# DESCRIPTION OF THE GAFFNEY AND KINGS MOUNTAIN QUADRANGLES

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## GEOGRAPHIC AND GEOLOGIC RELATIONS

### LOCATION

About two-thirds of the area included in the Gaffney and Kings Mountain quadrangles lies in South Carolina and one-third in North Carolina. This area, which is called in this folio the Gaffney-Kings Mountain district, is bounded by parallels 35° and 35° 15′ and meridians 81° 15′ and 81° 45′. Each quadrangle covers an area of about 244 square miles. The Gaffney quadrangle includes parts of Cherokee County, S. C., and Cleveland and Rutherford Counties, N. C. The Kings Mountain quadrangle lies east of the Gaffney quadrangle and includes parts of York and Cherokee Counties, S. C., and Gaston and Cleveland Counties, N. C. The principal towns are Gaffney, S. C., and Kings Mountain, N. C., from which the quadrangles are named, and Blacksburg, S. C. (See fig. 1.)

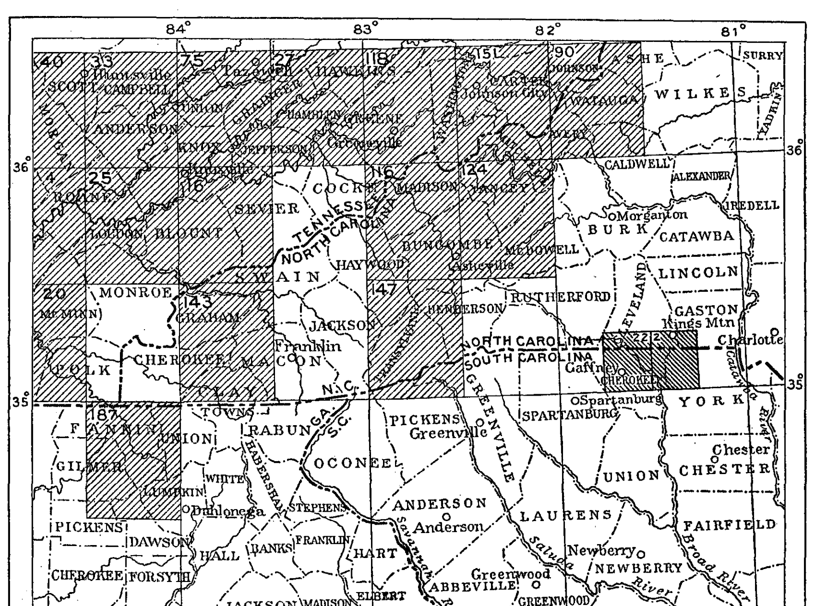


FIGURE 1.—Index map of the vicinity of the Gaffney and Kings Mountain quadrangles

The location of the Gaffney-Kings Mountain area (Folio 222) is shown by the darker ruling. Published folios describing other quadrangles, indicated by lighter ruling, are the following: Nos. 4, Kingston; 16, Knoxville; 20, Cleveland; 25, Loudon; 27, Morristown; 33, Briceville; 40, Wartburg; 75, Maynardville; 90, Cranberry; 116, Asheville; 118, Greeneville; 124, Mount Mitchell; 143, Nantahala; 147, Pisgah; 151, Roan Mountain; 187, Ellijay.

In geographic and geologic relations these quadrangles form part of the Piedmont province, the eastern division of the Appalachian Highlands.

### APPALACHIAN HIGHLANDS

#### SUBDIVISIONS

The Appalachian Highlands are composed of several distinct physiographic divisions. Among these divisions are the Piedmont province, the Blue Ridge province, the Valley and Ridge province, and the Appalachian Plateaus. The Appalachian Plateaus include the Cumberland Plateau, the Allegheny Plateau, and the lower plateaus and plains of Tennessee, Kentucky, and Ohio extending westward toward Mississippi River. They range from nearly flat country that has an altitude of about 500 feet above sea level at the west to table-lands, dissected plateaus, hilly country, and mountains that range from 2,000 to 4,500 feet in altitude at the east.

The Valley and Ridge province extends from Alabama northward into New York It includes several large valleys and numerous small ones. Among the large ones are Coosa Valley of Georgia and Alabama, the Great Valley of eastern Tennessee and Virginia, the Shenandoah Valley of Virginia, and the Cumberland Valley of Maryland and Pennsylvania.

At the south, in Alabama, the Valley and Ridge province has an altitude of about 500 feet above sea level, but to the northeast the altitude increases to more than 2,500 feet in Virginia and West Virginia and decreases to about 500 feet near the Potomac River and even less still farther to the northeast.

The drainage of the Valley and Ridge province depends largely on the geologic structure. In general the courses of the streams are determined by the hardness of the rocks and by the structure, making subordinate valleys in and parallel to the Great Valley. These longitudinal streams empty into larger transverse rivers that cut across the walls of the valley. The larger transverse rivers are the Tennessee, New or Kanawha, Roanoke, James, Potomac, Susquehanna, Schuylkill, Delaware, and Hudson.

The Blue Ridge province is an extended system of many mountain ranges with different local names. The ranges extend from northwestern Georgia into southern Pennsylvania and correspond to the Highlands of New Jersey and New York and the mountains of western New England. Prominent among these ranges are the Cohutta Mountains of Georgia, the Great Smoky and Unaka Mountains of Tennessee and North Carolina, the Blue Ridge and Catoctin Mountains of Virginia and Maryland, and South Mountain of Pennsylvania. The Piedmont province differs little geologically from the Blue Ridge province but is topographically so different that it has been given a separate name.

The Blue Ridge province rises gradually from an altitude of less than 1,000 feet above sea level in Georgia to more than 6,700 feet in western North Carolina. From this region the altitude decreases to less than 3,000 feet in southern Virginia, rises to 4,000 feet in central Virginia, and descends to less than 2,000 feet at the Maryland-Pennsylvania line.

The drainage of the mountains is carried in both longitudinal and transverse streams, according to the geologic structure in the different regions. In the areas of ancient rocks fan-shaped drainage basins have been developed by numerous crosscutting streams. Longitudinal valleys occur in sedimentary rocks that have been considerably folded and crop out in long bands.

As the Gaffney-Kings Mountain district lies wholly within the Piedmont province and as its geology and physiography depend mainly on this division of the Appalachians, this province only will be described here in detail.

### PIEDMONT PROVINCE

#### LOCATION

The Piedmont province is a broad eastward-sloping plateau which extends from the eastern Gulf States northeastward to New England and which lies between the Coastal Plain on the south and east and the Blue Ridge and Valley and Ridge provinces on the north and west. The Piedmont province has an average width of about 60 miles, but in the southern and central parts it is more than 100 miles wide. In general the borders are irregular and are not sharply marked, but in some places the passage from plateau to mountain or plateau to coastal plain is almost abrupt.

#### TOPOGRAPHY

The Piedmont province is a gently sloping plateau dissected by the rivers and streams that flow over its surface. The slope is gradual eastward and southeastward from the mountains toward the coast at an average rate of about 10 feet to the mile. In the southern part of the province the slope of the plateau is in general steeper near the mountains than it is in the eastern part. The altitude of the plateau ranges from a few hundred feet above sea level along the western border in the northern part and 1,500 feet in the southern part to 300 feet in places on the eastern border. Variations in relief have been produced by stream erosion of the original plateau surface. They are due in part to distance from the streams and in part to difference in hardness and structure of the rocks. These factors have resulted in several lesser plateaus in the general plateau region which are distinct from one another in altitude and extent.

On the western border of the province there are deep V-shaped valleys in a region of steep hills, which passes into the broken mountainous country that forms the eastern slope of the Blue Ridge. At a distance from the rivers there are considerable areas of plateau that have suffered but little from erosion. Farther out on the plateau rolling hill country lies at a distance from the rivers and either broad or narrow valleys stretch along the larger watercourses. These features extend as far as the eastern and southern border of the Piedmont province, where the distinctive features of the plateau are covered by the formations of the Coastal Plain, which lap over on the plateau with a very irregular boundary, giving a gradual transition from dissected upland country to rather flat plain. Near the eastern border of the province the valleys are in many places narrow and gorgelike, but the plateau features remain in the interstream areas.

In scattered areas, hills or small mountains stand 100 feet or more above the general level of the plateau. These points are especially prominent, as they can be seen for miles from all the higher parts of the plateau. Some of them are rather sharp peaks or ridges (see pls. 1–3), and others are broad and rounded; they occur in isolated masses and also in belts or ranges corresponding with the trend of certain rock formations or structure. The term "monadnock" has been applied to residual hills that stand above the general plateau surface, from Mount Monadnock, in southern New Hampshire, a typical example. In the Gaffney-Kings Mountain district Kings Mountain and Crowders Mountain are monadnocks.

The presence of a plateau is readily recognized by an observer who looks across the country from one of the higher ridges or from the side of the mountains along the northwest border. The effect is that of a nearly level country whose even sky line is broken by a few hills or peaks that stand above the general level. These features are common to the whole Piedmont province, even in areas dissected by deep valleys, for the presence of such valleys is not realized by an observer on the plateau surface until he comes to their borders, perhaps less than a quarter of a mile from the streams. (See pls. 4–6.)

#### DRAINAGE

The streams of the Piedmont province flow principally to the southeast, but there are many variations, as some flow nearly east in southern Virginia and others flow south in Georgia and Alabama. South of Roanoke River practically all the streams of the Piedmont province rise on the plateau or on the southeast slope of the Blue Ridge. North of Roanoke River the larger rivers, such as the James, the Potomac, and the Susquehanna, rise far to the west of the Piedmont province, and only the minor rivers rise in the Piedmont. The drainage basins of the rivers that are confined chiefly to the Piedmont have the characteristic treelike patterns.

Through most of the Piedmont province the courses of the larger streams bear little relation to the structure of the underlying rocks, but in some regions many of the smaller streams have adjusted their courses to the structure. Some of the larger streams in Georgia and Alabama are exceptions and follow the rock formations for long distances.

The passage from plateau to plain is accompanied by changes in the streams, which lose velocity by reason of diminished grade in passing from beds of hard rock to the softer formations of the Coastal Plain. Above the boundary of the Coastal Plain the streams are characterized by strong currents, rapids, and falls, and below by more sluggish waters most of which are navigable. This difference is so pronounced along much of the boundary of the Piedmont province and Coastal Plain as to give rise to the name "fall line."

#### GEOLOGY

The rocks of the Piedmont province are of both igneous and sedimentary origin. Both types of rock have been metamorphosed in many places. In some areas the metamorphic igneous and sedimentary rocks are not sharply distinct, for metamorphism has been so extreme that nearly all traces of their original nature have been obliterated. In many places also the metamorphic igneous rocks are not sharply separated from the ordinary igneous rocks, for a single intrusion may become metamorphosed in some parts, especially around its borders, during mountain building and show little if any evidence of change in other parts, particularly in its interior.

The metamorphic rocks of sedimentary origin in the Piedmont province consist of gneisses and schists, the principal types of which are those containing muscovite or biotite mica, garnet, kyanite, staurolite, chlorite, sericite, ottrelite, and in some places quartz and calcite. These rocks have resulted from the metamorphism of different kinds of rocks that made up the ancient sedimentary series, such as conglomerate, sandstone, shale, and limestone, together with numerous intermediate types. By metamorphism sandstone became quartzite, impure or shaly sandstone became graywacke and gneiss, shale became schist, and limestone became marble. Variations in the composition of the original sediments are represented by variations in the metamorphic rocks. Some of the sediments were in part of volcanic origin, such as wash deposits of volcanic ash or tuff, which contained varying amounts of ordinary land waste. The metamorphism of these rocks has produced transitional phases of crystalline rocks between those of sedimentary and igneous origin.

The metamorphic igneous rocks include schistose and gneissoid rocks of granitic, dioritic, volcanic, and other kinds whose minerals have been more or less changed. Some of these rocks have been so extremely metamorphosed that they have passed into mica and garnet gneisses or schists which can not be distinguished from those of sedimentary origin. Diorite and many basic igneous rocks have become schistose diorite, hornblende gneiss, hornblende schist, chlorite schist, serpentine, soapstone, and other varieties of metamorphic rocks.

The igneous rocks of the Piedmont province include a wide range of such rocks as granite, diorite, gabbro, pyroxenite, peridotite, porphyries, and diabase and intermediate types. These rocks have been intruded as batholiths, laccoliths, sills, dikes, and stocks or poured out as surface flows during different epochs. The older intrusive rocks have been more or less metamorphosed and are not everywhere sharply distinct from the metamorphic rocks.

The unmetamorphosed sediments of the Piedmont province include conglomerate, sandstone, shale, and intermediate types of sedimentary rock. These rocks are chiefly of Triassic age and occur in several basins in North Carolina, Virginia, Maryland, Pennsylvania, and New Jersey. In a few places similar kinds of rocks of Cretaceous age overlap the eastern border of the Piedmont province.

The strike of the formations of the Piedmont province is generally northeastward, or approximately parallel with the trend of the plateau and the Appalachian Mountains that border it, but in some places the beds trend nearly at right angles to the prevailing strike. The dips of the rocks are high but variable, and southeast dips prevail.

#### GEOLOGIC HISTORY

The geologic record of the Appalachian Mountains along the northwestern border of the Piedmont begins with Archean rocks that are among the oldest known in the world. They consist of metamorphosed igneous and sedimentary rocks, the origin of which is lost in obscurity. Others are extensively metamorphosed but still exhibit features characteristic of their origin. The unmetamorphosed sediments of the Piedmont province were laid down chiefly in Mesozoic or later time, but in the Appalachian region as a whole most of the Paleozoic rocks have been little metamorphosed. The igneous rocks have a wide range in age, intrusions having occurred from Archean to Triassic time. Almost inconceivable distortion has been produced in the Archean rocks of the Piedmont province by the mashing, folding, and faulting that accompanied the processes of mountain building to which this region has been subjected. The rocks have undergone these deformations two or more times, and the earliest deformation occurred during the Archean period.

After the deformation of the Archean rocks there was a long period of erosion, in the course of which the surface of the earth was gradually lowered, and the igneous masses and crystalline rocks that had formed deep below the surface were exposed over great areas. This period was the longest of its kind of which there is knowledge.

The Archean erosion was interrupted by volcanic activity, during which great sheets of lava were poured forth and large areas were depressed to such an extent that much fragmental material, such as tuff and mud, the product of the volcanic outbursts, was deposited in large bodies of water. These deposits, known as Algonkian, in turn were uplifted, exposed to erosion, and completely worn away over very large areas. This period of erosion was, however, far shorter than that which preceded the volcanism.

The depression of the Appalachian Valley and Piedmont provinces beneath the sea caused the deposition of sediments worn from the pre-Cambrian land, thus beginning the Paleozoic era. The early deposits, mainly sand and gravel, followed by mud, sand, and limestone, were laid down unconformably on the worn and upturned edges of the Archean gneiss, schist, and igneous rocks over parts of what is now the Piedmont province. The rocks of the southern Piedmont show no further record of the events of Paleozoic time, except that of deformation and igneous intrusion.

Near the end of Paleozoic time movements of the earth's crust and intrusions of igneous rocks subjected these sediments to intense folding, faulting, and metamorphism. The underlying Archean rocks received their final folding and metamorphism at this time. The immense forces exerted during these periods of crustal movement and mountain building folded the rocks into great arches and basins made up of many compressed and overturned folds. Excessive rock movement in some of the folds resulted in thrust faults, thus adding to the complexity of the structure of the rocks.

After a very long period of erosion portions of the Piedmont area were submerged in early Mesozoic time, and deposits of sediments were laid down unconformably on the older metamorphic rocks in shallow estuaries and basins. These sediments, chiefly red sand and mud with some coal, were consolidated without metamorphism and later cut by intrusions of diabase, uplifted, and faulted.

The last sediments deposited in this general region were those of the Coastal Plain, which now borders the Piedmont province on the east. These sediments range in age from Lower Cretaceous to Recent. Some of the beds have been consolidated into hard rocks, but many of the later beds, especially those of gravel and sand, still consist of loose or feebly compacted materials.

The development of the plain which by later uplift became the plateau of the Piedmont province was due to the processes of destruction. There is a total unconformity between the structure of the rock formations and the surface of the plateau, and the beds are sharply beveled across by the surface. The structure of the rocks is complex, and bedding that approximates the horizontal is rare. The Piedmont province was a vast uplifted plain on which the features of an ideal peneplain were highly developed before the uplift, during the time when the plain stood only a little above sea level.

With the exception of the monadnocks that rise above the plateau surface, most of the relief of the Piedmont is due to erosion subsequent to the uplift. The relief between valleys and hills or ridges ranges from a few feet to more than 400 feet. Changes of grade may be abrupt or gradual and in a measure depend on the nature of the rock formations and on the nearness of large streams.

The rocks have been extensively and deeply decomposed over the Piedmont province, and the mantle of residual soil is accordingly thick. Some rocks have yielded to the agencies of decomposition more readily than others, and the mantle of soil therefore differs in thickness in different places. Where decomposition has been thorough and deep, broad valleys with gently sloping walls have been formed along the rivers and creeks. Unaltered rocks whose structure is favorable were carved into steeper-walled valleys. A large part of the decomposition of the rocks of the Piedmont province took place during the development of the peneplain in the long period of erosion when the surface was nearly at sea level. Under such conditions erosion is extremely slow, and decomposition may proceed more rapidly than denudation.

After the uplift of the plateau the thick mantle of decomposed rock or soil offered little resistance to the natural drainage down the slope of the plain. The larger streams thus became established in their courses to the southeast, which they were able to maintain even after they had cut down to fresh rock. The courses of the larger rivers are nearly those which would result from the natural flow of streams over a tilted plain, and only slight adjustment to the structure of the rocks has taken place. Many of the smaller tributary streams, however, have adjusted their courses to the character and structure of the underlying rocks.

In the Gaffney-Kings Mountain district Broad River is a consequent stream—that is, it flows in a nearly normal course down the slope of the plateau with but few adjustments to the local rock structure. Some of the smaller streams are also chiefly consequent streams, such as Thicketty, Cherokee, Sarratt, and Crowders Creeks and Clark Fork. Most of the smaller creeks and branches are chiefly subsequent streams—that is, they have adjusted their courses to the underlying rocks and structure, following lines of least resistance to erosion. Many of the streams possess features of both consequent and subsequent development along different parts of their channels. The most perfect adjustment of valleys to rock structure is found in the longitudinal valleys that follow limestone outcrops, such as Dixon Branch and other headwaters of Kings Creek south of the town of Kings Mountain.

## TOPOGRAPHY OF THE GAFFNEY-KINGS MOUNTAIN DISTRICT

#### GENERAL FEATURES

The Gaffney-Kings Mountain district is in the central part of the Piedmont province, and its surface features may be considered as typical of the province. Broad flat or gently rolling ridges grade into more broken country near the larger streams, where deep valleys have been cut. Residual prominences have been left, both as isolated peaks and as elongated ridges, standing above the general level of the surrounding remnants of the plateau. (See pls. 1–3.) The sky line as viewed from the higher ridges is that of a nearly level country but may be broken by a monadnock or a residual peak or by the distant mountains to the northwest. The relief where the rivers and larger streams are cutting through hard rocks is considerable, and steep rocky hillsides have been formed.

A typical example of the rolling upland country may be seen between Grover and the town of Kings Mountain and from York northwestward to the foot of Kings Mountain, in the Kings Mountain quadrangle. In the Gaffney quadrangle the regions around Gaffney and to the northwest as far as the border of the quadrangle and also between Earl and Patterson Springs furnish good examples. The relief throughout considerable areas around these places is small, and the valleys are shallow. The cultivated land shows smooth fields covered with deep residual soil and only scattered outcrops of rock.

Many of the monadnocks are bordered by steep slopes or cliffs. The contrast is striking between these rugged summits and the smooth rolling upland, like that between The Pinnacle and the country around the town of Kings Mountain. (See pl. 2.) The smooth, broad interstream areas pass gradually into steeper slopes toward the stream valleys. Some of the valleys are V-shaped and have very steep walls and narrow bottoms.

#### RELIEF

The lowest altitude in the district is about 430 feet above sea level, at the point where Broad River leaves the Kings Mountain quadrangle, and the highest is 1,705 feet, at The Pinnacle, in the same quadrangle. With the exception of Crowders Mountain, which reaches 1,624 feet, several hills south of The Pinnacle, and Henry Knob, a monadnock near the east side of the Kings Mountain quadrangle, all the surface of the district stands less than 1,200 feet above sea level. The highest point in the Gaffney quadrangle is Whitaker Mountain, on the east border, about 1,140 feet above sea level. All the high points in the district are residual prominences that stand above the remnants of the plateau.

