographic history of the region. The record in the general region under consideration may be briefly summarized as follows:

The earliest event was the formation of the great bodies of gneiss. Though evidently in part of sedimentary origin, the rock as a whole discloses but little of its original character, so that the conditions of its formation are buried in obscurity. During succeeding epochs masses of igneous rock were intruded into the gneiss. The time represented by these intrusions was probably long, as igneous rocks of several sorts were intruded and later masses cut the earlier.

Next followed a long period of erosion, during which igneous masses that had solidified at considerable depths in the earth's crust were laid bare by the general lowering of the surface and volcanic rocks were erupted upon the surface in some parts of the region. No volcanic rocks have been found in the immediate neighborhood of the Ellijay quadrangle.

After more erosion the greater part of the region was submerged at or near the beginning of the Cambrian period, and sediments that were derived from the waste of the more ancient rocks and that now form conglomerate, sandstone, shale, and limestone were laid down upon the older rocks that formed the sea floor. Deposition continued, with numerous interruptions, until well into the Carboniferous period. It was not everywhere continuous, however, for at times the land was in part uplifted, so that freshly deposited sediments were exposed to erosion. The sea occupied most of the Appalachian province and of the Mississippi basin. The position of the eastern shore line of the interior sea is known only for small detached stretches and probably varied from time to time within rather wide limits. At first the land continued to sink and the sea advanced eastward, so that areas which had furnished sediment for earlier strata were covered by later deposits. Later the sea probably withdrew some distance to the west, as no strata younger than Silurian are found east of the Great Valley. The area now included in the Ellijay quadrangle at first lay near the eastern margin of the sea, and the materials of which the sedimentary rocks of this quadrangle are composed appear to have been derived largely from land to the southeast. The sea appears to have withdrawn permanently from this area at an early date, as only strata of Lower Cambrian age are found in the quadrangle.

Toward the close of the Carboniferous period the land was again elevated and the sea withdrew permanently from practically all the Appalachian region. This elevation was accompanied by great deformation of the rocks of the eastern part of the province, which resulted in the formation of an extensive mountain system. As the land emerged erosion began again throughout the region and has continued to the present time, constantly tending to reduce the surface to base-level. Such reduction has been from time to time interrupted by further uplift, with some warping of the surface. The record is not complete, but evidently there have been several periods of erosion and in the earlier periods the surface was at least in large part reduced to base-level.

TOPOGRAPHY.

RELIEF.

General features.—The greater part of the Ellijay quadrangle is in the Appalachian Mountains, but its southeast corner is a part of the Piedmont Plateau. (See fig. 3.) The bold escarpment of the Blue Ridge, forming the southeastern boundary of the mountain belt, faces this plateau, and farther northwest is a country of diverse topography, characterized by a number of mountain ridges or groups, surrounding and separating interior basins whose surfaces lie at a fairly uniform general altitude but are more or less dissected by valleys several hundred feet deep. The Piedmont Plateau extends around the southern end of the mountain escarpment, and a reentrant lobe of it occupies the southwestern part of the quadrangle.

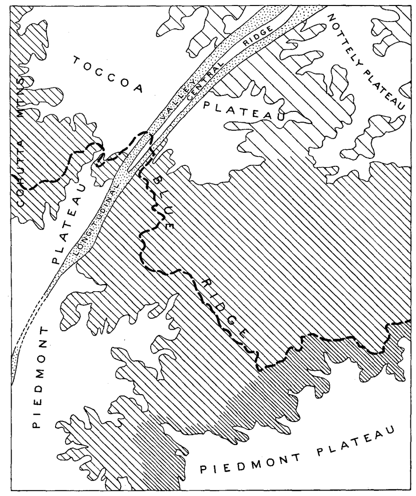


FIGURE 3.—Map of the topographic divisions of the Ellijay quadrangle.

Medium ruling represents the higher mountain groups, whose chief summits are over 3000 feet; open ruling, the lower mountain groups, whose chief summits are under 3000 feet; dense ruling, the Blue Ridge escarpment; unshaded areas, Piedmont and associated plateaus; stippled area, longitudinal valley.

The quadrangle thus exhibits a considerable diversity of surface and a variety of relief. The mountains rise 500 to more than 2000 feet above the general plateau level and the valleys of the main streams are sunk 300 to 500 feet below that level. In some of the lower mountain groups the topography is rather subdued and the slopes are comparatively gentle, but in the higher mountains the surface is very rough and the slopes are steep. The mountain crests are as a rule narrow and sharp and the peaks are small and abruptly rounded. The plateau areas are rather thoroughly dissected. The valleys of all but the largest streams are narrow and V-shaped, but the main rivers have narrow flood plains. The surface of the quadrangle, then, is generally sloping and includes only few and small level areas.

The mountain summits reach altitudes of 2200 to more than 4000 feet above sea level, all the principal peaks rising above 3000 feet. Big Bald, the highest summit in the quadrangle, near its center, attains an altitude of 4120 feet. The lowest point, which is probably in the valley of the Coosawattee below Ellijay, has an altitude of less than 1300 feet. The altitude of the plateau surfaces ranges from 1500 to 1900 feet.

Blue Ridge.—The escarpment which bounds the mountain belt on the southeast, and which is the continuation of the Blue Ridge of North Carolina, crosses the quadrangle from its eastern to its southern side and ends just south of the quadrangle in Grassy Knob, the southern end of the Blue Ridge escarpment. The crest of the escarpment rises to altitudes between 3500 and 3800 feet in the peaks, culminating in Springer Mountain at 3820 feet, and falls to altitudes between 2600 and 2800 feet in the gaps. The gap west of Amicalola Mountain is at only 2100 feet above sea level, not much higher than the plateau. Here and there a long spur projects a few miles southeastward into the lower country, but in general the face of the escarpment is steep and the surface falls abruptly to altitudes of 1900 feet or less at the base of the ridge. This escarpment is the most prominent topographic feature of the region and its higher points afford fine views embracing many miles of the Piedmont Plateau.

Back—that is, northwest—of the crest of the escarpment the topography is quite different. The surface is in general mountainous, the summits standing at about the same altitude as those of the Blue Ridge. It is broken here and there by the valleys of streams flowing northwestward but has no general slope in that direction. There is no escarpment on the northwest side of the "ridge," which is simply the sinuous divide between the streams flowing northwestward in the mountain valleys and those flowing southeastward down the face of the escarpment. Except in the neighborhood of Amicalola Falls this divide coincides with the crest of the escarpment.

In the Ellijay quadrangle the name Blue Ridge is applied to the divide between the streams that lie in the Tennessee drainage basin and those that flow more directly to the Gulf. This divide follows the Blue Ridge escarpment as far southwest as Springer Mountain, where it turns abruptly northwestward and runs for several miles along a high and bold ridge which culminates in the highest summits of the quadrangle. From

Rich Mountain it takes a general northward course and descends to the plateau level in the wide gap at Blue Ridge, where it again turns southwestward and westward and, rising abruptly, passes into the Dalton quadrangle along an eastern spur of the Cohutta Mountains.

Mountains.—The eastern and central portions of the quadrangle are wholly mountainous. The region is divided by the upper basin of Toccoa River into two general mountain groups, that of Wilscot Mountain and Duncan Ridge on the north, and that of the Blue Ridge on the south and west. The chief summits reach altitudes of 3000 feet or more, and four peaks attain altitudes of over 4000 feet. These are the four culminating points of the group of high mountains southeast of Cherrylog.

Burnt Mountain, a part of the Blue Ridge escarpment in the southwestern part of the quadrangle that is nearly isolated by the low gap west of Amicalola Mountain, and Grassy Knob, its prolongation southward into the Suwanee quadrangle, reach altitudes of about 3300 feet.

Several spurs of the Cohutta Mountains extend a few miles into the quadrangle along the northern part of its west side and the highest reach an altitude of 3500 feet. The northwest corner of the quadrangle lies on the southeast slope of Big Frog Mountain, a prominent range in the Cleveland quadrangle.

In the northern and northeastern parts of the quadrangle are several lower mountain groups and ranges, the ranges having a general northeast-southwest trend. Most of these mountains have rather gentle slopes and are low, only a few rising over 2500 feet above sea level, except a spur of Gumlog Mountain, in the northeast corner of the quadrangle, which has an altitude of 3060 feet.

Piedmont Plateau.—The southeastern part of the quadrangle forms a part of the Piedmont Plateau and slopes gradually southeastward from an altitude of 1800 to 1900 feet along the base of the Blue Ridge. The surface is much cut by valleys having a depth of several hundred feet, and but little level land is left in the interstream areas. Wissenhunt and Campbell mountains rise 400 to 500 feet above the surrounding plateau.

In the southwestern part of the quadrangle the basin of Cartecay River, although it lies behind the Blue Ridge escarpment, is continuous to the south and southwest with the main Piedmont Plateau, of which it may be regarded as a reentrant lobe. The plateau character of the surface of the basin is not very evident, as it ranges from 1600 to 1900 feet in altitude and is much cut by valleys, but there is more or less nearly level land in the interstream areas and the general altitude of the surface accords closely with that of the more definite plateau farther south. Talona Mountain, near the west side of the quadrangle, has an altitude of 2115 feet, rising about 500 feet above the plateau.

Intermontane plateau basins.—The chief of the interior plateau basins is the Toccoa plateau, which extends from the neighborhood of Morganton westward to the Cohutta Mountains and northwestward into Tennessee. Its surface is more or less dissected by valleys 200 to 400 feet deep, but as it lies at a fairly uniform general altitude of about 1800 to 1900 feet, and is nearly surrounded by mountains that rise 500 to more than 2000 feet higher, the Toccoa plateau or basin is one of the striking topographic features of the region.

A poorly developed plateau with a rather irregular surface lies in the basin of Ellijay River and Boardtown and Cherrylog creeks and forms a rude connection between the Toccoa plateau and the lobe of the Piedmont Plateau in the Cartecay basin. Its surface has a general altitude of 1600 to 1900 feet but is more or less hilly and is much cut by valleys.

A similar irregular plateau having a general altitude of about 2000 feet occupies a part of the basin of the Nottely, in the northeastern part of the quadrangle. It is much interrupted by hills and low mountains and appears to be continuous northward across Hiwassee River with the basin of Valley River in North Carolina—a rather large interior plateau.

The longitudinal valley.—A well-developed narrow longitudinal valley, whose floor is 300 to 400 feet lower than the adjacent plateau, extends diagonally across the quadrangle from Culberson, at its north side, nearly to Ellijay. Blue Ridge, Mineral Bluff, and Cherrylog are situated in this valley. Northeast of the Fannin-Gilmer county line the valley is double, consisting of two minor valleys which diverge northeastward to the State line, where they are over 2 miles apart. Southwest of Toccoa River the ridge dividing the valleys is low, nowhere rising more than about 150 feet above the floors of the valleys. Northeast of the Toccoa the central ridge is higher and bolder, and its summit reaches about the same altitude as that of the adjacent plateau.

This valley is not that of any single stream. As far southwest as Whitepath parts of it are occupied by short streams that flow either northeastward or southwestward into the main rivers. From Whitepath to a point a few miles beyond Ellijay the valley is very poorly developed, and, although followed for a few miles by the railroad, it is occupied only by small brooks. For a few miles south of Ellijay the valley is barely traceable, being simply a shallow depression across the general northwestward slope of the hills, but farther southwestward, in the Dalton quadrangle, it is again well developed and extends beyond Whitestone, in the valley of Talona Creek.

Character of surface.—The character of the surface differs greatly in different parts of the quadrangle. The plateau areas are nearly everywhere gently rolling, though here and there hills mantled with residual soil or with wash from the higher ground rise above the general level. Ledges are scarce, except along the streams or on the crests of some of the sharper ridges, and even the weathered rock is not as a rule well exposed except in road cuts and similar places. Most of the valleys have steep sides, but cliffs are rare except where lateral cutting by streams is now going on.

In some of the lower mountain groups the topography is subdued, the slopes are rather gentle, and the surface is largely covered with residual material, but in the higher mountains the surface is very rough, the slopes are steep, and ledges abound. Large surfaces of bare rock are, however, comparatively rare, and there are very few cliffs.

DRAINAGE.

Course.—All the drainage of the Ellijay quadrangle reaches the Gulf of Mexico but by three widely divergent routes. More than half of the area is drained northwestward into the Tennessee and nearly all the remainder southwestward into the Coosa-Alabama system, but a small part of the southeast corner is drained directly to the Gulf by the Chattahoochee system. The divides between the three drainage basins meet on the summit of Long Mountain, a peak of the Blue Ridge near the eastern border of the quadrangle.

Tennessee drainage.—Toccoa River, the principal stream, is formed near the eastern side of the quadrangle by the junction of several large creeks that drain the northern slope of the Blue Ridge and flows northwestward into Tennessee, where it bears the name Ocoee River. It drains about 412 square miles of the central and northwestern parts of the quadrangle, an area including all the northern slope of the Blue Ridge within the quadrangle. Its headwaters rise at altitudes of 2800 to 2900 feet and descend rapidly to about 2200 feet, where the main stream begins. For the first 20 miles of its course it has a grade of 12 to 15 feet to the mile, flows in a fairly open valley, and is bordered by a narrow flood plain of irregular width. Its principal tributaries in this upper portion of its course are Canada, Suches, Coopers, and Skeenah creeks from the east and north and Rock, Noontootly, and Big creeks from the south and west. Coopers and Noontootly creeks have narrow flood plains along their lower courses, but most of the other tributary streams have steep grades and rocky beds. Numerous small cascades and steep rapids alternate with quieter stretches. There are two cascades about 100 feet high, each known locally as High Falls—one on the lower course of an eastern tributary of Rock Creek, not far from Argo, the other, not shown on the topographic map, on a small branch of the Noontootly that flows down the southwestern slope of the John Dick Mountains.

At the west end of Wilscot Mountain the Toccoa enters a tortuous mountain gorge, through which it flows 9 miles to gain 2 miles of actual distance, with a grade approximating 20 feet to the mile. This part of the river is full of rapids and is bordered by steep slopes and many cliffs. Near the head of the gorge Stanley Creek enters the river from the southwest.

After emerging from the gorge, the river flows across the Toccoa plateau, in a valley 200 to 300 feet deep and leaves the quadrangle near the State line at an altitude of a little less than 1500 feet. In this part of its course it is again bordered by a narrow flood plain and receives the waters of Wilscot, Star, Hemptown, Hothouse, and Wolf creeks from the northeast, and of Charlie, Weaver, Sugar, and Fightingtown creeks from the southwest.

Nottely River drains about 125 square miles of the northeast corner of the quadrangle. It enters the east side of the quadrangle at a point northeast of Youngs Mountain and leaves the north side near Culberson, descending about 150 feet in the interval. Its channel lies about 200 to 300 feet below the surface of the plateau across which it runs and is bordered nearly everywhere by a narrow flood plain. Its chief tributaries within the quadrangle are Reece, Conley, Ivylog, and Moccasin creeks from the northeast, and Young Cane, Camp, Dooley, and Rapier creeks from the southwest.

Both Ocoee and Nottely rivers flow into the Hiwassee, one of the chief tributaries of the Tennessee from the southeast.

Coosa drainage.—Coosawattee River, which drains about 273 square miles of the southwestern part of the quadrangle, including all of the Piedmont Plateau lying back of the Blue Ridge escarpment but south of the Blue Ridge divide, is formed at Ellijay by the junction of Ellijay and Cartecay rivers. Each of those streams is formed by the junction of two large creeks, and each flows in a valley about 200 feet below the plateau level. Cartecay River has a rather steeper grade and a narrower valley, Ellijay River a lower grade and a wider flood plain. The chief tributaries of Cartecay River, in addition to Tickanetley and Anderson creeks, by which it is formed, are Pumpkin, Rolston, and Owltown creeks from the northeast, and Licklog and Turkey creeks from the southeast. Ellijay River is formed by the junction of Cherrylog and Boardtown creeks, in addition to which it receives Turniptown Creek from the east and Kells Creek from the north.

The southwest corner of the quadrangle is drained by several branches of Talking Rock Creek, which flows into the Coosawattee farther west, in the Dalton quadrangle.

Etowah River, another member of the Coosa-Alabama system, drains about 140 square miles of the southern slope of the Blue Ridge and of the main Piedmont area in the southern part of the quadrangle. Its source is at an altitude of about 2800 feet on the southern side of Hightower Gap, from which it descends to an altitude of about 1300 feet at the point where it leaves the quadrangle, where it has a well-developed but narrow flood plain. Like the other rivers of the area, it flows in a valley 200 to 300 feet below the surface of the plateau.

The principal tributaries of the Etowah within the quadrangle are Jones and Nimblewill creeks, both entering from the west. The southeastern slope of Amicalola and Burnt mountains is drained by branches of Amicalola Creek, which joins the Etowah farther south, in the Suwanee quadrangle.

All the streams flowing down the face of the escarpment have steep grades for a number of miles from their heads and several of them have rapids and small falls. The chief of these is Amicalola Falls, one of the principal waterfalls of Georgia and probably the highest, although its volume of water is small. It is situated on one of the headwaters of Little Amicalola Creek, which rises on the old plateau surface forming the crest of Amicalola Mountain, and it cascades down the steep southern slope for a vertical distance of about 600 feet, with one clear leap of about 100 feet. At Etowah Falls, near the head of the Etowah, two cascades, a short distance apart, have a total height of about 100 feet. There are smaller falls on other streams, especially on Jones and Nimblewill creeks.

Chattahoochee drainage.—An area about 30 square miles in the southeast corner of the quadrangle is drained by tributaries of the Chestatee, a branch of the Chattahoochee. There are small falls on both Cane and Clay creeks near the places where they flow from the harder rock of the Roan gneiss to the softer rock of the Carolina gneiss.

Drainage pattern.—All the rivers and some of the larger creeks, notably Fightingtown, Hothouse, Young Cane, and Nimblewill creeks, flow in very meandering courses, even where the valley has a depth of 400 to 500 feet, as in the gorge of the Toccoa near Wilscot, and at first sight they show little evidence of systematic arrangement. When considered as a whole, however, the streams of the northern half of the quadrangle exhibit a rough but noticeable conformity to a pattern of the sort known as "trellised" drainage. (See fig. 4.) Toccoa and

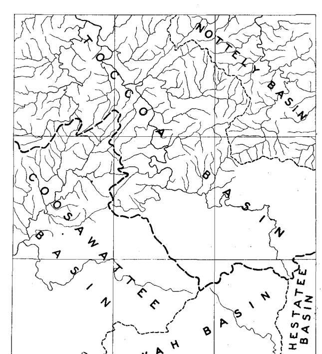


FIGURE 4.—Map of the drainage basins of the Ellijay quadrangle.

Shows also the smaller streams in the northern part of the quadrangle, illustrating to some degree a trellis system. The main divide, the Blue Ridge, is shown by heavy dashed line.

Nottely rivers, the trunk streams, flow in a general northwesterly direction. With few exceptions their tributaries flow northeast or southwest and join the main streams at approximately right angles, some of them having almost straight courses for several miles. Fightingtown, Hothouse, Cutcane, Star, and Young Cane creeks, which are apparent exceptions to the general rule, have departed from direct northeast or southwest courses by offsets to the northwest at approximately right angles to their general courses, but they still conform to a general trellised pattern.

Ellijay River and its tributaries show a less evident conformity to a trellised arrangement, and throughout the rest of the southern half of the quadrangle the streams show no conformity to a drainage pattern.

The arrangement of the streams in the quadrangle is in part the result of the geologic structure and of differences in hardness of rock, in part the result of the physiographic history of the region, as is explained under the heading "Geologic history" (pp. 10–12).

CULTURE.

Though nowhere densely settled, the quadrangle is practically everywhere inhabited, few areas being without houses. The rural population is, however, sparse, as agriculture is unprofitable in most of the area and in only a few places is there other means of livelihood to attract settlement. Owing to these conditions, to the ruggedness of the country, and to distance from main lines of travel, the quadrangle contains no large towns, the principal one being Blue Ridge, a railroad junction and the chief market town of the region. Ellijay and Mineral Bluff are smaller towns, the former, like Blue Ridge, being a county seat. The population is densest about Copperhill, which is the site of the smelters and the shipping point for the copper district and the chief industrial and commercial center of the quadrangle.

A branch of the Louisville & Nashville Railroad crosses the quadrangle from Copperhill to Ellijay and reenters at its southwest corner for a mile or two. Another branch traverses the northern part from Blue Ridge to Culberson. All parts of the area are reached by public roads, but owing to the character of the soil, the steep grades, the heavy rainfall, and the light travel most of the roads are poor. A few of the main roads, however, are maintained in good condition.

Agriculture is the chief occupation in the quadrangle, but the copper industry of the Ducktown district affords employment to a considerable population in the area about Copperhill, and more or less lumbering is done in the central and western parts. There is a large lumber mill at East Ellijay.

DESCRIPTIVE GEOLOGY.

STRATIGRAPHY.

AGE AND DISTRIBUTION OF THE ROCKS.

The rocks of the Ellijay quadrangle are in part of sedimentary and in part of igneous origin, all being more or less metamorphosed. In age they range from Archean to Cambrian. Rocks of later age are found in dikes cutting the Archean and Cambrian rocks, but with few exceptions the dikes are too small to be shown on the map.

The Archean rocks occupy the southern and eastern part of the quadrangle and the Cambrian rocks the northern and western part, including the longitudinal valley and all the area west of it. The two systems are not sharply differentiated, there being considerable doubt as to which system certain rocks represent, and several detached areas of rocks that are regarded as Cambrian lie within the area mapped as Archean. The rocks of the southeast corner of the quadrangle are probably the oldest; the latest are found along the longitudinal valley.

The various formations will be described in order of age, beginning with the oldest.

ARCHEAN SYSTEM.

CAROLINA GNEISS.

Distribution.—The Carolina gneiss occupies more than half the Ellijay quadrangle, lying in its central, southern, and eastern parts. It is named from its great extent in North and South Carolina and is the oldest formation in the region. Inclosed within it are numerous bodies of igneous rock, generally too small to be shown separately on the map.

General character.—The formation consists of an immense series of interbedded mica gneiss, garnet-kyanite gneiss, mica schist, quartz schist, garnet schist, conglomerate, kyanite-graphite schist, and fine granitoid layers, mostly light gray to dark gray and weathering dull gray or greenish gray. Layers of granitic material and lenses of pegmatite are abundant in some parts of the formation. In this quadrangle the greater part of the formation consists of mica schist, quartz schist, garnet schist, and conglomerate, but in the east-central part of the quadrangle the more strictly gneissic and banded beds are more numerous and the intercalated granitic layers occur.

The pebbles of the conglomerate beds are as a rule small and more or less scattered, and the rock ought perhaps to be called pebbly sandstone or sandstone with pebbly layers. The genuine pebbles are composed of quartz, but many beds contain apparent pebbles of feldspar which are uncrushed and probably of later origin than the groundmass of the rock and which are believed to be due to impregnation of the rock by a granitic magma. The schists are composed largely of quartz, with which is associated some sericite and as a rule some biotite and a little feldspar. Some varieties are composed almost wholly of quartz, some contain much biotite, and others include a great deal of garnet.

The schists are as a rule of fine grain and even texture, with the minerals uniformly distributed, and show marked schistosity. The beds range from a few inches to many feet in thickness. The gneisses are generally rather fine grained but well banded, the layers averaging less than an inch thick. Some of the granitoid layers are composed of quartz and feldspar only, but most of them contain more or less biotite and some muscovite.

Black schists.—In the northeastern part of the quadrangle there are numerous exposures of blackish, dark-gray, or bluish-gray schist, as a rule easily recognizable, but so involved in the Carolina gneiss that they are regarded as a part of that formation. There appear to be at least four or five beds, distributed through a vertical range of several thousand feet, and individual beds split up and taper off between layers of the gneiss, so that it is difficult to map them separately. For this reason they are shown on the map without definite boundaries.

These schists are composed largely of quartz, with a very little feldspar and some mica, and in most places enough graphite to give them a distinctive dark color. Garnet appears in many beds, and in places kyanite is abundant, the largest crystals measuring an inch or more in length. The schists are characterized by a silky luster and generally by a fine curly or crinkly texture, with a marked schistosity. In some places graphite is nearly or quite wanting and the schist is brownish or yellowish.

Garnet-kyanite gneiss.—A garnet-kyanite gneiss occurs abundantly, interbedded with conglomerate, in the area from Duncan Ridge on the northeast to Double Head Gap and Springer Mountain on the southwest. It is a coarse-grained dark-gray gneiss, with numerous small garnets, generally less than one-eighth inch in diameter, and abundant kyanite crystals, the largest one-half inch or more in length. It is very tough and exceedingly resistant to weathering, so that it has produced some of the roughest topography in the quadrangle. It is everywhere interbedded with other types of gneiss and is not shown separately on the map.

Pegmatite.—In the area mapped as Carolina gneiss are many veins and lenses of pegmatite, from a foot to over a hundred feet thick, and in places a mile or more long. They are in general parallel to the foliation of the gneiss but in many places cut it obliquely.

The pegmatite is made up of coarsely crystalline quartz, feldspar, muscovite, and biotite; at some places the micas are lacking, at others muscovite occurs in sheets several inches in diameter, and some merchantable mica has been mined at those places.

The pegmatite bodies are roughly grouped in three general areas. The largest lies on both sides of the Blue Ridge, in the eastern part of the quadrangle, between Campbell Mountain on the south, John Dick Mountains on the west, and Duncan Ridge on the north. The pegmatite of this area contains little biotite but a great deal of muscovite, and all the mica prospects are in this area. Another area of pegmatite dikes is in the northeastern part of the quadrangle, in the basin of Nottely River. In these dikes biotite is abundant, and muscovite, though in excess of the biotite, is in small crystals and does not reach the large development of the first area. The third area of pegmatite bodies is in the southwestern part of the quadrangle, in the basin of Cartecay River. In these pegmatites both micas are subordinate or lacking and the rocks are as a rule fine grained, but in places the feldspar crystals are large and there are some deposits of kaolin resulting from the weathering of the feldspar.

The pegmatite bodies are believed to belong to the same period of intrusion as the muscovite-biotite granite and to be of post-Cambrian age, but on account of their small size and irregular shape only one or two of the largest are separately mapped, the others being included with the Carolina and Roan gneisses, in which all of them occur.

Origin and metamorphism.—The Carolina gneiss occupies a greater area than any other formation in the region. On account of the uniform character of the rock throughout large areas and the great amount of folding and metamorphism which has occurred no true measure of its thickness can be obtained, and even estimates are worthless. It is apparently of enormous thickness, but beyond this nothing can be said. In the Ellijay quadrangle, except for the intercalated granitic layers, nearly the whole formation appears to be of sedimentary origin and much of it is certainly so. In a belt several miles wide, which enters the quadrangle from the east, in the basin of Coopers Creek, and trends southwest past Gaddistown to Hightower and Winding Stair gaps and thence southward to the southern border, the rock appears to be of igneous origin, but this is uncertain, owing to its extreme metamorphism.