The remnants of the plateau range in altitude from 700 to 1,000 feet. One of the highest of these remnants is the ridge on which the town of Kings Mountain is situated, which extends southwestward toward Grover. This ridge slopes from about 1,000 feet above sea level at Kings Mountain to less than 900 feet at Grover, and all the hilltops except Whitaker Mountain are progressively lower in this direction as far as Broad River. Along Broad River many of the ridges are lower than the remnants of the plateau a few miles back from the river and have approximately equal altitudes, which give them an aspect of belonging to a second lower plain. It is not certain whether or not these ridges represent a former peneplain developed along the river at some period of rest during the uplift of the Piedmont.

Considerable differences in altitude occur in some places within distances so short that the surface is very rugged. Thus, The Pinnacle and Crowders Mountain rise 800 feet above the valleys at their bases within half a mile. (See pls. 2–3.) Of this rise 600 feet occurs within a quarter of a mile, and on both mountains there are sheer cliffs from 50 to 200 feet high. Henry Knob, an isolated monadnock, is 300 feet above the surrounding remnants of the plateau. The relief along Broad River and some of its tributaries, which are carved below the plateau surface, is also large in places. Thus, there are differences in altitude along the river of 200 to 300 feet within a quarter of a mile at several places, as at McGowan Mountain and Abes Mountain.

#### DRAINAGE

Most of the district is drained by Broad River and its tributaries, but an area in the northeastern and eastern parts of the Kings Mountain quadrangle is drained by tributaries of Catawba River. Broad River is called successively the Congaree below Columbia, S. C., and the Santee below the junction with Wateree River. Catawba River is called the Wateree below Great Falls, S. C., and forms Santee River by junction with Congaree River. The course of Broad River is in general southeastward with minor variations. It enters the Gaffney quadrangle near the northwest corner, leaves that quadrangle near the southeast corner, and cuts across the southwest corner of the Kings Mountain quadrangle. The larger tributaries of Broad River in the Gaffney quadrangle are First Broad River, Buffalo Creek, and Cherokee Creek. Thicketty Creek drains the southwestern part of the quadrangle but does not enter Broad River within the quadrangle. Kings Creek is the largest tributary of Broad River in the Kings Mountain quadrangle. The southern and central parts of this quadrangle are drained by Bullocks Creek and its tributaries, and the northeastern and eastern parts chiefly by Crowders Creek and Allison Creek and their tributaries, which empty into Catawba River 10 or 12 miles to the east.

Broad River enters the Gaffney quadrangle at an altitude of about 660 feet above sea level and leaves the Kings Mountain quadrangle at an altitude of about 430 feet, a descent of about 230 feet in a distance of 26 miles. About 80 feet of this descent occurs within 4 miles below Cherokee Falls, but the rest is more evenly distributed with the exception of about 20 feet in 1 mile at Gaston Shoals.

## GENERAL GEOLOGY

### THE ROCK FORMATIONS

#### GENERAL FEATURES

The Gaffney-Kings Mountain district contains both metamorphic and igneous rocks, ranging in age from Archean to Triassic. The metamorphic rocks include some of sedimentary and igneous origin. The Archean rocks occupy the northwestern and southeastern parts of both quadrangles, separated by a belt of Algonkian and Cambrian rocks. The Archean rocks have been cut by masses of later igneous rocks, some of them large. In the Gaffney quadrangle the Archean rocks and later intrusive rocks occupy about two-thirds of the northwestern part and scattered areas in the southeastern part. In the Kings Mountain quadrangle Archean rocks with predominant later intrusive rocks occupy about one-fifth of the northwestern part and nearly one-third of the southern part. The Triassic rocks are rather generally distributed in narrow dikes throughout the Kings Mountain quadrangle and in the eastern part of the Gaffney quadrangle.

| System | Formation | Symbol | Columnar section | Thickness (feet) | Character of rocks |
|---|---|---|---|---|---|
| Cambrian. | Gaffney marble. | Ꞓg | | 30-300 | Fine-grained to medium-grained bluish-gray to white marble. |
| | Blacksburg schist. | Ꞓb | | 800-1,000 | Rocks ranging from fine graywacke to sericite schist or phyllite. |
| | UNCONFORMITY | | | | |
| | Kings Mountain quartzite with Draytonville conglomerate member. | Ꞓk (Ꞓkd) | | 5-500 | White quartzite, chloritic sericitic quartzite, kyanitic quartzite, and a thick-bedded quartz conglomerate. |
| | UNCONFORMITY | | | | |
| Algon. | Battleground schist. | Abg | | 1,000+ | Chiefly varicolored sericitic schist with manganese schist member and conglomerate. |
| Arch. | Metamorphosed sedimentary and igneous rocks. | | | | Gneiss and granite. |

FIGURE 2.—Generalized columnar section of sedimentary rocks in the Gaffney and Kings Mountain quadrangles

| System | Formation | Section | Symbol | Character of rocks |
|---|---|---|---|---|
| Triassic. | Diabase. | | Ŧd | Dense dark diabase. |
| Late Carboniferous (?). | Yorkville granite. | | yg | Gray to dark-gray coarse-grained biotite granite with porphyritic facies. |
| | Whiteside granite. | | wgr | Light-gray muscovite-biotite granite, slightly metamorphosed. |
| Archean. | Bessemer granite. | | Ⱥb | Medium to fine grained muscovite-biotite granite, much metamorphosed; porphyritic texture developed locally. |
| | Soapstone, pyroxenite, and allied basic rocks. | | Ⱥs | Basic dikes associated chiefly with Roan gneiss. |
| | Roan gneiss. | | Ⱥr | Chiefly hornblende schist, hornblende gneiss, schistose diorite, and diorite. |
| | Carolina gneiss (sedimentary). | | Ⱥc | Chiefly mica, garnet, and kyanite gneisses and schists; some staurolite schist and beds of marble. |

FIGURE 3.—Generalized columnar section of igneous and old crystalline rocks in the Gaffney and Kings Mountain quadrangles

The relations of the rock formations and their thickness and composition are shown in the columnar sections (figs. 2 and 3). Their order and method of production are shown in the accompanying table.

*Order of geologic formations and events in the Gaffney-Kings Mountain district*

Archean:
- Carolina gneiss. Mainly sedimentary sands and clays, many thousand feet thick and now metamorphosed.
- Roan gneiss. Igneous masses and dikes intruded into Carolina gneiss and now much metamorphosed.
- Soapstone, pyroxenite, gabbro, and similar basic igneous rocks. Occur chiefly in or associated with Roan gneiss.
- Bessemer granite. Intruded into Roan gneiss and pyroxenite and much metamorphosed.
- Pegmatite. Injected into Carolina and Roan gneisses in dikes and lenses.
- Great deformation and erosion.

Algonkian:
- Formation of volcanic rocks and deposition of some sediments began after erosion.
- Battleground schist, 1,000 feet thick. Mainly sedimentary clays, now metamorphosed.
- Great deformation followed by erosion.

Cambrian:
- Deposition of sedimentary rocks began after erosion.
- Kings Mountain quartzite, 5-500 feet thick. Mainly sedimentary sands, now metamorphosed.
  - Draytonville conglomerate member at base.
  - White quartzite phase, chloritic and sericitic quartzite phase, and kyanitic quartzite phase.
- Blacksburg schist, 800-1,000 feet thick. Sedimentary clay and sandy clay now metamorphosed.
- Gaffney marble, 30-300 feet thick. Sedimentary limestone now metamorphosed.

Late Carboniferous (?):
- Appalachian revolution began.
- Whiteside granite. Intruded into Carolina and Roan gneisses.
- Pegmatite. Injected into Carolina and Roan gneisses.
- Yorkville granite. Intruded into Roan gneiss.

Triassic:
- Great erosion interval, after end of Appalachian revolution.
- Diabase dikes. Intruded into all formations.

## ARCHEAN SYSTEM

### CAROLINA GNEISS

*Distribution.*—The Carolina gneiss is the oldest formation of the region and was named because of its extensive development in the Carolinas. It occupies nearly one-half of the Gaffney quadrangle and about one-eighth of the Kings Mountain quadrangle. It occurs chiefly in the northwestern part of each quadrangle and is cut by masses of later igneous rocks of different sizes.

*Character.*—The Carolina gneiss consists of an immense series of interbedded gneisses and schists, prominent among which are mica gneiss and schist, garnet gneiss and schist, kyanite gneiss and schist, and combinations of these different types, together with granitoid layers. Less abundant facies of the Carolina gneiss are graphite and staurolite gneiss and schist. Practically all the gneisses and schists contain either muscovite or biotite mica and quartz, but where other minerals, such as garnet or kyanite, are present they give the rock type its name. Thus garnet gneiss or schist may contain in addition to garnet either muscovite or biotite mica or both, quartz, feldspar, and accessory minerals.

The mica gneisses and schists exhibit great diversity in texture and composition. The schists range from coarsely crystallized to fine-grained rocks and in many places exhibit variations in both texture and composition within a thickness of a few inches. Most of the mica schists are composed of quartz and biotite or muscovite, with or without feldspar, magnetite, and other minerals. In some of the schists the mica scales are fine to medium in size, but in others they are as much as half an inch in diameter. The coarsely crystallized varieties are commonly associated with later igneous rocks, such as granite or pegmatite. The quartz and other minerals of the schists occur in aggregates of fine or coarse grains, the variations corresponding with those of the scales of mica.

In some of the schists fissility in more than one direction has been developed by compression of the rocks in more than one period and in different directions. In such rocks the later parting, or "slip cleavage," as it is called, is commonly due not to an arrangement of the mineral grains in parallel position but to a parting or faulting developed along a series of small close folds. In some places scales of mica have developed along and parallel with this slip cleavage, so that the cleavage closely resembles the original schistosity. Another variation in the mica schists is caused by the development of scattered coarse crystals of mica with the cleavage turned about at a right angle to the schistosity. These crystals of mica are secondary and were developed at a later stage than the metamorphism which produced the schistosity.

The mica gneiss of the Carolina gneiss is also variable in texture and composition. A portion of the Carolina gneiss is composed of banded granular layers of feldspar, quartz, and either muscovite or biotite or both, with accessory minerals. The texture is commonly much coarser and the foliation less pronounced than those of the mica schists. Some of this gneiss has developed from homogeneous rocks and therefore has a rather uniform texture and banding. Other parts of it have been derived from rocks of variable composition that produce a strong banding with variations in texture.

The mica gneisses and schists grade into other types by the addition of such minerals as garnet, kyanite, and graphite. Where garnet and kyanite are abundant and in large crystals the texture of the schist differs substantially from that of ordinary mica schist. These minerals tend to crystallize with little adaptation to the parallel arrangement of the other minerals of the schist and accordingly produce a porphyritic texture. Graphite where present occurs in plates or scales developed in parallel position with the mica and does not change the texture of the schist.

Marble of different kinds occurs with the Carolina gneiss at several places. In the Kings Mountain gold mine the shafts cut a considerable mass of medium to fine grained white to gray banded marble. A ledge of white medium-grained marble, about 20 feet thick, belonging to the Carolina gneiss, shows on the west side of Kings Creek nearly 3 miles southeast of Grover. A bed of very coarse grained marble about 3 feet thick is exposed in a stream bed a few hundred yards south of Thicketty station. About 1 foot of this rock is fairly pure, and the rest carries coarsely crystallized biotite, quartz, and feldspar. All these beds grade into the mica schist of the Carolina gneiss and are parallel with it wherever the contacts are exposed.

*Origin.*—The gneisses and schists of the Carolina gneiss are derived from ancient sedimentary, igneous, and probably volcanic rocks. The sediments and volcanic rocks were accumulated to unknown thickness and cut by great and small masses of igneous rocks. The igneous rocks have been separately mapped in as much detail as can be shown on maps of this scale. The small igneous bodies alternate with the sedimentary material in great number, so that in the mapping they must be included in the general mass of Carolina gneiss, although they do not belong in that formation. These rocks were metamorphosed during one or more periods of deformation and mountain building before the end of Archean time and were subjected to further metamorphism in late Carboniferous time.

The minerals of the gneisses and schists are those developed during metamorphism either as entirely new minerals or original minerals recrystallized or increased in size by the addition of secondary material.

*Thickness.*—The thickness of the Carolina gneiss is many thousands of feet, but owing to metamorphism and deformation it can not be measured with any approach to accuracy.

*Weathering.*—By weathering the Carolina gneiss has produced a variety of soils, in which some of the variations are due to the degree of weathering and others to variations in the composition of the gneiss. Biotite and feldspar were among the first minerals to decompose, and their alteration has allowed the rock to disintegrate and break down into soil. The thoroughly weathered or decomposed forms of the Carolina gneiss make sandy clay soils more or less reddened by iron oxides. Rocks in which quartz and muscovite were predominant have disintegrated but have not thoroughly decomposed, so that the resulting soils are sandy and rather light colored and contain abundant small scales of mica. The kyanite and garnet gneisses and schists have in general yielded dark-red clay soils through which ferruginous kyanite and garnet pebbles are scattered. The color of these soils results from the alteration of the iron-bearing minerals so commonly present—that is, garnet, biotite, pyrite, and magnetite.

### ROAN GNEISS

*Distribution.*—The Roan gneiss received its name from Roan Mountain, on the North Carolina-Tennessee border, where this formation is extensively developed. It occurs in large masses and in belts or dikelike bodies that cut the Carolina gneiss. It is most abundant in the southern part of the Kings Mountain quadrangle and the southeastern part of the Gaffney quadrangle.

*Character.*—The Roan gneiss consists chiefly of dark hornblende schist, hornblende gneiss, schistose diorite, and diorite. In places there are intercalated layers of mica schist and gneiss and garnet schist and gneiss not essentially different from similar rocks of the Carolina gneiss. These layers are probably original parts of the Carolina gneiss that have been included in the intrusions of Roan gneiss or interfolded with it. The very schistose forms of the Roan gneiss appear on casual inspection to be composed almost wholly of hornblende, but they contain also small amounts of quartz and feldspar. They are in most places merely very schistose phases of the original diorite. In places the hornblende schist contains interbedded layers of quartz or feldspar and forms hornblende gneiss. The hornblendic rocks range from fine-textured schist and fine-grained diorites to granular rocks whose crystal grains measure half an inch across. These coarse rocks contain hornblende, plagioclase feldspar, and quartz together with subordinate garnet, biotite, chlorite, magnetite, and epidote. These minerals are practically all secondary, having been recrystallized from similar original minerals during metamorphism. Pegmatite occurs through much of the Roan gneiss and has the same origin and characteristics as that in the Carolina gneiss.

*Origin.*—The origin of some of the hornblendic rocks of the Roan gneiss is not certain. Some of them are evidently derived from igneous intrusions, probably diorite and gabbro, and others, such as those in the belt just south and southwest of Blacksburg, may have been derived from volcanic rocks of similar composition. The extent of alteration produced in the Roan gneiss by metamorphism is undetermined, because the original nature of much of the rock is not known. Those rocks that were originally diorite or closely allied types appear to have recrystallized into nearly the same minerals but to have undergone changes in texture. The minerals in their new growths extended themselves in the directions of least pressure, so that a strong parallel arrangement of flattened and elongated mineral grains was developed. A prominent microscopic feature of the rocks that have a dioritic composition is the obliteration of polysynthetic twinning in the plagioclase feldspars during metamorphism.

*Weathering.*—In the hornblendic rocks of the Roan gneiss the decomposition of the feldspar and hornblende marks the beginning of weathering. The other constituents are less soluble and, where abundant, remain as unaltered masses in the resulting soils. The thoroughly decomposed rock is represented by a characteristic dark reddish-brown clay soil, generally of deeper color than that which results from the biotite gneiss of the Carolina gneiss. A less altered form of the hornblende rock is a rotted rock or saprolite that has a characteristic peculiar yellowish-brown color. This saprolite preserves the structure and texture of the original rock in many places and commonly shows stains or seams of black manganese oxide. A still less altered form of the hornblende rocks, in which the minerals have only in part disintegrated, produces greenish to yellowish-green and olive-green sandy clay soils. The color is due to the broken down or pulverulent condition of the hornblende, the powder of which is green. Where a quantity of organic matter has accumulated in such earth, as in wet tracts, a sticky dark-green clay soil results. With the exception of these gumbo-like greenish soils, the soils formed by the Roan gneiss are of good quality and fertile.

#### PYROXENITE, AMPHIBOLITE, SOAPSTONE, AND GABBRO

*Distribution.*—A number of areas of pyroxenite, amphibolite, and similar rocks together with soapstone derived from them are scattered through the Gaffney quadrangle, and three areas have been observed in the Kings Mountain quadrangle. These rocks occur chiefly in or near masses of Roan gneiss, but some isolated bodies appear in the Carolina gneiss and Bessemer granite. These rocks are most extensively developed 3 to 4 miles southwest of Gaffney, where the largest mass is 2 miles long. These rocks are intrusive, and possibly they are magmatic differentiates from the same magma as that of the Roan gneiss and are of similar age.

*Character.*—Among the rocks of this group that occur in the Gaffney-Kings Mountain district are hornblende hypersthenite or pyroxenite, hornblende-hypersthene peridotite, and olivine gabbro grading into peridotite, picrite, and amphibolite. In many places these rocks have in part or almost wholly gone over into soapstone, which is composed of talc, chlorite, and impurities, such as magnetite, unaltered hornblende, and pyroxene. The different rocks of this group have a similar mode of occurrence—that is, they are developed in lenticular or oval masses, ranging from a few feet thick and several yards long to a quarter of a mile thick and 2 miles long. In texture they range from medium-grained rocks to coarse varieties in which the mineral grains are as much as half an inch across. Most of these rocks have not yielded much to compression, though in some places near contacts a schistose structure has been developed. Soapstone is a hydration product of these rocks. The rocks richest in olivine have yielded the purer grades of talcose soapstone, and those in which hornblende and pyroxene were abundant have yielded chloritic soapstone. Most of the deposits of soapstone in this district are very impure and contain unaltered hornblende, pyroxene, and other minerals in shreddy masses.

*Weathering.*—The alteration of pyroxenite and allied rocks to soapstone is in part a process of weathering, but in some places the alteration may have been deeper seated and possibly accompanied by hydrothermal action. Chlorite at least develops plentifully in the surface weathering of the amphibolites and hornblende pyroxenites. The weathering of the soapstone is slow, and in most places the resulting layer of soil is thin, so that ledges or scattered boulders of unaltered rock project through it. In the weathering of pyroxenite spheroidal boulders of unaltered rock are generally left scattered through the surface soils. Complete weathering of the soapstone and pyroxenites generally yields yellowish-brown to reddish-brown clay soils.

#### BESSEMER GRANITE

*Distribution.*—The Bessemer granite, named from Bessemer City, in the Lincolnton quadrangle, north of the Kings Mountain quadrangle, is a highly schistose granite that occurs both in large masses and in small dikes cutting other rocks, especially the Roan gneiss. The largest belt is 4 miles wide and extends over 15 miles diagonally across the Kings Mountain quadrangle.

*Character.*—The Bessemer granite is a medium to fine grained muscovite-biotite granite that borders on quartz monzonite, in which a porphyritic texture is locally developed. In all outcrops it has a strong schistose structure, and in many places it has been metamorphosed into white and gray quartz-sericite schist that bears little or no resemblance to the original granite. Only in favorable outcrops can the gradation from the schistose granite to sericite schist be seen. The porphyritic phases of the granite have in some places been metamorphosed into sericite schist with quartz augen, or "bird's-eye" schist.

In the less altered portions of the granite the constituent minerals are quartz, orthoclase, oligoclase, muscovite, biotite, and a little magnetite and zircon, together with secondary clinozoisite and chlorite. In the metamorphism of the Bessemer granite to quartz-sericite schist the muscovite has been largely recrystallized into finer scales, and the potash feldspar has passed into fine scaly sericite. The quartz has in part recrystallized, but the larger grains or phenocrysts retain more nearly their original size and position in the rock, yielding the augen structure.

*Weathering.*—In the first stages of alteration secondary kaolin, clinozoisite, and chlorite form rather plentifully from the Bessemer granite. The final product of weathering is a light sandy soil. The sericite schist derived from the Bessemer granite weathers into light, very fine sandy soil through which are scattered blocks and fragments of vein quartz. Both types of soil are underlain by reddish clay subsoil.

*Age.*—The extreme metamorphism of this granite and the fact that it does not appear to cut younger rocks than the Roan gneiss and the soapstone indicate that it is of Archean age and younger than the Roan gneiss.

#### PEGMATITE

Granitic pegmatite is abundant in the areas of Archean rocks, and some was observed in other formations. The pegmatite is variable in composition, but in its normal aspect it is composed of feldspar and quartz, with or without mica and other minerals. There are some varieties, however, in which feldspar is practically absent, and the rock is composed chiefly of quartz and mica. The texture varies from that of coarse granite to that in which the individual crystals measure more than a foot across.

The pegmatite occurs in sheets, lenses, and irregular masses, ranging from an inch or two up to several yards in thickness and as much as several hundred yards in length. (See pl. 10.) These masses cut the Carolina and Roan gneisses either conformably with their bedding or at different angles to it. Most of the masses are too small to be shown on the geologic map, but some of the larger ones and those that are of interest because of their special minerals, such as tin oxide, have been mapped. A few of the pegmatites have a strong schistose structure, but most of them are only slightly if at all schistose. Some of the pegmatites, particularly the schistose varieties, are no doubt of Archean age, but the majority are probably later and are connected with intrusions of late Carboniferous (?) granite.

### ALGONKIAN SYSTEM

#### GENERAL FEATURES

The rocks that have been assigned to the Algonkian system lie in a belt 1 to 4 miles wide that extends from the area near the northeast corner of the Kings Mountain quadrangle southwestward across the central part of that quadrangle and across the southeastern part of the Gaffney quadrangle. This belt becomes narrower to the southwest and is only about half a mile wide at the southern border of the Gaffney quadrangle.

These rocks rest at different places upon each of the Archean formations, which are in part sedimentary and in part igneous, and are thus unconformable upon them. Some of the Archean rocks were formed at great depths, and their appearance then at the surface was due to uplift and prolonged erosion. The rocks deposited on such Archean rocks are thus separated from the Archean by an enormous interval of time. The rocks here called Algonkian are all of surface origin, whereas those of the Archean in contact with them were all deeply buried and deformed before reaching the surface.

The known Algonkian rocks beginning in North Carolina 50 miles north of these quadrangles and extending through Virginia and Maryland into Pennsylvania are typically surface volcanic flows and include much volcanic sedimentary material of the same sort as that shown in the Gaffney-Kings Mountain district. In the Gastonia quadrangle, just northeast of this district, basic volcanic rocks of the same kind as those in the known Algonkian areas underlie the Cambrian quartzites. The Algonkian rocks of these quadrangles underlie the rocks which on general grounds are assigned to the Cambrian.

#### BATTLEGROUND SCHIST

One formation of Algonkian rocks has been distinguished in this area, the Battleground schist, and this includes a member known as the manganese schist. The formation is prominently developed in the region of the Kings Mountain Battleground, after which it has been named. The manganese schist member occupies a broken belt, a few hundred yards to half a mile wide, along or near the northwest side of the Battleground schist. It has been named from the notable and constant presence of stains and deposits of manganese oxide along its outcrop, which has led to its being called locally "the manganese lead."

*Character.*—The Battleground schist is composed chiefly of white, gray, bluish, bluish-black, and mottled white and bluish sericite schists. Coarse sandy or quartzitic varieties with or without beds of conglomerate are also present in places. Near some of the beds of conglomerate the blue and white schists are strongly mottled. Very persistent beds of conglomerate that contain a large proportion of interbedded blue and white mottled sericite schist crop out in the southeastern part of the Gaffney quadrangle and south of The Pinnacle in the Kings Mountain quadrangle. These beds are distinct from the harder and more strongly developed Draytonville conglomerate, of Cambrian age, which is described on page 5. The conglomerate in the Battleground schist contains many small round pebbles of quartz and grains of sand in a matrix composed of material like that in the adjoining schist. The principal beds of conglomerate are shown on the geologic maps.

The schist of the Battleground formation is rather fine and even grained and has a strong schistose structure. The principal constituents are quartz and fine scaly sericite and in the bluish varieties an abundance of fine crystals of magnetite. The mottled appearance of some of the schist is caused by variable quantities of these fine crystals of magnetite in different parts of the rock. In some localities the schist contains crystals or fragments of crystals of orthoclase, albite, or oligoclase only partly altered to sericite. The schist also contains fragments of older rocks, apparently volcanic, most of them angular, in a great variety of sizes and colors. Locally these fragments form so much of the rock that it is recognizable as tuff. In a few places, probably near the top of the formation in contact with quartzite of the overlying rocks, the schist contains also ottrelite and chlorite. These minerals occur in the quartzite and associated sedimentary rocks, and the rocks containing them in the Battleground schist may in reality belong in the overlying quartzite.

Hand specimens of the fine white and gray sericite schist are not distinguishable from schistose parts of the Bessemer granite. The coarse sandy or quartzitic varieties of the schist are also distinguished with difficulty from the slightly porphyritic sericitic schist of the Bessemer granite. Some of the solid bluish and black schist closely resembles schist of other formations, but the mottled bluish and white or gray varieties are found only in the Battleground schist. They consist of either an excess of blue sericite schist inclosing flattened irregular patches of white or gray sericite schist or an excess of light-colored schist mottled with blue.

Locally in the Battleground schist there are compact masses of a bluish rock which does not show marked schistosity and in which a fairly coarse texture has been developed. This rock contains phenocrysts or fragments of phenocrysts of only partly altered feldspar in a dense groundmass of sericite and biotite with or without quartz, magnetite, and other minerals. It may consist of altered remnants of porphyritic lava beds. Quartz veins are common through much of the Battleground schist, and some of them carry auriferous pyrite.

*Thickness.*—It is difficult to estimate the thickness of the Battleground schist, because it has been intensely folded and faulted. It is more than 1,000 feet thick, and possibly as much as 2,500 feet. The manganese schist member has a maximum thickness of nearly 300 feet.

*Origin.*—The Battleground schist is probably of composite origin and was derived from interbedded volcanic, volcanic-sedimentary, and sedimentary rocks. The volcanic rocks consisted of tuffs and probably of flows of both rhyolitic and andesitic composition. By the intermixture of varying amounts of land waste washed into sedimentary basins the volcanic rocks graded into volcanic-sedimentary and sedimentary rocks. Thus deposits of volcanic breccia and tuff, volcanic ash or mud, gravel, sand, and silt were laid down. These deposits were later consolidated into breccia, conglomerate, sandstone, and shale. During the extensive metamorphism accompanying the late Carboniferous mountain building of the southern Appalachians these rocks were further metamorphosed into sericite schist that carries a few intercalated beds of conglomerate and quartzite.

Much of the evidence of the original nature of the schist of the Battleground schist has been destroyed, so that it resembles sericite schist of other origin. In many places, however, the strong mottling of blue with white patches, which is the common appearance of a schistose tuff, suggests a volcanic origin. This suggestion is supported by numerous deposits of tuff whose fragments have not been destroyed during metamorphism. Only the sedimentary volcanic rocks have been found in this region, but volcanic flows of Algonkian age appear in the Gastonia quadrangle, just northeast of this district, and in the Cranberry quadrangle, 50 miles to the north. The schist formed from the more basic volcanic rocks is characterized by the presence of an abundance of fine crystals of magnetite, which make it darker, and in some places by remnants of crystals of hornblende and varying amounts of chlorite.

*Weathering.*—Most of the rocks of the Battleground schist weather into light, fine sandy soils. Those formed from schist in which magnetite was abundant contain much fine magnetite sand, which is concentrated in the gutters along the roadsides. The more chloritic varieties of the schist have weathered generally into reddish or brownish soils. These characteristics are concealed in many places by a thin covering of light-colored fine sandy surface soil, and the brown is observed only in the subsoils. The quartz veins that cut the original schist are represented by blocks and residual boulders of quartz set free by the weathering of the inclosing rocks. These soils are for the most part poor, and the formation underlies a hilly, thinly settled country.

*Manganese schist member.*—The manganese schist member consists mainly of fine bluish-black to black sericite schist with which much manganese is associated. Some layers of fine silvery-white sericite schist without manganese oxide are not distinguishable from other portions of the Battleground formation, and parts are also tuffaceous, like such portions. The manganese occurs as masses of black oxides in lenticular vein fillings, with or without quartz, in places several feet thick. From these larger deposits innumerable small seams and veinlets of manganese oxide extend through large masses of the schist, filling cracks and joints. Thus much of the schist is impregnated with stains of black manganese oxide through nearly the entire mass.

The similarity between the manganese schist and the other beds of the Battleground schist suggests that they have a similar origin. The manganese in veins and veinlets is apparently of secondary origin and entered the formation in solution through fissures and fractures. The solutions penetrated the smallest fractures and joints in the schist and from these spread into the pore spaces between the mineral grains, depositing oxides and hydroxides of manganese. The larger veins represent the trunk channels through which the manganese solutions entered the rocks and from which all the smaller veins, seams, and impregnation deposits were fed.

Possibly, however, the manganese may have accumulated somewhat like bog ore in the same basin with the sediments, in this way being first widely disseminated through the formation and later concentrated by solutions in veins that cut the schist.

The widespread dissemination of manganese oxides through the soils derived from this formation and through the partly altered rock under the soil is apparently due to surficial action and concentration, for the unaltered rocks do not contain so much disseminated manganese.

The weathering of the manganese schist is similar to that of the Battleground formation, except that the resultant soils are generally stained dark brown to black from manganese oxide.

## CAMBRIAN SYSTEM

### GENERAL FEATURES

The Cambrian rocks in this region are a metamorphosed sedimentary series, and now they consist of squeezed conglomerate, quartzite, graywacke, slate, schist, and marble. No fossils have been found in them, and the rocks are placed in the Cambrian system on account of their extensive metamorphism, their similarity in detail and in general sequence to other known Cambrian rocks in the southern Appalachian region, their position above rocks already classed as Algonkian, and their position above a major unconformity of the magnitude that characterizes the base of the Cambrian throughout the Appalachian Mountains. The sequence of rocks assigned to the Algonkian and Cambrian in this district is a close duplicate of the known sequence of the Algonkian and Cambrian rocks in western North Carolina and Virginia.

The Cambrian rocks occur in long, narrow belts that extend northeast across the middle of the Gaffney-Kings Mountain district. Owing to thrust faulting, the rocks at many places do not occupy their normal sequence, and their mapping is accordingly difficult. Similarities between some of the schists of the Cambrian rocks and those of the Algonkian on the one hand and the Archean on the other add to this difficulty.

The earliest Cambrian rocks consist of conglomerate and quartzite. Three types of quartzite are recognized, apparently distinct in character in separated outcrops, but gradations between them are evident in some areas. Similar gradations also occur between some of the quartzite and the conglomerate. The beds of quartzite and associated slate and schist have been grouped under the name Kings Mountain quartzite because of their strong development in Kings Mountain and the neighboring region. The conglomerate will be described under the name Draytonville conglomerate member, as prominent exposures are found on Draytonville Mountain.

Differences exhibited by the quartzites are great, but separate names have not been applied to the different types. Each quartzite occurs near or in contact with the Draytonville conglomerate in one part or another of the region, and the conglomerate may be represented by a quartzite in some places.

The younger and finer-grained Cambrian rocks consist of slate, phyllite, sericite schist, mica schist, and limestone or marble. The schists have been grouped under the name Blacksburg schist, because the belt of schist passes through the town of Blacksburg. The limestone or marble is called the Gaffney marble because of its large development near Gaffney.

### KINGS MOUNTAIN QUARTZITE

*Distribution and general character.*—The Kings Mountain quartzite, including the Draytonville conglomerate member at the base, has its greatest development in Crowders Mountain, The Pinnacle of Kings Mountain, and between those hills and the town of Kings Mountain in the hills known as Yellow Ridge. Outcrops extend to the southwest beyond Gaffney, but these are chiefly narrow belts. Most of the beds of quartzite are hard and resistant to weathering and accordingly form hills or ridges. Prominent examples of these hills are Crowders Mountain, The Pinnacle, Whitaker Mountain, and Silver Mine Ridge, which extends northeastward from Cherokee Falls.

The Kings Mountain quartzite is a composite formation made up of a conglomerate and three distinct kinds of quartzite—kyanitic quartzite, white nearly pure quartzite, and chloritic and sericitic quartzite that grades into schist. These are gradations between the Draytonville conglomerate and the quartzite, or rather replacements of the conglomerate by the quartzite.

*Draytonville conglomerate member.*—The Draytonville conglomerate member occurs in a series of narrow belts and a few broader masses, which extend from the southern part of the Gaffney quadrangle northeastward through Draytonville Mountain, of which it is the principal rock, and through Cherokee Falls to Kings Mountain ridge and beyond. It appears again in the Lincolnton and Gastonia quadrangles, northeast of Kings Mountain.

The Draytonville conglomerate is a hard heavy-bedded rock, which generally crops out in cliffs or ledges. At a few places it has broken down to gravelly soil through which fragments of only partly altered conglomerate are scattered. Some of the outcrops are continuous for 3 or 4 miles, but others can be traced only a few hundred yards to abrupt terminations.

Some of the bodies of the Draytonville conglomerate, measured across the strike of its schistosity, are several hundred feet wide, but probably this apparent thickness is due to duplication by folding or to approximately flat beds in which the schistosity does not correspond with the bedding. The thickness is probably nowhere greater than 50 feet and in many places may be less than 25 feet. The Draytonville conglomerate is the basal member of the Cambrian rocks and overlaps on both Algonkian and Archean rocks.

The conglomerate is now almost a gneiss but still retains many of the characters of a conglomerate. It is composed largely of quartz together with some mica and other minerals. The quartz was originally present in the form of rounded pebbles and grains of sand with which variable quantities of silt or mud were mixed. By metamorphism the pebbles have been crushed and recrystallized into flattened forms that have nearly elliptical cross sections, the sand has been recrystallized into a quartzite filling between the pebbles, and the silty impurities have formed mica and other metamorphic minerals. A parallel arrangement of the flattened pebbles and mica scales has produced a decided gneissic structure. In some places the original rock was composed almost entirely of quartz pebbles and sand, which by metamorphism have yielded a rock resembling sheared quartzite. In this rock the pebbles are recognized with difficulty, on account of the obliteration of their outlines in the inclosing sand.

*Kyanitic quartzite.*—The kyanitic quartzite has its greatest development in Crowders Mountain and The Pinnacle, but smaller masses occur in scattered localities, as in Henry Knob, Jefferson Mountain, and the country east of The Pinnacle and Crowders Mountain.

Most of the kyanitic quartzite crops out in ledges or large blocks, but in some places it has broken down to a gravelly soil that contains cobbles and pebbles of kyanite. In Crowders Mountain and The Pinnacle cliffs rise almost vertically 25 to 200 feet above the steep talus slopes below. (See pl. 2.) As these summits supposedly represent the bottoms of rather broad synclines the greatest vertical height of the kyanitic quartzite that is exposed forms a measure of the thickness—that is, from 100 to 200 feet. The typical kyanitic quartzite is composed chiefly of quartz and kyanite with smaller quantities of other minerals, such as mica or sericite, magnetite, and hematite. In some places quartz is the predominant mineral, but in others kyanite is equally or even more abundant. The kyanite occurs in long-bladed crystals that lie in the rock at different angles. (See pl. 7.) In some occurrences the crystals are developed most strongly in certain beds and show a tendency to form with their lengths parallel with the bedding. At other places tufts or radiated groups of crystals occur. Stains of hematite and limonite are abundant in parts of the kyanitic quartzite and probably result largely from pyrite that was associated with the unaltered rock.

The quartzite ranges from medium to coarse grained, and some of the crystals of kyanite measure nearly 3 inches long and half an inch thick. Most of the rock is visibly schistose, and some is strongly banded in layers of varying composition. Some of the strongly metamorphosed beds that contain much mica are distinguished with difficulty from the kyanite gneiss of the Carolina gneiss.

The kyanitic quartzite resists weathering strongly, especially those layers in which kyanite is abundant. The more granular portions of the quartzite tend to crumble away faster than the crystals of kyanite, which accordingly stand out above the surface of the rock, and the layers of rock that are rich in kyanite project above those that contain less of that mineral. This differential weathering yields outcrops of rock that show very round surfaces from which sharp splintery crystals of kyanite project.

In the nearly vertical cliffs on The Pinnacle (pl. 2) and Crowders Mountain weathering has left great slabs of rough kyanitic quartzite standing apart from other masses or tilted over or fallen down on the talus slopes below, and irregular cell-like cavities as much as a foot or two across occur in the cliffs. Probably these cavities are due to weathering in which the purer granular quartz varieties of the rock have disintegrated more rapidly by the action of frost than the same material that has been cemented together by iron oxides or than that part of the rock in which crystals of kyanite act as a binding material. The kyanitic quartzite weathers to gravelly reddish soils that contain numerous pebbles and cobbles of partly altered and iron-stained kyanite.

*White quartzite.*—White quartzite crops out abundantly in a belt that extends from Gaffney through Blacksburg to Kings Mountain and on across the southeast corner of the Lincolnton quadrangle. The hard ledges stand a few feet above the surface or angular blocks of quartzite of different sizes are scattered along the ground. The quartzite in some places may be traced almost continuously for several miles in approximately one course. In other places the ledges are curved or bend back on themselves, and some terminate abruptly.

The beds of quartzite form high ground generally, and some of the persistent ledges form the backbone of high ridges, such as Whitaker Mountain and Silver Mine Ridge.

The white quartzite is not thick, probably nowhere more than 50 or 60 feet. Folding has duplicated the beds in some places, and as this structure is not invariably recognizable the apparent thickness may not everywhere be the actual one.

The white quartzite is composed chiefly of angular interlocking grains of quartz with here and there a few scales of mica or particles of other minerals. The texture is medium grained and there is a tendency to a schistose arrangement of the grains, especially where mica is present.

The white quartzite breaks down under the action of weathering into fine sandy soil through which are scattered numerous blocks and fragments of different sizes. The soil consists of a more compact sand than that which generally results from the weathering of granite.

*Chloritic and sericitic quartzite.*—The most extensive belt of quartzite containing variable quantities of chlorite and sericite is in the region around Crowders Mill Pond and southwestward beyond The Pinnacle. Another mass lies about 4 miles south of the town of Kings Mountain. In most places this rock occupies high ground and forms ridges that have rather steep slopes. Estimates made from the width of some of the outcrops indicate a thickness of more than 500 feet.

The Draytonville conglomerate is associated with the chloritic and sericitic quartzite in several places and appears to be in normal sequence with it. In the Lincolnton quadrangle the white quartzite is also associated with the chloritic and sericitic quartzite and represents a purer form of that rock. Gradations occur between the two varieties and also from white quartzite to the chloritic and sericitic slates and schists. These rocks are generally fine grained and are chiefly green, greenish gray, and gray.

The chloritic and sericitic quartzite is variable in composition and texture. The typical rock is composed chiefly of quartz with either chlorite or sericite or both. In many places other minerals are more or less abundant, such as ottrelite, magnetite, tourmaline, pyrite, and a little zircon. Only a few of these other minerals are original constituents of the sediments, and probably all constituents but the zircon have been recrystallized during metamorphism. The crystals of tourmaline were probably derived from outside sources, or at least part of their constituents, such as boron, were thus introduced. Pyrite may have formed either from original constituents or have been added from other sources during metamorphism.

The proportion of the minerals of the chloritic and sericitic quartzite differs much in the different outcrops, and variations in the amount of granular quartz yield rocks ranging from quartzite to schist.

As the content of quartz diminishes these rocks grade into typical chlorite-sericite schist. In places considerable secondary quartz has been deposited in them as lenses and broken veins, mostly conformable with the schistosity. Some of the outcrops of such rock resemble conglomerate.

The purer quartzitic phases weather to fine sandy soils, but where chlorite is abundant the resultant soils are tan-colored to brown and in some places resemble soils formed by the weathering of hornblendic rocks.

### BLACKSBURG SCHIST

*Distribution.*—The Blacksburg schist lies normally between the white quartzite facies of the Kings Mountain quartzite and the Gaffney marble. The position of the formation under the marble and over the quartzite is best seen just south of Gaffney. The schist is variably developed in belts that lie parallel with these formations in a general zone extending from the area south of Gaffney through Blacksburg and on through the town of Kings Mountain into the Lincolnton quadrangle. Because it is well developed in and around Blacksburg the formation has been named after that town. It has a thickness of about 800 to 1,000 feet.

*Character.*—The Blacksburg schist ranges from fine graywacke to fine-grained sericite schist or phyllite. In a measure it is a transitional formation between the older quartzite and the younger marble. As a general rule the more granular, coarser parts like graywacke lie near the quartzite, and the finer schists near the marble. The coarser beds are dark to light grayish, rather granular micaceous schists and are 200 to 300 feet thick. The finer beds consist of gray, bluish-black, and greenish sericite and mica schists.