Whatever the origin of the formation, the rocks evidently have been subjected to at least two periods of extreme deformation. In the first period their mineral character was thoroughly altered, metamorphic minerals were formed, and foliation was produced; in the second the earlier structures were deformed and in places new foliation planes were superposed on them. Possibly there were other still earlier deformations, but the metamorphism has been so great that it obliterated the original character and structures of these rocks, and little or nothing can be learned of their original attitude or earlier history.

The minerals now present were probably all formed during the metamorphism and are generally arranged with their greater dimensions parallel to one another and to the different layers, hence the schistosity of the rock. The coarser conglomeratic and granitic layers are the least and the mica schists the most schistose.

Weathering and soils.—The foliation of much of the Carolina gneiss permits its rapid disintegration, so that as a rule the rock is deeply weathered and solid ledges are rare except along streams and on steep slopes. The garnet-kyanite gneiss resists weathering more effectively and remains more generally in ledges.

The disintegration of the schists, which contain relatively little soluble material, produces light, poor, and thin sandy soils filled with bits of rock and vein quartz, flakes of mica, and other insoluble particles. The conglomerates, the gneisses, and the granitic layers, which contain more feldspar and other soluble material, form a heavier and richer soil, including considerable residual clay. The garnet-kyanite gneiss makes the poorest soil and its areas are thickly strewn with residual bowlders. As a whole the soils of the Carolina gneiss area are poor and relatively unproductive, though much fine timber grows on some of the mountain slopes where the rock is nearer the surface and the soil is fresher and more rapidly renewed.

ROAN GNEISS.

Distribution.—The Roan gneiss forms a number of long narrow lenticular or sheetlike bodies, inclosed by Carolina gneiss, in the southeastern part of the quadrangle. These bodies range in thickness from a few feet to several hundred yards and some of them have a length of several miles. Many are branched, some branches at length reuniting, and in places the sheets are complexly folded. Their dikelike form and their position in the Carolina gneiss, which surrounds them, indicate that they are later than that formation and were intruded into it, but the rocks are so much metamorphosed that the contacts throw no light on that point.

The formation is named from Roan Mountain, on the boundary line between Tennessee and North Carolina.

Character.—The Roan gneiss consists essentially of hornblende schist, hornblende gneiss, and schistose diorite. The areas mapped as Roan include intercalated mica gneiss, mica schist, and garnet schist, differing in no essential from the Carolina gneiss and being presumably part of that formation but too small to be shown separately. Similarly, very small bodies of the hornblendic rocks are not shown on the map, and there is so much interlamination of the two formations along the borders of some of the larger bodies that the boundaries as drawn have also been generalized to show substantially the mean positions of the contacts.

The rock of the Roan gneiss is largely and in many places almost wholly hornblende, in crystals from one-tenth inch to one-half inch long, with very subordinate amounts of quartz and feldspar and in some places biotite. The hornblende schist is of uniform composition even in masses of considerable thickness. The hornblende gneiss is formed of layers having essentially the same composition as the schist, alternated with thin layers composed of quartz and feldspar. In a few places, especially in the valley of Clay Creek, in the southeast corner of the quadrangle, the rock is nearly massive, having but little schistosity, and has the composition of hornblende diorite with the addition of some quartz, probably metamorphic.

Bodies of pegmatite, such as are described under the heading "Carolina gneiss," cut the Roan gneiss in the same manner.

Metamorphism, weathering, and soils.—The Roan gneiss has evidently been subjected to great deformation and metamorphism, but the extent of its alteration is uncertain because the original character of the rock is not known. Apparently, however, the rock was originally diorite and hornblendite, of much the same mineral composition as at present, hence it has been altered in textural character rather than in mineral composition. The minerals now composing the rock are, however, largely of secondary formation and are arranged in parallel layers or with their longer diameters parallel, causing the schistosity. The planes of schistosity are deformed, and the rock gives the same evidence as does the Carolina gneiss of having passed through at least two periods of considerable deformation. The bands of quartz and feldspar in the hornblende gneiss were evidently formed after the earlier and before the later deformation.

The weathering of the Roan gneiss is peculiar. Its more siliceous layers as well as the harder hornblende schists that it contains are extremely slow of disintegration, and the rock thus crops out in massive ledges and the areas where it occurs are thickly strewn with residual material. It is in general, however, less resistant to erosion than the Carolina gneiss, so that in many places it forms hollows between areas of that formation.

The final product of its decomposition is a dark-red or yellowish-brown residual clay of considerable depth, giving rise to a richer soil than that found in most of the mountain region, though this soil is full of small fragments of the rock, which must be removed before it can be cultivated to the best advantage.

PYROXENITE, DUNITE, AND SERPENTINE.

Distribution and relations.—A few small bodies of olivine-bearing rocks are found in the areas of Roan gneiss, principally south of Cooper Gap and in the valley of Cane Creek, on the south side of the Blue Ridge, and near Sarah on the north side.

The relation of these rocks to the Roan gneiss is not displayed in the Ellijay quadrangle but is suggested in quadrangles farther northeast, where such rocks appear to cut the layers of that formation and hence to be of later age. However, the evidently close association and lithologic affinities of the two sorts of rocks and the fact that the peridotitic rocks are not found except in areas where the Roan gneiss is abundant make it highly probable that they are of nearly the same age as that formation and are presumably differentiates from the same magmatic reservoir. Furthermore, they have been as greatly deformed as the Carolina and Roan gneisses and therefore are assigned to the Archean, as are those formations.

Character.—The assemblage comprises several sorts of rock, such as pyroxenite, picrite, dunite, and serpentine. The most common variety in the Ellijay quadrangle is a rock intermediate between pyroxenite and picrite. It is composed essentially and very largely of pyroxene, chiefly monoclinic but with subordinate amounts of enstatite, and contains more or less olivine, in places sufficient to make the rock a variety of peridotite. Among subordinate minerals magnetite is common and in some localities the rock contains more or less biotite. No chromite was found, but there are indications that some of the pyroxene is of a chromiferous variety, and it is possible that the rock contains chromite which was not distinguished from magnetite.

A little dunite, composed almost wholly of olivine, has been observed at two localities. The walls of the dunite dike on the long spur running south from Long Mountain are massive serpentine.

Alteration and weathering.—Talcose soapstone has been formed by the alteration of similar rocks at various places in quadrangles farther northeast, but none has been seen in the Ellijay quadrangle. The minerals are largely altered to chlorite, bastite, iddingsite, iron oxides, and the like, but no considerable amount of talc has been noticed. Except for such alteration products, the minerals which the rocks now contain are very similar to those of the original rocks. The serpentine may or may not be the result of regional metamorphism; no definite information on that point can be obtained.

These rocks are very resistant to weathering, because of the stability of the constituent minerals. As a consequence they stand up everywhere as ledges, and their exposures are larger in proportion to their mass than those of any other formation of the region. Both the individual areas of the rock bodies and the total area they occupy are so small as to produce no appreciable effect on the soils.

GRANITE.

There are three small areas of granite in the southeastern part of the quadrangle, two lying wholly within it, the third crossing the corner. The rock is a medium-grained biotite granite, composed of quartz, orthoclase, and biotite, with more or less plagioclase and magnetite; in the one thin section examined there is also considerable augite. The rock is gneissic and schistose, and has undergone thorough metamorphism. Much if not all of the quartz and mica has been recrystallized, and the mica having developed in nearly parallel flakes has given the rock much of its schistosity.

The granite is intrusive in the Carolina and Roan gneisses. This is also true of several other granites in the Appalachian Mountains. As the granite here exposed is not directly connected with other granites, it can not be correlated with any of them. There is reason to think it may be of the same age as the Cranberry granite of North Carolina. It is believed to be Archean, for it is intruded only in Archean rocks and has undergone the same deformation and substantially the same amount of metamorphism as the other Archean rocks of the region.

The granite weathers slowly, producing topographic forms similar to those of the Carolina gneiss. The final product is a light-yellow or red clay soil containing much fine mica and quartz.

CAMBRIAN SYSTEM.

GENERAL FEATURES.

The stratified rocks of Cambrian age in the Ellijay quadrangle are part of a great group of alternating sandstones and shales, upon which lies an immense thickness of limestones and shales that occupy large areas in the southern Appalachians. Fossils of Lower Cambrian age, chiefly *Olenellus*, are found as far down as the middle of this group of strata in quadrangles north of the Ellijay. The strata below the fossiliferous beds differ in no material respect from those beds. All were formed under the same conditions and all are part of the same group and are closely associated in distribution and in structure. The lower, nonfossiliferous beds constitute the Ocoee group of Safford.

The Cambrian rocks of the Ellijay quadrangle are part of Safford's Ocoee group. Until recently the age of these rocks was not known, although they were regarded as possibly of Algonkian age, but they are now assigned to the Cambrian on evidence gathered in quadrangles farther north and east, particularly in the Nantahala, Knoxville, Mount Guyot, Asheville, and Roan Mountain quadrangles. The evidence includes the structural position, lithologic details, and stratigraphic sequence of the formations, and the results of tracing recognizable beds throughout the region from points where their age is known, as in the Roan Mountain quadrangle.

It has thus been ascertained that the lower formations extend from northeastern Tennessee, where their relations and age have been determined, through western North Carolina into Georgia, and form the bulk of the stratified rocks of the Ellijay quadrangle. The upper formations, which are somewhat different in North Carolina from those of the same age in Tennessee, are almost absent from the Ellijay region.

Most of the Cambrian formations are rather thinner in the southern part of the Ellijay quadrangle than in the northern part, and three of them disappear southward within its limits. This disappearance is probably due chiefly to thinning out of the original deposits but not wholly, for it occurs invariably along fault lines, and there is a possibility that one of the three formations occurs again farther south, in the Suwanee and Cartersville quadrangles. One or two of the other formations appear to be thinnest in the region between Ellijay and Talona, and to be thicker again farther south.

The beds show also a marked difference in lithologic character from north to south. At the north they are more massive and contain more siliceous material, at the south they are more slaty, schistosity is more pronounced, there is less siliceous material, metamorphic minerals are more abundant, and, in several formations, graphite is a common constituent. This difference is partly due to greater metamorphism at the south, but there is also a general progressive change from coarse to fine in the texture of the rocks, conglomerates being abundant at the north and rare at the south.

Owing to thrust faulting parallel to the strike, there is nowhere in the quadrangle an entire section of the Cambrian strata, nor even any place where all the formations occur in normal sequence. Hence the determination of the succession of the formations and of their structural relations is exceedingly difficult; in fact, it is impossible from knowledge gained only in the Ellijay quadrangle. But in the Nantahala quadrangle, farther northeast, where the formations do occur in normal sequence, their succession and relations have been determined, and they have been traced from there into the Ellijay quadrangle.

GREAT SMOKY FORMATION.

Distribution.—The Great Smoky formation occupies about one-fourth of the quadrangle, including (1) all that part lying northwest of the longitudinal valley, (2) a narrow belt on the east side of the valley, extending the length of the quadrangle, (3) several small bodies infolded in the Carolina gneiss, and (4) a small area in the extreme southwest corner of the quadrangle.

Name and correlation.—The name of the formation is derived from that of the Great Smoky Mountains of North Carolina, where it is extensively exposed. The formation corresponds in position and general character to the Cochran conglomerate, which occurs in areas northwest of those mountains, but differences in bulk and in the sediments subsequently deposited have made it advisable to distinguish the two. It is possible that the Great Smoky represents a greater period of time than the Cochran.

Character.—The formation contains a variety of rocks, including conglomerate, graywacke, sandstone, quartzite, slate, mica schist, garnet schist, staurolite gneiss, and biotite gneiss. The original character of the beds is sufficiently plain in all the varieties, except possibly the staurolite gneiss, but it is plainest in the conglomerates and sandstones. The beds of the various sorts of rocks range in thickness from a foot to 50 feet, and all except the slate are decidedly gray, becoming lighter or whitish on exposure by the weathering of the feldspar that they contain. The staurolite gneiss is dark gray, its darker shade being probably due to graphite or carbonaceous material.

Conglomerate is more abundant in the northern part of the quadrangle and practically disappears toward the south. As a rule the pebbles are small, few of them over one-half inch long, and almost invariably much flattened by pressure. Although pebbles of white quartz predominate, feldspar pebbles abound, and some beds contain a few small pebbles of blackish slate. A coarse conglomerate, with pebbles but little flattened, and nearly everywhere containing staurolite, is found a short distance below the top of the formation as far south as Cartecay River, beyond which it disappears.

Much of the formation in the northwest part of the quadrangle consists of characteristic bluish graywacke containing a great deal of mica and many small feldspar pebbles which have the appearance of phenocrysts. The rock is completely recrystallized and has not only the texture but has to a considerable extent the composition and exhibits the characteristic weathering of an intrusive igneous rock, for which it might easily be mistaken. Lithologically this graywacke is almost identical with that which constitutes a large part of the Carolina gneiss.

The staurolite gneiss has a rather fine grained schistose matrix of quartz and mica, colored with some dark material and crowded with staurolite crystals, averaging rather more than 1 inch long by about two-thirds inch wide and one-third inch thick. So abundant are the crystals that the residual soil along the outcrop of this rock is composed largely of them and in places on some of the small saddles along the crest of the ridge from Chestnut Gap to McKenney Gap they cover the surface. In the general region between Chestnut Gap and Pierceville there are two belts of garnet schist in which staurolite crystals, some of great size, occur.

The spangled biotite gneiss, with beds of conglomerate, forms the uppermost 5000 to 6000 feet of the formation, practically the whole thickness of the formation in the areas east of the valley. It is a peculiar rock, having a fine-grained groundmass which is a network of small grains of quartz and flakes of muscovite, with some magnetite, a little feldspar and biotite, and alteration products. Embedded in this matrix are many small garnets, a few small scattered crystals of staurolite, and a great number of crystals of biotite. The biotite crystals are in general from one-tenth to one-eighth inch in diameter, a few having a diameter of one-fourth inch or more. They differ from the ordinary biotite crystals of metamorphic rocks in occurring in tabular or prismatic forms of a thickness approximately the same as their diameter and in lying in all positions in the rock instead of being oriented parallel to the schistosity or to the bedding planes. Both the biotite and the garnet crystals have surrounded and inclosed, during their formation, many grains of quartz and magnetite exactly like the grains of the groundmass. Many of the biotite crystals also contain numerous circular or elliptical dark-brown spots, which are highly pleochroic and which surround very small crystals, probably of zircon. These spots or pleochroic halos are believed to be due to discoloration of the biotite by the radiations from a very minute quantity of some radioactive element, probably thorium, in the zircons. The matrix of the comparatively fresh rock is grayish brown, and as the biotite crystals are shining black or dark brown, they are very conspicuous and give the rock a characteristic spangled appearance. The matrix of the weathered rock is as a rule yellowish gray or of a creamy tint and the biotite crystals weather brassy yellow.

Interstratified with the coarser rocks are numerous beds of mica schist and slate, making up a large part of the bulk of the formation along and near the western side of the quadrangle. These beds are light and dark gray, and near the western margin of the quadrangle they are very dark and contain considerable graphite, so that they are with difficulty distinguished from similar beds of the Nantahala slate.

The Great Smoky formation shows a decided difference in lithologic character not only from northeast to southwest, along the strike, but also on the two sides of the longitudinal valley separating its eastern and western areas. In the eastern areas the formation is composed almost wholly of conglomerate and spangled biotite gneiss; the sandstone, graywacke, mica schist, and slate which are abundant in the western area being rare or absent.

Thickness.—In the eastern areas the base of the formation rests on the Carolina gneiss but is extremely difficult to determine, for the Carolina is there composed of graywacke and conglomerate that are practically identical lithologically with a large part of the Great Smoky. No definite basal conglomerate has been found, nor any surface of unconformity, and the two formations have been separated more or less arbitrarily and on theoretical grounds. It is entirely possible that some of the rocks mapped as Carolina are in reality Great Smoky, as it was found impossible to draw boundaries anywhere in the eastern areas that would sharply separate the two formations. The balance of probability favors the view that all the questionable rocks are Carolina, hence the boundary has been drawn at the base of the beds that are distinctly conglomerate and spangled biotite gneiss, and the Great Smoky has been limited to the rocks above that horizon. This seems to be the best plan of separation under the circumstances, as it leaves fewer matters open to question than any other plan. The lower limit of the Great Smoky thus established includes several detached areas of conglomerate and spangled gneiss surrounded by Carolina gneiss, and it is possible that some smaller areas have not been recognized.

The base of the Great Smoky formation is nowhere exposed in the Ellijay quadrangle west of the longitudinal valley, but it is found farther northwest, in the adjacent quadrangles, where it is marked by a massive conglomerate. No Carolina gneiss is known in that area, however, the conglomerate being underlain by the Hiwassee slate, a Cambrian formation, which, in turn, is not exposed east of the valley.

The uncertainty as to the position of the base of the formation on the east side of the valley and the probably considerable folding of the rocks on the west side—folding that can not be worked out in detail because of the absence of distinctive beds—make it impossible to do more than estimate the thickness of the Great Smoky. The best data obtainable indicate that its thickness is 6000 to 6500 feet throughout most of the quadrangle and that it probably diminishes to 5000 feet, or perhaps less, at the southern margin of the area.

Metamorphism.—The rocks of the formation are very greatly metamorphosed, many of them having been completely recrystallized. The sandstone and quartzite are altered least, but secondary sericite is a common constituent of all the rocks examined, and in many specimens it makes up at least half of the bulk of the rock. The beds of graywacke are so greatly changed in many places as to have lost nearly every trace of their sedimentary origin and to have become so like metamorphic igneous rocks as to be mistaken for them. The same degree of alteration has occurred in much of the mica schist. So far as megascopic characters go, the spangled gneiss and the staurolite gneiss bear little resemblance to sedimentary rocks. The conglomerates, too, are extensively altered, the pebbles nearly everywhere being flattened and in several places stretched to several times their original proportion of length to thickness. Much secondary mica has been developed, many of the pebbles being coated with sericite or damourite. Staurolite and garnet are common minerals in the conglomerates.

The deformation of the Great Smoky formation has been enormous, and evidence is found of more than one period of deformation. Throughout wide areas all vestiges of the original bedding planes are nearly or quite obliterated, and in places later secondary structures are superposed on earlier ones. For example, in localities near Santaluca there are still traces of the original bedding of the fine-grained graywacke or micaceous quartzite. The beds were folded and schistosity was developed. A later deformation folded and crinkled the planes of schistosity and produced a marked slaty cleavage, now the most prominent structural character of the rock, and last of all joints that cut the rock at various angles were formed. Substantially the same sequence of events is recorded in structures found in mica schist and slate in the valley of Hothouse Creek.

Weathering and soils.—The rocks of the Great Smoky formation differ greatly in their resistance to erosion and in the resultant topographic form. The conglomerate, staurolite gneiss, and biotite gneiss, being composed of relatively resistant minerals and having a more massive structure, as a rule form ridges and mountain groups. The highest mountains in the quadrangle, with four summits attaining heights above 4000 feet, are formed by a great mass of conglomerate and spangled gneiss, and the group of mountains northwest of Santaluca are formed by conglomerate and staurolite gneiss. The graywacke, mica schist, and slate, on the other hand, are much less resistant and nearly everywhere occupy relatively low ground.

The graywacke breaks up almost completely and gives rise to a rather sandy soil containing more or less residual clay. The schists and slate give rise to a clay soil full of mica flakes. The soils of the areas occupied by these less resistant beds are as a rule rather poor. The coarser and more resistant rocks produce a stronger and richer soil, on which some of the best timber of the region grows, but the steep slopes and rugged topography of areas occupied by these more resistant rocks and the many residual bowlders strewn upon their surface render them difficult to cultivate.

NANTAHALA SLATE.

Distribution.—There are three areas of Nantahala slate in the quadrangle. The largest is a narrow belt extending along the east side of the longitudinal valley from the north side of the quadrangle, near Laudermilk Ford, southwestward to Talona Mountain, and thence southward to the valley of Fisher Creek, where it turns southeastward and passes out of the quadrangle about 2 miles west of Sharptop Mountain. Another strip, roughly parallel to the first, extends along the west side of the longitudinal valley from a point about a mile west of Culberson to a point about 4 miles south of Ellijay and reenters the quadrangle in its southwest corner. A third and much smaller area occupies the northeast corner of the quadrangle.

Name and thickness.—The formation is named from Nantahala River, in North Carolina, along which it is finely exposed. In the Ellijay quadrangle it ranges in thickness from about 2000 feet at the north side to about 1000 feet at the south side of the quadrangle, but its thickness is probably somewhat irregular.

Character.—As far south as the neighborhood of Ellijay the Nantahala slate is composed principally of blackish or dark-gray banded clay slate containing considerable finely disseminated graphite and iron oxide, which give the rock its color. It contains a few thin beds of white or light-gray quartzite and, at its base, a considerable thickness of banded garnetiferous and staurolitic quartz schists. These basal beds are best developed farther northeast; they are inconspicuous south of Cherrylog. From Ellijay southward the formation is of somewhat different character, being chiefly graphitic schist with more or less staurolite throughout its thickness and containing few or no siliceous beds.

Because of its uniform character throughout very thick beds and of the homogeneity of its texture the Nantahala slate does not show deformation so extensive as that of the underlying formations. In the northern part of the quadrangle the amount of alteration it has undergone appears to be comparatively small, being confined to the formation of some metamorphic minerals. Farther south, with the increase in proportion of foliaceous minerals, schistosity has been strongly developed and the metamorphic minerals are more widely distributed.

Weathering and soils.—These rocks do not break up very rapidly but are too soft to stand much wear, and hence outcrops, though abundant, are generally low and rounded, rising but little above the surrounding soil. The Nantahala is rather more resistant than the beds of the Great Smoky formation that immediately underlie it and nearly everywhere forms a low, rather inconspicuous longitudinal ridge. In the southern part of the quadrangle the more schistose character of the rock has rendered it less resistant to erosion, so that it there occupies the slopes below the plateau level.

The disintegration of this formation produces a stiff yellowish-brown or blackish-brown clay soil which, though badly washed by rains, seems to be somewhat more fertile than the average soil of the region.

TUSQUITEE QUARTZITE.

Distribution.—The Tusquitee quartzite forms two narrow belts along the slopes of the longitudinal valley, adjacent to the belts of Nantahala slate, along the valley rims. The eastern strip is interrupted for several miles in the neighborhood of Blue Ridge and ends southward just north of Cartecay River. The western strip narrows gradually and ends about 3 miles northeast of Ellijay. The quartzite has not been seen south of Cartecay River.

There is also a narrow strip in the northeast corner of the quadrangle, south of the area of Nantahala slate, and several slender lenses are inclosed in the Nantahala northeast of Jonica Gap.

Name and thickness.—The formation is named from the Tusquitee Mountains, in the Nantahala quadrangle, where it is well exposed. In the Ellijay quadrangle it is 500 to 600 feet thick throughout most of its extent, but south of Cherrylog it diminishes in thickness and it disappears between Whitepath and Ellijay. Its disappearance is in large part due to faulting, but as the formation is not known to occur south of Ellijay the deposit forming it probably tapered out in about that latitude.

Character.—The formation consists almost wholly of white quartzite of very uniform texture and appearance, and it is one of the most easily recognized and definitely determinable formations in the region. It is composed chiefly of fine-grained quartzite, with more or less feldspathic material in some beds, but in a few localities it includes thin beds of fine conglomerate. In the northern part of the quadrangle there are a few interbedded layers of dark-gray slate similar to that of the Nantahala formation. Owing to the certainty with which the Tusquitee can be recognized, its persistent uniformity in character, and its conspicuous difference in color from the adjoining formations, it is a useful key rock in unraveling the stratigraphy of the region, particularly in much-folded areas in quadrangles farther northeast.

Metamorphism and weathering.—In the Ellijay quadrangle the Tusquitee shows comparatively little effect of metamorphism beyond silicification and induration. It has undergone no extensive deformation and is little or not at all schistose. A great deal of it is comparatively thin-bedded, and a cleavage parallel to the bedding has been developed in it in most places, but it shows slight folding.

The rock resists erosion rather strongly, but as it is well bedded and is therefore easily penetrated by water along the bedding planes it is much broken by the action of water and frost. It is therefore considerably less resistant than the Nantahala slate and is nearly everywhere found along the slope below that formation. Owing to the narrowness of the outcrop of the Tusquitee and to its general occurrence on slopes, its effect on the soils of the region is negligible.

BRASSTOWN SCHIST.

Distribution.—The Brasstown schist occupies several long, narrow areas adjacent to the strip of Tusquitee quartzite along the east side of the longitudinal valley. The largest area enters the north side of the quadrangle about 3 miles east of Culberson and extends nearly to the Toccoa. A second area begins just south of Blue Ridge and extends beyond Cherrylog, and a third extends from Whitepath nearly to the Cartecay. The formation is not known south of that river.

A small area on the west side of the valley enters the quadrangle west of Culberson and extends to Sweetgum, and a small triangular area lies in the northeast corner of the quadrangle.

Name and thickness.—The formation is named from its type locality on Brasstown Creek, in the Nantahala quadrangle. In the Ellijay quadrangle it reaches a maximum thickness of about 1500 feet, but it is probably thinner in places. Its disappearance southward is due primarily to faulting, but, like the Tusquitee quartzite, it presumably was not deposited south of the latitude of Ellijay.

Character.—The formation consists of banded slate and ottrelite schist, chiefly dark bluish or bluish gray, though some of the more siliceous layers are lighter. In general the ottrelite schist is in the upper part of the formation, and the slate without ottrelite is in the lower part. In the Ellijay quadrangle the formation occupies relatively small and disconnected areas and is of minor importance in the stratigraphy, but in quadrangles farther northeast it underlies large areas and is an important formation.

The principal results of metamorphism are the recrystallization of the minerals and the production of the schistosity. The beds are not greatly deformed, and, as in the Tusquitee quartzite, a fair degree of cleavage has been developed parallel to the bedding. The most noticeable effect of metamorphism is the development of the ottrelite by which so much of the formation is characterized, more especially because the ottrelite crystals lie with their cleavage planes at all angles with the schistosity of the rock instead of conforming with it as do most foliated minerals.

Weathering and soils.—The rocks of the formation are fairly resistant to weathering but rather less so than the Tusquitee quartzite, hence it occupies a position farther down the slopes than the latter. At many places in the valley this sequence in topographic position is displayed, the Brasstown lying along the lower slope, the Tusquitee well up toward the top, and the Nantahala forming the crest of the slope. The part of structure section B-B near Jonica Gap illustrates this relation.

The formation disintegrates rather rapidly, leaving considerable residual débris, but ledges are fairly abundant. The deeply weathered rock of the ledges is crowded with conspicuous crystals of ottrelite, weathered bright brassy yellow. The soils resulting from the disintegration of the rocks differ to some extent, but they are in general brownish or yellowish clays of no great fertility.