A lumpy texture, which is most evident in partly weathered phases of the schist, is due to rather coarse scales or bunches of scales of mica. The variety showing this texture is sometimes called fish-scale schist and is especially common near the marble beds in this region. No sharp contact has been found between the Blacksburg schist and the Gaffney marble. Near the marble the schist is calcareous and contains free calcite in scattered grains, lenses, and thin sheets, which become more abundant toward the marble.

The Blacksburg schist weathers readily into dark-brown or green clayey soils, ranging from a sandy to a very sticky clay of moderate fertility. The transitional calcareous forms between the Blacksburg schist and the Gaffney marble weather to a dark reddish-brown, very fertile soil.

#### GAFFNEY MARBLE

*Distribution.*—The Gaffney marble extends in broken belts from the quarries 1 mile south of Gaffney northeastward through Blacksburg and on beyond the town of Kings Mountain. The outcrops are generally obscure, and many of them have been prospected by pits or quarried. Most of them occur in low ground along the valleys of streams. The largest exposures are in the quarries near Gaffney, and the formation has been named from that town. To the south and east of Grover there are two marble belts, in both of which quarries have been opened. Toward the town of Kings Mountain only one belt has been located.

*Character.*—The Gaffney marble ranges from very fine to medium fine grained and from bluish gray to white. All varieties are locally called limestone, but the texture is sufficiently crystalline for them all to be classed as marble. Most of the rock has a schistose or banded structure made plain by the presence of impurities such as mica and hornblende. Outcrops of the Gaffney marble observed in the different deposits range from 30 feet to about 300 feet across in the Whisnant quarry, two-thirds of a mile southeast of Grover, where the beds are duplicated by folding and dip 35° NW., so that the thickness of the marble would be less than 120 feet. At least 50 feet of mixed pure and impure marble is exposed in the large pit of the Gaffney Lime Co., but this is not the full thickness of the formation at this place. The beds that originally formed the top of the Gaffney marble are not known, nor are any later sedimentary rocks known here, because overlying beds have been completely removed by erosion.

The purer grades of marble consist chiefly of granular calcite, together with small quantities of quartz, biotite or phlogopite, and tremolite or other light-colored hornblende. In some of the rock epidote and pyrite are present. In some places the Gaffney marble is highly magnesian, one of the upper beds in the Gaffney limestone quarry carrying 41.19 per cent of magnesium carbonate. The blue marbles are the purest in lime, and the white beds carry more magnesia. The less pure marbles contain quartz, biotite, both light and dark hornblende, epidote, and other minerals in increasing quantities and accordingly grade into calcareous biotite and hornblende gneisses and schists.

*Weathering.*—In most places the Gaffney marble has weathered to the depth of ground water or deeper. Thus longitudinal valleys or lines of low gaps and hollows have formed along the marble belts. By solution at the surface and along joints and fissures irregular channels have been produced in the marble, and in places only nodular masses of the rock have been left scattered through residual clay. The soils over the marble are generally dark red or brown sticky clays.

### LATE CARBONIFEROUS (?) INTRUSIVE ROCKS

#### WHITESIDE GRANITE

*Distribution.*—Granite is abundant in the northwest corner of the Kings Mountain quadrangle and along the adjoining border of the Gaffney quadrangle. Smaller bodies of it are also scattered over other parts of the Gaffney quadrangle. The name was taken from Whiteside Mountain, in the Cowee quadrangle, which lies west of the Pisgah quadrangle (see fig. 1), where the granite is very prominently developed and crops out in huge cliffs. The Whiteside granite is found in many areas in the region between the Gaffney-Kings Mountain district and the Pisgah quadrangle, especially where geologic mapping has been done in the Lincolnton, Morganton, and Saluda quadrangles.

*Character.*—The granite consists chiefly of orthoclase, microcline, and oligoclase feldspars, quartz, muscovite and biotite micas, and such accessory minerals as magnetite, apatite, and zircon. Other minerals of secondary development are garnet, epidote or zoisite, chlorite, and kaolinite. The feldspars are the predominant minerals; muscovite is the most plentiful mica, and in some places biotite is present only in small quantities. Garnet is plentiful in some parts of the granite, especially those which have yielded to metamorphic processes and have received a schistose structure; in some of this rock the garnets measure a tenth of an inch in diameter. Zoisite, chlorite, and kaolinite are products of the weathering of certain of the minerals of the granite and are common in outcrops.

The granite is generally light gray, but those varieties in which biotite is scarce are nearly white. Most of it has a medium to fine grain, and in some places it has a porphyritic texture, as in the mass that passes through Gaffney.

The Whiteside granite has yielded to metamorphism in different degrees. Parts of it exhibit a schistose structure of varying intensity. In many places there is a gradation from massive granite in the interior of a mass to strongly schistose or gneissic granite at the border. However, the bulk of the granite shows only moderate metamorphism, and in many places it is difficult to detect any structural planes.

In places the Whiteside granite exhibits flow banding in roughly parallel layers of mineral. The structure may have developed in two ways—either during the intrusion of the granite magma after a partial segregation of the minerals had taken place, or by the mashing and flowing of granite which had included and partly absorbed masses of other rocks. The flow structure may be present in one part of a granite mass and absent in another a few feet distant but is more common near the contacts with other rocks.

*Relations.*—The Whiteside granite is intrusive into the Carolina and Roan gneisses, and it is cut by the diabase described below. The intrusive relations of the granite are shown by the domed structure of masses from the borders of which the strata of the gneiss dip away at different angles, by the inclusion of masses of the various gneisses with which it is in contact, by the occurrence of dikes both conformable with and cutting across the bedding of the inclosing gneisses, and by the relations to pegmatite that cuts other rocks.

Around Cherryville, in the Lincolnton quadrangle, north of the Kings Mountain quadrangle, a large mass of the Whiteside granite has formed many sills in the gneiss, especially to the southwest of the main mass. Apparently there is a large batholith beneath this region. The interbedded masses of gneiss and granite dip to the south and southwest, away from the main mass of granite. Larger masses of the granite occur in the northeastern part of the Kings Mountain quadrangle, but their relations to the inclosing gneiss are not so evident. Sill-like dikes of the granite are abundant in the gneisses, especially near the larger masses, and in some places these dikes branch out or cut across the schistose planes from one bed to another.

Irregular bodies of pegmatite occur in the granite and extend from it into the surrounding rocks. These pegmatites range from extremely coarse grained rocks to those that have the texture of coarse granite, and in places they appear to grade into the granite. The constant association of the pegmatite with the granite and the gradation of the one into the other show a genetic relation between them. In places the gneisses and schists have been so intruded by granite pegmatite that only the rock that predominates in a given area is represented on the map.

*Inclusions.*—Masses of the invaded rocks are included within the Whiteside granite, particularly where the hornblendic rocks of the Roan gneiss are cut by the granite. The relations are most clearly shown in a large area 3 to 5 miles south of Cherryville, in the Lincolnton quadrangle. In many places the inclusions have been more or less absorbed by the granite magma, on which they have left their trace in the changed composition. The absorption of the schists of the Carolina gneiss has yielded streaks of highly micaceous granite that grade into highly micaceous schist. The hornblendic rocks when intruded were broken up into more blocklike bodies that passed out into the granite magma. Such inclusions were more or less dissolved by the inclosing magma, so that the magma became more basic near them. Thus the composition of the granite was changed through considerable masses, and there are gradations seemingly from inclusions of diorite to quartz diorite, to hornblende-biotite granite, to granite rich in biotite, and to the normal Whiteside granite.

*Weathering.*—The Whiteside granite weathers first to a friable sandy gray mass that closely resembles the original granite. The feldspars and biotite mica in this material are only partly decomposed. Further weathering results in a thorough decomposition or kaolinization of the feldspars and the complete breaking down of the biotite, which yields a red clayey soil that contains scattered quartz sand and scales of muscovite. The surface soil formed by this weathering is generally light colored and very sandy on account of the washing away of the lighter kaolin products and the concentration of the quartz grains in this layer.

*Age.*—Because of the relations of the Whiteside granite to the rocks associated with it that are described below, and because of its little-metamorphosed character, the granite is considered to be younger than Cambrian, with a probability that it was intruded during the mountain-building activity at the end of the Carboniferous period.

#### YORKVILLE GRANITE

*Distribution.*—The occurrence of large bodies of granite in the region around York (formerly known as Yorkville), especially northwest of that town, in the Kings Mountain quadrangle, led to the adoption of the name Yorkville granite. The rock crops out abundantly in the southeastern part of the Kings Mountain quadrangle and in a small part of the northeast corner. Other extensive deposits occur to the south, in the Sharon quadrangle.

*Character.*—The Yorkville granite is generally a gray to dark-gray coarse-grained rock that has a porphyritic texture. In some places there is a roughly parallel arrangement of the feldspar phenocrysts. Microscopic examination of two specimens of the typical granite showed the presence of microcline, orthoclase, anorthite, and oligoclase feldspars, quartz, biotite, and hornblende, together with small quantities of iron ores, titanite, and secondary epidote and zoisite. The feldspars occur as large phenocrysts, in some places more than an inch across. The biotite occurs in lustrous black scales. Quartz is variable in quantity and size of grain. The accessory minerals are also variable in quantity.

The granite invades the Roan gneiss as large batholiths and in smaller masses and dikes. Many of the contacts are ill defined, especially between the granite and the diorite. Gradations in composition occur from the typical granite into diorite, a result of the absorption of diorite blocks by the granite. These blocks were floated out into the granite magma during the mechanical stoping by the invading granite and more or less dissolved by it, yielding successively more basic rock toward the diorite inclusion or contact. Thus were formed biotite granite, hornblende-biotite granite, quartz diorite, and diorite. Epidote is an abundant secondary mineral in the contact zones of the Yorkville granite and occurs in the hornblendic portion of the rock as scattered grains, aggregations of grains, and veinlets.

*Age.*—The Yorkville granite, like the Whiteside granite, cuts the Roan gneiss, and is therefore younger than the gneiss. It is cut by the diabase and is therefore older than the Triassic period. Owing to the lack of evidence of as strong dynamic metamorphism as that which occurs locally in the Whiteside granite, the Yorkville granite is thought to be younger than the Whiteside and was probably intruded during the mountain building at the end of the Carboniferous period.

*Weathering.*—The Yorkville granite weathers to many striking forms, such as large rounded masses or bosses on the hillsides, floors of bare granite that cover many square yards, and large residual boulders that range from a few feet to 25 feet or more in thickness. The most striking features are the odd-shaped boulders that have the appearance of great mushrooms, with spreading tops and stemlike bases attached to the underlying granite. (See pls. 8, 9.) Other boulders have little caves and pocket-like cavities and peculiar markings due to unequal weathering, and these forms appear to be confined to the purer coarse porphyritic granite and are due chiefly to disintegration by frost.

The partial disintegration of the Yorkville granite leaves a coarse sandy to gravelly soil. More complete decomposition yields sandy reddish clay subsoils, and the washing out of clay and lighter products of decomposition produces a light sandy soil at the surface. In the hornblendic varieties of the granite near the bodies of diorite the soils are progressively darker red to brownish and contain less quartz or other light-colored sand. These hornblendic rocks generally leave numerous blocks of epidote in the soils, set free by decomposition from sheets of epidotized fine-grained granite.

### TRIASSIC SYSTEM

#### DIABASE

*Distribution.*—Diabase occurs in numerous long, thin dikes in different parts of the Gaffney-Kings Mountain district but is most abundant in several belts 2 to 5 miles wide that strike northwest. One belt extends through the Smyrna-Blacksburg region, another from Filbert to a place about 3 miles southwest of the town of Kings Mountain, and another through the northeast corner of the Kings Mountain quadrangle. Very few dikes were observed in the western part of the Gaffney quadrangle, and only two southwest of Broad River. Some of the dikes can be traced 6 to 9 miles and cut across the bedding of all the other formations of the region; others extend only a few hundred yards. Most of the dikes strike northwest and have a nearly vertical dip, in strong contrast with the older formations, which strike chiefly northeast.

*Character.*—The diabase is a hard dark-gray to greenish-black fine to medium grained rock that has a dense or close texture. The weathered surface is yellowish brown to reddish brown or rust-colored. The diabase from three widely separated localities is closely similar in composition as determined from microscopic examination, for each specimen contains calcic labradorite, augite, olivine, and magnetite, together with pyrite in one specimen and secondary chlorite in another. In all the specimens the ophitic or diabasic texture is strongly developed, and the rock may be classed as typical olivine diabase. As a general rule the interior of the boulders produced by the weathering of the diabase shows very little alteration and is hard and fresh.

The diabase dikes range from a few inches to a few yards in thickness. Some that are less than 25 feet thick crop out for several miles, and others that are less than 6 feet thick crop out for more than a mile. It is thus evident that the diabase was intruded as a highly fluid magma.

*Weathering.*—Residual boulders of diabase are abundant along the outcrops, persisting for long periods and becoming widely scattered over the surface, especially on hill slopes. Prolonged weathering along the cracks in the dikes under the surface produces a highly rust-stained sandy earth, especially rich in iron hydroxides, some of which has the properties of ocher.

Most of the outcrops now consist of numerous rounded boulders or "niggerheads," a few inches to 2 feet thick, scattered over the surface. In road cuts where the dikes are exposed the boulders are in process of formation. Weathering proceeds along joint planes, which cut the dikes into blocks. Corners are reduced faster than the plane surfaces of the joints, and rounded forms result.

*Age.*—The diabase of this district is similar in composition, mode of occurrence, and structure to the diabases characteristic of other parts of the Piedmont province. The latter are of Triassic age wherever their age has been determined. The diabase of this district is therefore believed to be Triassic.

## STRUCTURE

### GENERAL FEATURES OF THE APPALACHIAN REGION

*Types of structure.*—Three types of rock structure prevail in the Appalachian region, each in general characteristic of the geographic division or divisions in which it occurs. In the Appalachian Plateaus, at the west, the rocks are essentially flat and except for consolidation have undergone but little change from their original composition. In the Valley and Ridge province the formations have been variously folded and faulted, with the result that the beds have slight to very steep dips and show in part a slaty cleavage. In the mountain districts and the Piedmont, on the east, the rocks have been extensively folded, faulted, and mashed, so that strong cleavage and extensive metamorphism have resulted. Thus the folding, faulting, and metamorphism to which the rocks have been subjected in the Appalachian region are progressively more intense from northwest to southeast—that is, from the Appalachian Plateaus to the Appalachian mountains and the Piedmont.

*Folding and faulting.*—All stages of folding occur from those in which the strata dip slightly to those in which they are steeply inclined or even overturned. In the southeastern parts of the Appalachian region—that is, in the Appalachian mountains and the Piedmont—steep dips are the rule and overturned strata are common. Owing to the extensive folding and, the corresponding prevalence of steep dips, only the eroded edges of most of the rocks are exposed.

The structure in these regions is extremely complex, for many of the rocks have been subjected to more than one period of deformation. Thus the older rocks present more irregularities in outcrop than the younger rocks and as a rule are traced across country with greater difficulty. Most of the younger rocks, which have been subjected to notable compression during only one period and that a compression which acted principally in one direction, have been folded into very long anticlines and synclines. The outcrops of the different formations made by such folds consist chiefly of long straight belts, which are duplicated in reverse order on the opposite side of the axes of the folds.

Coincident with the periods of great folding there was much overthrust faulting that resulted from the breaking of the strata along the lower sides of overturned anticlines under continued pressure. Some of the faults are large and are measured by miles of overthrust. Others may have throws of only a few feet.

These features are abundant in the Appalachian valleys and mountains and in the Piedmont. They trend northeastward, conforming approximately with the shore line of the ancient continent. Local variations occur where secondary forces have acted from other directions than the southeast. The structure of the older rocks, especially the Archean of the mountain and Piedmont regions, is more complex as a result of the action of forces that caused deformation at more than one period and in different directions. These various compressions have left their traces on the rocks in both large and small structures. Thus some of the Archean rock structure is so complex that it does not give even an approximate idea of the different stresses to which the rocks have been subjected. Some of the great compressions of different periods have acted in similar directions and produced roughly parallel folds.

The latest compression that led to extensive mountain building, which took place at the end of the Carboniferous period, has left a strong impress on the rocks of all periods. Thus the main structural features of many of the Archean and Algonkian rocks, as well as those of the Cambrian rocks, follow the general trend of the Appalachians through long distances. As a rule, however, the large structural features of the Archean rocks in the Piedmont differ materially from those of the Algonkian and Cambrian rocks in their irregularity. There is a broad difference in the direction of the schistose planes, the structural axes, and the belts of outcrop of the two sets of formations; the Cambrian and Algonkian features trend in comparatively straight lines about N. 30°–60° E., whereas the Archean features may trend in any direction but generally trend more nearly north than east. This relation is particularly obvious in the vicinity of the great batholiths of granite, which have thrust and forced up the surrounding rocks in great domes. The upward pressure exerted by these batholiths was very unlike the horizontal pressure by which most of the folds of the region were formed.

*Metamorphism.*—A prominent result of the different stresses to which the rocks have been subjected during folding and faulting is metamorphism, which includes the development of schistosity in one or more directions, slip cleavage, slaty cleavage, new minerals, and general recrystallization of the rocks. As would be expected, the oldest rocks show the greatest metamorphism.

The prevailing schistose planes of the metamorphic rocks of the Appalachians strike northeast and dip southeast, generally at high angles. In some places the dips are low, and in others the beds are vertical. In a few places the dips are to the northwest, but in most places they range from 50° to 80° SE.

In many places where metamorphism was extreme the original texture and mineral composition of the rocks have undergone so great a change that it is not possible to distinguish between sedimentary and igneous rocks. Thus, mica schists and mica gneisses of very similar appearance have developed from rocks of both kinds. Such changes and transformations are described more in detail in the section on the individual formations on pages 3–6.

### LOCAL STRUCTURE

*Larger features.*—Extremely complex rock structure has resulted from the deformation of the sedimentary and igneous rocks in the Gaffney-Kings Mountain district. The sedimentary rocks must have originally been deposited in nearly horizontal layers. The igneous rocks were intruded in the usual forms as batholiths, sills, and dikes in a great variety of attitudes. The sedimentary rocks have all been metamorphosed, the older rocks more than the younger. The igneous rocks range from those which have been so intensely metamorphosed as to have lost their identity to those which do not exhibit any trace of metamorphism. The older and more metamorphosed igneous rocks, such as the Roan gneiss, are compressed into folds approximately parallel with those of the inclosing rocks. Later intrusives, such as the Yorkville granite and the diabase, are only in part affected in this way or are free from metamorphic action.

The broader structural features of the Gaffney-Kings Mountain district comprise straight, corrugated synclinal troughs of Algonkian and Cambrian rocks that extend northeastward across the middle of the area, great arches of older rocks on both sides that are composed of many lesser anticlines, and domelike intrusions of later granite. The synclinal troughs of younger rocks have been preserved because these rocks were deeply infolded and infaulted in the older rocks and still extend to considerable depths below the present surface, which has been developed by erosion. The two anticlinal areas have been uplifted by folding and faulting above the synclinal troughs and to some extent have been thrust toward each other, as is shown in some localities by the thrust faults that dip northwest and southeast on opposite sides of the synclinal trough.

*Folding.*—Only bare approximations of the larger folds of the Archean rocks can be arrived at in this district. Some of the details of the smaller folds and those last superimposed on the rocks can be worked out, especially where rocks of widely different nature are in contact. Especial difficulty is encountered in working out the structure of those parts of the Carolina gneiss which show few variations in composition and which do not inclose other rocks, such as hornblende gneiss or granite.

Large areas of Carolina gneiss in which only a few other rocks are inclosed occur in the western part of the Gaffney quadrangle. The outcrops of this gneiss strike prevailingly north and east of north and have variable dips. Wide local variations in strike occur; thus, near Broad River in the neighborhood of Abes and Jolly Mountains the strikes fall in all quadrants of the compass. Most of the dips of this gneiss over wide areas are low, ranging from 10° to 30°, but abrupt changes to high or vertical dips are common. In many small sections observed in road cuts and similar exposures in this region the strata of the Carolina gneiss show a series of small folds. These folds range from a few feet to a number of yards across, and their flanks do not generally have dips greater than 25°. This structure causes approximately horizontal beds of the same formations to crop out over considerable areas.

The presence of large folds in the Carolina gneiss is in general realized only where other rocks of a different character are inclosed, and even there the complexity of the folds can be appreciated only after considerable areas have been mapped in detail. The hornblendic beds of the Roan gneiss inclosed in Carolina gneiss can be recognized in most outcrops, and their occurrence in long, narrow belts with branching outcrops or in larger areas with zigzag contacts shows folded structure of more or less complexity. Nearly parallel beds which join and dip in the same direction but at different angles are probably parts of overturned folds. These folds occur east of Earl, in the Gaffney quadrangle, and near the town of Kings Mountain, in the Kings Mountain quadrangle.

The structure of the younger rocks of this district—that is, the Algonkian and Cambrian—is less complex than that of the Archean rocks, but nevertheless it is far from simple. Elongated belts of these rocks (such as the conglomerate, quartzite, or marble) predominate, but locally irregular and broken outcrops occur. The long belts represent the outcrops of eroded edges of simple folded or faulted strata, and the more irregular outcrops show the more complex structure, where crumpling and faulting have been extreme or where anticlinoria or synclinoria pitch up or down from the surface. Thus, where the anticlinoria of Roan gneiss and Bessemer granite that extend southwestward toward Gaffney pitch under the surface along Peoples Creek they give rise to an extremely complex series of outcrops in the Kings Mountain quartzite and associated rocks. Similar complexities doubtless occur in many other places where anticlinoria of older rocks pitch under later rocks, such as the Roan gneiss and Bessemer granite under the Battleground schist, but the absence of a recognizable sequence of beds in the Battleground schist makes it impossible to work out the details of this structure. The folds in the Cambrian rocks are overturned toward the southeast in the Kings Mountain quadrangle and toward the northwest in the Gaffney quadrangle, as shown in the structure-section sheets.

Around some of the large intrusions of Whiteside and Yorkville granites the strata have been uplifted or domed. The best example of this feature occurs around Cherryville, in the Lincolnton quadrangle, north of the Kings Mountain quadrangle. There the Carolina gneiss has been domed up by a batholith of Whiteside granite, and the surrounding strata have been intruded by sills of the same rock. The outcrops of these sills and the inclosed gneiss curve around the main mass of granite and dip away from it. The batholiths of Whiteside granite that occur in the northwestern part of the Kings Mountain quadrangle and adjoining parts of the Gaffney quadrangle must have produced considerable doming of the formations, but the present erosion surface cuts them below the depth at which these relations would be prominently exhibited. Very much the same may be said of the large batholith of Yorkville granite in the southeastern part of the Kings Mountain quadrangle.

*Faulting.*—Thrust faulting has produced a lack of symmetry in the sequence of strata of nearly parallel similar groups, as in many places along the belts of the Kings Mountain quartzite, Blacksburg schist, and Gaffney marble. Many of the interruptions in the outcrops of the Draytonville conglomerate member are also probably due to thrust faults. Some of these faults are shown on the areal-geology maps and in the structure-section sheets, but undoubtedly there are many others which have not been detected because they occur in large formations that lack easily distinguished beds by which fault offsets can be determined.

The fault planes have variable dips, some of them very steep and others as low as 30°, with inclinations to the northwest or to the southeast in different parts of the region, as shown in the structure-section sheets. Most of the faults along the belt of Cambrian rocks dip to the northwest in the Kings Mountain quadrangle and to the southeast in the Gaffney quadrangle. The faults are associated with folds that are greatly compressed and overturned, and they dip in the same direction as the overturned axial planes of the folds.

No direct measurement of the amount of throw of any of the large faults has been possible, but the fault which thrust the Archean rocks upon the Gaffney marble at the quarries near Gaffney must necessarily have had a throw of several times the thickness of the underlying Blacksburg schist and Kings Mountain quartzite, which is probably more than 1,000 feet. From this size the faults decrease to those whose throws are measured in inches.

The folds and faults are of very different lengths, some of them only a few yards long and others more than 10 miles. Those which can be traced the farthest are in the Cambrian beds that extend from the area near Gaffney northeastward through Blacksburg nearly to the town of Kings Mountain. In many places it is impossible to tell whether the outcrops owe their position to folding or faulting because of the gradation between the two features and the lack of good exposures. The Kings Mountain quartzite and the Gaffney marble have proved the most suitable beds for tracing, and accordingly it has been possible to determine their structure in the most detail.

*Fissuring.*—Another and much later form of structure occurs in connection with the diabase dikes of Triassic age. The molten rock that now forms the diabase was forced into open fissures, most of them less than 50 feet across but miles in length. These dikes and fissures have nearly parallel trends of N. 20°–50° W. and cut directly across all other structural features and rocks. As no offsetting of the formations is visible where the fissures have cut them, there was evidently little or no motion in the rocks. The dikes and fissures are approximately vertical and undoubtedly descended to great depth, so that they reached the deeper parts of the earth's crust and reservoirs of molten rock. The fact that the fissures remained open enough to receive the diabase shows that the rocks were in a state of tension that was the direct opposite of the strong compression which they suffered during the formation of the older structural features. Such tension might have resulted from a doming of the earth's crust so that its upper parts were relatively longer. The diabase dikes and fissures are found here and there over a large area in the Piedmont of Georgia, North Carolina, and South Carolina and closely resemble similar rocks and fissures of known Triassic age in other parts of the Piedmont.

## ECONOMIC GEOLOGY

### MINERAL RESOURCES

#### DEPOSITS WORKED

The Gaffney-Kings Mountain district has been the scene of considerable prospecting and mining at different times in the past. Among the minerals that have been mined are gold, iron ore, barite, limestone, monazite, kaolin and clay, rock for furnaces and for building, tin, and emerald. Other minerals that have been prospected are lead, manganese, pyrite, mica, graphite, garnet, and corundum.

Among the minerals mentioned as having been mined very few have proved profitable when all the expenses of operation are taken into consideration. Among those which may have paid all costs are limestone, monazite, kaolin and clay, barite, and iron ore. Some of these deposits, such as the iron ores and monazite, would require very careful operation to pay under present conditions but were profitable under the conditions that prevailed at the time of operation. Individual mines of the other minerals have been worked successfully, at least during part of the time, whereas other mines have proved failures.

#### GOLD

*General features.*—Deposits that carry gold in veins and placers have been found over a considerable area in the southeast half of the Kings Mountain quadrangle and the southeast corner of the Gaffney quadrangle. More than twenty of these deposits have had a good deal of prospecting. Several have proved to be promising, and one vein with its accompanying placers—that of the Kings Mountain mine—has yielded gold whose total value has been estimated at $750,000 to $1,000,000.

The belt of gold deposits extends northeastward across the middle of the Kings Mountain quadrangle from the southwest corner nearly to the northeast corner. Most of these deposits are quartz fissure veins in sericite or hornblende schist derived from the Bessemer granite or Roan gneiss respectively. A few similar deposits occur in the Battleground schist near outcrops of Bessemer granite. The deposit at the Kings Mountain mine is somewhat different. Here the ore body has replaced beds of limestone or marble. A number of typical deposits are described below.

*Kings Mountain or Catawba mine.*—The deposit at the Kings Mountain mine was discovered in 1834 and was worked intermittently until about 1895. Operations then ceased, but from 1910 to 1913 prospecting was carried on around the old workings and preparations were made to reopen the mine. The condition of the mine at present is such that nothing can be seen of the underground workings, and the accompanying description has been prepared from the literature and from a study of surface conditions and the dumps.

The mine is about 2 miles south of the town of Kings Mountain, at the border of Gaston County. Placers have been worked over an area of a few acres along the branch below the mine.

Twelve or more shafts have been sunk, some of which connect with drifts, crosscuts, and stopes. Some open-cut work and sluicing was also done. Two of the shafts are more than 300 feet deep, both being reported to be 330 feet deep, and others are reported to range from 50 feet to more than 200 feet. The position of the surface workings is shown on the sketch map (fig. 4).

It is difficult to piece together the published information concerning this mine with that furnished by people now best acquainted with it and with that obtainable from the workings in their present condition. There appear, however, to be three veins—the Front vein on the southwest, the Beckwith vein, and the East vein on the northeast. A number of ore shoots found in different parts of these veins have been stoped out from the upper levels.

Some of the decomposed rock or saprolite associated with the vein carried considerable gold that could not be easily saved. A method of sluicing and washing, however, was devised by which the gold could be caught on amalgamated copper plates, and a large body of the saprolite was washed at the locality numbered 5 on Figure 4.

The gold deposits are associated with beds or lenses of blue to gray banded dolomitic marble inclosed in chloritic mica schists of Archean age. These schists also carry a belt of graphite schist along the southeast side of the marble and ore bodies. A mass of schistose granite, also of Archean age but intrusive into the schists that contain the ore bodies, lies 100 feet or more southeast of the veins. A few hundred feet northwest of the gold veins is a belt of chloritic epidote rock, in places rich in magnetite. Prospects have been opened in this belt at a number of places, and a little copper and gold were found in one of them (locality 8, fig. 4). The belt of chloritic mica schist and its inclosed marble and graphite is bordered on the northwest by fine black sericite schist, probably of Cambrian age. The relations and approximate boundaries of the different rocks are shown in Figure 4.

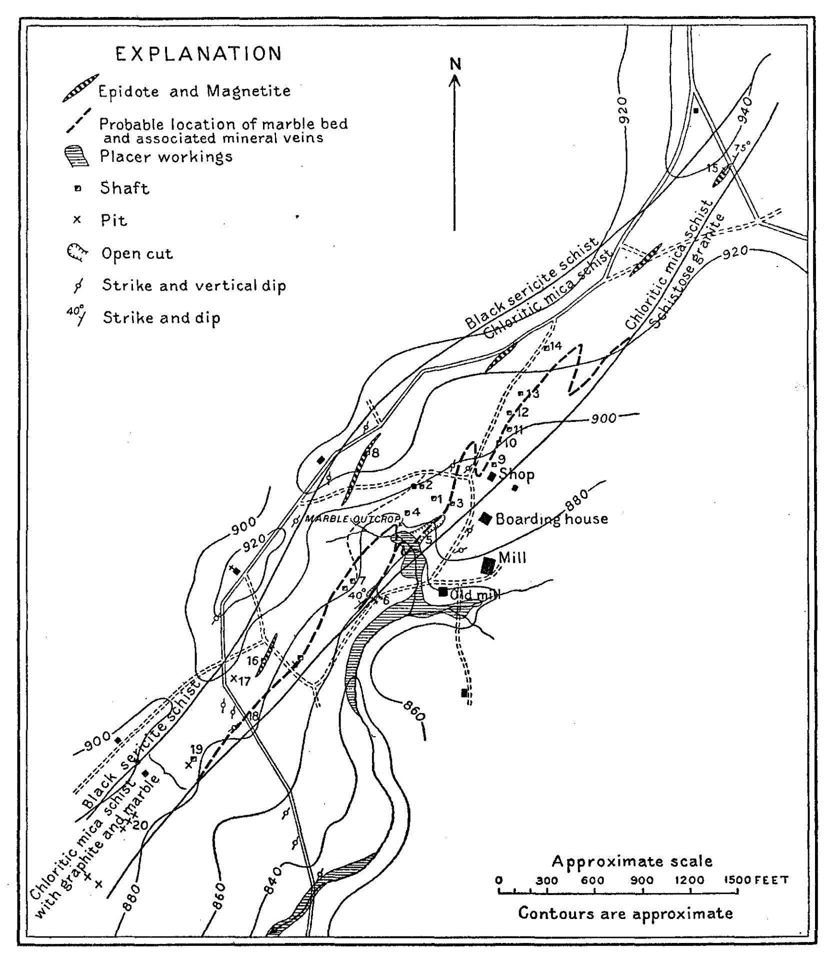


FIGURE 4.—Sketch geologic and topographic map of the region around the Kings Mountain gold mine, Gaston County, N. C., 1913

Shafts and pits: 1, Holliday shaft, reported to be 330 feet deep and to have cut the vein at a depth of 250 feet. 2, Pump shaft, reported to be 330 feet deep and to have a drift to the east that cuts the vein at a distance of 75 feet from the shaft. 3, Cow shaft, one of the old shafts nearly on the vein, reported to be about 200 feet deep. 4, Rock shaft, reported to be 200 feet deep and to have a drift to the east to the vein. Graphite schist, marble, and pyrite on dumps. 5, Large open cut 225 feet long from which saprolitic ore was hydraulicked. Graphite schist along southeast wall. 6, Open cut; kyanite and graphite schist wall rock that dips slightly in some places and as much as 40° W. in others. 7, Richard shaft, reported to be 200 feet deep. Kyanite schist wall rock and sulphides in siliceous marble in bottom. 8, Shaft reported to be 200 feet deep in an area of epidote and magnetite rock Blocks of magnetite 8 inches across on surface. A little gossan and oxidized copper ore found in the shaft is reported to contain gold. 9, Shaft reported to be 75 feet deep with drift 8 feet east to vein. 10, A new shaft about 100 feet deep in soft, decomposed vein material containing cellular quartz. 11, Hufstettler shaft, reported to be 300 feet deep. Fine grained mica schist wall rock containing gray siliceous marble and cellular quartz, some of which is auriferous. 12, Shaft reported to be 250 feet deep and to have cut an ore body. Gray siliceous marble and quartz in mica schist. 13, Gld shaft; little to be seen. 14, One of the later shafts, 50 feet deep. Decomposed chloritic mica schist with cellular manganese-stained quartz. 15, Prospect pit in deposit of magnetite near contact with schistose granite. 6, Old shaft in body of epidote and magnetite carrying some sulphide. 17, Prospect pit; little to be seen. 18, Outcrop in roadside. Graphitic mica schist containing quartz lenses and streaks from 1 inch to 2 feet thick. Some of the quartz is cellular and sugary. 19, Shaft 40 feet deep and prospect pits. Outcrop of hard kyanite-graphite schist. 20, Four prospect pits; little to be seen.

The general strike of the formations is northeast, ranging from north to N. 70° E., and the prevailing dip is northwest, chiefly at a high angle. Great variations from this attitude occur locally. In a gully 50 feet south of the Rock shaft there is a curved outcrop of marble in graphite schist. This outcrop appears to represent a small fold that has a pitch of about 20° NE., but its relation to the veins or mineralized deposits of the marble is not definitely known. The details of the structure of the rocks with which the gold veins occur can not be worked out, but evidently there has been folding, possibly accompanied by thrust faulting. Probably the marble was mineralized only along the flanks of the folds, and there has been little replacement along the axes. Possible positions of the outcrop of the marble that carries the ore bodies are shown in Figure 4. Mineralization on the flanks of the folds only would give three separate ore bodies—one in the open cut shown at locality 6; another through the wash cut, locality 5; and another through the line of workings north of the mill shown at localities 9, 10, 11, etc., in Figure 4. As the folds pitch northeastward ore shoots along their flanks would pitch northeastward also, as was actually found in mining.

The veins are reported to range from 2 to 20 feet in width. At the surface they consist of iron-stained cellular quartz in a decomposed earthy matrix, also stained with iron. These conditions prevail to the level of ground water, below which the vein matter is hard and consists of siliceous dolomitic marble with stringers of quartz and gangue minerals. Pyrite and other sulphides are plentiful in this part of the veins also. The richest ore consisted of the small veins or stringers of quartz that carried pyrite, but portions of the marble mineralized by sulphides were sufficiently rich in gold to be milled.

Among the minerals found in the ore Becker[1] mentions fluorite, biotite, pyrite, pyrrhotite, chalcopyrite, mispickel, galena, zinc blende, tetrahedrite, altaite, nagyagite, bismite, and bismutite. The ore is reported to have been rich along the footwall of the veins. The average content of gold in different parts of the workings is variously estimated at $3 a ton and more. One engineer's estimate was $8 a ton during the time of his supervision.

The mine is equipped with powerful pumps, hoists, and a 30-stamp mill.

The probable origin of the deposit can be given only in outline. The limestone and inclosing rocks were doubtless considerably folded before the intrusion of the granite. The intrusion mashed and crushed the adjoining rocks, aiding in their metamorphism. From the deeper portions of the solidifying granite probably came the solutions which replaced and mineralized the limestone, already partly marbleized. These solutions passed through fractures and deposited their mineral contents where conditions were favorable. Calcium carbonate was easily replaced by the ore minerals, which accordingly accumulated in the marble beds wherever channels were open.

*Ferguson mine.*—The Ferguson mine is 2 miles S. 50° E. of the Kings Mountain Battleground. It has been operated during several different periods, but the last work was done in 1905. Little can be learned from an examination of the workings in their present condition, and reports are variable but agree in the statement that rich ore was found in parts of the mine. Some ore was hauled to Blacksburg for treatment, some was concentrated and shipped, and some was milled at the mine.

The principal country rock has been called altered volcanic tuff by Graton,[2] but the field evidence gives no reason for separating it from the Bessemer schistose granite, which covers large areas in this region. Belts of hornblende schist are inclosed in the highly schistose granite of this region, and some was cut in the workings. The main body of the hornblende schist lies to the southeast of the deposit. The formations strike about northeast and dip steeply southeast. The vein is approximately conformable with the inclosing rocks but shows variations in mineral content in different parts. Four roughly lenticular bodies of ore were developed.

The ore deposit consists of fairly rich pyritiferous vein quartz accompanied by some partly replaced wall rock. The vein quartz is reported to have contained the richer ore and the replacement material was classed as low-grade ore. With the gold occur quartz, calcite (in veinlets), pyrite, a little magnetite, and ilmenite. The mineralized wall rock contains pyrite and quartz that have replaced some of the original minerals. The pyrite-quartz ore is reported to average $10 to $15 a ton in gold, and the replaced wall rock about $3 a ton.

*Darwin mine.*—The Darwin mine is 3½ miles in a direction west of south of Kings Creek station. It is nearly in the center of a belt of deposits opened within a mile and a half to the north and a mile and a half to the south of it. Another group of deposits has been opened two-thirds of a mile in a direction north of east of the Darwin mine. The Darwin mine is one of the older mines of the region. Lieber mentions it as the only one in operation at the time of his visit to this region in 1856. Work at the Darwin and other mines has been intermittent, and the last work was done in 1911 and 1912. The Smith mine, two-thirds of a mile in a direction north of east of the Darwin mine, was in operation during 1913. The McGill mine is also north of the Darwin, on Beech Branch.

Openings have been made at intervals on the Darwin vein on the Darwin ground and on the Ross & Carroll ground, to the north. From the Darwin mine openings are irregularly scattered along the vein for more than a mile to the south on the Leach, Ramsay, Bolin, and other properties.

The country rock is principally sericitized schistose granite or sericite schist derived from the Bessemer granite and contains inclusions of belts of hornblende schist of the Roan

[1] Becker, G. F., Gold fields of the southern Appalachians: U. S. Geol. Survey Sixteenth Ann. Rept., pt. 3, p. 309, 1895.

[2] Graton, L. C., Reconnaissance of some gold and tin deposits of the southern Appalachians: U. S. Geol. Survey Bull. 293, p. 96, 1906.

gneiss. At the south end of the workings a large mass of Roan gneiss swings in near the deposits from the east. On the north end of the Darwin ground a lens of talcose chloritic schist or soapstone is inclosed in the granite and hornblende schists. Along most of the Darwin vein the schists strike slightly east of north and dip vertically or steeply east. At the south end the strike is more to the northeast. At nearly all the mines two or more veins have been found, generally less than 75 feet apart. The veins strike irregularly northeast, dip in different directions, and do not show any close relation to the major structure of the inclosing rocks. In the Darwin mine two veins a few feet apart have been opened in a crosscut trench. These veins have irregular dips of less than 25° to the northwest and to the southeast, cutting across the schistosity of the country rock. At the Ross & Carroll mines two or more veins that strike northeast have been opened. One of these veins dips southeast and the other northwest.

The veins are composed chiefly of quartz and variable quantities of pyrite. In the surface workings most of the pyrite has been oxidized, leaving heavily iron-stained cellular quartz, the cavities in which are filled with limonite. The veins range in width from a few inches to about 6 feet, but the pyrite is only sparingly scattered through the whole mass and is generally concentrated in streaks a few inches to a foot thick along one or the other wall or within the mass of the quartz. Chalcopyrite and other minerals occur in the ore in places, and in the 85-foot shaft at the Darwin mine grains of calcite and plates of muscovite mica were found in vein quartz.

The oxidized ores are free milling, and free gold can be observed in some specimens. Where unaltered pyrite is present the ores require cyanidation, and the recovery by simple crushing and amalgamation is low. Some soft brown oxidized ore that was shipped for treatment from different mines is reported to have ranged in value from $25 to $114 a ton.

*Smith and other mines.*—At the Smith mine quartz débris covers the ground over an area more than 100 yards square. Several prospects and two shafts have exposed at least four veins of rusty cellular quartz that range from 6 inches to 4 feet in width. Unaltered pyrite and chalcopyrite were observed in some of the quartz.