VALLEYTOWN FORMATION.

Distribution.—The Valleytown formation occupies the floor of the longitudinal valley and forms the central ridge that divides the valley. It lies in a long strip of irregular width, which extends from the north side of the quadrangle near Culberson to the west side, opposite Talona Mountain, and which is cut by longitudinal thrust faults into several long narrow areas that are thus structurally separated although areally contiguous. The formation also occurs in a narrow strip crossing the southwestern part of the quadrangle between the belts of Nantahala slate.

Name and thickness.—The formation is named from Valleytown, in the Nantahala quadrangle, near which place it is well exposed. Owing to its extensive folding and faulting its thickness in the Ellijay quadrangle is difficult to estimate, but it is probably 1800 to 2000 feet in the northern part and perhaps several hundred feet less in the neighborhood of Ellijay. There is some reason to believe that it is thicker in the southwest part of the quadrangle.

Character.—In the northern part of the quadrangle the rocks of the Valleytown formation consist of biotite schist, sericite schist, andalusite schist, and fine-banded, somewhat plicated mica gneiss or graywacke, with a few thick beds of quartzite, arkose, and fine conglomerate. South of Cherrylog the coarse beds disappear and the formation is a nearly homogeneous mass of sericitic mica schist and siliceous slate with some talcose material. There are many graphitic schist beds in the upper part of the formation from Toccoa River south to Ellijay. South of Ellijay for several miles the exposed part of the formation is reduced by faulting to a narrow strip of talcose and siliceous slates. In the belt crossing the southwest corner of the quadrangle the rock is of still different character, the predominating type being siliceous mica slate, curly phyllite, or augen gneiss, according to the coarseness of grain. In certain sections the rock has an appearance very similar to that of bird's-eye maple, the "eyes" being lumps of quartz and feldspar of apparently extraneous origin, presumably due to impregnation by a granitic magma since the latest deformation. On bedding surfaces that have been weathered to a certain stage the scales of mica are highly iridescent, and if the "augen" or "eye" structure is well developed the rock is strikingly beautiful. Talcose slate and thin beds of fine conglomerate are interbedded with the phyllite and augen gneiss. The formation is therefore of finer grain in the middle part of the quadrangle, coarser beds coming in both in the northern and southern parts.

Metamorphism.—In the number and variety of the kinds of rock making up the strata, in the general lack of competency of the strata to withstand lateral thrusts, and in a general mineral composition permitting extensive alteration by metamorphism, the Valleytown formation resembles the Great Smoky formation much more than it does the formations lying between. Therefore, like the Great Smoky and unlike the intermediate formations, it is extensively deformed, and some of its constituent beds have been so much altered as to have lost all their original characters. Evidences of two periods of deformation are shown by the structures now to be seen in the rocks, such as a later schistosity superposed upon an earlier one, and plication and cleavage imposed upon schistosity. The alteration is of the same degree as the deformation, nearly all the minerals being of secondary origin, so that many of the beds have now little resemblance to sedimentary rocks.

Weathering and soils.—The coarser beds and siliceous slates of the formation are highly resistant to weathering, and the central ridge dividing the longitudinal valley as far south as Cherrylog owes its altitude to the presence of such beds. The ridge reaches its maximum height and boldness northeast of Mineral Bluff, where the conglomerate beds are most numerous and thickest. The schistose beds of the formation, on the other hand, are the least resistant rocks of the region, except only the Murphy marble, and everywhere occupy low ground, in the valley bottoms or on the lowest slopes, below the outcrop of the Brasstown schist.

Disintegration is fairly rapid in the schists, and the residual soil is a slippery but highly tenacious yellow clay, which is fairly fertile but which makes very bad roads during the rainy season. Much of the area occupied by these beds is covered with coarse detrital wash from the steep surrounding slopes, or, farther out on the valley bottoms, with fine alluvial soil derived from the best materials of all the formations, which makes the most fertile land of the quadrangle. The soil on the ridges, derived from the coarser beds of the formation, is thin, sandy and full of small stones, and not fertile. Very little of it is cultivated, and it is largely covered with a scrubby growth of the poorer sorts of timber.

MURPHY MARBLE

Distribution.—The Murphy marble occurs at several places along the longitudinal valley from Culberson nearly to Ellijay, and also in the southwest corner of the quadrangle. All the outcrops are small and the total area occupied by the formation in this quadrangle is probably not greater than a square mile. Knowledge of the location and extent of the marble has been derived largely from excavations and drilling, hence the areas as represented on the map may be too large or too small. Probably they are as a rule shown too large, as it has been necessary to exaggerate some of the smaller ones in order to show them on the map at all. It should be understood, therefore, that although the areas of the formation as shown on the map give the positions of all the known bodies of marble, they do not necessarily show their correct sizes.

Like several other Cambrian formations, the marble extends some distance southward, beyond the limits of the quadrangle.

Name and thickness.—The formation is named from the town of Murphy, a few miles northeast of the quadrangle, in North Carolina. Its thickness in the Ellijay quadrangle is not certainly known, but it is probably nearly 300 feet at Culberson and somewhat less farther south. In the Suwanee quadrangle, still farther south, it is thicker again.

Character.—The formation consists of fine-grained marble that has been completely recrystallized. Its predominant color is white, but considerable portions are dark grayish or bluish, and many layers are banded or mottled blue and white. Several analyses of the marble show that it contains 58 to 93 per cent of calcium carbonate and 3 to 36 per cent of magnesium carbonate; hence the original strata included both limestone and dolomite.

The formation is a decided exception in general character to the Cambrian formations of the Appalachian Mountains. In a general way it corresponds to the limestone and dolomite that overlie the Cambrian quartzites along the northwest front of the mountains. The sequence of the underlying formations is roughly the same, and the limestone and dolomite mark a great change in the character of the sediments.

Metamorphism.—The marble has been greatly deformed, along with the other rocks of the region, and schistosity has been developed in it nearly everywhere. Originally the rock consisted of layers of limestone and dolomite, the latter predominating in the lower part of the formation. Through metamorphism the calcium and magnesium carbonates were recrystallized, with no considerable change of form. Silicates, such as tremolite and garnet, were developed throughout the mass of the rock, and deposits of talc were formed in some of the portions that were richest in magnesium. The formation of these minerals involved the addition of silica to the materials already in the rock. They are rather sparingly disseminated through the formation and are concentrated in certain beds or localities. The tremolite occurs in radiating bunches, which have no definite relation to the schistosity of the rock, and is also associated with the talc.

Another result of the metamorphism was the formation of metallic sulphides, especially pyrite, chalcopyrite, and galenite, small amounts of which are found in the marble in some localities.

Weathering and soils.—As the marble is almost completely dissolved in weathering, it everywhere occupies low ground and outcrops are very few and are found only in or close to the streams. The single area of the formation in the southwest corner of the quadrangle is an exception to both of these statements, as it occurs on a low flat-topped ridge and is at some distance from any stream. Fresh rock lies comparatively near the surface under the alluvial gravel along the streams, as has been shown in several places by borings or excavations.

The final insoluble residue from the disintegration of the marble is a fine white sand, which in some places overlies and conceals the rock. Its effect as a soil maker is negligible.

ANDREWS SCHIST.

In the Murphy and Nantahala quadrangles, farther northeast, the Murphy marble is overlain by 50 to 300 feet of calcareous schist, known as the Andrews schist. This formation contains thin beds of limonite, and weathers to whitish or light-yellow clay containing nodules of the iron ore. No outcrops of this formation are known in the Ellijay quadrangle, but along the southeast side of the belt of marble that passes through Culberson, at the north side of the quadrangle, a narrow space between the outcrops of the marble and the Nottely quartzite is occupied by such a clay containing nodules of limonite. It undoubtedly is in the place of the Andrews schist, but it is too narrow to be shown on the map.

NOTTELY QUARTZITE.

There is only one area of Nottely quartzite in the quadrangle—a very narrow strip at its north side, extending through Culberson and crossing the State line into Georgia. The rock is a dense, in some places almost glassy, white quartzite, composed almost wholly of quartz, but with a very little feldspathic material and secondary muscovite. It is slightly schistose parallel to the bedding and has been thoroughly recrystallized by metamorphism, so that the original sedimentary quartz grains are now cemented by secondary quartz into a compact mass.

The formation is named from Nottely River, along which it is exposed. Its thickness in the Ellijay quadrangle is unknown, as it is bounded above by a fault, but it is at least 200 feet. It is almost insoluble and very resistant to weathering, standing as a sharp ridge between the areas of low ground occupied by the Murphy marble on one side and the Valleytown formation on the other.

PSEUDODIORITE.

Distribution and occurrence.—Many cobbles and small bowlders of rather fine grained crystalline rock resembling quartz diorite or porphyritic dacite are scattered generally over the surface of the quadrangle, except in the area intruded by the Roan gneiss. They are fairly well rounded and have a brownish weathered crust. Outcrops of the same sort of rock are comparatively rare, most of those noted being in the northern part of the quadrangle, especially in the Ducktown mining district, where the surface is bare of forest. In the outcrops that were seen the rock occurs in masses in the Carolina gneiss, in the Great Smoky formation, or, sparingly, in the Nantahala slate. In neighboring quadrangles the masses have been observed in all the Cambrian formations below the Murphy marble.

The masses occur in two general forms—sheetlike or lenticular and ball-like or nodular. The sheetlike masses appear at first sight to be intrusive; they are of rather uniform thickness, have nearly parallel sides, and are generally conformable with the inclosing strata. Some, however, have irregular branches or protuberances, so that in places the contacts cross the bedding, not uncommonly at the ends of the masses. These masses range in thickness from less than an inch to several feet and in length from a few inches to more than 50 feet. So far as is known, their lateral extent is in general commensurate with their length; hence most of them have probably the form of thin lenses.

The nodular masses are in general roughly ellipsoidal, although a few are nearly spherical and some are of irregular shape. They range in diameter from a few inches to 2 or 3 feet. As a rule they are completely isolated but tend to occur along certain horizons. They lie in all positions in the beds, but the longer diameters of most of them are roughly parallel to the bedding. The contacts in most places cross the bedding, but in a very few places the beds seem to be deformed about the nodules and to be parallel to their outlines. In the Murphy quadrangle, in a part of the Ducktown district where the large balls are abundant in the rocks, a number have been weathered out and lie on the surface. Some of the small weathered bowlders of the rock scattered over the region were doubtless originally such balls, though others are presumably fragments of the lenticular masses.

Character.—The rock is composed essentially of quartz, plagioclase, hornblende, and garnet, but the relative amounts of those minerals differ greatly in different masses and in different parts of the same mass. In many places the rock contains a little muscovite, in others it contains considerable biotite with or in place of the hornblende, and in still others it includes more or less orthoclase. Some parts of the rock contain considerable calcite and zoisite. Pyrite is a common minor constituent, and pyrrhotite and possibly chalcopyrite are found in a few specimens.

In color the fresh rock ranges from nearly white where there is little hornblende or biotite to nearly black where there is much of one or both of those minerals. Parts containing much garnet are pinkish. The most common phase is a grayish rock containing black crystals of biotite or hornblende and resembling granite or quartz diorite in general appearance. The weathered rock is dirty yellowish white where the iron-bearing minerals are scarce and rusty brown where they are abundant.

In texture the rock is wholly crystalline and granular and ranges from very fine—so fine as to be almost aphanitic—to coarse, the coarser type containing apparently porphyritic crystals of hornblende one-half inch or more long. The ordinary phase has a medium-grained granular texture, the minerals being rather uniformly distributed. The garnet appears to have been formed last, as it contains abundant inclusions of the other minerals, especially quartz. Schistosity is very rare.

Most of the masses more than a few inches in diameter have a fairly well developed zonal structure. Many are coarsest and most feldspathic in the center, where the rock contains comparatively little hornblende or biotite, which occurs in rather large aggregates having the appearance of phenocrysts. Near its contact with the inclosing strata the rock is finer grained and includes a larger proportion and more even distribution of dark minerals in some nodules and little or no dark minerals in others. Generally the contact is not very sharp, the rock merging by gradations in texture and composition into that inclosing it. In some places the bedding of the graywacke passes more or less distinctly into or quite through the nodules or through portions of the irregular branching masses. At a few places there are, on the contrary, distinct contacts, the apparently intrusive rock being different in texture and composition from the surrounding rock and in places being coarsest next to the contact.

The rock is generally dense and very tough and weathers slowly, forming small residual bowlders covered with a light brown crust one-fourth inch to one-half inch thick, marked by darker spots due to the oxidation of iron sulphides. The bowlders are abundant, but, like quartz pebbles, they remain and accumulate after the inclosing rocks have wholly disappeared and thus give a false impression of the abundance of the rock from which they were derived. The amount of the rock in the region is in reality too small to produce an appreciable effect on the topography or the soils.

Origin and age.—The pseudodiorite occurs throughout a considerable area, probably at least 3000 square miles. It is abundant in the Murphy and Nantahala quadrangles, north and northeast of the Ellijay; in the Dalton and Cartersville quadrangles, on the west and southwest; in at least a part of the Suwanee quadrangle, on the south; and possibly even farther south. The rock has hitherto been regarded as igneous and intrusive and has been described in previous publications as quartz diorite, its character and structural relations in the few outcrops that were seen having given no reason for any other opinion. The same opinion prevailed during the mapping of the Ellijay quadrangle, as no new facts were obtained in the few outcrops examined. Since the Ellijay quadrangle was mapped, however, detailed work in the Ducktown district has brought to light a number of facts, especially in the Murphy quadrangle, where, in the region around the copper mines and the smelters, the soil is denuded of all vegetation and the rocks are well exposed. Much was also learned in the mines, where the rock is in relatively fresh condition and good material for chemical analyses can be obtained.

The facts thus ascertained regarding the composition and structural relations of the supposed diorite, especially in the great number of isolated nodular masses that were found, lead to the conclusion that the rock is not igneous and generally not intrusive. It is regarded as having been formed in place by a complete recrystallization of portions of the original sedimentary rock, as an extreme result of the regional metamorphism. Whether any part of the rock was actually melted under pressure is uncertain but seems rather improbable. It is believed that percolating solutions played the chief part in the recrystallization, and that its localization and generally very slight extent is due to its having occurred only in those parts of the rock in which the texture and composition were favorable to its formation. The recrystallized masses are found only in beds that originally had the general composition and texture of graywacke, whatever their age, and there is some indication that the recrystallization took place only in parts of the beds that were somewhat more calcareous than the rest. A brief statement of the new conclusions regarding the rock has been published by Keith,[a] and a detailed explanation will be given by Keith, Laney, and Emmons in a report on the Ducktown district, to be published by the United States Geological Survey.

As regards the time of the recrystallization not much is known, but there are a few facts bearing on the question. It is believed that it occurred at a time of great regional metamorphism but that the process itself was static and was not accompanied or followed by any considerable deformation of the rocks. Few of the pseudodiorite masses are appreciably deformed. Some of them are apparently folded, but they probably replaced already deformed beds and have not themselves been folded. The general absence of schistosity in the masses is thus due to the fact that they were not mashed and sheared. It seems probable, then, that they were formed during the closing stages of the latest great deformation to which the rocks of the region were subjected, and undoubtedly at a great depth. The latest great deformation is commonly believed to have occurred near the close of the Carboniferous period, and the evidence therefore leads to the view that the recrystallized masses are of late Carboniferous age.

POST-CAMBRIAN IGNEOUS ROCKS.

MUSCOVITE-BIOTITE GRANITE AND PEGMATITE.

The Carolina gneiss in the northeastern part of the quadrangle contains many bodies of granite and pegmatite of roughly lenticular shape and of all sizes, the largest 2 or 3 miles long and several thousand feet thick. These bodies have a general trend roughly parallel to the strike of the inclosing gneiss. A few of the largest are shown on the map. As the pegmatite described under the heading "Carolina gneiss" has essentially the same composition as this granite, and as the two rocks intergrade in places, they are believed to be of the same age and of common origin. It has already been stated that pegmatites are abundant in the southern and eastern parts of the quadrangle also, and that they cut the Roan gneiss as well as the Carolina.

The granite is white or light gray, of fine to medium grain, and is composed of quartz, orthoclase, plagioclose, biotite, and muscovite. There is much more orthoclase than plagioclase, and much of the quartz and orthoclase is microscopically intergrown, forming what is called the micrographic structure. In general biotite is the dominant mica, but in some places, especially in some of the pegmatites, muscovite is in excess, and in other pegmatites there is little or no mica of either sort. The granite is typically rather fine grained, but some of the pegmatite bodies contain mica crystals several inches across and others contain large crystals of quartz and feldspar.

The granite and pegmatite bodies have been deformed to some extent since their formation, and the rock shows evidence of crushing and shearing, but there has been almost no development of metamorphic minerals. Garnet, which is an abundant secondary constituent of most other kinds of rock in the quadrangle, has not been noted in these rocks. Although the granite and pegmatite bodies conform roughly in general trend to the inclosing gneisses, they cut the strike of those rocks in many places and are clearly later than and intruded into the Archean rocks. As they evidently have been affected by the later but not by the earlier of the two great structural deformations recorded in the rocks of the region they are of post-Cambrian age.

The granite has not been traced into other areas and correlated with granites of known age, but in its lithologic character and general relations it resembles closely the Whiteside granite of North Carolina, and the two may be of the same age. From its structural relations the Whiteside granite is believed to be of late Paleozoic age.

Owing to the granular texture of the granite and the ready decomposition of some of its minerals, it weathers at about the same rate as the surrounding rocks, and its topography is therefore not essentially different from that of the rocks about it. Only the larger bodies form distinctive soils. The residual soil that it forms is light-colored or white sandy clay, full of small grains of quartz and shining flakes of mica.

GABBRO.

Several dikes of gabbro-like rock occur in the northwestern part of the quadrangle, near Madola and Fry. The largest, which extends northeastward from a point near Pierceville past Copperhill into the Murphy quadrangle, has a length of more than 4 miles in the Ellijay quadrangle and is 100 to 300 feet thick. The dikes trend about N. 40° E. and, so far as known, dip steeply southeastward, thus being roughly parallel to the bedding of the Great Smoky formation, into which they are intruded. They are not straight, and the large one has a sharp double flexure near the State line.

The rock of the dikes is dark gray and rather fine grained, having the general appearance of a diabase or fine diorite, and is composed of feldspar, hornblende, and augite. The feldspar is almost wholly plagioclase, and hornblende predominates decidedly over augite. The rock therefore has the composition of an augite diorite that is rather poor in feldspar. In mass, however, it has a distinctly gabbroic appearance, and, as the proportion of feldspar is so small, it seems probable that the rock was primarily a gabbro or diabase in which a large part of the augite has been altered to uralitic hornblende. This can not be determined, for the rock has been so much crushed that none of the minerals retains its original crystal outlines. The schistosity of the rock is largely due to the hornblende, but the crushing of the rock and the irregular form of the dikes show that they have been subjected to considerable deformation.

The gabbro dikes show about the same structural relations to the inclosing rocks and the same amount of deformation as the muscovite-biotite granite and must be of the same general age—that is, probably late Paleozoic. Further than that nothing is known of their age. There are no other dikes of the sort with which they can be correlated, except possibly some dikes of similar rock in the Dalton quadrangle.

The dikes weather at about the same rate as the inclosing Great Smoky formation, with no characteristic resultant topography. Outcrops are scarce, but the surface along the course of each dike is strewn with much residual material. Their effect on the soils is negligible.

[a] Bull. Geol. Soc. America, vol. 24, 1913.

SURFICIAL DEPOSITS.

At many places in the quadrangle, along and near the rivers, there are irregular deposits of gravel, ranging from rather fine materials to large cobbles and small bowlders. They lie at various altitudes, the highest standing more than 100 feet above the present beds of the streams. They are not sufficiently continuous or definite in form to be called terraces, nor do they lie at a sufficiently uniform altitude to be correlated with a former stage of the streams. Their origin has not been satisfactorily determined. They seem to be identical with deposits which are found in similar situations in much of the southern part of the Appalachian province and which have been thought to belong in part to the Lafayette formation and in part to the Columbia group, and thus to be of late Tertiary and Quaternary age. Their relation to the topography and to former base-levels of erosion is not clear, and it will be necessary to make a systematic study of these gravels over a large area before satisfactory conclusions regarding them can be drawn.

In the plateau areas much of the lower ground is covered with a thin wash of sand and residual quartz gravel derived from the slopes. Near the base of some of the mountains these deposits are fairly thick and in some places they contain placer gold.

Here and there along the rivers and larger creeks are alluvial deposits of gravel, sand, and silt, constituting flood plains, which are generally narrow. Their thickness is unknown, but it must be slight, as all the streams are actively cutting down and flow over rock bottoms for the greater part of their courses.

STRUCTURE.

GENERAL FEATURES.

The rocks of the Ellijay quadrangle have undergone many changes in form and position, having been folded, faulted, crushed, and greatly metamorphosed. The strata must have been originally almost horizontal but are now nearly everywhere inclined, their edges appearing at the surface. In the area occupied by Cambrian rocks the structure can generally be worked out by carefully mapping the distinctive beds, but in the Archean area the masses of the same sort of rock are so great and distinctive beds are so rare that it is difficult to discover the larger features of the deformation, although the rocks have obviously been greatly disturbed. Most of the igneous masses can be mapped without much difficulty, but they afford little help in working out the structure, as they are intrusive and their original position and shape are not known.

The broad structural features of the Ellijay quadrangle consist of a synclinal basin in the northwestern part and what seems to be an anticlinal fold in the southeastern part. The synclinal basin contains one principal trough, complicated by smaller folds and broken by large thrust faults, and several parallel minor troughs on each side. The principal trough coincides with the longitudinal valley, and in its axis, along the valley bottom, are the youngest stratified rocks of the quadrangle. The main uplift was in the southeastern part of the quadrangle, where the oldest formations now stand at considerably greater altitudes than the younger rocks in the longitudinal valley. The Cambrian formations are as a rule more highly metamorphosed toward the south side of the quadrangle, but in one or two of them the metamorphism is greater near the middle of the quadrangle than toward the north and south sides. The Archean rocks have been metamorphosed to about the same extent everywhere throughout the quadrangle.

A line drawn from Talona Mountain, on the west side of the quadrangle, to Grassy Gap, on the east side, would mark the approximate position of an axis of pronounced change of structural trend. North of that line general structural trend is nearly everywhere northeast-southwest, although in some places in the northeast part of the quadrangle the local trend is northwest-southeast or even west-east. For 5 or 6 miles south of the line the trend is nearly north-south, and along the southern border of the quadrangle it is northwest-southeast. Thus for about two-thirds of the way across the quadrangle from its north side the formations, folds, faults, and cleavage planes have nearly everywhere a southwest trend and for 5 or 6 miles farther a general southward trend, but near the south side of the quadrangle they swing more or less sharply southeastward.

FOLDING.

Synclinal basin.—The structure of the synclinal basin, at least in the principal trough, differs somewhat from that of the rest of the quadrangle. The area as a whole is characterized by close folding, the strata on opposite sides of the axis being nearly parallel in most of the folds. For miles across the strike in parts of the area, and apparently nearly everywhere, the beds dip southeastward, but the later schistosity and the cleavage also dip southeastward, and in places where the bedding is nearly obliterated by those structures their dip is likely to be mistaken for the dip of the strata. In reality the beds in some places are vertical or dip northwestward and here and there are almost horizontal. The predominating dip, however, is 60°–75° SE., and the strata in the greater part of the area are therefore almost on edge.

The part of the quadrangle northwest of the longitudinal valley is occupied wholly by the Great Smoky formation. Even if that formation is as much as 6000 feet thick it must be folded a number of times, as the belt in which it is exposed is about 13 miles wide, but the extreme alteration of much of the formation and its lack of distinctive beds make any determination of the folds nearly impossible. Since the Ellijay quadrangle was studied detailed mapping on a large scale, in which individual distinctive beds were traced as far as possible, has been done by F. B. Laney in the Ducktown mining district, a part of which lies in the Ellijay quadrangle and all of which is occupied by the Great Smoky formation. That work has shown that the beds are very closely folded, the folds being overturned to the northwest, and that the larger folds are complicated by many minor ones, so that both the strike and the dip of the beds are highly irregular. It has also shown that faults are more numerous than had been supposed.

Longitudinal valley.—Along the valley the number of formations and their lithologic differences permit the structure to be worked out in detail. As the higher formations occur only in or along the sides of the valley, the Great Smoky formation occupying most of the synclinal basin, the principal trough is in general a rather deeply infolded crease in the strata. It is not, however, a simple fold, for throughout much of its length it consists of a central subordinate anticline with a minor syncline on each side (section D–D of structure-section sheet). At the north side of the quadrangle the trough is wider and includes several subordinate anticlines (sections B–B and C–C). The complex structure appears to be confined to the part of the valley north of Cherrylog, several miles north of which place the central anticline disappears. South of Cherrylog the trough is a single narrow, closely folded syncline, overturned toward the northwest (section G–G), and from Ellijay southward the beds dip gently eastward, those forming the east wall of the valley being inverted (section I–I).

The structure of the valley is further complicated by thrust faults along or close to the axes of the subordinate synclines, separating the rocks into long, narrow blocks of generally southeastward-dipping beds and greatly obscuring the original folding. The sections on the structure-section sheet will give a better understanding of the structure and the probable deformation than can be conveyed by an extended verbal explanation.

Anticlinal area.—The Archean rocks in the southeastern half of the quadrangle do not differ radically in structure from the Cambrian rocks, but, so far as can be discovered, are broken by no such extensive faults as occur in the longitudinal valley. The rocks show considerable evidence of folding, but their predominant structures, everywhere obvious, have been produced by metamorphism. As the rocks are mostly of sedimentary origin, it is possible to work out some of the larger features of the folding, especially in the northeastern part of the quadrangle, where the black schist beds occur (section B–B), and about the infolded bodies of the Great Smoky formation in the central part of the quadrangle. Presumably the Archean rocks are in places faulted, but because of the lack of distinctive beds or of other means of working out the details of their structure the faults have not been found.

The Archean area probably is in general anticlinal, but the data required to determine its structure must be found outside the Ellijay quadrangle. The axis of the supposed anticline, as nearly as can be determined, traverses the area intruded by the Roan gneiss in the southeast corner of the quadrangle, and the greater part of the Archean area within the quadrangle forms the northwest limb of the general anticlinal fold.

In places it is possible to make out some of the minor details of the folding. The data obtained lead to the view that in the central and northeastern parts of the quadrangle there are three subordinate anticlinal folds and at least two synclines. The folds are difficult to trace and apparently either die out or plunge southward and northeastward, and each fold is probably complicated by minor folding. The most obvious of the folds is the syncline occupied by the large mass of the Great Smoky formation, in the west-central part of the quadrangle. It can not be traced south of Dyke nor far northeast of Toccoa River and is only about 15 miles long, but in its middle portion it is pronounced and is probably several thousand feet deep. (See sections E–E, F–F, and G–G.) The other folds are so obscure and have so little effect on the areal distribution of the rocks that they need not be described in detail.

Cross axis.—A line drawn northwestward across the quadrangle from Grassy Gap through Cherrylog represents approximately the position of an axis of cross warping. As explained under the heading "Geologic history" (p. 10), this line is presumably not an axis of actual warping but is nearly in the position of the greatest northwestward thrust and hence of the greatest vertical component of the folding. The resultant effect on the structure of the region is, however, substantially the same as that of warping. On each side of the line there is a noticeable fan structure, that on the northeast side plunging northeastward and that on the southwest side plunging southward.

This is not very apparent within the Ellijay quadrangle, and, in fact, in order to get a comprehensive view of such larger structures it is necessary to know the structure of a region comprising at least six quadrangles. Something of the northeastward-plunging structures is shown, however, in the northern part of the Ellijay quadrangle by the disappearance of the anticlines, the opening out of the synclines, and the coming in of higher formations northeastward. The mapping of the Ducktown mining district on a large scale has revealed the same northeastward-plunging structures in that area. Enough reconnaissance work has been done in the Dalton and Suwanee quadrangles to show that the folds there have a corresponding southward and southwestward plunge, although there is little evidence of it in the Ellijay quadrangle. The cross axis does not seem to be so pronounced in the Archean as in the Cambrian and it appears to be somewhat complicated in the Archean by other factors, but it is nevertheless recognizable.

FAULTING.

Character.—The faults follow closely the trend of the folds from which they have been developed. All the faults that have been recognized are of the overthrust type, with the thrust from the southeast or east. The outcrops afford little direct evidence of faulting, and the positions of the faults are determined primarily from the distribution and known sequence of the formations. Several of the main faults, however, can easily be traced nearly their whole length, because their outcrops are almost everywhere marked by residual material from veins of quartz and limonite formed in the fault fissures, the veins being so thick in places that they have been mined for iron. In only a few places are the fault planes so clearly exposed that their attitude can be determined, but their dip is in general probably not very different from that of the faulted beds, being toward the southeast or east at angles ranging from 35° to 75°.

Chief faults.—Five principal faults enter the quadrangle from the northeast (fig. 5), but two of them die out in a few miles and a third, the Young Stone Creek fault, merges into the Murphy fault near the line between Fannin and Gilmer counties, so that only two persist across the quadrangle. Those, the Murphy and the Whitestone faults, are the main faults of this part of the Appalachian Mountains. They extend northeastward into the Nantahala quadrangle and southward into the Suwanee quadrangle and possibly some distance beyond.

The Whitestone fault is named from Whitestone, in the Talona Valley, just outside the western margin of the Ellijay quadrangle, where the Nantahala slate is clearly shown overlying the Murphy marble with a nearly horizontal fault contact (fig. 6). It defines the east side of the longitudinal valley from a point near Marble Hill, in the Suwanee quadrangle, northward and northeastward into the western part of the Nantahala quadrangle, where the valley loses much of its definite character and the fault dies out northeastward. In the Ellijay quadrangle the eastern row of areas of Murphy marble lies along or just west of the Whitestone fault.

The Murphy fault is named from Murphy, in North Carolina, where it is exposed as it crosses Hiwassee River on the west side of the town. It is probably the second longest fault in the southern part of the Appalachian Mountains, being exceeded in length only by the Cartersville fault, which extends along the west side of the mountain belt. It extends northeastward nearly to the east side of the Nantahala quadrangle, and southward halfway across the Suwanee quadrangle and probably for some distance, perhaps for many miles, into the Cartersville quadrangle. It has been traced and mapped for about 75 miles, and its total length must be nearly if not fully 100 miles. It defines the west side of the longitudinal valley from the north boundary of Gilmer County southward beyond Jasper in Pickens County. Northeast of the Fannin-Gilmer county line the fault lies along the west base of the central ridge dividing the valley and forms the southeast boundary of the western row of exposures of marble.

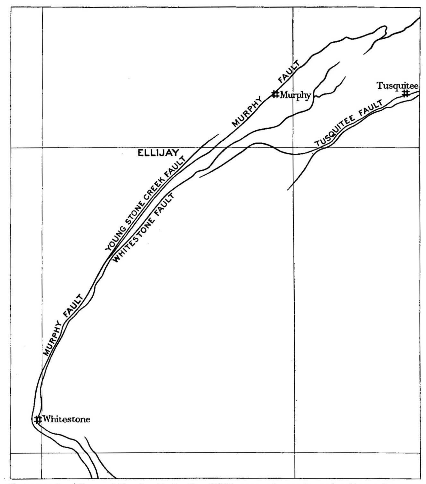


FIGURE 5.—Plan of the faults in the Ellijay quadrangle and adjacent areas.

The Young Stone Creek fault, named from a stream that runs close to it, splits off from the Murphy fault near the Fannin-Gilmer county line and extends northeastward for 18 or 20 miles. It appears to die out before reaching Nottely River, in the Murphy quadrangle. It defines the west side of the longitudinal valley as far as it extends, and throughout its length appears to follow very closely the upper limit of the Tusquitee quartzite.

The Tusquitee fault, named from Tusquitee, in the Nantahala quadrangle, is important in North Carolina and marks the position of a strong flexure in the rocks. In the Ellijay quadrangle it is of minor importance, but it defines the zone of fracture about the northern end of the huge overthrust anticlinal area occupied by the Archean rocks. It appears to die out a few miles inside the northern border of the quadrangle, but it has its counterpart in the fault separating the Archean and Cambrian rocks west of Sharptop Mountain, at the south side of the quadrangle.

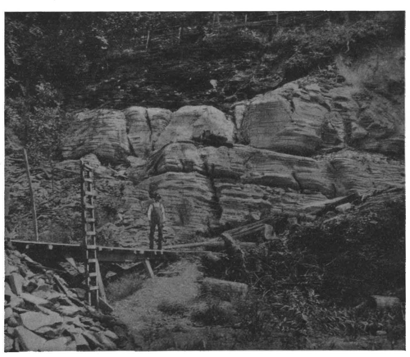


FIGURE 6.—Whitestone fault in a quarry at Whitestone in Talona Valley, west of the Ellijay quadrangle.

In the upper part of the picture the overthrust Nantahala slate is shown resting on the Murphy marble.

The unnamed fault that enters the east side of the quadrangle between Reece and Ivylog creeks and dies out within a short distance is also an important fault in the Nantahala quadrangle, where it separates the Archean and Cambrian rocks. It belongs, with the Tusquitee fault, in the general zone of shearing and fracture along which the Archean rocks have been thrust upon the Cambrian rocks throughout a distance of many miles.

METAMORPHIC STRUCTURES.

Schistosity.—The most pronounced metamorphic structure of the quadrangle is schistosity, which has been developed nearly everywhere and in all sorts of rocks as a result of the compression to which they have been subjected. Slaty cleavage also has been produced where the texture of the rock and other conditions were favorable and is a striking feature of some formations. The dip of the schistosity and of the cleavage is in general steep—55°-60° or more—and is nearly everywhere inclined to the southeast. The strike and dip of the planes of schistosity appear to be more regular than those of the strata. They present local irregularities due to differences in the rigidity and in the folding of the beds, and in places they diverge somewhat around harder portions of the rock, but in general the cleavage has nearly the same attitude throughout the quadrangle. Schistosity is on the whole rather more highly developed in the rocks in the southern part of the quadrangle than in those in the northern part. Some of the rocks show abundant evidence of an earlier schistosity that has been deformed and upon which a more recent schistosity has been superposed. The earlier schistosity is, however, a negligible factor in the structure of the quadrangle as a whole.

Pseudoconglomerates—A peculiar effect of excessive deformation is the production of the pseudoconglomerates found in two areas in the quadrangle. What is apparently a conglomerate containing abundant quartz pebbles crops out along the railroad north of East Ellijay, and a similar zone is exposed at a number of places along the road from Ellijay to Santaluca.[a] Both zones are in the Great Smoky formation. The apparent pebbles are of white quartz, generally of rectangular or rhombic cross section, and are long and slender, many resembling broken-off pieces of four-sided pencils. They have accumulated in large quantities where they have weathered out of the decomposed rock in cuts.

Another pseudoconglomerate occurs in the fine-grained garnet-mica schist of the Carolina gneiss in the southeast corner of the quadrangle, about 2 miles northeast of Hedwig and on the main road from Dahlonega southwest.[b] The apparent pebbles are of the same composition and texture as the matrix but are slightly denser and more siliceous and therefore more resistant, and they weather out exactly like true pebbles. They have a flattened elliptical cross section and curved outline, tapering at both ends. Their most noticeable features are their astonishingly large size and their proportions, many of them being 1 to 2 inches in diameter at the middle and 1 to 3 feet long.

At all three localities the rocks were at first regarded as conglomerates, but their real nature and origin were discovered later. They appear to have been formed by the close folding, crushing, and fracturing of the rocks and the rolling of the fragments under great pressure, in the manner described in detail under the heading "Geologic history."

Another striking structural effect of the deformation of the rocks of the region is the flattening and crushing of the pebbles of true conglomerates. This is well displayed in several parts of the quadrangle but especially in a zone of conglomerate crossing the upper part of Kells Creek and passing Double Knob, Chestnut Gap, and Curtis, to Franklin Mountain.

SECTIONS.

Explanation.—The structure-section sheet shows ten cross sections, the locations of which have been selected with a view to illustrating the structure of the quadrangle and, so far as possible, the manner in which the structure has been developed. The sections show the rocks as they would appear in the sides of deep trenches cut across the country. The lines at the upper edges of the blank spaces show the positions of the sections with reference to the map. The vertical and horizontal scales are the same, so that the sections show the actual relief and slope of the land surface as well as the actual attitudes of the rocks. They represent the structure as it is inferred from surface observations of dip, strike, and other features. On the scale of the map they can not show the minute details of structure and are therefore somewhat generalized from observations made in belts a few miles wide along the general courses of the sections. A fault is indicated on the map by a heavy solid or broken line, and in the sections by a heavy line whose inclination shows the probable angle of dip, the arrows indicating the relative directions in which the rocks have been moved.

Description.—All phases of the structure of the longitudinal valley are shown, from the rather open trough at the north broken by four faults (section B–B), through the closely pinched syncline near Ellijay with only two faults (sections G–G and H–H), to the overturned and broken syncline in the southwest corner of the quadrangle (section I–I). Sections B–B, C–C, D–D, G–G, and I–I are so located as to pass through outcrops of the Murphy marble, showing its relation to the other beds; others are located primarily to show in profile the relief of the quadrangle. Section F–F in particular is located to exhibit the profile rather than the structure. It crosses the longitudinal valley where that is most pronounced, passes

[a] McCallie, S. W., Stretched pebbles from Ocoee conglomerate: Jour. Geology, vol. 14, 1906, p. 55; Some notes on schist conglomerate occurring in Georgia: Idem, vol. 15, 1907, p. 474.

through the highest summits of the quadrangle, and crosses the Blue Ridge escarpment at a place where that feature stands conspicuously above the Piedmont Plateau. It is remarkable in that, although drawn in a northwest-southeast direction, it crosses the Blue Ridge divide three times. There is perhaps no other area in the Appalachian Mountains where a northwest-southeast section would cross the divide so many times.

A comparison of sections B–B and C–C with sections F–F, G–G, and H–H shows well the difference in closeness of folding between the northern and western parts of the quadrangle. A comparison of sections A–A and I–I with any of those along the longitudinal valley will show the difference in the character of the thrust at the ends and in front of the great overthrust Archean mass.

GEOLOGIC HISTORY.

PRE-CAMBRIAN TIME.

The earliest event recorded in the rocks of the Ellijay quadrangle is the deposition of the sediments now forming a part of the Carolina gneiss. Nothing is known of the source of this material or of the conditions of its deposition, but it seems to have consisted of detritus derived from a land surface of considerable relief and to have been deposited as mud, sand, and fine gravel. The graphitic schist in the northeastern part of the quadrangle was presumably deposited as carbonaceous silt and indicates the existence of plant life on the neighboring land.

The deposition of a great thickness of strata was terminated by uplift of the land and deformation of the rocks, followed or perhaps accompanied by the intrusion of the magma that formed the granitic layers now intercalated among the sedimentary beds. Later the material now forming the Roan gneiss was intruded, apparently only into the lower part of the mass of strata, and still later the magma forming the bodies of augite-biotite granite was intruded into the complex. The different sorts of igneous rock were erupted at widely separated times and the assemblage must represent a very long period. During that period erosion was in progress on the surface and eventually proceeded so far that the igneous rocks, which must have been intruded at great depths in the earth, were in some parts of the region laid bare. Near the close of the long period of erosion volcanic eruptions occurred in areas some distance northeast of the Ellijay quadrangle and quantities of lava were poured out upon the surface. In and about the quadrangle no volcanic rocks are found and erosion appears to have continued until the beginning of the Paleozoic era.

PALEOZOIC ERA.

CAMBRIAN PERIOD.

Great Smoky deposition.—Early in Cambrian time the Appalachian region, which had probably been reduced by erosion to a surface of low relief, was gradually submerged and the deposition of sediment began again. In the region of the Ellijay quadrangle the submergence appears to have proceeded from north to south. The quadrangle, which in earliest Cambrian time was still dry land, was invaded from the north by the sea, and sheets of gravel, sand, and mud, with a few highly calcareous layers, were spread upon the sea bottom. The deposition of coarse and fine sediment alternated frequently and subsidence was probably not regular and continuous but was doubtless interrupted by short periods of uplift during which erosion was accelerated on the neighboring land. No remains of animal life have been preserved in the rocks, but the occurrence of graphitic beds in the Great Smoky formation indicates the existence of plants from which the carbonaceous matter was derived.

Nantahala deposition.—The deposition of the coarse beds was followed by comparatively stable conditions, during which a thick sheet of carbonaceous mud was spread upon the sea bottom. Some parts of the slate are highly calcareous but contain no remains of organisms. From time to time the deposition of mud was briefly interrupted by the deposition of thin layers of sand. The Nantahala slate extends throughout a large area and the Cambrian sea probably covered a greater part of the region at the time it was deposited than at any other. The neighboring land, which lay somewhere to the southeast, must have been low and flat, with a deep residual soil and abundant plant growth.

Tusquitee deposition.—The accumulation of black mud was at length brought to a close and was followed by the deposition of quartz sand. A slight uplift seems to have reduced the size of the sea a little and may have caused the change in the character of the sedimentation. A quantity of white sand, mingled with a little feldspathic material, was brought down by the streams and spread evenly over an area of considerable size but smaller than that over which the mud had been deposited. The streams still brought down mud and from time to time deposited thin layers of it alternately with layers of sand. The sea at this time probably contained some animals. No fossils are found in the Tusquitee quartzite, but in the Cartersville quadrangle, southwest of the Ellijay, a few poorly preserved Lower Cambrian fossils have been collected from the Weisner quartzite, which is believed to be of about the same age as the Tusquitee.

Brasstown and Valleytown deposition.—The conditions remained fairly uniform throughout the period of accumulation of the sand and sandy clay from which the schists and slate of the Brasstown formation were formed, but the area of deposition seems to have been reduced by further uplift. The sediments contained more comparatively fresh detrital material than had been brought by the streams for some time, hence erosion was more active.

The uplift continued for a time, during which the streams brought down detritus that was increasingly coarser, fresher, and more varied, but the uplift was apparently due to warping, as the area of deposition was not diminished. In fact the Valleytown formation is now found in a larger area than the Brasstown, but there is no proof that it originally covered a larger area. There were minor oscillations of level and variations in the character of the deposits, beds of gravel and clay being laid down alternately with beds of fine white sand. No remains of animal life are preserved in the rocks, but thin beds of carbonaceous mud were again formed and the land probably bore vegetation. Erosion seems to have been most active near the middle of the epoch and quieter conditions prevailed during the deposition of the later beds, which are finer grained and composed more largely of residual detrital material. The change in conditions of deposition that introduced the next epoch of sedimentation was foreshadowed by the formation of beds of clay very rich in magnesium and calcium carbonates, which were consolidated into dolomite and eventually metamorphosed into tremolite, and which by later alteration became the beds of talc at the top of the Valleytown formation.

Murphy and Andrews deposition.—With the close of the Valleytown sedimentation a great change took place. Up to that time almost all the sediment had been of detrital origin, but the deposition of that sort of material then ceased and was followed by the formation of calcium and magnesium carbonates, possibly as chemical precipitates, as the beds have yielded no fossils. Such deposition prevailed over a considerable area and continued during the time of the accumulation of the material now forming the Murphy marble.

After a considerable thickness of nearly pure carbonates had been accumulated detrital deposition began again, before chemical deposition ceased. Much sand and clay was washed in, forming the beds that now constitute the Andrews schist. The Andrews represents simply the closing stage of the period of limestone deposition, when so much detritus was mingled with the carbonates that the mixture could not form true limestone.

Nottely deposition.—Detrital deposition was finally wholly resumed, spreading over the sea floor a great bed of nearly pure quartz sand. This sand forms the final record of Lower Cambrian time in the area. The Nottely quartzite is not very widely distributed. It now barely enters the north side of the Ellijay quadrangle, but whether it was deposited generally over the quadrangle and has been removed by faulting and erosion can not be determined.

Later Cambrian events.—The history of the quadrangle during Middle and Upper Cambrian time is a blank. Strata of later age than Lower Cambrian are not found east of the Appalachian Valley, but that such beds once extended farther east seems very probable, though whether they were deposited in the Ellijay quadrangle is not known.

LATER PALEOZOIC TIME.

Earlier deformation.—Little is known of the history of the Ellijay quadrangle during most of Paleozoic time. It seems finally to have emerged from the sea rather early in the era, at least as early as the close of the Ordovician if not at the close of the Lower Cambrian. The lowering of the surface by erosion was several times interrupted by uplift, and at least two of the uplifts were accompanied by extensive deformation of the rocks.

The earlier deformation apparently affected no rocks younger than Ordovician, and there are other reasons for thinking that it occurred at the close of the Ordovician period, when there was a widespread emergence of the land in the Appalachian province. Other uplifts took place in the Silurian and Devonian periods and the deformation may possibly have occurred in one of those periods. How greatly the strata were deformed is uncertain, as they have been subjected to further deformation since. The evidence indicates that the beds were considerably folded by the earlier movements but that the more intense folding and faulting was produced by the later. The earlier movements, however, resulted in much greater metamorphism of the rocks. The development of schistosity, the partial obliteration of original structures, and the recrystallization of the rocks occurred largely during the earlier movement.

Igneous intrusion.—For a long time after the earlier deformation, probably no small part of Paleozoic time, the history of the area is a blank except as it is recorded by the intrusion of the gabbro dikes and of the bodies of muscovite-biotite granite and pegmatite. The time of intrusion of either is not certainly known, but there is reason to think that the granite and pegmatite are of Carboniferous age.

POST-CARBONIFEROUS DEFORMATION.

Folding and faulting.—Near the close of the Carboniferous period uplift was renewed and the rocks were again subjected to great compressive force, acting, as elsewhere in the Appalachian province, in a general northwest-southeast direction. The rocks were closely folded and the folds were overturned, mostly to the northwest. As the compression continued the folds broke in places where the rocks were being stretched, and the fractures thus formed developed into thrust faults along which the rocks were shoved northwestward. The shortening of the lateral extent of the formations by the folding and faulting must have been very great.

The main syncline had probably been given its general form, with its axis not far from the line of the present longitudinal valley, in the earlier deformation. When compression began again the syncline was deepened and narrowed, partly because of the arching of the strata along each side. The bottom of the trough buckled and was thrown into minor anticlines, at least along that part of the fold northeast of Whitepath. As the strain increased fracturing occurred along the flanks of the fold, and the rocks of the bottom of the trough were thrust upon the western flank and those of the eastern flank were thrust over the trough. The central anticline also broke and its eastern limb was thrust upon its western one.

This great lateral compression of the Cambrian strata was confined practically to the part of the synclinal basin that is included in the Ellijay quadrangle, in which the Archean rocks were thrust farther northwest than elsewhere and the Cambrian strata were correspondingly compressed. Section E–E on the structure-section sheet is approximately in the position of the axis of greatest northwestward thrust, which occurred in an area where the Archean contains a great body of sedimentary rock that appears to have been especially competent for its transmission. The compressed Cambrian strata were, on the contrary, in an area of minimum resistance, an area where the Valleytown formation contains no conglomerates or other massive beds and the Great Smoky formation includes fewer such beds than elsewhere. Hence the vertical component of the folding was greatest along the axis of maximum thrust, which thus agrees closely in position with the axis of apparent cross warping that separates the northeastward and southwestward pitching fan structures.

At its northern and southern ends the great lobe or mass of rock thus thrust northwestward is separated by faults from the rocks upon which it has been thrust, but the direction of movement is there nearly parallel to the strike of the faults and of the strata. There are indications of several minor axes of cross folding, especially one in the southwestern part of the quadrangle, on the line of the divide extending southwestward from Burnt Mountain. However, the general structure of the region and its dynamic history can not be completely worked out until the quadrangles bordering the Ellijay on the east, south, and west have been studied and mapped.

Metamorphism.—As already stated, probably the greater part of the dynamic metamorphism of the rocks was produced by the earlier deformation. The later deformation, however, was also accompanied by metamorphism, which, though less intense, affected the rocks of a greater part of the province. In the Ellijay quadrangle the bulk of the metamorphic minerals that occur in apparently porphyritic crystals or metacrysts—such as garnet, staurolite, kyanite, and part of the biotite—were probably developed during the later compression. Quartz veins, some of them sulphide bearing, were probably formed in the final stages of or after both deformations.

The recrystallization of parts of some of the formations into the masses of pseudodiorite described under the heading "Stratigraphy" is believed to have taken place at great depths during the closing stages of the deformation. Under the combined influence of heat, pressure, and percolating solutions portions of the rock that had the texture and general composition of graywacke and were possibly somewhat more calcareous than the rest were completely recrystallized into a rock resembling granite or quartz diorite. That the formation of the copper deposits in the Ducktown district by the replacement of limestone beds occurred about the same time seems probable.

The most apparent effect of the metamorphism produced by the later deformation was the superimposition of new rock structures upon those previously formed. A new schistosity was developed in a great part of the area and slaty cleavage was developed nearly everywhere. The pebbles of conglomerates in several parts of the quadrangle were squeezed and stretched, and the pegmatite dikes and lenses were bent, crushed, and sheared. Last of all the rocks were thoroughly jointed, but the jointing may be the result of warping that occurred much later.

The pseudoconglomerates near Ellijay and near Dahlonega, described under the heading "Structure," were produced during the later deformation. Those near Ellijay are explained[a] as due to the shearing off of fragments of quartz veins, the fragments being subsequently crushed and rolled into the semblance of squeezed and stretched pebbles. The pseudo-conglomerate near Dahlonega is explained as due to the similar shearing off of the crests of plications in the schist, the sheared-off portions being later squeezed, rolled, and compacted into the form in which they are now found.

Physiographic development.—It is difficult to decipher the physiographic history of the quadrangle during the deformation from the obscure and fragmentary records preserved in the quadrangle and the immediately adjacent region, but the general development of the southern Appalachians at that time has been partly worked out. The deformation resulted in the final withdrawal of the sea from the entire region and the upheaval of a great mountain system. The available evidence indicates that the main streams of the present Appalachian Mountains—those flowing northwestward from the mountains into the Appalachian Valley—are antecedent, that is, they began flowing in approximately their present courses as the land emerged from the sea, and during the uplift they deepened their valleys as rapidly as the surface was elevated and thus held their courses across the rising mountains.

MESOZOIC ERA.

Earlier cycles.—During the Mesozoic era, as probably during the greater part of the Paleozoic, the southern Appalachian region was a land surface undergoing erosion. At first it must have had a high and rugged surface, across which the main streams flowed northwestward in courses that conformed neither to the trend of the mountain ranges nor to the geologic structure. In the Ellijay quadrangle Toccoa and Nottely rivers were streams of that sort. As erosion proceeded a large part of the surface was eventually reduced almost to a peneplain, whose altitude was controlled by the local base-level of the streams. Probably the southern Appalachian Mountains have never been wholly reduced to a peneplain since the last great deformation, large areas having always remained as residual mountain masses. At several times before the region had been wholly reduced to base-level a new uplift rejuvenated the streams and the development of a younger and lower peneplain began. Fragments of all the older peneplains are probably preserved somewhere in the mountain region and the evidence at hand indicates that at least two and possibly three peneplains were developed in the southern Appalachians early in the Mesozoic era.

The surface of the Ellijay quadrangle was probably completely reduced to base-level in the earliest cycle thus recorded. The loftiest summits in the quadrangle reach heights of 3800 to 4100 feet and agree fairly well in altitude with the remnants of the oldest recognized peneplain in neighboring quadrangles where the mountains are higher. After revival of erosion by uplift a great part of the surface was reduced to a younger peneplain, the remnants of which now stand at altitudes of 2800 to 3000 feet in the Ellijay and neighboring quadrangles. There are indications that after another uplift, of only a few hundred feet, a third peneplain, the few remnants of which have a present altitude of 2400 to 2600 feet, was developed over a considerable part of the area. The remnants of this peneplain in the Ellijay quadrangle are not very obvious but can be easily traced in other parts of the region. The extent of the peneplain in the quadrangle is purely conjectural, but the fact that so few indications of its existence have been preserved leads to the view that it could not have occupied much more of the present surface than do the existing plateaus and that residual mountain masses must have had about the same extent as at present.

More or less warping of the surface doubtless accompanied each uplift, hence the scattered remnants of each ancient peneplain do not now lie everywhere at the same altitude. The warping, if it occurred, was, however, so slight or so slow that it did not change the general northwestward course of the main streams, and it is probable that practically all the area was still drained into those streams.

Adjustment of drainage.— During the upheaval of the mountains the main northwestward-flowing streams, such as the Toccoa and the Nottely, remained, as has been said, in their courses and cut down their valleys across the rising mountain ranges. All the tributary drainage, however, must have been consequent upon the plications of the deformed surface. The tributaries of the first order flowed in the northeast-southwest longitudinal valleys between the rising ridges and joined the rivers nearly at right angles, as some of them still do. The tributaries of the second order flowed down the slopes of the ridges with increasing velocity and erosive power as the uplift and plication of the surface continued. The drainage pattern of the first cycle after the upheaval must, then, have had a markedly trellised arrangement, at least in that part of the area where the surface was thrown into comparatively regular and parallel folds, the streams being closely adjusted to the surface configuration and hence to the geologic structure.