A number of other mines have been opened in the Kings Creek-Smyrna region, on deposits of the same general character as those described. Among these are the Terry & Horne mine, 1½ miles due south of Kings Creek station and 2 miles north of west of Smyrna; the Wright mine, 1½ miles S. 65° W. of Smyrna; the Hardin mine, 1½ miles S. 55° W. of Smyrna and nearly half a mile southeast of the Wright mine; the Wyatt mine, three-fourths of a mile N. 35° W. of Smyrna, close to the railroad; the Allison mine, three-fourths of a mile N. 15° W. of Smyrna, back of Canaan Church; the Wallace mine, 1¾ miles due north of Smyrna and the same distance east of Kings Creek; and the Love mine, adjoining the Wallace mine on the north and about half a mile south of Piedmont Springs. Other deposits that have been opened but were not visited are the McCaw, about 2 miles southwest of Smyrna, and the Love, about 1 mile southeast of Kings Creek, on the east side of the railroad.

Farther to the northeast a number of deposits of the type already described have been prospected or operated intermittently. These deposits include those of the Logan mine, 2½ miles northwest of Bethany; the McCarter mine, 2¼ miles S. 55° W. of Bethany; the Patterson mine in South Carolina, 1¾ miles N. 30° W. of Bethany; the Patterson mine in North Carolina, 3 miles S. 85° E. of The Pinnacle; the Flint Hill mine, in the extreme southeast corner of the Gaffney quadrangle; the Lockhart mine, 3 miles S. 25° E. of Gaffney; the Durham mine, 1¼ miles south of Stepps Gap; and the Caledonia mine, 2 miles S. 60° E. of The Pinnacle.

*Placers.*—In the country between Cherokee Falls and Gaffney placers have been mined along several small branches. The source of the gold in these placers has not been determined, but two possible sources are known—one the eroded quartz veins inclosed in the Carolina gneiss that makes the country rock which formerly lay immediately around the deposits and the other the Cambrian quartzites and conglomerates in the hills above the placers. If the latter source is the one that furnished the gold there must have been placer deposits already developed in Cambrian time.

## IRON ORES

No iron has been mined for a number of years in this region, but a large number of old workings give evidence of the development of this industry in times past. The principal mining for iron was done prior to and during the Civil War, and most of the ore was smelted in local furnaces. Three principal varieties of ore were mined—magnetite, hematite, and limonite. Siderite was found in such quantity in the Cameron lead mine that its use as an ore of iron was considered. The ores occur in several different types of deposits associated with different rock formations. Some of the ores are mixed so that they can not be described separately, especially the specular ores or hematite and magnetite.

The five principal types of deposits that have been recognized are (1) ore in serpentine in Roan gneiss and Bessemer granite; (2) ore in chloritic mica schist near contacts with Bessemer granite; (3), ore in schistose tuff; (4) ore in quartzite and ottrelite; (5) brown ore in Carolina gneiss.

Of these different ores probably all but those in schistose tuff have been worked profitably under the conditions that existed at the time of their operation. It is not likely that any of the deposits would prove profitable under the conditions of mining and markets that prevail now or that are likely to prevail in the near future.

*Ore in serpentine.*—The iron-ore deposits in serpentine are inclosed in areas of Roan gneiss intruded by Bessemer granite. Most of the deposits have been found in a mass of such rock that lies southeast of Blacksburg and extends to the southwest across Broad River. These deposits furnished considerable ore to the furnaces of this region during the Civil War.

The Black iron mine, known as pit No. 2, is 3¾ miles S. 50° W. of Blacksburg, in a small valley that drains into Broad River. It was worked by an open cut about 50 feet long, 30 feet wide, and 35 feet deep at the inner end, which was driven northeastward into the face of a steep hill. The country rock is hornblende schist of the Roan gneiss, cut by layers of schistose granite. The ore is composed of magnetite and serpentine and other magnesian minerals, such as talc, chlorite, tremolite or actinolite, and dolomite. The magnetite occurs in masses and grains disseminated through the serpentine, chlorite, and tremolite. The disseminated ore would require concentration, but the selected ore shows a large content of metallic iron. Little could be seen of the size of the ore bodies, but evidently the ore occurs in several shoots or lenticular masses inclosed in the distorted body of serpentine-like rock. The ore deposit possibly originated through the action of mineralizing solutions or other agents given off by the intrusions of Bessemer granite upon an included mass of dolomite from the Archean sediments in Roan gneiss. The ore deposits would therefore be of Archean age, which would agree well with their metamorphosed and distorted condition. A number of other iron-ore pits were opened less than 2 miles northeast of the Black pit No. 2, and still others on the same lead southeast of Blacksburg. These deposits are apparently very similar to the deposit at pit No. 2, but in some the serpentine and allied minerals seem to be less abundant. Near the hornblende schists epidote is mixed with the magnetite. Southwest and south of the Black pit No. 2, between Broad River and Peoples Creek, a number of other pits have been worked for ore of similar character.

These deposits also contain serpentine and similar minerals and are inclosed in areas of hornblende schist and intruded schistose granite. The deposits bear a similar relation to the mass of Roan gneiss and the Bessemer granite intruded in it in the different localities. From the Black pit No. 2 northeastward the deposits lie near the northwest contact of this mass of rock. On the southwest side of Broad River the deposits also lie near the contact of the same formations where they pitch under other rocks.

*Ore in chloritic mica schist.*—Certain chloritic mica schists that contain considerable quartz, which are mapped as Archean and are bordered by Bessemer granite, carry considerable magnetite. These schists have been prospected at a number of places, and some of the deposits were mined for ore. Large pits were made in deposits of this ore along the west side of Doolittle Creek near Cherokee Falls and between Cherokee Falls and Draytonville Mountain. In this general region some of these deposits are difficult to distinguish from the ores in the quartzite, especially in their weathered condition and proximity to each other. The ore at these places consists of granular magnetite scattered thickly through chloritic mica schist or gneiss and in some localities almost entirely replaces the schist.

The deposits of magnetite southeast and east of the town of Kings Mountain in similar rocks belong to this group also, but some of them carry sulphide at depth. The magnetic iron ore deposit near the Kings Mountain gold mine has been opened by a number of prospects, but probably little ore was shipped. The main workings were between The Pinnacle and the town of Kings Mountain, along the west side of Yellow Ridge, where large quantities of ore are reported to have been mined.

The deposits of this group were probably formed by solutions or other mineralizing agents given off by the Bessemer granite that acted on certain adjacent beds of schist.

*Ore in schistose tuff.*—The ore in the schistose tuff has not been regularly mined, but prospects have been opened at a few places, and blocks of good ore have been observed on the surface at other places. These deposits consist of fine granular magnetite and specular hematite impregnating certain layers of the Battleground schist. A few prospects were opened along the northwest side of the Kings Mountain range near Stepps Gap and at the north end of Crowders Mountain. Good surface specimens were obtained from beds of coarse schistose tuff east of The Pinnacle.

*Ore in quartzite and ottrelite.*—The ore in quartzite and ottrelite has been mined extensively on Silver Mine Ridge, north of Cherokee Falls, and in the region along Peoples Creek and Furnace Creek, between Cherokee Falls and Gaffney. Surface specimens of ore of the same type were observed along the east slope of Crowders Mountain. The deposits were opened by numerous pits and trenches, crowded close together where the ore bodies were large. Little ore had been left in place in the openings, and studies could be made only of surface specimens.

The ores consist of magnetite and hematite disseminated through the quartzite and siliceous schists of the Kings Mountain and Battleground formations. In some places abundant grains of ottrelite are mixed through the sandy material, which was probably discarded as ore. The waste left around the old ore pits contains only lean ore that serves to show the accompanying minerals. Specimens examined contained quartz, sericite, chlorite, magnetite, and hematite, with ottrelite in some places. The content of iron in the best ores from these deposits is reported to have been not very high, though the ores were readily smelted to iron of good grade.

*Brown ore in Carolina gneiss.*—Brown iron ore, consisting chiefly of limonite and some intermixed hematite, has been mined several miles west and northwest of Gaffney. The deposits are scattered over an area a few miles square. The ore was smelted near the mines, in a furnace on Cherokee Creek. The deposits occur in the highly crumpled varieties of the garnet and kyanite schists of the Carolina gneiss and fill fissures and cracks in the gneiss. Some of the deposits appear to have replaced or to have resulted from original sulphides and others to have been simply deposited from solutions that circulated through fractured rocks. Most of these deposits are in the form of scoriaceous rusty-looking masses. Where the inclosing rocks have weathered away the ore is left in large and small fragments scattered through the surface soils.

## BARITE

*General features.*—Barite has been found at a number of places in a belt that extends from the area southwest of Kings Creek station northeastward across the Kings Mountain quadrangle to the north end of Crowders Mountain. One prospect was found in the Gaffney quadrangle about a mile east of Lawn. Several deposits of barite have been regularly mined, and prospecting has been carried on at some others. At the present time the deposit of the Cherokee Chemical Co., along the railroad near Kings Creek, is the only one in operation. Some of the mines are over 30 years old and have not been recently worked.

The deposits occur in white, bluish, or mottled quartz-sericite schist. The barite occurs in veins or elongated lenticular masses inclosed in the schist, generally about parallel with the planes of schistosity. The veins worked are generally 2 feet in width, but smaller veins and seams cut across the bedding in many places around the larger deposits. The veins contain scattered inclusions or sheets of wall rock ranging from a small fraction of an inch to several inches thick.

Quartz in grains and irregular masses is scattered through the barite in many of the deposits, and galena, sphalerite, pyrite, and stains of iron are found in some of them. The barite ranges from medium to coarse grained and resembles marble. Some of the massive barite crystals have cleavage faces nearly 2 inches across. The purest barite is snow-white, but some that is used commercially is light pink.

*Mine of the Cherokee Chemical Co.*—The deposits near the town of Kings Creek, in the Kings Mountain quadrangle, part of which are being worked by the Cherokee Chemical Co., are about a quarter of a mile east, south, and southwest of the town. The workings east of the town are old and are not now being operated. The latest operations are south and southwest of the town on both sides of the railroad and consist chiefly of open-cut work. On the northeast side of the railroad the schist and the inclosed beds of barite strike about N. 25° E. and dip about 30° SE. In the workings across the railroad the beds are reported to dip in the opposite direction. On the northeast side of the railroad the veins of barite lie nearly parallel with the slope of the hill and are being worked from a point near the level of the stream to a point 25 or 30 feet higher. Until the veins are worked down to the bottom of the valley the barite can be removed by open cuts with a minimum stripping of overburden.

The veins are for the most part in the Battleground schist near the contact with the Bessemer granite, but some are also found in the schistose parts of the granite. They range from 1 to 6 feet thick and differ in quality locally. In places sheets of sericite schist or quartz are inclosed in the veins or the barite may be badly stained. Much of it, however, is of very good quality and ranges from pure marble-white to pink. Both grades are milled for shipment.

*Lawson mine and workings near by.*—The Lawson mine is about two-thirds of a mile east of the south end of Crowders Mountain. The deposits have been opened through a distance of half a mile on the Lawson property and at other places within a mile in a direction a little west of south. Two prospects also have been opened at the north end of Crowders Mountain. The work at the Lawson mine was on a fairly large scale, and the old work on the Craig place, now the south end of the Lawson property, was also extensive. The Lawson mine was opened by several shafts 30 to 100 feet deep, by drifts, and by pits and open cuts. Two main veins were found about 100 feet apart. In most of the mine they ranged from 2 to 6 feet in thickness, but in one place they were nearly 12 feet thick. On the old Craig place two similar parallel veins were worked by open cuts and shafts to a depth of 35 feet. The ore bodies here are reported to have been very similar to those at the main working of the Lawson mine.

The country rock at these mines is fine white siliceous sericite schist of the Battleground formation, which strikes N. 10°–20° E. and dips steeply west or is vertical. Bodies of Bessemer granite occur near the barite deposits, and a ledge of hard kyanite quartzite crops out not far west of some of the workings. The main deposits of barite are approximately conformable with the inclosing schist, but smaller veins that cut the schistosity were found in the workings. Much of the barite occurs in massive granular pure-white form. Locally galena and sphalerite occur in streaks and patches in the barite, and some of the ore near the surface is slightly pinkish.

*Other deposits.*—A barite deposit in the extreme southeast corner of Gaston County, N. C., has been worked by a trench about 150 feet long and shafts. The workings are badly overgrown and caved, but a quantity of good barite is reported to have been shipped from them a number of years ago. Apparently two veins were opened in siliceous white sericite schist.

An old mine 2 miles northeast of the Kings Mountain Battleground was opened by a trench about 60 feet long and 8 feet deep. The vein of barite is reported to have been 6 feet thick. Waste rock on the dumps shows that the barite in places incloses sericite schist and other impurities.

Later prospects have been opened from 1 to 2 miles north of Piedmont Springs and 1½ miles south of the Kings Mountain Battleground. Veins ranging from a few inches to 2 feet in thickness were exposed in some of these openings. They were inclosed in white sericite schist, in approximate conformity with its northeast strike and nearly vertical dip. The ore taken out was very similar in quality to that at the larger mines.

### LIMESTONE

Most of the so-called limestone of this region should be classed as marble. Some of it is even coarse-grained marble, but most of it is rather fine grained. Much of it is magnesian, and some contains sufficient magnesium to be classed as dolomitic marble. The most productive deposits belong to the Gaffney marble and are of Cambrian age. Three deposits associated with Archean rocks have also been found but have not been used commercially. These are at the Kings Mountain gold mine (fig. 4), on Kings Creek 4 miles north of Kings Creek station, and near Thicketty. The last is a small bed of coarse marble.

The Cambrian marble has been found or quarried at intervals all the way from Limestone Springs, 1 mile south of Gaffney, northeastward through Blacksburg, to the southeast and east of Grover, and on to the town of Kings Mountain. Deposits have also been found in the Lincolnton quadrangle and still farther northeast. More than 15 quarries have been opened at different times in the Kings Mountain and Gaffney quadrangles to obtain rock for burning into lime. Most of these quarries were small, but one near Gaffney has been worked on an extensive scale. The limestone has been burned near the quarries, and the lime generally has been used locally. A few quarries, especially those near Gaffney, have supplied lime for shipment to considerable distances. Most of the quarries have been operated intermittently, and at only three have modern continuous-burning kilns been installed.

Most of the deposits are in low ground, and the outcrops from which development work proceeded occur chiefly in stream beds. This fact and the fact that the limestone is likely to contain solution channels where spring waters flow make some of the quarries wet and rather difficult to operate.

*Gaffney quarries.*—The Gaffney quarries are about 1 mile south of the center of Gaffney and along the south line of the town. Eight or ten pits and open cuts have been made, ranging from pits 30 feet across and 10 feet deep to the main quarry of the Gaffney Lime Co., the last one worked, which is about 400 feet long, 150 feet wide, and 75 feet deep. Work in this quarry was begun on the outcrop and was carried backward and downward on the dip of the beds. The beds strike about northeast and dip between 20° and 40° SE. This dip necessitated the removal of an increasing quantity of overburden and finally caused the stoppage of the work in 1913. As quarry operations proceeded, after the soil was removed the overburden consisted of 15 to 20 feet of white dolomitic marble, and in the area last worked the dolomite was overlain by about 10 feet of white calcareous quartzite. The lower part of the marble in the quarry is bluish gray and according to Sloan[3] contains nearly 97 per cent of calcium carbonate. This part was worked for burning into lime and was 20 to 30 feet thick. Some parts of the marble contain inclusions of fine hornblende schist, biotite-hornblende schist, and other impurities, but these can readily be sorted out. Fine crystals of pyrite occur in places in the marble but not in sufficient quantity to injure the lime prepared from it.

The marble reaches its greatest development in this locality, and the area underlain by it is especially wide on account of the unusually low dips. The beds were folded rather lightly in the area occupied by Limestone College, north and west of the quarries, but on the southern margin of the area they were overturned from the southeast, so that older quartzite and gneiss were brought above the marble. The overturning was probably accompanied by thrust faulting, which in places brought the underlying gneiss next to the marble.

In many of the other quarries along the limestone or marble belts the quality of the rock and the relations of the beds are similar to those in the Gaffney quarries. The beds of marble, however, are not so thick as in the Gaffney quarries, and most of them dip more steeply. The bluish-gray beds burn into the best lime, and most of the white marble is discarded. In some of the quarries two beds of bluish marble are worked, generally not more than 10 to 15 feet thick and separated by a few feet of fine calcareous biotite schist and in some places hornblende schist. Most of the deposits have southeasterly dips, which result from folds overturned by compressive forces that acted from the southeast.

### MONAZITE

Monazite, which is valued for its content of thorium, a substance used in the manufacture of incandescent gas mantles, has been mined rather extensively in the western part of the Gaffney quadrangle. The mines, which are operations on placer deposits along the beds of small streams, are 3 to 10 miles west and northwest of Gaffney. Most of the monazite has been caught in simple sluice boxes fed through perforated iron plates or screens. (See pl. 8.) In some places a preliminary ground-sluicing of the gravel beds precedes washing in the boxes.

Because of its high specific gravity (about 5) the monazite is concentrated in the lowest beds of gravel in the streams and in the bottom lands along the streams. The gravel beds commonly range from less than a foot to several feet in thickness, and unless sufficient water can be obtained to sluice off the upper few feet of overburden they generally can not be profitably mined. The monazite of the placers is derived from certain rocks that have been decomposed, leaving the resistant monazite concentrated in the soils. The wash from these soils in the hills along the stream valleys has supplied the bottom lands with the gravel beds and the monazite. In the stream beds of small valleys, along which the hills are cultivated, the deposits can be worked profitably over and over again, in some places three or four times in one year, for fresh supplies of monazite are washed into the stream beds during heavy rains.

A large number of minerals are found in the first crude monazite concentrates, including garnet, magnetite, rutile, ilmenite, zircon, cassiterite, kyanite, corundum, tourmaline, and staurolite. In some of the deposits in the northwestern part of the monazite belt in Rutherford and Burke Counties, N. C., gold is saved, but in the monazite deposits of the Gaffney region little gold has been found. Zircon is plentiful in some of the monazite concentrates and could be extracted if sufficient demand should arise. The monazite-bearing gravel has been derived through the erosion of areas in which granitic and pegmatitic rocks are abundant. In some places, especially in Cleveland County, N. C., the Whiteside granite and the associated pegmatite forms the bulk of the rocks underlying and surrounding the monazite placers, but as a rule the country rock consists of some variety of the Carolina gneiss together with granitic and pegmatitic material. As a rule these schists and gneisses are saturated with pegmatitic material in the areas of rich monazite deposits, and in some places the pegmatization has been so extensive that the rocks and their resultant soils are difficult to distinguish from granitic rocks.

Monazite in some places forms as much as 1 per cent of the rock. In many places the decomposed pegmatized rock or saprolite will yield from a few grains to more than a teaspoonful of monazite to a shovelful when concentrated in a pan. Monazite has been found most plentifully in biotite schist, generally more or less graphitic and strongly pegmatized by the addition of feldspar, quartz, muscovite, monazite, and other minerals.

In Cleveland County, N. C., such rocks were quarried and milled for monazite. The monazite content varied widely in the different beds within a thickness of 18 feet across the layers. One bed over 3 feet thick averaged about 1 per cent of monazite, and other beds yielded less than 0.03 per cent.

[3] Sloan, Earle, Catalogue of the mineral localities of South Carolina: South Carolina Geol. Survey, 4th ser., Bull. 2, p. 235, 1908.

### KAOLIN AND CLAY

Kaolin-like clay of fairly good grade has been mined in the region around Grover. Most of it has been used for fire brick and for special high-grade light-colored bricks. This clay is derived from granitic and pegmatitic rocks and is partly in place and partly only a short distance from its place of formation. It is grayish to white, contains considerable intermixed quartz sand, and is plastic and rather sticky. It occurs near the heads of small hollows, where it readily accumulates by the washing and sliding down of kaolin-like residue formed by the decomposition of the feldspathic rocks in the surrounding hillsides. The deposits have a maximum thickness of 10 feet or more, are easily worked, and are conveniently near the railroad.

Common clay has been dug and burned into bricks at several places in the Gaffney-Kings Mountain district. Some of the bricks have proved of very good grade, but others have worn very poorly, possibly as much through poor manufacture as through the quality of the clay. The brick clays have been obtained from residual and semiresidual deposits in the small valleys, where the ordinary products of rock decomposition have remained in place and similar material from the hillsides has slid or crept down and accumulated. These clays are commonly bluish gray and contain variable amounts of organic matter together with quartz sand and clayey material.