In the part of the area that was reduced to base-level the folds in the rocks were truncated and the strata were beveled by denudation, and belts of rock differing in resistance to erosion were thus exposed on the newly formed surface. When, by fresh uplift, erosion was again accelerated the surface was lowered more rapidly along the belts of rock of least resistance. It happens in the Ellijay quadrangle that most of the belts of less resistant rock lie along synclinal axes, hence the present longitudinal valleys agree closely in position with the original synclinal valleys formed by deformation. They lie somewhat southeast of the position of the original valleys, as the strata and structures dip southeastward and with the progressive lowering of the general surface by denudation the consequent topographic features have been shifted in that direction.

Many of the streams that were already adjusted to the structure were, when rejuvenated by uplift, in substantial adjustment to the hardness of the rock and continued to flow in practically their old courses, except for the slight southeastward shift down the dip. A few streams in the northern part of the quadrangle, besides those in the longitudinal valley and its neighborhood, have courses adjusted to the structure or to the hardness of the rock and conform rudely to a trellised pattern, as stated under the heading "Topography." The courses of Young Stone, Cutcane, Papermill, and Rapier creeks and of the upper part of Cherrylog Creek lie along the outcrop of the Murphy marble and of the more schistose parts of the Valleytown formation, or along lines of weakness due to great faults. Hothouse, Weaver, Butler, Wolf, Dooley, Star, Wilscot, and Stanley creeks in parts of their courses flow on more easily eroded beds in the Great Smoky and Carolina formations, or possibly in some places along minor synclinal axes. Parts of Fightingtown Creek and some of its tributaries and perhaps parts of Boardtown, Skeenah, and Young Cane creeks are similarly adjusted.

On the other hand the meandering courses of the rivers and some of the larger creeks and the manner in which such partly adjusted streams as Fightingtown, Sugar, Weaver, Hothouse, Hemptown, and Star creeks cross from one longitudinal valley to another, flowing for some distance across the strike of the rocks, show that other factors have intervened to disturb the adjustment of the streams. It is probable that in one of the earlier cycles the greater part of the quadrangle was reduced so nearly to a plain that the streams were largely free to seek new courses wholly unrelated to structure. Local irregularities in the next uplift may have diverted some parts of the streams and other diversions may have been due to capture by tributaries of other streams. It is noteworthy that all but one or two of the diversions are to the northwest and this is thought to indicate that they are due chiefly to tilt of the peneplain in that direction at the time of the next uplift. The time at which the diversions occurred is not known, but it was doubtless one of the earlier cycles, as the streams appear to have been flowing in their present courses during the period of the development of the Cumberland peneplain.

A curious example of lack of adjustment is presented by Ellijay River. From the north side of the quadrangle southward to Whitepath the valley along the outcrop of the Valleytown and Murphy formations is occupied by longitudinal streams. From Whitepath southward to the head of the valley west of Talona Mountain the topography is independent of the structure, except in minor features, and the main drainage valley is entirely west of the axis of the syncline, across which the streams from the east flow to the river. Though apparently conforming in its general course to the strike of the beds, the river does not flow on the easily eroded Valleytown and Murphy formations but follows a sinuous course on the Great Smoky formation a mile or so west of the synclinal axis.

Development of the Cumberland plain.—By another uplift, of 500 or 600 feet, the streams were again rejuvenated and again began to deepen their valleys and to dissect the new plateau. In the cycle thus begun a new factor made itself felt in the development of the surface of the area. During possibly all the Paleozoic era the region east and southeast of the Appalachian province, as well as the greater part of the present Piedmont Plateau, was land of unknown extent eastward and southward. The streams of at least the western part of the land then flowed northwestward into the interior Paleozoic sea and continued to flow in that direction during a part of the Mesozoic era, although their ultimate point of discharge is not known. At some time between the close of the Pennsylvanian epoch and the beginning of the Jurassic period the greater part of the ancient land, including probably most of the region now the Coastal Plain, was submerged by the Atlantic. The surface of the southeastern part of the Appalachian province was given a slope toward the ocean and the streams draining it flowed in that direction. The divide between the new southeastward drainageways and the ancient streams flowing northwestward was somewhere southeast of the present Blue Ridge.

The streams flowing southeastward had shorter courses, steeper grades, and more rapid currents, and they not only rapidly reduced to base-level practically all the region drained by them but also, by headward erosion, pushed back the divide between themselves and the northwestward-flowing streams. They extended the newly reduced surface up to the base of the residual mountains and so developed the Blue Ridge escarpment, on whose face they had their sources and along whose crest the divide became established.

Certain streams flowing southward to the Gulf had a similar advantage over the ancient rivers, and in conjunction with those flowing to the Atlantic they developed a new peneplain throughout what is now the Piedmont Plateau. The divide was pushed so far back that the new plain extended into the southern part of the Ellijay quadrangle and that part of the area has since been drained southward. In the southeastern part of the quadrangle the new peneplain seems to have extended somewhat farther north than the preceding one and to have encroached upon the residual mountains, hence in that part of the area the Blue Ridge escarpment is very pronounced.

While this was going on the streams flowing northwestward were also engaged in reducing a part of their basins to base-level and formed an imperfect peneplain on what are now the Toccoa and Nottely plateaus and in the basins of Ellijay and Cartecay rivers. The same peneplain was developed throughout a large part of the southern Appalachians and is named the Cumberland peneplain from its nearly perfect preservation on the Cumberland Plateau in eastern Tennessee. Owing to the great distance from the sea by the courses of the rivers and to local conditions farther downstream the base-level of the northwestward-flowing streams was at a greater altitude in the mountain part of their courses than that of the streams on the Piedmont plain. Hence the imperfectly developed peneplains in the basins of those rivers lay 200 feet or so higher than the inner margin of the piedmont, but a nearly continuous plateau surface can be traced around the end of the Blue Ridge from one area to the other and there is little doubt that all are of the same age and formed parts of the Cumberland peneplain.

The streams must have reduced the area to base-level some time before the interruption of the cycle by further uplift, as all of the rivers of the quadrangle and several of the larger creeks, especially Fightingtown, Hothouse, Young Cane, and Nimblewill creeks, have very meandering courses, even where their valleys are now several hundred feet deep. The meanders were formed in the cycle when the streams were flowing on the Cumberland peneplain, if not in a still earlier cycle, and were inherited when the streams were once more rejuvenated.

Cretaceous uplift.—The Cumberland peneplain was well developed, at least about its seaward margin, at the beginning of Cretaceous time. Its surface slopes southwest, south, and southeast beneath the basal Cretaceous strata at the inner margin of the Coastal Plain. It is not certain that all the plain is older than Cretaceous, as its development may have been progressing inward toward the heads of the streams while sediments were being deposited upon its outer margin, but a large part of it must be pre-Cretaceous and the rest is at any rate of early Cretaceous age if not older. The cycle was eventually terminated by uplift, accompanied by broad warping of the uplifted surface, and the streams once more began deepening their valleys.

CENOZOIC ERA.

TERTIARY PERIOD.

The record of the Tertiary period in the Ellijay quadrangle appears to show continuous downcutting by streams and dissection of the surface of the Cumberland peneplain, now a plateau. In the southern Appalachian region outside the mountain belt two more peneplains have been developed since the uplift that terminated the development of the Cumberland plain, but, owing to the distance of the area from the sea and the shortness of the erosion cycles, the streams of the Ellijay quadrangle were not able to reduce any of its area to base-level and no part of the later peneplains was developed in the quadrangle. No physiographic features in the quadrangle can be definitely assigned to either of the later erosion cycles that the region passed through. The gravels found high on the slopes along the valleys of the Toccoa and Cartecay and in similar places elsewhere in the area may have been deposited during a temporary cessation of downcutting by the streams that was directly connected with some of the continental movements recorded in other parts of the region, but no definite information on this subject has been obtained.

During the Tertiary period the topography of the quadrangle assumed practically its present form. The streams intrenched themselves in valleys cut 300 to 500 feet below the Cumberland peneplain and many of their meanders were preserved during the valley cutting, so that some of the deep, narrow valleys are at present very tortuous, the most striking being the meandering gorge of Toccoa River west of Wilscot Mountain, described under the heading "Topography." The Blue Ridge escarpment is so pronounced within the quad-

[a] Phalen, W. C., On a peculiar cleavage structure resembling stretched pebbles near Ellijay, Ga.: Jour. Geology, vol. 18, 1910, p. 561.

rangle and there is so little plateau surface at its crest that practically no further backward pushing of the divide has taken place since the formation of the Cumberland peneplain, except at Amicalola Falls. At that place a headward-eroding tributary of Little Amicalola Creek has captured one of the headwaters of Klotz Creek, a tributary of the Cartecay. At the point of its capture the beheaded stream, which was flowing on a remnant of one of the older peneplains southwest of Bucktown Mountain, approached the crest of the escarpment so closely that a gully down the face of the scarp gnawed back far enough to tap it and turn its whole flow down the present cascade.

The present surface of the quadrangle displays some relation between topography and the nature of the underlying rocks. The highest mountains are formed largely of conglomerate and spangled biotite gneiss that are highly resistant to erosion. The spurs of the Cohutta Mountains that extend eastward into the quadrangle are made up largely of conglomerate and grit, whereas the lower areas on either side are occupied chiefly by slaty and schistose rocks. Duncan Ridge and the part of the Blue Ridge between Double Head Gap and Winding Stair Gap are due chiefly to the resistant qualities of garnet-kyanite gneiss, a rock so tough that the resultant topography is the most rugged in the area and is characterized by a surface abundantly strewn with residual fragments. The longitudinal valley has been eroded along the strike of the Murphy marble and the Valleytown formation, both of which are less resistant than most of the other formations. The walls of the valley are formed by the more resistant Tusquitee quartzite and Nantahala slate and the central ridge by the harder and coarser beds of the Valleytown formation.

On the other hand the same formations and the same sorts of rock are found in the Blue Ridge as on the Piedmont Plateau at the south or in the mountain valleys at the north. Where the escarpment is most pronounced, rising from 1500 to 1800 feet above the plateau, the same formations are found in both and they trend so as to pass from the plateau up the face of the scarp and across the Ridge.

QUATERNARY PERIOD.

Few important events in the physiographic development of the quadrangle have occurred in the Quaternary period. Since the latest uplift the streams have not had time to become adjusted to the present base-level. They flow for the most part of their courses over rock beds, with numerous rapids and small falls. Not only the streams of the Tennessee drainage basin but a number of those rising on the face of the Blue Ridge escarpment and flowing across the Piedmont have small falls at points along their courses where differences in rock hardness or other conditions cause sudden changes in grade. Along the rivers and one or two of the larger creeks are some stretches where the current is slow, the valley bottom has been widened slightly, and some alluvial deposit has been formed.

A stream capture of the sort that formed Amicalola Falls is, geologically speaking, imminent at another place on Klotz Creek, where practically the whole of that stream will eventually be diverted, if nothing interferes, by a small tributary of Amicalola Creek that is working headward through the pass now traversed by the road from Amicalola to Licklog. Nothing more than a low fall can be formed at that place, however, as the streams are still half a mile apart and their difference in altitude is less than 100 feet. At one or two other points along the escarpment, as on Burnt Mountain and in the neighborhood of Grassy Gap, similar captures will presumably occur at some remoter time.

ECONOMIC GEOLOGY.

By W. C. Phalen.

MINERALS FOUND.

The mineral resources of the Ellijay quadrangle include, among the metals, gold, copper, iron, manganese, silver, and lead, the last three of which are not of much importance, and among the nonmetals such structural materials as marble and the lime which may be made from it, building stone other than marble, kaolin, clay, sand, and gravel, and also road-making material of various kinds. Other miscellaneous nonmetallic resources are mica, talc, abrasive material, graphite, and also marble, or dolomite, which is used in the manufacture of carbonic acid and Epsom salts and as a flux in the copper-smelting operations at Ducktown, Tenn. The mineral springs are of some importance and the rivers and mountain streams furnish cheap and easily available water power for use in the mining and lumber industries and in lighting the towns.

GOLD.

Forms of occurrence.—Gold occurs in the Ellijay quadrangle in at least two forms—(1) in veins and (2) as free or placer gold in gravels which are now or have been associated with streams. The quadrangle also contains gold-bearing saprolite, or disintegrated rock in place. The gold-bearing veins are of two kinds—(1) those in which the metal is associated with quartz and small amounts of pyrite, chalcopyrite, and other minerals and (2) those in which it is associated with sulphides alone, with little or no quartz. The veins occur in practically all the rocks of the area except the Murphy marble. The gold-bearing gravels represent the residual insoluble portions of rock masses long since decayed; their gold content represents the concentration of the metal which formerly existed in a more or less disseminated state in those rock masses. Of the different classes of deposits the gold-bearing gravels are of greatest importance, but even these have at present little economic interest and are worked only intermittently, when at all. The placer gold deposits include gold-bearing gravels found on the hillslopes along stream courses, such as occur northwest of Roy post office, where the gravel has been worked for gold as high as 100 feet above the present river. Genetically the gold in the gravel is secondary and that in the veins is primary and the gold-bearing veins will therefore be described first.

Gold-bearing quartz veins.—The most common type of quartz vein in the Ellijay quadrangle is the fissure vein. These veins generally conform to the trend of the inclosing schist or gneiss and are then called interfoliated veins; less commonly they may occur in other attitudes. They appear also to have been formed at different times, for some of them partake of the metamorphism of the inclosing rocks, whereas others, which cut across the schistosity of the inclosing rocks, have been formed later. It is probable that quartz veins of the same genetic class but of different age occur in the same general locality.

The veins differ greatly in thickness, the thinnest being mere films, the thickest measuring several feet across. They branch and reunite, inclosing "horses" of wall rock some of which constitute a large part of the "vein zone." Many of the veins in northwest Georgia that are only a few inches thick contain considerable amounts of gold and some of these probably occur in the Ellijay quadrangle. The veins pinch and swell and are likely to disappear within very short distances, this fact making systematic mining hazardous. The veins that are not interfoliated with the inclosing schist or gneiss are generally regarded as more persistent and uniform than the interfoliated veins. On the other hand it is probable that in this area, as in certain other parts of northwest Georgia, notably in Cherokee County, some of these conformable quartz veins attain lengths as great as 60 or 70 feet. These veins lie considerably northwest of the extensive gold-bearing belts mapped by the Geological Survey of Georgia.[a]

As stated above, the chief mineral in these veins is quartz, which may or may not contain small amounts of sulphides—pyrite, chalcopyrite, galena, sphalerite, and possibly pyrrhotite, minerals with which the gold is usually associated. As a rule the quartz is of the compact opalescent or milky variety, with hypidiomorphic structure, in some places completely crushed and in others without evidence of shearing or crushing such as has affected the inclosing country rock. When examined under the microscope the specimens of crushed vein quartz give little or no internal evidence of their history. A great deal of such vein material has been completely recrystallized.[b] Generally the sulphides have been weathered and the outcrop of the veins is marked by a brown stain of iron oxide. The presence of sulphides or their decomposition products in the veins, however, does not necessarily indicate the presence of gold, and, on the other hand, their absence does not necessarily mean that the veins contain no gold. Very little is known about the distribution of the gold in the veins. It is probably for the most part directly associated with the sulphides where those are present.

Veins of the type described above are found in several places in the Ellijay quadrangle, chiefly in the Carolina, Great Smoky, and Valleytown formations. A typical quartz vein occurs a short distance northwest of Roy, Gilmer County, in the valley of Cartecay River. The vein has not been worked recently and when visited the walls of the shaft had fallen in. The vein appears to be 2 to 3 feet thick and to consist of bluish-white saccharoidal quartz, the bluish tint resulting in places from an admixture of country rock. It has probably undergone metamorphism, as is indicated by its large content of muscovite. The wall rock could be determined only from material on the dump, and footwall and hanging-wall rock could not be differentiated. Most of the rock is quartzitic and represents a highly siliceous phase of the common type of the Carolina gneiss of the region. It is virtually an aggregation of biotite and quartz, which may or may not contain feldspar, and has been called a biotite or mica gneiss. It is thought to be a metamorphosed ferruginous sandstone. Some of the ore taken from this vein is said to be among the richest ever obtained in northern Georgia. The vein appears to run nearly east and west and dips steeply to the north. Placer gold has also been obtained in the vicinity. This will be referred to subsequently.

[a] Jones, S. P., Second report on the gold deposits of Georgia: Bull. Georgia Geol. Survey No. 19, 1909, map, p. 36.

[b] Phalen, W. C., On a peculiar cleavage structure resembling stretched pebbles near Ellijay, Ga.: Jour. Geology, vol. 18, 1910, p. 561.

Other gold-bearing quartz veins in Gilmer County are reported in the vicinity of Cartecay, Santaluca, Cherrylog, and Licklog. At several localities along or near the great faults of the longitudinal valley are quartz veins associated with pyrite, chalcopyrite, and their oxidation products. Among these are the Searcy property, near Cherrylog, where several such veins have been prospected to some extent. Other and similar occurrences are reported near Santaluca post office, at the head of Cutcane Creek, Fannin County, and near and to the east of Blackjack Mountain, Union County. The gold-bearing quartz veins mined near Blairsville, the county seat of Union County, east of this area, are excellent examples of the quartz veins of this general region. They are reported to be controlled by the Union Gold Mining Co., which has run a tunnel on the property. It is reported that five shafts were sunk on the line of this tunnel. The gold is associated with some pyrite and iron oxide, and the ore was regarded as free-milling. The plant is rather large and well equipped for this district but was in a state of decay when visited. The quartz veins near Blairsville lie near bodies of muscovite-biotite granite, which is probably the latest rock in the region. There is probably a genetic relation between the granite bodies and the quartz veins.

Gold has been mined near Chipeta, in Fannin County, in placer deposits and in quartz veins. The vein deposits consist of numerous small stringers of saccharoidal quartz more or less honeycombed with rust-stained cavities. These veinlets occur in a saprolite on interbedded graywacke and mica schist. The vein quartz was once treated in a mill erected near the mine.

It is probable that there are numerous quartz veins of the Dahlonega type in Lumpkin County, in the southeastern part of the quadrangle. These veins were formed at or near the contact of the mica schist (Carolina gneiss) and the amphibolite or hornblende gneiss (Roan gneiss), or along or near the contact of the mica schist and biotite granite. Veins belonging to this class have been worked extensively near Dahlonega, but so far as known none have been worked in the Ellijay quadrangle. The deposits are in part "stringer leads," to use an expression of Becker,[a] and in part distinct veins, composed of a series of flat, lenticular bodies of quartz, conformable with the schistosity. The quartz is as a rule compact, milk-white or glassy, of coarse, hypidiomorphic texture, with drusy cavities and, rarely, with comb structure. Much of the gold is primary. Gold is found in the wall rock but principally in the quartz. The mode of alteration of the wall rock suggests that there may have been two epochs of vein formation, in which the physical conditions differed.

Gold-bearing sulphide deposits.—The copper deposits of the Ducktown region are traceable in some parts of the northwest corner of the Ellijay quadrangle. The large mines of the district, however, are farther north. They occur in the mica schist of the Great Smoky formation and are associated with limestones, which they are thought to replace. The deposits are huge tabular and lenticular masses in which the common ore is an aggregate of pyrrhotite, pyrite, chalcopyrite, sphalerite, bornite, specularite, magnetite, actinolite, calcite, tremolite, quartz, pyroxene, garnet, zoisite, chlorite, micas, graphite, titanite, and feldspars.[b] The copper content is small, averaging not more than 2 per cent, and the ore yields, according to recent figures, 31.4 pounds of copper and 5 cents in gold and silver to the ton. It should be added, however, that this value in precious metals is recovered from only a part of the Ducktown ores, as some of the casting copper is shipped abroad unrefined.[c] The value in precious metals, however, can not be more than 10 cents a ton, or double the figure given above, which is much below what is locally supposed to be recovered. For descriptions of the sulphide deposits carrying small amounts of gold and possibly other precious metals, the reader is referred to the section on copper (p. 13).

Placer deposits.—The placer deposits are genetically connected with the gold-bearing quartz veins and the sulphide veins, especially with the former. They contain gold that has been concentrated in stream gravels formed by the disintegration of the quartz veins and the rocks containing them, the insoluble residual material, including gold, having been transported by water to the stream valleys. They include not only gravel in the stream bottoms and flood plains of the present time but also gravel terraces formed by streams in previous epochs and hillside gravel, or colluvial deposits. The gravel in the lower parts of the valleys is near the present level of the streams and in the stream beds, and unsuccessful attempts have been made to divert streams, as Cartecay River near Roy, in order to work stream-bed gravel that is thought

[a] Becker, G. F., Reconnaissance of the gold fields of the southern Appalachians: Sixteenth Ann. Rept. U. S. Geol. Survey, pt. 3, 1895, pp. 251–331. Also Lindgren, Waldemar, The gold deposits of Dahlonega, Ga.: Bull. U. S. Geol. Survey No. 293, 1906, pp. 223–225.

[b] Emmons, W. H., and Laney, F. B., Preliminary report on the mineral deposits of Ducktown, Tenn.: Bull. U. S. Geol. Survey No. 470, 1911, pp. 151–172.

[c] McCaskey, H. D., Gold, silver, copper, lead, and zinc in the Eastern States (mine production): Mineral Resources U. S. for 1908, pt. 1, U. S. Geol. Survey, 1909, p. 672.

to be rich. Placer gold has also been obtained on hillsides near Roy. Many rich deposits are found in alluvial fans formed at places where small mountain streams emerge into the large valleys. Here their flow is arrested and much of their burden of sand, clay, and gravel is deposited. The gravel consists principally of pebbles of quartz or, less commonly, of the gneiss, slate, and schist of the region, which have remained undecayed. The rock fragments are either well rounded or subangular.

The gravel in valleys near gold-bearing quartz veins generally contains gold, and the richer the veins the richer the neighboring placers. This association of valuable stream gravel and gold-bearing quartz veins is conspicuous on parts of Cartecay River and on Noontootly Creek and some of its branches. Even though the presence of placer deposits points to the existence of near-by gold-bearing quartz veins, the veins may not have been discovered.

Placer-gold deposits occur near Whitepath, the more important lying along Whitepath Creek, as indicated on the economic-geology map. They appear to consist of alluvial fans lying at the mouths of gulches between long mountain spurs running southwest from Aaron Mountain. The gold is supposed to have been derived from auriferous quartz veins, but though these veins have been diligently sought they have not been found. It is possible, however, that the gold there has been derived from stringers of quartz that are too small to attract attention. Mining was abandoned some years ago and the original workings are now overgrown with brush. The total area of the old workings probably does not exceed 50 acres and much of it has been worked over several times. It seems probable, therefore, that the unworked area must be rather small. It is reported that the largest nugget of gold ever found in Georgia came from the Whitepath placer mine, and that it weighed 4½ pounds and was valued at $1100.[a]

About 2 miles south of Whitepath, on Little Turniptown Creek, placer gold has been obtained in small amount. It occurs in a narrow gorge and in the adjacent wide expanse of bottom land. About a mile northwest of Roy post office, in the valley of Cartecay River, much work has been done in hunting for placer gold. The north side of the river has been worked for nearly a quarter of a mile below the small stream flowing into the river from the north. Little or no work has been done on the south side or in the bed of the main stream. Gold probably exists in the gravel of the main river, and an attempt was made some years ago to divert the river from its present course but without success. The gravel has been successfully worked to an elevation of 100 feet above the stream. The methods employed were very crude and it is likely that gold in paying quantities may still be found. The workings are very close to the gold quartz vein described above. About 2 miles southeast of Roy, on a small branch flowing into Cartecay River from the west, placer gold has been found in the creek gravel. The workings are more than 30 years old. Gold in placer deposits has been obtained near Chipeta. The placer workings are confined to a small branch emptying into Noontootly Creek, a few hundred yards northwest of the vein deposits already referred to. Placer gold was also found in the valley of Lovengood Creek, one of the tributaries of Noontootly Creek from the southwest.

SILVER.

Some of the gold-bearing quartz veins on the Searcy property near Cherrylog, Gilmer County, are reported to contain small amounts of silver. The gold and silver content of the cupriferous sulphide ores of the Ducktown region has been referred to. The amount of precious metals in these copper ores, as already stated, is extremely small.

COPPER.

The following data on copper in the Ellijay quadrangle were furnished by W. H. Emmons and F. B. Laney, who respectively studied the ore deposits and the geology of the Ducktown district during the summers of 1910 and 1911.

History of discovery.—Copper was discovered in the Ducktown district, a portion of which is included in the northwestern part of the Ellijay quadrangle, in 1847, and active mining began there in the early fifties. Prospecting for copper began with the discovery and opening of the Ducktown mines and quickly spread throughout the region around the Ducktown district, resulting in the discovery of a number of more or less promising prospects within the Ellijay quadrangle, a few of which were opened. The Civil War caused the nearly complete cessation of prospecting and mining. Since the war two or three of the most promising of the old prospects have been periodically opened, operated for a few months, and then abandoned. The most important of these are Mine No. 20, the Mobile mine, the Pisgah mine, the Sally Jane mine, and the Jeptha Patterson mine, all in the Great Smoky formation, in the northwest part of the quadrangle.

[a] Yeates, W. S., McCallie, S. W., and King, F. P., A preliminary report on a part of the gold deposits of Georgia: Bull. Georgia Geol. Survey No. 4-A, 1896, p. 9. Also Jones, S. P., Second report on the gold deposits of Georgia: Bull. Georgia Geol. Survey No. 19, 1909, pp. 270-271.

Prospecting has been done in other places—for example, on Young Cane Creek, northeast of Young Cane post office, and on the road between Higdons Store and Chestnut Gap, on the right bank of Little Fightingtown Creek.

Mine No. 20.—About 3 miles southwest of Copperhill, and about 1 mile northeast of Pierceville, a mine known as Mine No. 20 was opened in 1861 or 1862 by three Cornishmen, James Phillips, Harvey Falls, and Thomas Pill, and was operated by them during the greater part of the Civil War. About the close of the war work was stopped and the mine remained closed until 1877 or 1878, when it was reopened and a considerable amount of ore was taken out. Work was continued only a short time and the mine was again closed and remained idle until it was purchased in 1905 by its present owner, Judge James F. Howe, of Knoxville, Tenn. Several test pits and two shafts have been sunk in the lode and it is fairly well developed by diamond drilling. Only development work was done in 1905, and the ore then taken out consisted largely of the so-called "black copper," probably chalcocite, which was stored in sheds near the mine. It was reported that the ore thus stored would average nearly 10 per cent copper. In addition to the "black copper" ore there were also several piles of yellow sulphide, chalcopyrite, which looked very promising and was said to carry nearly 3½ per cent copper. Chalcopyrite appears to be more abundant in this ore than in that now coming from the Ducktown mines.

The ore body has been developed for nearly 1000 feet along the strike of the lode and has been tested in some places to a depth of 500 feet. The lode is said to be in places about 30 feet thick, and taken as a whole it appears to be a promising ore body. This lode, like all others in the district, is not a simple tabular body but is more or less irregular in outline. It probably replaced a limestone lens and therefore lies parallel with the bedding of the country rock, which strikes N. 35°–50° E. and dips about 70° SE. The metallic minerals of the ore body include pyrrhotite, pyrite, chalcopyrite, chalcocite, sphalerite, and galena. The gangue minerals are actinolite, tremolite, zoisite, pyroxene, garnet, quartz, and calcite. The heavy silicates, with quartz and calcite, occur commonly as rounded or irregular masses in the sulphide ore. The gangue minerals are largely calcium-bearing silicates and are characteristic of copper deposits that replace limestone. This fact and the fact that almost pure crystallized limestone occurs in the East Tennessee mine, in the Ducktown district, the ore and minerals of which are the same as those just described, form the basis for assuming a replacement origin for this ore body.

Mobile mine.—The Mobile mine is near Pierceville, about 3½ miles southwest of Copperhill, Tenn. It was opened in 1858 by the Mobile & Atlanta Mining Co. Two shafts, 175 feet apart, were sunk in the ore body, one 170 feet deep, and the other 155 feet deep. These shafts were connected by a drift, and from each shaft a drift was driven along the strike of the lode for about 300 feet, thus developing the ore for nearly 800 feet. A small smelter was erected near the mine, in which the ore was smelted after being roasted in open heaps. It is reported that the mine was operated successfully until it was closed in 1861 because of the Civil War. Nothing further was done until 1891 or 1892, when the property was purchased by Mr. Harvey Schafer, of Pittsburgh, who had the shafts cleaned out and retimbered and everything put in readiness for active work. No mining was done, however, and the workings were allowed to refill with water. In 1912 the shafts were caved and everything was in a dilapidated state. The property still belonged to the Schafer estate.

The ore body is reported to be lenticular, to have a maximum thickness, near the center, of 35 feet, and to thin to a few feet at each end. It trends N. 48° E. and dips steeply to the southeast. Its outcrop is not clearly exposed but is said to have been well defined where the shafts were put down. According to such reports of the old workings as are available the ore carries from 2½ to 4 per cent of copper. Very little "black copper" was found at this place. The ore from this mine, as far as could be determined from material on the dump, is of the Ducktown type—that is, it consists of pyrrhotite, pyrite, and chalcopyrite in a gangue of calcium-bearing silicate minerals, with quartz and calcite. The country rock is the usual graywacke and mica schist of the more highly metamorphosed phases of the Great Smoky formation.

Mount Pisgah prospect.—A so-called mine, which is only a prospect, is located on Mount Pisgah, about 10 miles southwest of Copperhill, Tenn., and about 1½ miles southwest of Higdons Store. According to report, the outcrops were discovered and a small amount of prospecting was done in the late fifties. At different times since then more or less work has been done at the place, but apparently with little success. At least the workings have thus far failed to progress beyond the stage of prospects.

The ore crops out near the top of a mountain about 400 feet above the wagon road at Higdons Store and is difficult of access. The ore is chalcopyrite with some pyrite and pyrrhotite, either in a quartz gangue or interstratified with more or less silicified layers of the mica schist or mica gneiss that forms the country rock. Near the ore is a well-defined band of staurolite schist, which trends northeast-southwest and can be traced by disconnected outcrops and by staurolitic débris in the soil for a considerable distance. An outcrop of pegmatite that carries a large quantity of black tourmaline also occurs on the top of the ridge near the openings, but no traceable connection exists between the pegmatite and the copper ores. The deposit, is apparently not of the Ducktown type. Careful search was made for the gangue minerals that are so characteristic of the Ducktown ores—that is, heavy calcium-bearing silicates—but without results. The workings consist of two shallow shafts and a small amount of tunneling.

Sally Jane prospect.—Midway between the Mobile mine and Copperhill is the Sally Jane prospect, owned by the Harvey Schafer estate. It is reported to have been opened in the late fifties. Two shallow shafts were sunk, one on a hillslope, the other near the bank of a small branch near by. No ore was found in the shaft on the hill, but a little "black copper" is said to have been taken from the shaft near the branch. Nothing as to the character of the ore could be learned from the dump. A band of staurolite schist is exposed in the upper shaft and can be traced some distance toward the southwest. This band indicates that the prospect may be at the same horizon in the series of schists as the Mobile mine.

Jeptha Patterson prospect.—The Jeptha Patterson prospect consists of two or three caved shafts on a ridge about half a mile southwest of Pierceville. The work was done many years ago and little remains on the dump to show the character of the material taken out. It is reported that a small amount of ore, somewhat like that at the Mobile mine, was found, but the only evidence confirming this report consists of a few pieces of copper-stained rock found in the old dump. The band of staurolite schist that occurs at the Mobile mine can be traced within a few yards of this prospect, and it therefore seems probable that it is at the same horizon in the country rock as the Mobile mine.

Genesis of the primary ore.—The ore bodies—that is, in so far as they are of the Ducktown type—are considered by Emmons and Laney[a] as replacements of limestone lenses, a conclusion which is supported by several kinds of evidence. All the lodes are inclosed in sedimentary rocks, chiefly mica schists and graywackes, and, except where faulting has occurred, the deposits are parallel to the bedding, of which staurolitic beds that parallel some of the lodes for great distances serve as reliable markers. The association of ore and gangue minerals in the Ducktown lodes is characteristic of deposition at considerable depth under pressure, and it is improbable that spaces of so great width (exposures of the ore zone being in some places over 200 feet wide) could remain open at the depths at which the minerals are believed to have formed. Other facts that contravene the idea that the lodes are fissure fillings are the absence of characteristic structural features, such as comb structure or open spaces or druses lined with banded crusts.

That the ores replace limestone is indicated by the fact that all the abundant gangue minerals except quartz contain considerable lime. The lime minerals include the carbonate calcite and the silicate minerals actinolite, tremolite, pyroxene, garnet, and zoisite. These minerals constitute a considerable portion of great masses of the ore. Moreover, in certain places in nearly all the mines, masses of marbleized limestone are inclosed in the ore or in the tremolite or actinolite rock and the ore grades along the strike into rock composed almost entirely of these two minerals together with calcite. Such marbleized masses have not been found outside the ore zone.

It is probable that the limestones were replaced by magmatic waters. The gangue minerals of the ore zone, with the exception of quartz and calcite, are lime silicates and are typical of those associated with ores resulting from the replacement of limestones near intrusive masses. The ore minerals include pyrrhotite, pyrite, chalcopyrite, zinc blende, galena, magnetite, and specularite. These minerals are intergrown in such manner with the calcite and heavy silicates that they must have been formed simultaneously with them. Though the ores are somewhat metamorphosed and have been bent and twisted they do not exhibit well-defined schistosity, and they were probably deposited after the rock that now incloses them and the limestones they replace had been subjected to considerable dynamic metamorphism.

IRON AND MANGANESE.

Character and location.—Iron and manganese ores occur in many places along or near the faults of the longitudinal valley, but in comparatively few places is there a sufficient quantity to repay systematic development. Most of the iron ores are hydrous ferric oxides, so-called "brown ore," but the analyses available are so incomplete that little can be told about the original content of water in the ore, so it is uncertain whether

[a] Emmons, W. H., and Laney, F. B., Preliminary report on the mineral deposits of Ducktown, Tenn.: Bull. U. S. Geol. Survey No. 470, 1911, pp. 165-168. Emmons, W. H., The enrichment of sulphide ores: Bull. U. S. Geol. Survey No. 529, 1913, pp. 205-207.

it is turgite, goethite, or limonite. The fact that the ores are entirely amorphous shows that they were formed later than the rocks with which they are associated and therefore after the periods of deformation during which the neighboring rocks were affected. Hence the deposits are secondary.

The deposits are located as follows:

1. Near the State line between Georgia and North Carolina, southwest of Culberson, N. C.

2. In the vicinity of Blue Ridge, Fannin County.

3. On the Searcy property, southwest of Cherrylog, Gilmer County.

4. At Ore Knob, a small and somewhat isolated hill near the mouth of Little Turniptown Creek, just east of the Louisville & Nashville Railroad, about 4 miles northeast of Ellijay.

5. About a mile east of Ellijay, just north of Cartecay River.

6. About 6 miles southwest of Ellijay, just outside the Ellijay quadrangle, 1½ miles north of Talona station. This deposit is at the boundary between the Murphy marble and Valleytown formation.

Culberson.—About a mile southwest of Culberson, near the highway between that town and Sweetgum, iron ore occurs in the form of residual pebbles in the soil. As the ore is known to be very close to or along a main fault it was probably formed by waters circulating in the fault zone.

Blue Ridge.—A few openings have been made on the McKinney property, in the southern part of the town of Blue Ridge, Fannin County, just west of the railroad. They are open cuts that strike with the formation, a little east of north. It is reported that large shipments of iron ore were made from this place. Though no manganese ore has been shipped from this locality, a considerable quantity is associated with the brown iron ore. The iron and manganese ores lie near the fault that extends along the west side of the longitudinal valley which here separates the slates and schists of the Valleytown formation on the east from the Tusquitee quartzite on the west. Both the iron and the manganese ore occur in the form of nodules in the residual clay. On the east side of the ore-bearing zone is a narrow belt of quartz impregnated with iron oxide and to some extent with manganese oxide. The quartz is mostly compact but is in places somewhat cellular. The ore has been leached from the adjacent formations by water circulating in and along the zone of faulting and then deposited in lenses or pockets.

Searcy.—The ore in the Searcy property, southwest of Cherrylog, is associated with a quartz breccia which is genetically connected with the eastern fault. The ore is highly siliceous and therefore not very valuable.

Ore Knob.—Iron ore has been exposed by several open cuts and pits at Ore Knob, between Whitepath and Little Turniptown creeks, just east of the railroad. Most of these openings are in a quartzitic sandstone or quartzite, though one test pit from which considerable ore has been removed has a footwall of lustrous blue schist, characteristic of the Valleytown formation as exposed along the road between Blue Ridge and Ellijay. It is reported that several shipments of ore were made from the property and that one consisted of 29 carloads. All the ore seen lies well above drainage level.

The rock with which the bulk of the ore is associated appears highly siliceous. Along the public road south of Ore Knob, silvery mica schist of the Valleytown formation outcrops in several places, east of which lie ore and sandy débris. A short distance to the east, in the valley of Little Turniptown Creek, the typical blue Nantahala slate was observed. All the observations made in this locality indicate dips of 40° or more, generally to the southeast. The strike of the rocks is generally east of north but in places swings around nearly to north, and as nearly as could be determined the trend of the ore belt conforms closely to that of the adjacent rocks. The ore apparently lies along the line of the thrust fault, a fact that accords with observations on the character of the ore itself, some of which is a quartzite breccia cemented by iron oxide. Much of the ore is highly siliceous, some being a mere film of iron oxide on a quartzitic nucleus. Some of it is black, suggesting an admixture of manganese oxide, but the bulk of the material is common limonite or brown ore. Though the ore is siliceous in part, much of it is very pure, and the study of that already uncovered indicates that with careful culling good ore can be had in quantity large enough to invite the development of the deposits.

The ores appear to have been leached from the surrounding rocks and deposited by descending water, for no sulphides are associated with the ore. If this supposition is correct, the deposits will be of slight depth but may have considerable linear extent.

East Ellijay.—The deposits a mile east of Ellijay are just north of Cartecay River, on the west side of Randall Branch. The hill in which the ore occurs rises about 300 feet above the bed of the river. The old workings are now inaccessible, but according to reports the ore occurs in at least two veins, a main vein and another of less thickness, which are exposed in a tunnel 200 feet long, driven from a point near the east base of the hill. In the tunnel a winze was driven nearly 50 feet deep, wholly in ore. A surface cut has also been made at one point, exposing an ore body said to be 40 feet thick, though the thickness shown in the tunnel is only about 25 feet. A few open cuts and an old shaft, said to be 70 feet deep, have also been sunk on the ore. On the south side of the hill, at the roadside, another tunnel was evidently started. The ore can be traced intermittently for several hundred feet northward along the hill, and the underground and surface observations made indicate that a fairly large body of ore lies above drainage level. The strikes of the rocks in the immediate locality, among which the blue Nantahala slate predominates, are various, ranging from N. 15° E. to N. 44° E. The main ore body strikes about N. 30° E. and dips 50° SE., its strike and dip thus conforming to that of the inclosing slate. The country rock to the east is blue slate, regarded as characteristic Nantahala. Farther south, in the town of East Ellijay, the same slate crops out along the roadside, striking about N. 30° E. and dipping steeply to the southeast. At the bridge over Cartecay River the blue slate also crops out. Some of the rock in the valley of Randall Branch is grayish mica schist, not characteristic of the Nantahala. The ore appears to lie close to a fault contact between the Nantahala slate and the Valleytown formation.

The ore itself is the usual brown ore or limonite. Some of it is rather siliceous, but the analyses given below indicate an ore of high grade.

Analyses of iron ore east of Ellijay, Ga.

	1	2	3	4
Metallic iron	51.48	54.61	55.71	50.88
Silica and insoluble	8.29		4.65	9.28
Phosphorus	1.06	.917	.226	1.90
Sulphur	Trace		.148	.01
Moisture at 212° F				1.12

1. Average sample of ore taken across the big vein in the main tunnel by Hall Bros., mining engineers, Atlanta, Ga. Analysis made in the N. P. Pratt laboratory, Atlanta, Ga.

2. Ore from vein in main tunnel. Analysis by John M. McCandless, Atlanta, Ga.

3. Ore from outcrop. Analysis by Hodge & Evans, Anniston, Ala.

4. Sample taken entirely across the face of vein by S. W. McCallie. Analysis made in the N. P. Pratt laboratory, Atlanta, Ga.

These analyses show that the ore contains a fair amount of metallic iron, much phosphorus, and, with the exception of the outcrop sample analyzed by Hodge & Evans (No. 3), little sulphur.

Like the ores at Ore Knob, the ores east of Ellijay appear to have been deposited by surface or shallow underground waters which leached the iron from the garnet, staurolite, pyrite, and other iron-bearing minerals contained in the rocks and deposited it in its present position. The planes of schistosity in the slates of this region, especially where the rock is at all calcareous, would facilitate the movement of such solutions. The movement of such waters would probably be more pronounced along the fault, where the ore would be most likely to occur in largest amount.

Talona.—Though the deposits near Talona occur just outside the Ellijay quadrangle, they will be described here, as they are of a type which may prove common in the Ellijay quadrangle. They occur near the point where Talona Creek crosses the Louisville & Nashville Railroad, about 1½ miles north of Talona station. Here a thick vein of iron ore has been exposed in an open cut on the west side of the valley, near the valley floor. The Murphy marble underlies the valley and extends a short distance up the hillside to the west. The ore occurs between the marble on the east and a dull reddish brown or blue satiny schistose rock of the Valleytown formation on the west. The schist strikes N. 20° to 25° E. and dips from 40° to 50° SE. In the open cut already excavated the ore appears as a practically solid ledge. To judge from ore in place, west of the cut, the lead is nearly 50 feet thick, although it may not all be solid ore. It can be traced for a long distance northward and not so far southward. A spur track has been built to the railroad and active mining has been in progress for several years.

The ore is limonite and does not differ materially from that above described. Its origin, however, is distinctly different in that it apparently does not lie along a fault plane. The Murphy marble underlies the valley floor; the schist to the west is in the Valleytown formation, lying normally below the marble. Such a contact between insoluble schists and a marble offers a natural channel for the descent of surface water, and it is possible that iron oxides leached from the ferruginous minerals in the adjacent formations may concentrate along such a contact and be subsequently oxidized. The ore body probably extends only to a moderate depth, but the quantity of ore above ground-water level may prove to be large, for the deposit is of great extent.

Two analyses of this ore, kindly furnished by Mr. H. A. Field, of Ellijay, show that the Talona ore is of fairly good grade. Phosphorus is high, but if it does not run any higher on further development it is not objectionable. These analyses are as follows:

Partial analyses of Talona iron ore.

	1	2
Metallic iron	49.00	51.80
Silica	16.50	12.04
Manganese		.30
Phosphorus	.37	.67

1. Childers & Hunter, Knoxville, Tenn., analysts.

2. Analysis made by the Virginia Coal & Coke Co.

Gossan ores.—Gossan ores—the oxidized outcrops of underlying sulphide veins—occur at many places in the Ducktown region, where they are of great importance and have been extensively worked for iron. As they are worked downward the brown oxide gives way to pyrite and chalcopyrite, the original ore of copper, and the material is no longer available as iron ore. Gossan leads have been located in the Ellijay quadrangle near Cherrylog and a few miles south of Chastain Bridge.

MARBLE.

Occurrence.—The Murphy marble underlies a number of long narrow areas in the longitudinal valley. From the northern border of the quadrangle southwestward beyond Blue Ridge these areas lie in two converging lines along the two main faults. Two other areas that lie in similar structural positions are the one extending southward from a point west of Whitepath to Turniptown Creek and the one in the valley of Fisher Creek, in the southwestern part of the quadrangle. There are other areas near Cherrylog and in the valley of Talona Creek, in the Dalton quadrangle, about 6 miles south of Ellijay. The north end of the area last named, which is mainly in the Dalton quadrangle, just touches the west edge of the Ellijay quadrangle near the railroad crossing west of Talona Mountain.

The northernmost area of marble along the eastern valley fault in this quadrangle is near the head of Rapier Creek, a small stream flowing northeastward to Nottely River. Though of good quality the marble here has not been developed. The area appears to be of rather small extent. About a mile southwest of this locality the marble crops out at the head of Cutcane Creek in a narrow band extending some distance downstream. In the upper part of the valley the marble appears in ledges at the surface, on both sides of the creek, but farther down it is covered by alluvium. A little work has been done on the marble here. At places still farther southwest, down the creek, the marble has been noted but has not been quarried. For some distance to the southwest the marble is cut out by the fault, but it again appears at a place west of Paris Mountain, from which place southwestward to a point east of Blue Ridge it is probably continuous. It crops out at a few places and has been found by prospecting at others, and at still others there are good surface indications of its presence, such as outcrops of talcose schist or surficial deposits of talc or of the fine white siliceous clay that is produced by the decomposition of the marble. The map showing the economic geology indicates very closely where the marble may be expected and where it should be looked for in prospecting. The courses of the creeks, which are almost perfectly straight from northeast to southwest, are significant in this connection. They coincide closely with the lines of faulting and hence with the lines along which the marble occurs. The course of Cutcane Creek and of the lower part of Weaver Creek shows strikingly the relation between drainage, geologic structure, and rock composition.

Along the western valley fault the northernmost area of marble in this quadrangle is near Culberson, N. C. It has been exposed in two or three pits near the line between the States and has been quarried near Culberson. The southern end of this area is thought to lie just east of Sweetgum. There is a small area of marble near Arp, and another on Young Stone Creek near Cole Crossing, where the marble has been burned for lime. When excavations were made for the piers of the railroad bridge over Toccoa River, southwest of Mineral Bluff, marble was discovered and since then a large pit has been dug just west of the bridge to reach the marble. The bottom of this pit is below water level so that the marble is not easily accessible and has therefore not been worked. Southwest of Blue Ridge the marble lies in a long, narrow strip west of the road between Ellijay and Blue Ridge. So far as known no marble has been quarried along this particular outcrop.

Marble is reported to occur in the alluvial flat southwest of Cherrylog. It probably is a small mass in the axis of a pinched syncline. Another long, narrow strip extends southward from the vicinity of Whitepath station. It has been located at several points by borings or excavations. The railroad trestle is nearly in the middle of the strip. It is reported that a 70-foot test drill hole was bored 10 to 15 feet west of the trestle. The marble is also exposed at the place where the public road crosses Whitepath Creek. Galena and pyrite are associated with the marble here and also near the mouth of Little Turniptown Creek.

The broadest expanse of marble in the quadrangle underlies probably the greater part of the broad valley just east of the junction of Turniptown and Little Turniptown creeks. At several points it has been prospected with the drill. It crops out in the bed of Turniptown Creek but for the most part is covered to various depths with the valley alluvium. So far as known it has not been worked commercially.

Five or six miles south of Ellijay, in the valley of Talona Creek, the marble crops out at the head of a tributary of that creek which lies along the railroad. The marble was located at a point in the creek due west of the railroad crossing and it probably extends north of this place, for the soil along the road at the place where it turns abruptly to the northwest strongly suggests the presence of an underlying limestone. The marble just referred to is the north end of a mass that extends southward along the valley of Talona Creek beyond Whitestone station. This strip, except its northern end, lies outside the Ellijay quadrangle. Marble has not been found everywhere in this strip, but the configuration of the surface and the relations of the rocks indicate that the valley is everywhere underlain by the marble. In the Dalton quadrangle, at Whitestone (see fig. 7) and at a place north of Talona station on the west side of the valley, the marble has been worked to some extent and its character and relations are known. In describing the character of the marble in this general area, therefore, recourse will be had to observations made at these two places.

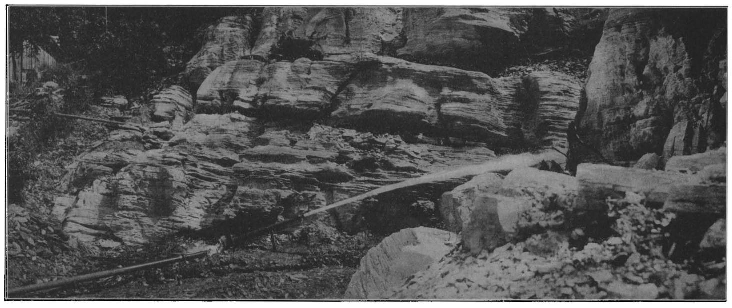


FIGURE 7.—Murphy marble in a quarry at Whitestone in Talona Valley, just west of the Ellijay quadrangle.
The marble contains magnesium carbonate, which is extracted for use in the manufacture of magnesium sulphate and carbonic acid.

In the southwest corner of the quadrangle the marble crops out in large quantity in the valley of Fisher Creek. It lies well above Fisher Creek and is fairly accessible to the railroad near the mouth of the creek, so that it particularly invites commercial development.

Physical properties.—The marble in the Ellijay quadrangle is chiefly white, bluish gray, or mottled. Some of it is banded with black, but the three shades first mentioned are commonest. Rarely a beautiful flesh-colored variety is obtained, as near Culberson, N. C. In the eastern marble belt, at the west base of Hightop Mountain, there is a bed of flesh-colored marble tinged with green, closely resembling the marble from the Etowah quarries of the Georgia Marble Co., in Pickens County. The pink color is regarded as due to the presence of hematite crystals. Some flesh-colored marble seen was reported to have come from Whitestone.

As a rule the marble is fine grained, but in several places it is coarse grained. Some of it contains a considerable percentage of magnesium carbonate, and at Whitestone the magnesian or dolomitic phase is finely crystalline as compared with the nonmagnesian portion, which tends to be coarse. This statement in general holds true for all the Georgia marbles. In a boring made by the N. P. Pratt Laboratory Co. at Whitestone, Gilmer County, the upper 35 feet of the section is dolomitic in layers, and it was reported that the rock was magnesian in places to a depth of 55 feet. This magnesian phase is quarried and shipped to Atlanta, where it is used by the company in the manufacture of carbon dioxide and Epsom salts. Part of the marble at Whitestone shows micaceous layers which on fresh fracture are almost invisible. These layers do not appear to be nearly so prominent in the dolomitic phase. It is possible that the mica is more perfectly developed at the tops of the outcropping beds, for this part of the mass was subjected to the greatest strain during the overthrust from the east, as indicated by its sheared structure, which is well brought out by weathering. The overlying rock, structurally speaking, which is the Nantahala slate, is well exposed in the Whitestone quarries and may be seen in figure 6 (p. 9). The contact between the Murphy marble and Nantahala slate may also be seen at this place. Muscovite is a common accessory mineral in the marble in other parts of the quadrangle, but as a general rule it does not occur in sufficient quantity to injure the appearance of the marble when weathered, and before weathering it is hardly noticeable at all. The other common accessory minerals are tremolite, quartz, and hornblende, besides the minerals biotite, graphite, and hematite, to which the different shades other than white are due; and among the sulphides chalcopyrite, galenite, and pyrite have been observed in small quantity. In general it may be said that all accessory minerals are objectionable, chiefly because on weathering they affect the durability and appearance of the marble; and mica, if arranged in definite planes, may be prejudicial to the strength.

No tests on the crushing strength of the marble from this quadrangle have been made, but tests made on 1-inch cubes of the marble from Pickens County gave a compressive strength of 10,204 to 13,900 pounds per square inch.

In general it may be stated that the marble in the Ellijay quadrangle ranks, so far as can be judged from physical appearances alone, with the marble in Pickens County, which is among the best in the country. Its strength, low absorption, and resistance to weathering make it particularly suitable for exterior work, and its varied colors make it attractive for ornamental indoor work.

Analyses.—No analyses of Georgia marble have been made by the United States Geological Survey, but the first three in the following list, from a report of the Geological Survey of Georgia,[a] are types of high magnesian marble from the Ellijay quadrangle. The remaining four were furnished to the author by Mr. H. A. Field, of Ellijay.

No analyses of low magnesian or nonmagnesian marble from the Ellijay quadrangle are given in the reference cited, but analyses of such marble from quarries farther south, in Pickens County, show a range of magnesia (MgO) from 0.75 to 1.12 per cent.

Analyses of marble from the Ellijay quadrangle and vicinity.

No.	CaO.	MgO.	Fe_2O_3, Al_2O_3.	Insoluble siliceous matter.	Loss on ignition.	Total.
1	31.53	21.30	0.24	0.10	47.26	100.43
2	31.61	21.06	.78	1.01	46.49	100.95
3	31.89	19.64	.74	1.73	undet.	----------
4	53.74	1.39	.25	1.78	43.44	100.60
5	52.54	2.53	.34	.52	44.05	99.98
6	52.66	2.45	.22	.50	44.03	99.86
7	53.10	1.31	.28	2.18	43.14	100.01

No. 1. Fine-grained gray marble from the Dickey property, at the bridge of the Louisville & Nashville Railroad over Toccoa River.

No. 2. Fine-grained bluish-gray marble from the Holt property near the junction of Turniptown and Little Turniptown creeks.

No. 3. Fine-grained white marble from Fannin County.

No. 4. White marble from Hensley, near the railroad bridge.

No. 5. White marble from Hensley, near Ray.

No. 6. Marble from Talona Creek.

No. 7. Core from a drilling on Holt farm, at junction of Turniptown and Little Turniptown creeks. A type of low magnesian marble from same location as No. 2.