### ROCK FOR CONSTRUCTION

At several places in the Gaffney quadrangle quarries were opened in the sandy or siliceous varieties of the sericite schist that borders the conglomerate beds inclosed in the Battleground schist, and the rock was used chiefly in the iron furnaces before and during the Civil War. The principal quarries for this rock were about 5 miles south of Gaffney.

Quarries for rock for large construction work have been opened at several places and operated as needed. Thus large quantities were required for the power dams at Ninety-nine Islands, Cherokee Falls, and Gaston Shoals on Broad River. At Ninety-nine Islands and Cherokee Falls hard varieties of the Bessemer granite and the Roan gneiss inclosed in it were used both in the concrete work and as blocks in heavy construction. At Gaston Shoals and at the dam on First Broad River somewhat porphyritic biotite granite gneiss of the Whiteside granite was quarried for block and concrete construction.

No large quarries for building granite have been opened in the Gaffney-Kings Mountain district, but small openings have been made in the Yorkville granite near Filbert for blocks for construction and building material in York and Clover. So far the principal supply has been obtained from large boulders or loose slabs on the surface. Some of the bare floors or bosses of granite that crop out in the region northwest of York offer favorable places for opening quarries.

### TIN

*Distribution.*—The presence of cassiterite, the native oxide of tin, in apparently rich deposits at many places in the Kings Mountain quadrangle and at one place in the Gaffney quadrangle has led to much prospecting and many attempts at mining. In at least one place—the Ross mine, near Gaffney—placer mining was temporarily done at considerable profit. Several prospects and mines have also been opened in the Lincolnton and Gastonia quadrangles, north and northeast of the Kings Mountain quadrangle. Practically all the work on cassiterite-bearing veins has been done at a loss, but this work has not been sufficiently conclusive to prove or disprove the value of some of the deposits.

The cassiterite deposits have been found in a belt extending from a place 2 miles northeast of Grover, nearly parallel with the general trend of the rock formations, through the town of Kings Mountain. (See pl. 10.) So far as known the Ross tin mine, near Gaffney, is an isolated deposit but falls in nearly the same belt of rock formations as those between Grover and Kings Mountain.

*Inclosing rocks.*—The tin deposits occur in masses of pegmatite that cut Archean rocks, either the Roan gneiss or the Carolina gneiss along or near its contact with the Roan gneiss. These gneisses comprise hornblende schist, hornblende gneiss, diorite, mica schist, and mica gneiss with or without accessory garnet and kyanite. The formations have steep dips along the tin belt. The matrix of the cassiterite is invariably pegmatite and the accompanying greisen. Some of the masses of pegmatite are conformable with the bedding of the inclosing schists, but others cut across the bedding with various dips and strikes. There are many bodies of pegmatite which are similar to those that carry cassiterite but in which this mineral has not yet been found.

The bodies of pegmatite range from less than an inch to as much as 100 feet in width, and from a few inches to probably more than half a mile in length. Some are only two or three times longer than wide; but others are a great many times longer. Some of the pegmatites occur in more or less parallel position, others in a belt with their ends overlapping or in line with one another, and others lie at different angles. The pegmatites in places branch, fork, swell and pinch out abruptly or taper down at the ends, or the larger bodies are connected by dikes. These variations may occur in different planes. Some of the pegmatites are more regular and hold one direction of strike and dip for considerable distances.

*Origin of pegmatite.*—The pegmatites are chiefly intrusions in the inclosing rocks, but the relations are modified in some places by the action of solutions or gases—that is, some of the pegmatites have been deposited from aqueo-igneous solutions. To which class many of the bodies of pegmatite belong is in places a matter of uncertainty. Both are believed to be the products of granitic magmas. In the crystallization of a granite magma water is excluded and therefore may accumulate in the parts of the magma that remain unsolidified. This remaining magma accordingly becomes more fluid until it is a concentrated aqueous solution rather than a magma. The expulsion of these very liquid magmas and solutions into surrounding rocks results in masses of pegmatite that grade between typical dikes and typical veins.

*Occurrence of cassiterite.*—The pegmatites of the tin belt, including those that carry cassiterite, are diverse in composition. Some are composed of the usual minerals—feldspar, quartz, and mica — without appreciable quantities of other constituents. Others carry spodumene and cassiterite. Cassiterite occurs both in pegmatites which carry spodumene and in those which do not. The other minerals observed in the cassiterite-bearing pegmatites are few and not worthy of note. Such minerals as wolframite and arsenopyrite, which are associated with tin ore in other regions, appear to be absent here. Variations in composition consist chiefly in differences in the proportions of the different minerals present. In some deposits feldspar predominates, in others quartz. In some mica is absent and in others it is abundant.

Great irregularities occur in the distribution of the minerals. Quartz is segregated into large separate masses in some deposits and mixed through the rock in coarse grains in others. Cassiterite in small deposits occurs in scattered grains through one part and is absent a few feet distant in another part of the same pegmatite. In some of the large pegmatites the cassiterite is irregularly scattered through large masses of the rock, and in others it is more or less irregularly concentrated along one wall of the pegmatite as a smaller vein that is connected with the main mass. In some of the pegmatites rich in cassiterite feldspar is only sparingly present if not absent. Deposits of this type, then, have the nature of greisen and have been observed as lenses or streaks in larger bodies of pegmatite and along their contacts with other rocks.

The cassiterite appears to have been one of the first minerals in the pegmatite to crystallize. Its boundaries are sharp, although crystal outlines are rather rare, and there are no inclusions of other minerals in it. In some places the concentration of the cassiterite in greisen along the pegmatite border indicates metamorphic action, during which there were mutual reactions between the dike and the wall rock. The reaction of wall rock and dike is also evident by the unusual coarseness of the mica schist of the wall in many places.

*Age of the tin deposits.*—The rocks in the tin belt are of two classes—the gneisses and other rocks of Archean age and the granites, pegmatites, and quartz veins that cut the Archean rocks. The Archean rocks are greatly altered by deformation, but the younger rocks show little or no alteration. The Whiteside granite was locally rendered schistose but in large areas is massive and unaltered. It is therefore concluded that most of that granite is younger than the mountain-building movements that deformed and altered this entire region. This conclusion assigns to the Whiteside granite a late Carboniferous age. Similar reasoning assigns a probable late Carboniferous age to some of the pegmatites and the quartz veins.

It seems probable that granite, pegmatite, and quartz veins form a cycle—that is, the granite invaded the Archean rocks nearly at the end of the Carboniferous period, the pegmatite represents a later stage of intrusion, partly in mass and partly by permeating solutions, and the quartz veins are the final products of the cooling magma. The general distribution of the rocks favors this view, for the tin-bearing pegmatites are not in the granite but are near its general southeast margin, whereas the quartz veins, which are more or less mineralized, occupy a general belt southeast of the granite and farther away from it.

*Local developments.* — The only tin mine in the Gaffney quadrangle is the Ross mine, near Gaffney.

Twenty or more places have been prospected for cassiterite in the Kings Mountain quadrangle, and at a few of these places extensive work was carried on. During 1907 the Blue Ridge Tin Corporation worked in the town of Kings Mountain and at several places southwest of the town along a line of prospects opened by Ledoux in 1888 and 1889. Among other prospects that have been tested a promising one was the Faires place, which was tested by Capt. S. S. Ross and others, of Gaffney. Named in order from the north border of the Kings Mountain quadrangle southwestward some of the mines and prospects are the old mine of the Blue Ridge Tin Corporation, on the west side of the railroad tracks in the town of Kings Mountain; the prospect belonging to Mrs. Elizabeth Falls, two-thirds of a mile south of the town; the Faires prospect, eight-tenths of a mile in a direction a little west of south of the town; prospects tested by the American Tin Plate Co., which adjoin the Faires prospect on the southwest; the prospect belonging to Mike Plonk, $1\frac{1}{4}$ miles southwest of the town; a series of openings made by Ledoux & Co. in 1907, beginning $1\frac{1}{2}$ miles southwest of the town and extending one-third of a mile to the southwest along a ridge; an old prospect of Ledoux & Co., $1\frac{3}{4}$ miles southwest of the town; the principal workings of the Blue Ridge Tin Corporation, 2 to $2\frac{1}{3}$ miles southwest of the town, consisting of two deep shafts, tunnels, and some placer work; three prospects of the Blue Ridge Tin Corporation that lie west of the placer ground and within half a mile to the southwest; other prospects to the southwest; and one two-thirds of a mile southeast of Crocker, which was opened by Captain Ross in 1903. Still other prospects are reported southwest of the one last mentioned but were not examined. Float tin has been found at several places in the town of Kings Mountain and along the belt southwest of town.



*Ross mine.*—The Ross tin mine is about $1\frac{1}{2}$ miles northeast of Gaffney, in and along the northwest side of a small hollow that drains northeastward into a tributary of Providence Branch. The work consists of many open cuts and placer washings and a shaft more than 130 feet deep, within a space about 600 feet long from northeast to southwest and 100 feet wide. Placer mining has been done on the lower part of a slope where water was available, and placer ore from above this area has been carted down to the sluice boxes. In this way the greater part of the hill slope from the area near the shaft northeastward to the branch, a distance of about 400 feet, has been worked over.

The shaft and underground workings were not open when visited, but portions of the vein were exposed in shallow workings, which, together with descriptions by Sloan[4] and Graton,[5] have furnished material for the notes here given. A crosscut was driven from the shaft northwestward to the vein on the 63-foot level, and winzes were sunk on the vein from this level to the 90-foot level and there connected by a drift. The shaft cuts the vein at a depth of nearly 100 feet.

The placer ground contained both weathered vein material nearly in place and hillside débris from the vein. Where the drift material was washed the work was carried to depths of only a foot or two, but where the weathered vein in place formed the placer material it was excavated to depths of more than 10 feet.

The country rock is interlayered hornblende schist and fine biotite gneiss of the Roan gneiss. These rocks strike about northeast and the dips that were measured range from 25° SE. in the stream to 60° SE. in the mine workings. In the stream the rocks were but little altered, but in the underground workings the saprolite was more than 60 feet deep and passed gradually into less altered rock. From the lower workings hard, fresh wall rock was brought up, but the vein material was partly altered. The wall rock on the dump consists of rather coarse hornblende schist and garnetiferous biotite gneiss. The pegmatite in the upper workings was decomposed by kaolinization of the feldspars. Specimens examined from the lower workings were hard, compact, and schistose and contained an abundance of compact fine sericite or pinite and a fibrous mineral like sillimanite. Under the microscope partly sericitized orthoclase, oligoclase, muscovite, sericite, sillimanite, cassiterite, a prismatic mineral that is probably staurolite, and iron ore were observed.

In the upper workings the streaks of hornblende schist have weathered to dark yellowish-brown saprolite and the mica and garnet gneiss to dark-grayish saprolite. The pegmatite is represented by masses of white kaolin and a little intermixed quartz together with some mica.

The cassiterite-bearing pegmatite occurs as a series of irregular sheets and lenses nearly conformable with the inclosing gneiss and schists—that is, it strikes northeast and dips 50°–60° SE. The belt of pegmatite bodies or veins ranges from 1 foot to nearly 10 feet in thickness, and the individual masses from less than an inch to 4 feet. The tin content of the pegmatite varies; in some places the rock carries a large proportion of cassiterite, and in others only a few scattered grains. Graton[6] mentions a 100-pound sample taken across a pegmatite body on the 75-foot level, which contained 9 pounds of cassiterite, or about 6.5 per cent of metallic tin.

Most of the ore from the Ross mine was decomposed and soft and could be readily concentrated in sluice boxes. The ore from the lowest workings, however, was hard and required crushing before concentration. The concentrates obtained have generally averaged more than 65 per cent of metallic tin. Sloan[7] states that the total shipments of cassiterite concentrates from the Ross mine from its opening to 1906 amounted to about 130 tons. In 1907 the shaft was sunk to its present depth of more than 130 feet. Since that time only a little surface testing and some sluicing has been done, resulting in the production of several thousand pounds of concentrates.

[4] Sloan, Earle, op. cit., p. 85.
[5] Graton, L. C., op. cit., pp. 49–50.
[6] Idem, p. 50.
[7] Sloan, Earle, op. cit., p. 92.

*Kings Mountain mine.*—At the Kings Mountain mine of the Blue Ridge Tin Corporation, three shafts were sunk from 50 to 75 feet deep and some drifts were run from them. A mill was erected near at hand for treating the ore. The workings were not available for examination when visited, and little could be learned of the result of the operations. Rich ore was found in pegmatite débris on the surface, and similar rich ore was reported from parts of the underground workings.

The country rock is strongly folded coarse mica schist, and there is a body of similarly folded hornblende schist less than 100 feet to the south. The strike of the schistosity of these rocks is north to west of north and the dip is nearly vertical, but the contact of the two formations extends nearly east and west, although jagged in detail. This relation is due to rather close folding with a strong northerly pitch in the folds. The cassiterite-bearing pegmatites are about conformable with the schistosity of the inclosing rocks, and the ore shoots probably pitch northward in conformity with these folds. The veins of pegmatite range from less than a foot to several feet in thickness as exposed near the top of the western shaft. Most of the pegmatite, especially that containing much feldspar, is weathered and soft in the upper part of the workings, but some of the greisen-like ore rich in cassiterite is but little altered, even at the surface.

Cassiterite-bearing pegmatite crops out about 150 yards southeast of this mine in the gutter of one of the side streets of the town of Kings Mountain and is reported to have been found in a well about 300 yards farther south. A number of loose crystals of cassiterite were found one-third of a mile west of the railroad on both sides of the street leading toward Shelby.

*Falls prospect.*—The Falls prospect is on the east side of a hollow in the southern part of the town of Kings Mountain. It was tested a number of years ago by trenches along the hillside and by some shafts. Large masses of pegmatite were exposed in the hillside workings, but little cassiterite was found in them. A shoot of rich greisen was found in a shaft on top of the hill east of the trenches. Here the cassiterite-bearing greisen formed a pocket or shoot about 2 feet wide in a body of pegmatite about 8 feet wide. The pegmatite is inclosed in chlorite schist that lies between hornblende schist on the northwest and mica schist on the southeast. A ledge of tourmaline-quartz rock crops out in the branch about 75 yards southeast of the place where the tin lead crosses it. This ledge is composed of gray to smoky quartz penetrated by a large number of long, thin black crystals of tourmaline. In some places the tourmaline appears to be massive and to compose about half the vein.

*Faires prospect.*—Development work on the Faires property, a quarter of a mile southwest of the Falls prospect, consists of several pits and a 40-foot shaft with about 200 feet of drifts, now badly caved in. A 10-foot pit, at a place where rich float ore was found, exposed a body of cassiterite-bearing pegmatite 3 feet wide that strikes N. 30° E. and dips steeply to the northwest. The vein was cut on the 40-foot level by a crosscut from the shaft on the southeast. The pegmatite is reported to have been about 3 feet wide where it was cut by the tunnel and to have carried cassiterite. A drift to the northeast showed the pegmatite to be wider and to carry more cassiterite. Another body of pegmatite was prospected 33 feet southeast of this vein but showed no cassiterite. The pegmatite in the underground workings is badly decomposed, and most of the feldspar is kaolinized. The parts richest in cassiterite contained less feldspar and remained harder. Some of this ore was very rich, and in one section exposed the rock was estimated to carry about 10 per cent of cassiterite. The country rock is hornblende schist, badly decomposed. A tourmaline-quartz vein is inclosed in the schist a number of yards southeast of the pegmatite.

Other prospects were opened southwest of the main workings on other outcrops of pegmatite. Cassiterite was found in some of these also, and in one of the exposures the quantity appeared to be promising. About 300 or 400 yards southwest of the main deposit a large body of spodumene-bearing pegmatite over 40 feet wide crops out prominently in the north side of a small valley. No cassiterite was observed in this rock. Similar outcrops of spodumene-bearing pegmatite occur within half a mile to the southwest, but most of them lie northwest of the belt in which tin ore has been found.

*Plonk prospect.*—On the Plonk property a long trench was cut across the formations, exposing both spodumene-bearing pegmatite and cassiterite-bearing pegmatite inclosed in hornblende schist. The formations strike N. 35° E. and dip 75° NW.

*Old Ledoux prospects.*—Considerable prospecting was done along the ridge adjoining and to the southwest of the Plonk property, first by Ledoux & Co. in 1888 and 1889 and later by the Blue Ridge Tin Corporation. At the northeast is an old crosscut trench where little can be seen at present. Next is a trench about 200 feet long and 5 to 20 feet deep along the east contact of a large mass of pegmatite. At the surface the contact strikes N. 25° E. and dips 80° NW., but at a depth of 20 feet it dips 60° NW. Coarse garnetiferous mica schist forms the southeast wall of the pegmatite. Cassiterite was found in a greisen-like phase of the pegmatite along the southeast wall. The cassiterite-bearing portion was from 1 to 3 feet wide and was rich in some places and poor in others. It is reported that a diamond-drill hole sunk over 100 feet west of the vein cut 5 feet of ore at a depth of 275 feet. The pegmatite at this place is probably at least 25 feet wide. To the northwest lie other large masses of pegmatite separated from one another by several feet of schist. These pegmatites do not crop out distinctly, but boulders have rolled between them, giving an appearance of one large deposit several hundred feet wide. Some of them carry considerable spodumene but apparently no cassiterite. The cassiterite-bearing mass is inclosed in mica schist, but most of the other masses are inclosed in hornblende schist.

About 50 yards southwest of the long trench a shaft 85 feet deep, called No. 1 by the Blue Ridge Tin Corporation, was sunk near a pit where good ore had been found. A 60-foot crosscut from the shaft cut three veins, one of which carries cassiterite. These veins are inclosed in interlayered hornblende schist and garnetiferous mica schist. Farther southwest is a trench 100 feet long and 3 to 12 feet deep on a contact similar to that just described. This contact strikes about N. 25° E. and dips 80° W. Cassiterite was found in part of this trench, and some of the ore looked promising. A short distance southwest two shafts had been sunk, one on spodumene-bearing pegmatite. Cassiterite was reported in both of these shafts.

Near the end of the ridge a trench was made along the southeast contact of another large mass of spodumene-bearing pegmatite. This pegmatite carried cassiterite along the southeast wall, which is chloritic mica schist.

On a knoll about 200 yards west of this ridge, across a small valley, another old shaft 60 feet deep is sunk in a large mass of pegmatite carrying spodumene. A little cassiterite was found at this place and also at another outcrop of pegmatite about 200 yards to the southwest, which is opened by two pits. The rock inclosing the pegmatite at each of these prospects is hornblende schist.

*Main works of the Blue Ridge Tin Corporation.*—At the northeast end of the outcrops on the property of the Blue Ridge Tin Corporation a shaft 80 feet deep (No. 4) was sunk, and a 60-foot drift was driven to the southwest from it on the 60-foot level. A 20-foot prospect shaft was sunk south of the main shaft. Two veins were found—one in the 20-foot shaft and the other along the northwest side of the drift on the 60-foot level. The material in these veins consists of schistose greisen-like pegmatite and is reported to have been badly crushed in the underground workings.

About 200 yards to the southwest shaft No. 5 is sunk to a depth of 130 feet. Underground workings cut two veins that carry cassiterite. One of these veins, which crops out 15 feet southeast of the shaft, was cut a few feet from the shaft in a crosscut to the southeast on the 85-foot level and dipped into the shaft near the bottom. This vein is said to contain fine-grained ore at the surface but coarser ore underground. The outcrop of the other vein was not found, but the ore was reached in the crosscut on the 85-foot level. It was reported to have been coarse-grained rich ore. Another vein of cassiterite-bearing pegmatite was opened by a 25-foot shaft about 60 yards west of the main shaft.

A large vein of spodumene-bearing pegmatite about 15 feet thick crops out between shafts Nos. 4 and 5. Débris of cassiterite-bearing pegmatite or greisen was found near this vein, and a little cassiterite was observed in the spodumene-bearing part.

The country rock at these workings consists of interlayered hornblende schist and bluish mica schist that strikes northeast and dips steeply to the northwest or is nearly vertical. The veins seem to be at least approximately conformable with the inclosing schist.

Placer deposits have been worked in the bottom land along the valley southwest and south of the mine. The ground favorable for this work is 50 to 100 yards wide at the lower end and narrows northwestward to shoals where the tin lead crosses. It has a length of over 200 yards. Water is available, and parts of the placer ground are reported to have been tested with favorable results. This placer ore was hauled up an inclined track to a concentrating mill on the hillside, but although several thousand pounds of concentrates were washed out, the work was not profitable with such equipment.

On the hill on the southwest side of the same valley a 25-foot shaft was sunk and a 10-foot crosscut vein. A mass of spodumene-bearing pegmatite, 5 feet wide, inclosed in hornblende and chlorite schist, was penetrated in this shaft. A little cassiterite is reported to have been taken out. In two prospects within half a mile to the southwest openings were made in similar spodumene-bearing pegmatite, inclosed in hornblende and chlorite schist. Cassiterite is reported to have been found in both. A body of tourmaline-quartz rock occurs about 10 feet southeast of one of these masses of pegmatite.

*Ross prospect.*—At the old prospect two-thirds of a mile southeast of Crocker, which was opened by Capt. S. S. Ross in 1903, a pit was sunk on the southeast side of a mass of pegmatite about 20 feet wide. This pegmatite contained considerable cassiterite in a streak several inches thick along the southeast wall, but only a few scattered grains within the mass. Bluish mica schist forms the wall rock, but 45 feet to the southeast is a belt of hornblende schist. A vein of tourmaline quartz is inclosed in the hornblende schist about 50 yards southeast of the pegmatite.

### BERYL AND EMERALD

Beryl occurs at several places in these quadrangles, and at one place the variety known as emerald has been mined. The beryl occurs in crystals of different sizes in pegmatite dikes that cut rocks of different kinds.

Large crystals of beryl were found in an outcrop of pegmatite in the tin belt, three-quarters of a mile southeast of Crocker, only a few hundred yards northeast of the tin prospect opened by Capt. S. S. Ross. The country rock is coarse mica schist, and the pegmatite in which the beryl occurs is apparently 10 to 15 feet thick. Nearly a dozen crystals, the largest of them 4 inches in diameter, were observed. Some of this beryl is transparent and some translucent, but most of it is opaque. None of it has a strong color, but some is pale bluish green.

At another locality, $1\frac{2}{3}$ miles south of Patterson Springs, a few crystals of beryl were found in large residual boulders of massive quartz left by the weathering of pegmatite. This quartz contained also hexagonal cavities left by the weathering out of other crystals.

*Old Plantation emerald mine.*—Emeralds were discovered on the W. B. Turner place, nearly 4 miles west of Patterson Springs, in 1909. After some prospecting the property was purchased and worked until 1913 by the Emerald Co. of America, under the name of the Old Plantation mine. About 3,000 carats of rough crystals of emerald, whose estimated value was at least $15,000, were obtained. The cut gems have been sold for $5 to $100 a carat wholesale.

The emeralds occur in pegmatite that cuts a mass of hornblende hypersthenite and associated gabbro inclosed in hornblende gneiss. The body of hornblende hypersthenite and its associated gabbro is about 100 feet thick and probably 300 feet or more long. It is inclosed in a belt of diorite or hornblende gneiss of the Roan gneiss, 300 or 400 feet thick. The Whiteside granite has intruded these formations to the south and forms a belt along the east side of them. Smaller masses of the granite have worked into the other rocks, and partial absorption of the ferromagnesian rocks has taken place along the contacts. Thus there are gradations between the diorite and granite around the inclusions of diorite in the granite. The gabbro occurs along the south side of the hypersthenite mass in contact with granite into which it grades by absorption.

Several dikes that cut the hornblende hypersthenite closely resembled the emerald-bearing pegmatite, but emeralds were found in only one of them. This pegmatite dike ranged from a thin seam to a mass 6 feet in thickness; it had a length of about 40 feet and extended to a depth of about 20 feet. The whole dike was removed in mining, leaving only a seam in the hypersthenite to show where it had pinched out to the west and in the bottom. In the east end of the cut the pegmatite either pinched out near or joined a boss of coarse-grained granite or fine-grained pegmatite that was exposed by the workings. This part of the dike was removed and the boss exposed without especial attention being paid to its relations to the emerald vein. Other veins that extend from the boss were prospected, but no emeralds were found.

The emerald-bearing pegmatite ranged from medium to fairly coarse grained. It was composed of quartz and feldspar, part of which, at least, was albite, and through it were scattered some black tourmaline and a few crystals of emerald or green beryl. The crystallization of the minerals of the pegmatite was imperfect, but a few partly developed crystals were found in small irregular miarolitic cavities. The crystals found in these cavities were colorless and smoky quartz, albite feldspar, black tourmaline, and a little beryl. The small cavities were partly filled with reddish-brown greasy-feeling clay, and the same material, together with limonite stains, had permeated joints and seams through the pegmatite. The feldspar of the pegmatite had partly decomposed in places, so that the rock broke down rather easily. Some of the crystals of emerald were firmly attached to other minerals, and some were loose and could be obtained by washing the semidecomposed matrix. At first many small fragments and crystals of emerald were found in this way, but later gem emerald was found in place in the harder rock.

The emeralds were simple hexagonal crystals of beryl that had the prism faces and base. Many of them were deeply striated and etched, especially on the prism faces, which gave them an appearance like that of tourmaline. Other crystals had internal striations or irregularly shaped tubes extending through their length. These tubes ranged from subcapillary size to those that composed an appreciable part of the crystal. Some had been filled with clay or stains of iron. The finer tubes appeared as silky striations in the crystals. The crystals ranged in size from that of a portion of a large needle to a broken specimen seven-eighths of an inch thick and nearly 5 inches long.

Some of the emeralds were of fine quality, but most of them were of only medium grade. The best stones had the deep grass-green or emerald-green color characteristic of that gem, and only the average amount of flaws or defects common in good emeralds. Other stones had a fine and deep color, but defects, such as cracks, cloudiness, or silky inclusions, were prominent. Some gems of paler grass-green color but almost flawless were found. The gems have been cut in both faceted and cabochon forms with good effects. Gems cut cabochon which contain many silky internal striations give a cat's-eye effect when tipped to and fro. The quality of many of the emeralds could not be judged from their external appearance, as the exterior was badly striated and the reflection of the light made the stone appear both of lighter color and more imperfect than it proved to be when cut.

In all the other prospecting on the Old Plantation emerald mine property the most promising discovery was the occurrence of beryl in pegmatite in a cut 90 feet from the main working in a direction south of east. This beryl occurred in small partly clear crystals with a pale aquamarine color. It cut into brilliant gems. Other rough crystals of beryl, some with patches of good aquamarine color, were found in pegmatite in the trench 200 feet east of the main workings. These workings are apparently outside the limit of the hypersthenite and gabbro formations.

Emerald contains a small percentage of chromium oxide. An analysis of Colombian emerald by F. Wöhler showed 0.186 per cent of chromium oxide. Analyses of the hornblende hypersthenite and olivine gabbro from the Old Plantation emerald mine showed 0.16 per cent and 0.17 per cent respectively. Beryl has been found in pegmatite that cuts gneiss and schist at other places in this region, but the only emerald deposit found is in pegmatite that cuts a chromium-bearing rock. This association seems to be a natural one and suggests that there was a partial absorption of the basic rocks by the granite magma and that some of the constituents of the basic rocks were taken into solution.

Pegmatite associated with hypersthenite and gabbro can not everywhere be expected to carry emerald, for beryl has been found in only a very small proportion of the large number of pegmatite masses that occur in the region. Besides chromium-bearing basic rock and pegmatite, the presence of the chemical elements that enter into the composition of beryl in the original pegmatite-producing solutions or magmas would be necessary. Outcrops of basic rocks similar to those at the emerald mine occur in a number of localities in this region, and some of these are near granite if not associated with it. Pegmatite cuts some of these masses of basic rock, and in some of the outcrops crystals of black tourmaline, quartz, and quartz-inclosing actinolite occur as at the emerald mine. Other areas of hornblende hypersthenite and hornblende-hypersthene peridotite are shown on the areal-geology map of the Gaffney quadrangle, and several outcrops occur north of that quadrangle within 2 or 3 miles of the emerald mine.

### LEAD

Galena, or sulphide of lead, occurs in some of the barite deposits, especially at the Lawson mine and at the Kings Mountain gold mine, and was obtained during the Civil War at the Cameron lead mine, $2\frac{3}{4}$ miles southeast of Gaffney. The Cameron deposit is reported to have been worked to a depth of about 140 feet and to have produced in all only a few hundred tons of lead ore. It was opened first as a copper prospect and was later worked for lead. The country rock is hornblende schist inclosed in intrusive granite gneiss. The formations strike about N. 35° E. and near the mine dip 40°–70° SE. The workings show the vein to be nearly parallel with the schistosity of the inclosing rock. Specimens of the minerals of the vein that were found on the dumps included siderite, quartz, galena, and chalcopyrite. Other metallic minerals, such as pyrite, pyrrhotite, and tetrahedrite, and secondary minerals, such as pyromorphite and malachite, were reported to have been present, especially in the upper part of the mine.

### MANGANESE

About 15 or 20 prospects have been opened for manganese ore in the Gaffney-Kings Mountain district. They are all included in the manganese schist member of the Battleground schist and are scattered along this member from Crowders Mill or Philipsburg southwestward across both quadrangles.

The nature of the deposits has been briefly outlined in the description of the rock with which they are associated. The manganese occurs as black oxides and hydroxides, both in masses and disseminated in films and stains through a wide belt of the schist. Where the manganese ores have accumulated in masses they are generally associated with considerable quartz and occur in irregular veins that are more or less conformable with the inclosing schists. The veins range from mere seams to deposits several feet thick. In many places streaks of the schist are included in the larger veins or lie between parallel veins. Smaller veins branch out from the larger ones and cut the schists at different angles. In one place a vein may be largely filled with manganese oxides, whereas in another place the same vein may carry more quartz than manganese minerals. The weathering of the manganese veins sets free large quantities of manganese oxides, which stain the surrounding schist strongly, and leaves boulders of ore on the surface, thus giving the appearance of larger deposits than are really present.

Irregularities in the veins and the deceptive appearance of indications at the weathered surface make prospecting for the manganese ores uncertain. Long crosscut trenches have to be made in some places to locate the richest deposits, and veins of apparent promise at the surface pinch or become less promising with an excess of quartz at depth. Other veins hold out fairly well on continued prospecting but are not sufficiently large to guarantee profitable working at depth. Several carloads of manganese ore from such veins are reported to have been shipped from this region. Analyses of the ores show a range from 15 to 57 per cent of metallic manganese, according to the care used in sorting.

Most of the prospects consist of surface pits or cuts and shafts only 20 or 30 feet deep, but a few shafts have been carried down 50 feet or more. At a deposit 1 mile northwest of the Kings Mountain Battleground a shaft was sunk about 125 feet deep, and some drifting was done from it along the vein. Because of irregularities in the vein and the consequent uncertainties of the quantity of ore to be expected in mining, work was abandoned. The manganese deposits of this region have not proved of present value but may be of value in the future.

### PYRITE

A pyrite deposit in the Lincolnton quadrangle, north of the Kings Mountain quadrangle, has been worked on a large scale to supply ore for a sulphuric acid manufacturing plant at Blacksburg, but only a few small pyrite prospects have been tested in this region. One of these prospects is on the Ross property, $2\frac{2}{3}$ miles S. 22° W. of Kings Creek station, and another is $3\frac{3}{4}$ miles nearly due north of Kings Creek station, close to Kings Creek.

The Ross prospect is in a bed of quartz-sericite schist several feet thick, inclosed in a large body of Bessemer granite. The schist was heavily impregnated with small grains of pyrite, and in places pyrite constitutes nearly all of the rock. An analysis by Sloan[8] shows nearly 42.5 per cent of sulphur and 40 per cent of metallic iron with the rest chiefly insoluble material.

In the other prospect the ore consisted chiefly of vein quartz heavily impregnated with small crystals of pyrite. It occurred in a vein about 5 feet thick in chloritic mica schist belonging to the Carolina gneiss and near its contact with Roan gneiss and Bessemer granite. Pyrite composed only about half the bulk in the specimens seen.

The ore obtained at some of the gold mines contains so much pyrite that the possibility of saving the pyrite has been considered.

### MICA

Mica-bearing pegmatites occur in the Gaffney-Kings Mountain district, but only a few small prospects have been opened, chiefly in the Kings Mountain quadrangle. At one of these prospects, about $3\frac{1}{2}$ miles southwest of the town of Kings Mountain, plates of mica more than 3 inches across and of good quality were found in a shaft that is now filled up. Some of the outcrops contain crystals of mica 2 to 3 inches across, but few of them are sufficiently promising to warrant development. This prospect lies in the Whiteside granite close to the Carolina gneiss. The mica deposits in the Lincolnton quadrangle have produced a quantity of fine-grade mica. The formations most likely to contain mica are the highly metamorphic varieties of the Carolina gneiss inclosing pegmatite.

### GRAPHITE

Graphite has been found at a number of localities, chiefly in areas of the Carolina gneiss, but no deposits have yet been found that could be profitably worked. In some places the graphite is sparingly scattered through mica, kyanite, and garnet schists and gneisses, in pegmatized gneiss, and in the marble and associated schists at the Kings Mountain gold mine. The deposits that have appeared most promising consist of graphitic mica schists in which the graphite forms only a very small percentage of the mass. Such deposits have been prospected near Blacksburg—in the gap of Whitaker Mountain, at three places west of the town, and about 3 miles north of the town.

### GARNET

Garnet occurs abundantly in the form of crystals, the largest of which are 4 inches or more in diameter, scattered through the gneisses and schists, especially of the Carolina gneiss. In some places garnet occurs in compact masses as much as 3 feet thick, consisting of small grains generally mixed with quartz and stained with manganese oxides.

Most of the crystals of garnet in the schists have been more or less crushed and fractured, and near the surface they have undergone various stages of alteration along the cracks. In many places entire crystals of garnet have decomposed, leaving only patches of iron and manganese oxides or rust behind. In other places only portions of the crystals have decomposed, leaving fragments of fresh garnet inclosed in the iron and manganese oxides developed along the fractures. At a few places near the surface and in most places below the zone of weathering the fractured garnet remains fresh and practically unaltered. By the weathering of garnetiferous rocks the partly decomposed crystals of garnet are set free and in some places cover the surface like pebbles of rusty gravel.

In a few places clear, flawless pieces of rich red garnet are found by breaking up the larger crystals. It is usually necessary to remove the coating of rust from weathered fragments with acid before the quality shows itself. A few specimens with good color and of sufficient size for cutting into gems have been found. Garnet has been observed most plentifully in the northeast corner of the Gaffney quadrangle. Specimens suitable for gems have been found in this area in the vicinity of Earl.

The abundance of garnet in the soils and in some of the rocks would seem to indicate that it might have a value as an abrasive material. So far as known this value has not been tested. In cleaning the monazite sands of this region a large quantity of garnet in grains has been separated from the concentrates. An attempt was made to market this product for use as an abrasive material, but owing to the rounded corners and the small size of the grains, which did not permit them to be crushed much finer, the material was rejected or brought only small prices.

### CORUNDUM

Specimens of corundum have been found in several of the monazite placers and in the placer gravel at the Ross mine. Many specimens have been found in the soil about 4 miles west-southwest of Earl, along a belt about $1\frac{1}{2}$ miles long that has a northward trend and crosses from South Carolina into North Carolina. No excavations have been made, but in one place small crystals of corundum were observed in the matrix.

The country rock consists of muscovite-biotite schist that incloses streaks of biotite granite and is surrounded by a large body of Whiteside granite. All the rocks have weathered greatly, and only some highly micaceous beds that have resisted decay more strongly remain to show the trend of the formations. These beds have an average strike of nearly north and an easterly dip of 20° to 30°. In one such ledge small crystals of gray corundum were inclosed in a schist that consists almost wholly of muscovite and biotite.

Most of the corundum has been found loose in the soil in crystals that are as much as 2 inches thick and 6 inches long. The greater number of the crystals are tapering and roughly hexagonal in shape. Many of them are coated with micaceous products of alteration. The corundum is gray to bronze-colored, and some crystals show a strong sheen or chatoyancy.

### SOILS

The alluvial soils along the bottom lands were originally very rich, but many of these lands have deteriorated by denudation and the accumulation of sand and gravel over the surface during floods. Most of the bottom lands are covered with 2 feet or less of fine loam underlain by a layer of gravelly sand that rests on the bedrock. Drainage is usually good, and there are no extensive swamps.

The upland residual soils are variable, and their character depends on the character of the rocks from which they have formed and the extent of weathering that they have undergone. In general, after thorough decomposition, the limestone formations have weathered to the richest residual soils. The hornblendic rocks, biotite granite, biotite gneiss and schist, and mica-garnet-kyanite gneiss, form soils in a descending grade of fertility, and the quartzite and quartz-sericite schist probably make soils that are among the poorest. Where rock decay has not extended deeply or has been only partial this order of fertility of soil derived from different formations does not hold. As a whole, the depth of rock decay corresponds closely with the order of fertility as given.

In some areas of hornblendic rocks there is a dark-greenish sticky gumbo-like soil which has a tendency to form swampy or boggy depressions, even on the ridges. These soils are poor and hard to cultivate. Partly disintegrated granite or sandy soils lose their moisture too easily by drainage and evaporation and accordingly do not stand droughts well. The mica-garnet-kyanite gneiss and schist leave ferruginous pebbles scattered thickly on the surface in many places, even where well decomposed. The less decomposed masses form extremely gravelly or rocky soils in which the loose fragments are covered with thick stains of iron oxide. Most of the quartz-sericite schists leave fine light-colored sandy soils, which are commonly not very fertile. The quartzite soils usually contain many fragments and blocks of the quartzite, and ledges are common.

### WATER RESOURCES

*Surface water.*—The Gaffney-Kings Mountain district is well supplied with surface water. Practically all the surface water, except that of Broad River, First Broad River, and Buffalo Creek, is derived from the springs of the district. The two rivers head in the high forested lands of the Blue Ridge. The springs and streams are very abundant and of excellent quality for ordinary uses. Almost all the water comes from springs that emerge from schist, gneiss, and other rocks that contain numerous partings (schistose planes), which are generally inclined at high angles to the surface. Through these partings the underground water readily reaches the surface where the topographic form is favorable, as it is throughout practically all the district except the areas near the divides between the drainage basins. Small areas around Kings Mountain and Gaffney, for example, are only gently rolling, and the springs are fewer and streams do not gather as quickly as in most other parts of the quadrangles. Within a mile or two of their heads practically all the streams have sunk their channels into sharp, narrow valleys with rather steep sides, which afford easy access to the water table. This feature is characteristic of the region as a whole, which is a plateau that is now being deeply dissected.

*Ground water.*—The region is well supplied with ground water suitable for drinking. This water becomes available both as springs and by the digging or drilling of wells. Springs are rather numerous along the sides of the valleys and within them and yield good flows for domestic use. The spring waters are in general cool and potable. In the uplands water of similar quality can be reached by wells from 30 to 60 feet deep. It is rarely necessary to dig deeper than 60 feet, and in favorable places 20 to 30 feet will procure a water supply.

A number of mineral springs have been found in the district, and a few of them have been developed on moderate scales for medicinal water and as health resorts. Among these springs are Piedmont Springs, Patterson Springs, Lipscombe Spring, and Allhealing Spring. The Piedmont Springs water is a mild sulphate water. A slight odor of hydrogen sulphide is noticeable in the water of Patterson Springs.

*Water power.*—The water power of the quadrangles is large, for the rainfall is heavy and the slopes of the streams are steep. The larger and more valuable power sites are located along Broad River. This stream flows from northwest to southeast across the Gaffney quadrangle and the southwest corner of the Kings Mountain quadrangle. The fall is concentrated mainly at Gaston Shoals and at Cherokee Falls and within 4 miles just below the falls, among the Ninety-nine Islands, where the river crosses very resistant beds of rock. These places contain by no means all the power, however, for the river falls within the district from 650 feet above sea level at the northwest to 430 feet at the southeast. Small tributaries of the river, such as First Broad River, Thicketty Creek, Clark Fork, Kings Creek, and Buffalo Creek, are capable of furnishing some power, for they drain well-watered and forested basins and have greater amounts of fall than Broad River itself.

Developments on Broad River at present (1925) consist of a 72-foot dam of the Southern Power Co. at Ninety-nine Islands, half a mile above the mouth of Kings Creek; a dam creating a 48-foot head at Gaston Shoals; and a 9-foot dam, with possibilities of increasing the height, at Cherokee Falls. The capacity at Ninety-nine Islands is 31,200 horsepower and at Gaston Shoals 18,000 horsepower. The water power at Ninety-nine Islands and Gaston Shoals is converted into electric energy and transmitted considerable distances. At Cherokee Falls the power is used directly in operating a cotton mill. Another hydroelectric plant is in operation on First Broad River about 2 miles southeast of Sharon. Smaller power developments on the different creeks are used locally in flour mills and cotton gins.

[8] Sloan, Earle, op. cit., p. 116.