Miscellaneous uses.—In addition to its use as a building stone the marble from this region is now used also in the manufacture of carbon dioxide and Epsom salts (magnesium sulphate), for flux in smelting the copper ores of the Ducktown district, and for making lime. In general the surface portions of the marble may prove suitable for making lime when not adapted, owing to cracks and other imperfections, to use as building stone. The marble has been burned for lime in Fannin County in the vicinity of Cutcane, about 4 miles northeast of Mineral Bluff, and at a point 2 miles farther down Cutcane Creek, and also near Cole Crossing on Young Stone Creek. Marble quarried and thrown out about a mile east of Mineral Bluff has been used for making lime, and some quarried in Gilmer County on the Holt property, near the junction of Turniptown and Little Turniptown creeks, has been so used; also blocks quarried in places along Talona Creek.

BUILDING STONE OTHER THAN MARBLE.

Building stones other than marble occur abundantly in the Ellijay quadrangle, but they are not of exceptionally superior quality and though they may be of value for local use they probably will not be shipped far. The Great Smoky formation and the Carolina gneiss, made up chiefly of mica schist, quartzose schist, and gneiss, contain the greatest amount of building stone. Some of the denser and less foliated portions of the spangled biotite gneiss of the upper part of the Great Smoky formation might serve well for rough massive work, such as bridge abutments and masonry dams, as the rock is dense, tough, and massive. A large part of the quartzite and fine and even grained graywacke of the same formation might be used in the same way where staining would not make much difference, but the rock contains some pyrite, which unfits it for finer work.

[a] McCallie, S. W., Marbles of Georgia: Bull. Geol. Survey Georgia No. 1, 2d ed., 1907, p. 109.

The main granite masses of the area are found in the valley of Hemptown Creek, Fannin County, and on Anderson Creek, Union County. Those on Hemptown Creek are well exposed and project above the valley bottom in the adjacent hills to the north. A few smaller masses of granite were observed in the hills between Hemptown and Camp creeeks. This granite, as will be observed from the map, occurs as small bosses, and that on Hemptown Creek is comparatively fresh. The granite area on Anderson Creek has been mapped from the surface granitic débris and is not exposed. The granite on Hemptown Creek is gneissoid in structure and might properly be termed a gneiss. Weathering does not discolor it and at a distance it appears perfectly white. The feldspars become white when kaolinized and the quartz particles stand out in relief. Muscovite is present though not abundant. Some parts of the rock, which contain biotite, are stained brown by weathering, the stain being produced by iron oxide. These granite masses are so far from the railway that they are of little or no commercial value at the present time.

Conglomerate of various texture and homogeneity occurs in many places in the quadrangle. Some of the more uniform beds that contain pebbles of moderate and uniform size and a sufficiently dense matrix would serve well for massive masonry construction. Much of the conglomerate and the quartzite and sandstone are too greatly sheared or too heterogeneous to make good building stone.

KAOLIN AND CLAY.

Kaolin.—Kaolin, a hydrous aluminum silicate, results in this area from the disintegration and decomposition of the feldspar that occurs in veins or dikes of pegmatite, a coarsely crystalline rock composed chiefly of quartz and feldspar but which may also contain mica. In a region so extensively intruded by pegmatite bodies, some of them of great size, deposits of both feldspar and kaolin might be expected, but none are known to have been worked. No large crystals of feldspar were noted, nor were any masses of that mineral seen in the pegmatite. The residual soil associated with some of the pegmatite bodies is largely made up of kaolin, but it contains also considerable grit or finely divided quartz, which makes it of local value as a scouring material. As a general rule the pegmatite bodies in the southwestern part of the quadrangle looked more promising as sources of kaolin than those of the southeastern part. One reason for this is that in the southwestern part the residual mantle of disintegration and decomposition containing kaolin is thicker than in the mountains of the southeastern part, where the residual clay and kaolin have been washed away. The bodies of pegmatite in the southeastern part, however, are of economic interest on account of their mica content, which will be described later.

Some kaolinized pegmatite masses near Roy, Cartecay, and Licklog, Gilmer County, are of great areal extent, especially those in the vicinity of Cartecay. Along the main highway about 2½ miles southeast of Roy, on the hillsides north of the creek, there are exposures of thoroughly kaolinized pegmatite. The kaolin is mixed with quartz. About a mile south of Licklog post office, on the trail ascending Burnt Mountain, masses of pegmatite occur. These have been prospected, but not for the kaolin contained in them. Some of the largest pegmatite masses observed lie just within Dawson County. These masses contain, besides feldspar and kaolin, muscovite and quartz and in places small pockets of crystallized hematite, the last mineral having excited the local interest which has resulted in the exploration of the deposits. The deposits on Burnt Mountain appear to be very small. They are possibly of hydrothermal origin, as may be inferred from their banded structure. These particular masses may therefore be regarded as true veins. Both north and south of Cartecay large masses of pegmatite in places cover the surface. The kaolin in this general area is associated with much quartz and will probably never prove to be of value. It is, moreover, remote from lines of transportation.

Kaolinized feldspar occurs in association with pegmatite masses at many places, but the more important deposits have been mentioned. Even some of these are small and of very doubtful value, and all are so far from railroads and centers of consumption that they may never be of any commercial importance.

Clay.—Clay is abundant in the Ellijay quadrangle. The clay found is an insoluble hydrous aluminum silicate resulting from the decay of the gneisses, schists, granites, and most other rocks of the area. Generally it is mixed with sand and mica.

Residual clay resulting from the decomposition of such rocks covers the surface of almost the entire area, though on the hillsides along the streams are colluvial clays, and in the stream valleys are alluvial deposits, principally sand, clay, and gravel. Though so widely distributed and so abundant, especially in the flood plains of the larger streams, these clays have been little used, for there are no large towns in the area and hence little local demand for them. Material so common as brick clay will not bear the cost of transportation to any great distance; hence none of the clay deposits have been worked to any material extent. Clay suitable for making ordinary building brick, vitrified paving brick, drain tile, sewer pipe, terra cotta, fireproofing, hollow building tile or block tile, and pottery will be found in the flood plains and along the edges of the larger streams. Bricks made from such clays have been used for building the foundations of some houses in Ellijay. This clay was obtained in part on the west bank of Ellijay River, a mile north of the town. A mile southeast of Mineral Bluff clay has also been used for making bricks.

The less siliceous portions of the Valleytown formation, consisting of talc and sericite slates and andalusite schist, produce, when weathered, a stiff, plastic, yellow clay. This clay is characteristic of the valleys cut in this formation. It occurs in almost unlimited amount and appears to be suitable for making the coarser grades of pottery.

SAND AND GRAVEL.

Sand and gravel are found in the alluvial deposits along the streams. The available supply of sand is more than ample for the local needs. Most of the gravel consists of bowlders or cobbles of residual vein quartz, not much waterworn and generally subangular. Such material might be useful for surfacing macadamized roads. In the valleys of the larger rivers, especially the Toccoa, beds of gravel of uniform and small size are found. Not much of this material has been utilized, for the railroads through the area have ballasted their road beds with crushed slag from the Ducktown copper smelters and crushed marble.

ROAD-MAKING MATERIAL.

Road materials are plentiful in the quadrangle and are found at many places. Several kinds of rock should furnish excellent stone for road surfacing. The gabbro dikes of the northwestern part of the quadrangle; the intrusions of Roan gneiss, largely made up of hornblende and pyroxene, of the eastern and southeastern parts of the area; and the "pseudodiorite," of which so many residual bowlders are found nearly everywhere in the quadrangle, fall in the better class of road materials. The fine-grained, dense, tough spangled biotite gneiss of the Great Smoky formation should furnish an excellent quality of crushed stone.

Some portions of the Tusquitee quartzite and some of the highly siliceous slate of the Valleytown formation, which has flat cleavage planes, should afford excellent and cheap flagging. Much of it is friable, but portions are tough and of a dense, fine grain. Flagstone has been quarried near Mineral Bluff and near Blue Ridge.

MICA.

Muscovite, or white mica, is a constituent of various rocks in the Ellijay quadrangle, but the commercial variety, that is, the mica that occurs in flakes of considerable size, is found only in pegmatite, a coarse-grained granitic rock. The pegmatite occurs in lenses, veins, and irregular masses. Some are traceable for long distances; others are local. Some of the pegmatites in this area were possibly formed by deposition from solution, but most of them are regarded as intrusive igneous masses. The former, strictly speaking, should be known as veins, and the latter as dikes, but the terms are sometimes used indiscriminately and there are all gradations between the two.

A number of muscovite deposits are known in the Ellijay quadrangle, but mica mining has never become well established in the region and the amount of development work done at most of the mines and prospects has not been great. The irregularity of the distribution of the pegmatite in which the mica occurs, and of the mica itself, makes the success of any mica-mining venture very uncertain and is probably the chief reason for the smallness and irregularity of the industry in this area. Most of the mica deposits occur in the southern third of the quadrangle and are found at various altitudes here and there on the Piedmont Plateau and the southern flank and summit of the Blue Ridge. The deposits are very similar to those of North Carolina, both as to type of country rock and nature of the pegmatite.

The following notes on recent development of mica deposits in this area are from a report by D. B. Sterrett.[a]

During 1907 and 1908 the Pitner Mica Co was developing a group of mica mines in Lumpkin and Fannin counties, 6 to 10 miles northwest of Dahlonega. These mines are in the Piedmont Plateau at the foot of the Blue Ridge, on the Blue Ridge itself, and in the mountainous country to the north. The work has consisted chiefly of prospecting, though some mica has been obtained at the same time. The mica in all these mines except one is light colored. Portions of it are of good quality, though some of it shows "ruling," "wedge," and "A" structures, clay stains, and other faults.

Among the mines and prospects owned by the Pitner Mica Co. are the Ward, Eph Lee, Masters, Graham, and William Gooch, yielding "rum"-colored mica; the Green Vein, F. G. Williams, and Sain, yielding light-green mica; and the Matt Gooch, yielding dark and partly "specked" mica. The company owns other deposits, which were not visited. The Eph Lee, William Gooch, and Green Vein mines are old and have not been reopened recently. The other deposits mentioned were prospected by the Pitner Mica Co. The Masters, Sain, Williams, and Graham mines are a few miles east of Falls post office, in the southeastern part of the quadrangle. The Eph Lee, Ward, and Green Vein mines are on the top of the Blue Ridge near Ward Gap, on the boundary line between Union and Lumpkin counties. The William Gooch mine is about a mile north of Ward Gap, and the Matt Gooch mine is near Gaddistown, Union County.

At the Ward mine the mica occurs in pegmatite that cuts the mica gneiss country rock unconformably. At the Eph Lee mine the granitic mica gneiss country rock has been contorted by small folds and is cut by pegmatite near the axis of one of these folds. The pegmatite mass here is not large, ranging in thickness from a few inches to 2½ feet. It has yielded sheets of mica several inches across. The country rock at the Masters mine is kyanite-mica gneiss, with variable strike and dip. The pegmatite occurs in lenses that are more or less connected, and ranges in thickness from a few inches to several feet. The main lead of the lenses has been traced northeastward for about 75 yards. Branch "veins" or lenses of pegmatite occur on the northwest side of the main lead and in places yield good mica. Some fair-sized sheet mica has been obtained at this mine, together with a large amount of the "ruled" and "A" varieties. The pegmatite at the Graham mine strikes N. 60° E. and has a vertical to southeast dip. It contains a quartz streak, parallel to its surface, 30 feet long, ranging in thickness from a fraction of an inch to 2 feet. Where exposed in one opening the pegmatite is 10 feet thick. A branch streak of pegmatite extending to the northwest is exposed at this place. The old workings at the William Gooch mine, now badly caved, cover an area about 50 feet wide and over 100 feet long in a northeast direction. They consist of several pits, shafts, and tunnels, which encountered considerable massive quartz. The Green Vein mine was opened by a cut 20 feet deep, which extends 40 feet back into the side of the hill. The mica gneiss country rock strikes north and dips 30° E. The pegmatite mass, ranging in thickness from 1 to 5 feet, cuts across it with the same strike and a nearly vertical dip. The pegmatite at the Sain mine is very irregular in shape and includes "horses" of mica gneiss and diorite. The "vein" has a northeast strike and a vertical dip. Several tons of mica were found in pockets within a few feet of the surface. Some of the crystals seen were 15 to 18 inches across, though cut into smaller plates by "ruling." At the F. G. Williams mine the pegmatite has an irregular northwest strike and a dip of 20° NE. It cuts across the mica gneiss country rock, which has a northeast strike and a southeast dip. Some of the mica crystals found were 18 inches across, though somewhat "ruled" and A-shaped. At the Matt Gooch mine a trench and open cut in a hillside exposed a pegmatite body at least 6 feet thick with a north strike and a low west dip. The pegmatite contains irregular quartz masses and segregations, with which the mica is associated.

Mica has also been mined recently near Hickory Flats and on Rock Creek about a mile and a half below the mouth of Frozen Branch. It is understood that this mine is owned by J. H. White, of Cheyenne, Wyo.

TALC.

One of the chief deposits of talc in the United States is at Hewitts, in the Nantahala quadrangle, northeast of the Ellijay. These deposits are associated with the Murphy marble, which, as already stated, crops out at many places in the Ellijay quadrangle, though in only one place has talc in large quantity been seen where it can be certainly regarded as associated with the Murphy marble. The conditions in the Nantahala quadrangle, however, indicate that deposits of talc may be discovered along the marble belt in the Ellijay quadrangle.

Talc has been mined in three places in the Ellijay quadrangle—near Culberson, near Mineral Bluff, and a few miles southwest of Blue Ridge. At Culberson the talc is probably associated with the Murphy marble. Near Mineral Bluff and Blue Ridge this association can not be definitely proved, but at both these localities the talc deposits are very near or almost on one of the faults along which the marble is known to occur. When these deposits were visited only the Blue Ridge deposit was being mined, and therefore it is the only one whose relations were clearly determined. At this place the talc occurs as a vein or lens about 6 feet thick, striking about 22° NE. and having an irregular dip. The talc occurs in a slick brown clay called umber. The highest-grade talc occurs in small masses, weighing 20 pounds or more, embedded in the clay. Stratified layers of the umber, of varying colors, are interlaminated with thin contorted layers of talc. A wall or band of sandstone of irregular strike divides the talc deposit. West of this sandstone lie small patches of white talc; east of it talc of various colors is found in paying quantities. At a point about 100 feet south of the main talc pit the sandstone either dies out or plunges downward; at any rate it was not found at that point, and the talc deposit there is 40 feet thick, apparently the thickness of the two bands east and west of the sandstone horse to the north. About 200 feet south of the main or northernmost pit, or 100 feet south of the 40-foot lens just described, the yellow or varicolored phase of the talc disappears, but float of white talc is present at the surface. A pit beyond the point where the sandstone horse disappears is very probably west of the position of the sandstone. A tunnel dug about 35 feet below the surface revealed no talc, not even the reddish, mottled, impure variety.

On the whole the talc at this deposit is of good quality. It is massive and nearly free from grit. Its relation to the surrounding strata and its origin are obscure. It is primarily of sedimentary origin, but whether it is a part of the Murphy marble or occurs in the Valleytown formation is uncertain and the regional metamorphism or the metamorphism associated with the faults in the region may have recrystallized it in its present form. As will be observed from the structure-section sheet, the deposit lies in a wedge tapering downward between two main faults. Its southward and downward limits are unknown, and though it may extend northward no large amount of talc has been reported in that direction.

Powdered foliated talc, such as has been quarried near Blue Ridge, is now used instead of mica for imparting luster to wall paper. It is also replacing kaolin in the manufacture of paper, to which it imparts strength and durability, whereas clay tends to make paper brittle. It is also used as a pigment in high-grade paints, and owing to its nonconductivity of heat it is used in boiler and pipe covering. It is used as a lubricant, and for polishing glass, dressing skins and leather, and sizing cotton cloth, as well as in toilet powders and dynamite. Tips of gas burners and electrical appliances have been made from the better quality of talc found near Blue Ridge. Coarser grades and grades that are off color have been used for foundry facings.

At Culberson and southwest of Mineral Bluff small deposits of talc were exploited several years ago. At Mineral Bluff the talc occurred in calcareous rock, 4 feet thick, between beds of quartzite, about 20 or 25 feet below the top of the Valleytown formation. The occurrence near Culberson is thought to be associated with the Murphy marble and probably represents a silicified magnesian phase of a limestone subsequently metamorphosed.

Along the eastern valley fault, east of Blue Ridge, there are evidences of talc in a churchyard. This deposit has not been worked nor even prospected.

In the neighborhood of East Ellijay, in the Valleytown formation, the soil seems talcose and may contain a small amount of talc. Other deposits of talc probably occur in the area, but they can be located only with great difficulty, as the material is soft and weathers readily, crumbling away and leaving little on the surface to indicate what might be valuable deposits below. The more important deposits mentioned above are all within short distances of the railroad.

ABRASIVE MATERIALS.

Near the top of the Great Smoky formation there is generally a bed of conglomerate. This bed is well exposed on Cartecay River not far east of East Ellijay and may be traced northeastward for some distance. At its outcrop by the river the conglomerate has been quarried for millstones. Many other beds in the quadrangle would furnish similar material and the supply available is far greater than any probable future demand.

Some of the beds in the Great Smoky formation are fine-grained siliceous rocks. The evenness of their texture, the sharpness of their grain, and the ease with which they are worked make them valuable for use in the manufacture of the finer grades of oilstones and whetstones. Such beds, however, are not likely to be uniform in extent, thickness, or texture. Material of this kind is plentiful enough to supply all local requirements. Some of the beds in the Tusquitee quartzite and the more siliceous beds of the Valleytown formation also furnish fair material for grindstones and whetstones.

GRAPHITE.

The Nantahala formation in this quadrangle is typically a graphitic slate, and parts of the Valleytown and the Great Smoky formations also are in places very graphitic. Good, clean, reasonably pure graphite was not observed in this area, but many beds in the Nantahala and the other two formations

[a] Mineral Resources U. S. for 1908, pt. 2, U. S. Geol. Survey, 1909, pp. 749–750.

contain an amount of graphite sufficiently large for use as a coloring agent in fertilizers. The graphitic phases of the Nantahala color the soil black in many places.

FLUXING ROCK.

Quartz is used as a flux in the copper smelters of the Ducktown district. It has been obtained at Kinsey, in the Murphy quadrangle, from the Nottely quartzite, a pure, dense quartzite almost like vein quartz in texture. The same bed passes through Culberson, extending about 2 miles into the Ellijay quadrangle. This rock is worked just at the edge of the quadrangle by a large quarry which was not in operation when visited. The Murphy marble or the magnesian phase of it obtained near the iron mine of the North Georgia Marble Co. north of Talona, has also been used as a flux in copper smelting.

WATER RESOURCES.

Mineral springs.—Copious springs are abundant in the Ellijay quadrangle, many of them impregnated by mineral salts. At Whitepath, about 6 miles northeast of Ellijay, there are two mineral springs, one chalybeate and the other magnesian. The place is a summer resort, with a small hotel and cottages. The oxidation of pyrite, which is disseminated through nearly all the rocks in the several formations, produces alum, which impregnates ground water that emerges in alum springs. The main hotel at Ellijay is well supplied with spring water from the hills to the northwest.

Water power.—The Ellijay quadrangle contains great water power resources. It lies in a region of heavy rainfall, of greatly fractured and deeply weathered rocks, and most of it has heavy forest cover, so that its streams flow copiously rather constantly throughout the year. Gaging stations have been maintained at several points in the quadrangle, and the data obtained regarding the flow of the streams at those stations have been published in Water-Supply Papers 197, 242, 243, 263, and 283 of the United States Geological Survey. In general the results of these measurements show that the maximum flow is about twice the minimum, the proportion varying with local conditions and with the season or state of the weather, and that the flow is at all times sufficient to afford a steady source of power if adequate reservoirs are provided for its equalization. The maximum flow occurs in spring and the minimum in autumn, corresponding roughly with the times of maximum and minimum rainfall, but the flow is affected by the conditions of the area of run-off and by the melting of snow at the close of winter.

Little use has been made of the water power of the region except locally and in a small way. There are many small sawmills and corn mills, and electric power is furnished to the town of Blue Ridge by a plant on Fightingtown Creek. In the southeastern part of the quadrangle a number of streams have furnished water for the hydraulic gold mining done in that district. Rather elaborate engineering work has been undertaken, though not completed, to increase this flow by diverting some of the tributaries of Toccoa River into a tunnel through the Blue Ridge. In the abandoned placer-mining districts about Chipeta and Whitepath the streams were at one time extensively used for hydraulic mining.

At many places in the quadrangle, especially along Toccoa River and some of the larger creeks, a large amount of power could be developed. Some of the streams running down the south slope of the Blue Ridge have a rapid fall, which would in part compensate for their relatively small volume. At one or two places in the quadrangle the conditions are favorable for developing considerable power by diverting a stream into a neighboring valley that has much steeper grade than the valley in which it is flowing. This is especially possible at the gap west of Amicalola Mountain, where a natural diversion of Klotz Creek by the head of Amicalola Creek is, geologically speaking, imminent and an artificial diversion could be accomplished without great expense.

February, 1912.

U.S.GEOLOGICAL SURVEY
GEORGE OTIS SMITH, DIRECTOR

TOPOGRAPHY

GEORGIA-NORTH CAROLNIA-TENNESSEE
ELLIJAY QUADRANGLE

LEGEND

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

DRAINAGE
printed in blue

Streams

CULTURE
printed in black

Roads and buildings

Private and secondary roads

Trails

Railroads

Bridge

State line

County line

Bench mark

H.M.Wilson, Geographer in charge.
Triangulation by S.S.Gannett.
Topography by W.L.Miller R.H.Mc.Kee and A.E.Murlin.
Surveyed in 1895-96.

TRUE NORTH
MAGNETIC NORTH
APPROXIMATE MEAN DECLINATION 1910.

Scale $\frac{1}{125000}$

1 ½ 0 1 2 3 4 5 Miles

1 ½ 0 1 2 3 4 5 Kilometers

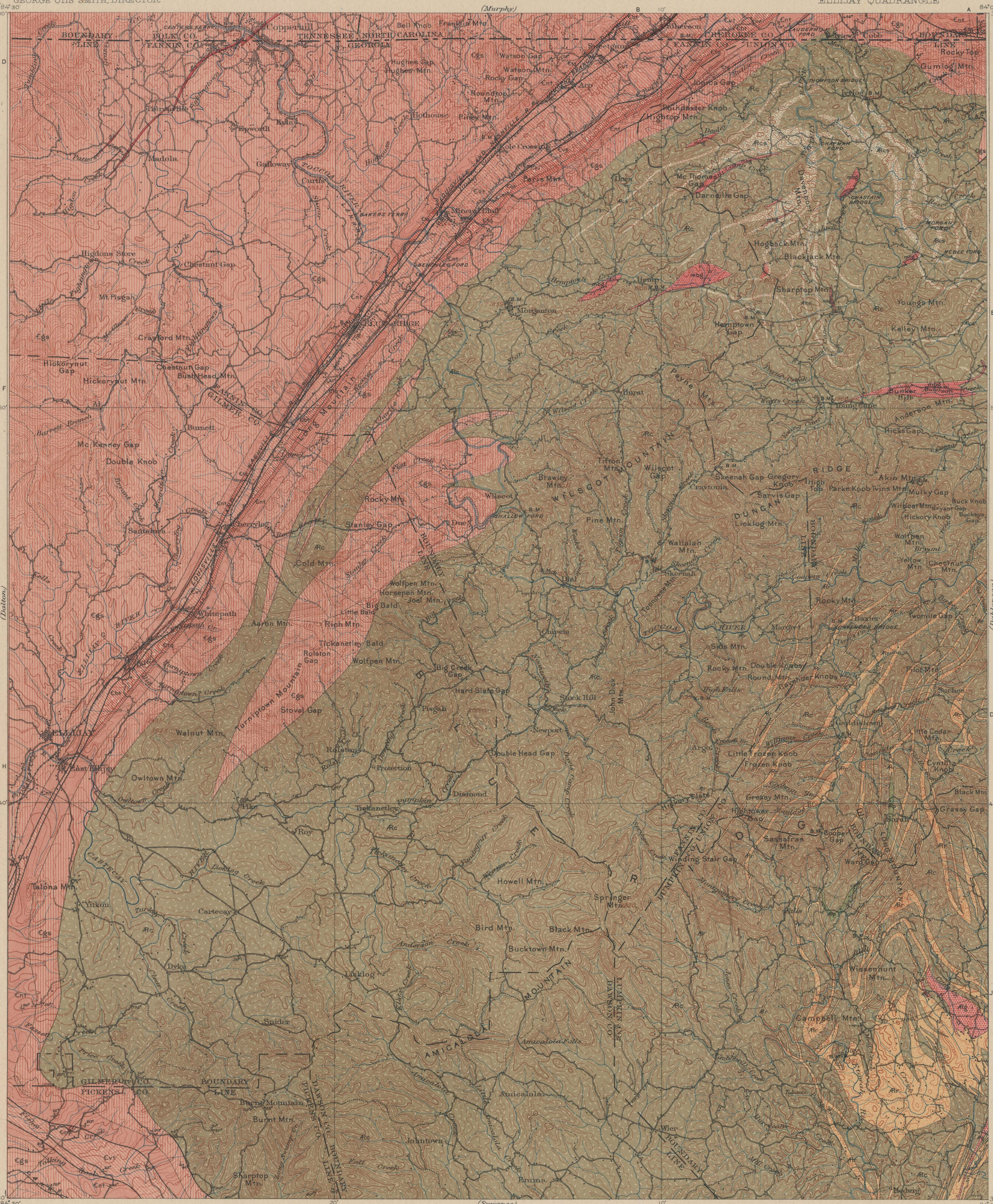
Contour interval 100 feet.
Datum is mean sea level.

Edition of Aug. 1912.

U.S. GEOLOGICAL SURVEY
GEORGE OTIS SMITH, DIRECTOR

AREAL GEOLOGY

GEORGIA–NORTH CAROLINA–TENNESSEE
ELLIJAY QUADRANGLE



H.M. Wilson, Geographer in charge.
Triangulation by S.S. Gannett.
Topography by W.L. Miller R.H. Mc.Kee and A.E. Murlin.
Surveyed in 1895-96.

Scale $\frac{1}{125000}$

1 ½ 0 1 2 3 4 5 Miles

1 ½ 0 1 2 3 4 5 Kilometers

Contour interval 100 feet.
Datum is mean sea level.

Edition of Nov. 1912.

TRUE NORTH
MAGNETIC NORTH
APPROXIMATE MEAN DECLINATION 1910.

Geology by Laurence LaForge,
assisted by D.B. Sterret, W.C. Phalen, F.B. Laney, and L.A. Kolbe;
under supervision of Arthur Keith.
Surveyed in 1905-1911.

LEGEND

SEDIMENTARY ROCKS

(Areas of subaqueous deposits are shown by patterns of parallel lines; metamorphism is indicated by hachures combined with the line patterns)

CAMBRIAN — *Lower Cambrian series*

- Єny — **Nottely quartzite** *(white quartzite)*
- Єmp — **Murphy marble** *(white and blue marble, thin calcareous schist at the top probably represents Andrews schist)*
- Єvt — **Valleytown formation** *(chiefly mica schist, mica slate, talcose slate, and graywacke)*
- Єbt — **Brasstown schist** *(blue and black banded ottrelite schist and slate)*
- Єtq — **Tusquitee quartzite** *(white quartzite)*
- Єnt — **Nantahala slate** *(banded black graphitic slate with some garnet-staurolite schist)*
- Єgs — **Great Smoky formation** *(chiefly graywacke, mica slate, and mica schist; conglomerate and staurolite gneiss near the base)*

IGNEOUS ROCKS

(Areas of igneous rocks are shown by patterns of triangles and rhombs; metamorphism is indicated by hachures)

POST-CAMBRIAN

- gb — **Gabbro**
- mbg — **Muscovite-biotite granite and pegmatite**

ARCHEAN

- Ʀg — **Granite** *(gneissoid augite-biotite granite)*
- Ʀp — **Pyroxenite, dunite, and serpentine**
- Ʀr — **Roan gneiss** *(chiefly hornblende gneiss, hornblende schist, and schistose diorite)*

METAMORPHIC ROCKS OF PARTLY UNKNOWN ORIGIN

(Areas of metamorphic rocks of unknown origin are shown by patterns of short dashes)

ARCHEAN

- Ʀc, Ʀcs — **Carolina gneiss** *(graywacke, conglomerate, mica gneiss, mica schist, and garnet-staurolite gneiss, with some cyanite-graphite schist, Ʀcs)*

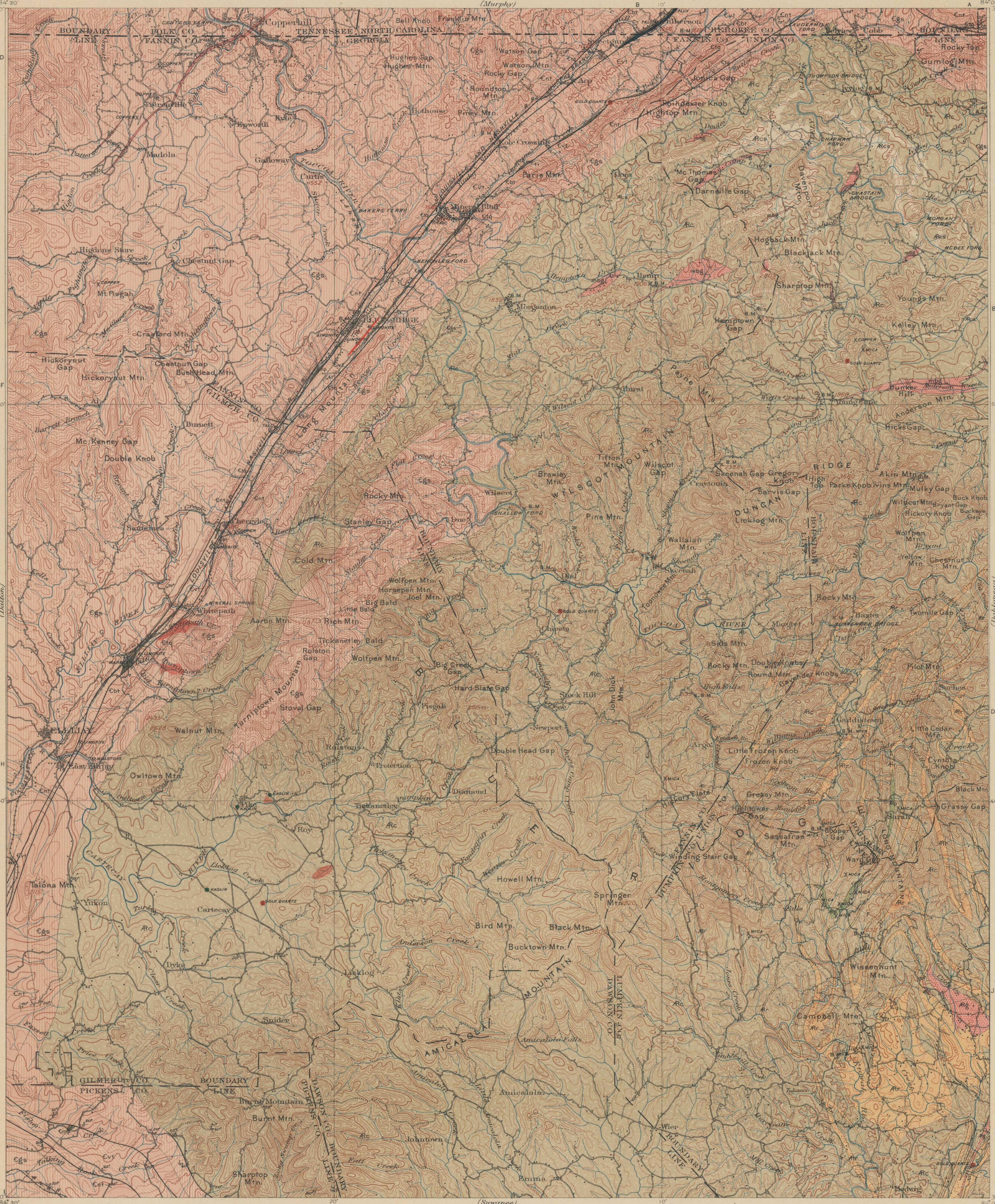
Faults

20° *Strike and dip of stratified rocks*
80° *Strike and overturned dip of stratified rocks*
Strike of vertical stratified rocks

U.S. GEOLOGICAL SURVEY
GEORGE OTIS SMITH, DIRECTOR

ECONOMIC GEOLOGY

GEORGIA–NORTH CAROLINA–TENNESSEE
ELLIJAY QUADRANGLE



84°30′ 35°00′ — 84°00′ 35°00′ — 34°30′ 84°30′ — 34°30′ 84°00′

H.M. Wilson, Geographer in charge.
Triangulation by S.S. Gannett.
Topography by W.L. Miller R.H. Mc.Kee and A.E. Murlin.
Surveyed in 1895-96.

Scale $\frac{1}{125000}$

1 ½ 0 1 2 3 4 5 Miles

1 ½ 0 1 2 3 4 5 Kilometers

Contour interval 100 feet.
Datum is mean sea level.
Edition of Nov. 1912.

TRUE NORTH / MAGNETIC NORTH
APPROXIMATE MEAN DECLINATION 1910.

Geology by Laurence LaForge,
assisted by D.B. Sterret, W.C. Phalen, F.B. Laney, and L.A. Kolbe;
under supervision of Arthur Keith.
Surveyed in 1905-1911.

LEGEND

SEDIMENTARY ROCKS

(Areas of subaqueous deposits are shown by patterns of parallel lines; metamorphism is indicated by hachures combined with the line patterns)

Lower Cambrian series — CAMBRIAN

- €ny — Nottely quartzite *(white quartzite)*
- €mp — Murphy marble *(white and blue marble, thin calcareous schist at the top probably represents Andrews schist)*
- €vt — Valleytown formation *(chiefly mica schist, mica slate, talcose slate, and graywacke)*
- €bt — Brasstown schist *(blue and black banded ottrelite schist and slate)*
- €tq — Tusquitee quartzite *(white quartzite)*
- €nt — Nantahala slate *(banded black graphitic slate with some garnet-staurolite schist)*
- €gs — Great Smoky formation *(chiefly graywacke, mica slate, and mica schist, conglomerate and staurolite gneiss near the base)*

IGNEOUS ROCKS

(Areas of igneous rocks are shown by patterns of triangles and rhombs; metamorphism is indicated by hachures)

POST-CAMBRIAN
- gb — Gabbro
- mbg — Muscovite-biotite granite and pegmatite

ARCHEAN
- Ag — Granite *(gneissoid augite-biotite granite)*
- Ap — Pyroxenite, dunite, and serpentine
- Ar — Roan gneiss *(chiefly hornblende gneiss, hornblende schist, and schistose diorite)*

METAMORPHIC ROCKS OF PARTLY UNKNOWN ORIGIN

(Areas of metamorphic rocks of unknown origin are shown by patterns of short dashes)

ARCHEAN
- Ac, Acs — Carolina gneiss *(graywacke, conglomerate, mica gneiss, mica schist, and garnet-staurolite gneiss, with some cyanite-graphite schist, Acs)*

Faults

Known mineral deposits

- *Gold-bearing gravels (in stream valleys)*
- *Iron ore (limonite)*
- *Marble (Murphy marble, white or blue banded)*
- *Kaolin (decomposed feldspar in pegmatite dikes)*
- *Quartzite flux (Nottely quartzite)*

20° *Strike and dip of stratified rocks*
80° *Strike and overturned dip of stratified rocks*
Strike of vertical stratified rocks

⚒ *Mines and quarries*
x *Prospects (gold, iron, copper, marble, quartzite, talc, mica, kaolin, flagstone, and millstone)*

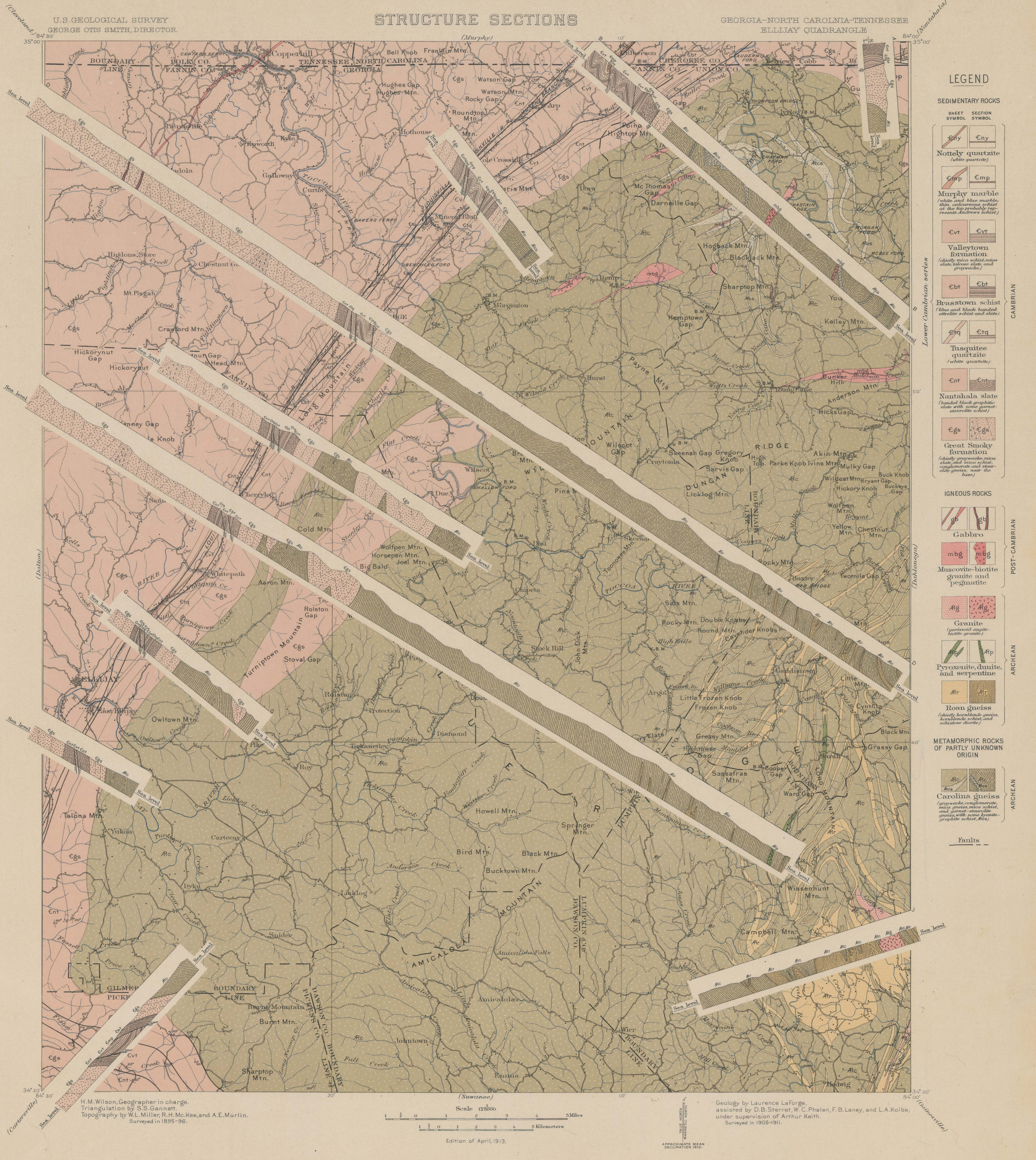
• *Mineral springs*

Note. *Building stone is obtained from Great Smoky formation, Carolina gneiss, and muscovite biotite granite; flagstone from the Valleytown formation; millstone from the Great Smoky formation.*

U.S. GEOLOGICAL SURVEY
GEORGE OTIS SMITH, DIRECTOR

STRUCTURE SECTIONS

GEORGIA–NORTH CAROLNIA–TENNESSEE
ELLIJAY QUADRANGLE



H.M. Wilson, Geographer in charge.
Triangulation by S.S. Gannett.
Topography by W.L. Miller, R.H. Mc.Kee, and A.E. Murlin.
Surveyed in 1895-96.

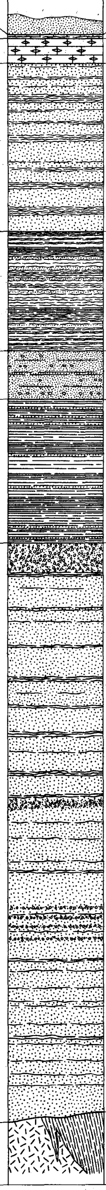
Edition of April, 1913.

Geology by Laurence LaForge,
assisted by D.B. Sterret, W.C. Phalen, F.B. Laney, and L.A. Kolbe;
under supervision of Arthur Keith.
Surveyed in 1905-1911.

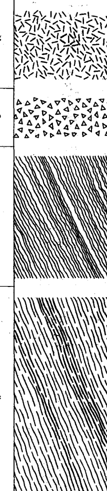
COLUMNAR SECTIONS

GENERALIZED SECTION OF THE SEDIMENTARY ROCKS OF THE ELLIJAY QUADRANGLE.

SCALE: 1 INCH = 1000 FEET.

System.	Formation Name.	Symbol.	Columnar Section.	Thickness in Feet.	Character of Rocks.	Character of Topography and Soil.
CAMBRIAN	Nottely quartzite.	€ny		200+	Fine white quartzite.	Sharp, narrow ridges. Rocky soil.
	Andrews schist (not mapped).			50	Calcareous schist with ottrelite and iron ore.	Low terraces and slopes. Yellow clay soil.
	Murphy marble.	€mp		50-300	Thick-bedded white, blue, and blue and white banded marble.	Valley floors washed over with gravel and clay.
	Valleytown formation.	€vt		1200-2000	Fine conglomerate, feldspathic quartzite, graywacke, and fine-grained gneiss, interbedded with dark garnet and ottrelite schists, graphitic schist, talcose mica slate, and augen gneiss.	Irregular ridges, knobs, flat-bottomed valleys, and lower slopes. Thin sandy and micaceous soil.
	Brasstown schist.	€bt		1200-1500	Blue and black banded ottrelite schist, garnet schist, and slate with a few layers of fine graywacke. Black slate usually at the base.	Steep slopes, low irregular ridges, and knobs. Thin sandy and clayey soil.
	Tusquitee quartzite.	€tq		20-600	Coarse and fine white quartzite with some quartz conglomerate.	Steep slopes. Sandy and rocky soil.
	Nantahala slate.	€nt		1000-2000	Black, bluish-black, and gray slate; in places altered to fine black schist with garnet. Contains a few beds of gray sandstone and graywacke.	Steep slopes, irregular ridges and knobs. Clay soils with slate and schist fragments.
	Great Smoky formation.	€gs		5000-6500	Quartz and feldspar conglomerate. Interbedded conglomerate, graywacke, quartzite, mica gneiss, biotite gneiss, mica schist, and graphitic schist. Thick conglomerate and staurolite gneiss in lower part.	High mountains and ridges of irregular trend and plateau country with low irregular ridges. Deep clayey soils mixed with small particles of rock and sand.
	UNCONFORMITY					
ARCHEAN	Gneisses and granite.				Light-gray granite, fine-grained granite, gneissoid granite, mica gneiss, conglomerate, graywacke, and kyanite-graphite schist.	Mountainous country and plateau areas.

GENERALIZED TABLE OF PRE-CAMBRIAN IGNEOUS AND METAMORPHIC ROCKS OF THE ELLIJAY QUADRANGLE.

System.	Formation Name.	Symbol.	Lithologic Symbol.	Character of Rocks.	Character of Topography and Soil.
ARCHEAN	Granite.	ARg		Biotite granite and granite gneiss, coarse and fine, light gray, dark gray, and white. Includes fragments of hornblende gneiss and mica gneiss.	Irregular hills and ridges. Yellow and brown clay soils.
	Pyroxenite, dunite, and serpentine.	ARp		Pyroxenite and dunite, in part serpentinized.	Yellow clay soil with many ledges and fragments of rocks.
	Roan gneiss.	ARr		Hornblende gneiss and schist, with some massive and schistose diorite. Includes many beds of mica gneiss, mica schist, and hornblende mica gneiss, and dikes of altered and unaltered biotite granite.	Mountainous country or depressions between Carolina gneiss areas. Dark-red and brown clay soils.
	Carolina gneiss.	ARc		Interbedded graywacke, mica gneiss, and mica schist, coarse to fine and bluish gray to gray, with some conglomerate. Contains many small beds of hornblende gneiss, large bodies of garnet schist, graphite-kyanite schist, and garnet-kyanite gneiss, and dikes of biotite granite, both altered and unaltered.	Ridges, peaks, spurs, high mountains with irregular crests, and plateau areas. Red and brown micaceous and clayey soils.

PUBLISHED GEOLOGIC FOLIOS

No.*	Name of folio.	State.	Price.†
			Cents.
‡1	Livingston	Montana	25
‡2	Ringgold	Georgia-Tennessee	25
‡3	Placerville	California	25
‡4	Kingston	Tennessee	25
‡5	Sacramento	California	25
‡6	Chattanooga	Tennessee	25
‡7	Pikes Peak	Colorado	25
‡8	Sewanee	Tennessee	25
‡9	Anthracite-Crested Butte	Colorado	50
‡10	Harpers Ferry	Va.-Md.-W.Va.	25
‡11	Jackson	California	25
‡12	Estillville	Ky.-Va.-Tenn.	25
13	Fredericksburg	Virginia-Maryland	25
‡14	Staunton	Virginia-West Virginia	25
‡15	Lassen Peak	California	25
‡16	Knoxville	Tennessee-North Carolina	25
‡17	Marysville	California	25
18	Smartsville	California	25
‡19	Stevenson	Ala.-Ga.-Tenn.	25
20	Cleveland	Tennessee	25
21	Pikeville	Tennessee	25
22	McMinnville	Tennessee	25
23	Nomini	Maryland-Virginia	25
24	Three Forks	Montana	25
25	Loudon	Tennessee	25
‡26	Pocahontas	Virginia-West Virginia	25
27	Morristown	Tennessee	25
‡28	Piedmont	West Virginia-Maryland	25
29	Nevada City Special	California	50
30	Yellowstone National Park	Wyoming	50
31	Pyramid Peak	California	25
32	Franklin	West Virginia-Virginia	25
33	Briceville	Tennessee	25
34	Buckhannon	West Virginia	25
35	Gadsden	Alabama	25
36	Pueblo	Colorado	25
37	Downieville	California	25
38	Butte Special	Montana	25
39	Truckee	California	25
40	Wartburg	Tennessee	25
41	Sonora	California	25
42	Nueces	Texas	25
43	Bidwell Bar	California	25
‡44	Tazewell	Virginia-West Virginia	25
45	Boise	Idaho	25
46	Richmond	Kentucky	25
47	London	Kentucky	25
48	Tenmile District Special	Colorado	25
49	Roseburg	Oregon	25
50	Holyoke	Massachusetts-Connecticut	25
51	Big Trees	California	25
52	Absaroka	Wyoming	25
53	Standingstone	Tennessee	25
54	Tacoma	Washington	25
55	Fort Benton	Montana	25
56	Little Belt Mountains	Montana	25
‡57	Telluride	Colorado	25
58	Elmoro	Colorado	25
59	Bristol	Virginia-Tennessee	25
60	La Plata	Colorado	25
61	Monterey	Virginia-West Virginia	25
62	Menominee Special	Michigan	25
63	Mother Lode District	California	50
64	Uvalde	Texas	25
65	Tintic Special	Utah	25
66	Colfax	California	25
67	Danville	Illinois-Indiana	25
68	Walsenburg	Colorado	25
69	Huntington	West Virginia-Ohio	25
70	Washington	D. C.-Va.-Md.	50
71	Spanish Peaks	Colorado	25
72	Charleston	West Virginia	25
‡73	Coos Bay	Oregon	25
74	Coalgate	Oklahoma (Ind. Ter.)	25
75	Maynardville	Tennessee	25
76	Austin	Texas	25
77	Raleigh	West Virginia	25
78	Rome	Georgia-Alabama	25
79	Atoka	Oklahoma (Ind. Ter.)	25
80	Norfolk	Virginia-North Carolina	25
‡81	Chicago	Illinois-Indiana	50
82	Masontown-Uniontown	Pennsylvania	25
‡83	New York City	New York-New Jersey	50
84	Ditney	Indiana	25
85	Oelrichs	South Dakota-Nebraska	25
86	Ellensburg	Washington	25
87	Camp Clarke	Nebraska	25
88	Scotts Bluff	Nebraska	25
89	Port Orford	Oregon	25
90	Cranberry	North Carolina-Tennessee	25
91	Hartville	Wyoming	25
92	Gaines	Pennsylvania-New York	25
93	Elkland-Tioga	Pennsylvania	25
94	Brownsville-Connellsville	Pennsylvania	25

No.*	Name of folio.	State.	Price.†
			Cents.
95	Columbia	Tennessee	25
96	Olivet	South Dakota	25
97	Parker	South Dakota	25
98	Tishomingo	Oklahoma (Ind. Ter.)	25
99	Mitchell	South Dakota	25
100	Alexandria	South Dakota	25
101	San Luis	California	25
102	Indiana	Pennsylvania	25
103	Nampa	Idaho-Oregon	25
104	Silver City	Idaho	25
105	Patoka	Indiana-Illinois	25
106	Mount Stuart	Washington	25
107	Newcastle	Wyoming-South-Dakota	25
108	Edgemont	South Dakota-Nebraska	25
109	Cottonwood Falls	Kansas	25
110	Latrobe	Pennsylvania	25
111	Globe	Arizona	25
112	Bisbee	Arizona	25
113	Huron	South Dakota	25
114	De Smet	South Dakota	25
115	Kittanning	Pennsylvania	25
116	Asheville	North Carolina-Tennessee	25
117	Casselton-Fargo	North Dakota-Minnesota	25
118	Greeneville	Tennessee-North Carolina	25
119	Fayetteville	Arkansas-Missouri	25
120	Silverton	Colorado	25
121	Waynesburg	Pennsylvania	25
122	Tahlequah	Oklahoma (Ind. Ter.)	25
123	Elders Ridge	Pennsylvania	25
124	Mount Mitchell	North Carolina-Tennessee	25
125	Rural Valley	Pennsylvania	25
126	Bradshaw Mountains	Arizona	25
127	Sundance	Wyoming-South Dakota	25
128	Aladdin	Wyo.-S. Dak.-Mont.	25
129	Clifton	Arizona	25
130	Rico	Colorado	25
131	Needle Mountains	Colorado	25
132	Muscogee	Oklahoma (Ind. Ter.)	25
133	Ebensburg	Pennsylvania	25
134	Beaver	Pennsylvania	25
135	Nepesta	Colorado	25
136	St. Marys	Maryland-Virginia	25
137	Dover	Del.-Md.-N. J.	25
138	Redding	California	25
139	Snoqualmie	Washington	25
140	Milwaukee Special	Wisconsin	25
141	Bald Mountain-Dayton	Wyoming	25
142	Cloud Peak-Fort McKinney	Wyoming	25
143	Nantahala	North Carolina-Tennessee	25
144	Amity	Pennsylvania	25
145	Lancaster-Mineral Point	Wisconsin-Iowa-Illinois	25
146	Rogersville	Pennsylvania	25
147	Pisgah	N. Carolina-S. Carolina	25
‡148	Joplin District	Missouri-Kansas	50
149	Penobscot Bay	Maine	25
150	Devils Tower	Wyoming	25
151	Roan Mountain	Tennessee-North Carolina	25
152	Patuxent	Md.-D. C.	25
153	Ouray	Colorado	25
154	Winslow	Ark.-Okla. (Ind. Ter.)	25
155	Ann Arbor	Michigan	25
156	Elk Point	S. Dak.-Nebr.-Iowa	25
157	Passaic	New Jersey-New York	25
158	Rockland	Maine	25
159	Independence	Kansas	25
160	Accident-Grantsville	Md.-Pa.-W. Va.	25
161	Franklin Furnace	New Jersey	25
162	Philadelphia	Pa.-N. J.-Del.	50
163	Santa Cruz	California	25
§164	Belle Fourche	South Dakota	25
§165	Aberdeen-Redfield	South Dakota	25
§166	El Paso	Texas	25
§167	Trenton	New Jersey-Pennsylvania	25
§168	Jamestown-Tower	North Dakota	25
§169	Watkins Glen-Catatonk	New York	25
§170	Mercersburg-Chambersburg	Pennsylvania	25
§171	Engineer Mountain	Colorado	25
§172	Warren	Pennsylvania-New York	25
§173	Laramie-Sherman	Wyoming	25
§174	Johnstown	Pennsylvania	25
§175	Birmingham	Alabama	25
§176	Sewickley	Pennsylvania	25
§177	Burgettstown-Carnegie	Pennsylvania	25
§178	Foxburg-Clarion	Pennsylvania	25
§179	Pawpaw-Hancock	Md.-W. Va.-Pa.	25
§180	Claysville	Pennsylvania	25
§181	Bismarck	North Dakota	25
§182	Choptank	Maryland	25
§183	Llano-Burnet	Texas	25
§184	Kenova	Ky.-W. Va.-Ohio	25
§185	Murphysboro-Herrin	Illinois	25
§186	Apishapa	Colorado	25
§187	Ellijay	Ga.-N. C.-Tenn.	25

* Order by number.
† Payment must be made by money order or in cash.
‡ These folios are out of stock.

§ These folios are also published in octavo form.

Circulars showing the location of the area covered by any of the above folios, as well as information concerning topographic maps and other publications of the Geological Survey, may be had on application to the Director, United States Geological Survey, Washington, D. C.