GEOLOGICAL SURVEY OF GEORGIA

S. W. McCALLIE, State Geologist

BULLETIN NO. 43

GEOLOGY OF THE TATE QUADRANGLE, GEORGIA

BY

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UNIVERSITY OF ILLINOIS

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THE ADVISORY BOARD

OF THE

GEOLOGICAL SURVEY OF GEORGIA

in the Year 1928

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LETTER OF TRANSMITTAL

GEOLOGICAL SURVEY OF GEORGIA,

ATLANTA, November 15, 1928.

To His Excellency, L. G. Hardman, Governor and President of the Advisory Board of the Geological Survey of Georgia.

SIR: I have the honor to transmit herewith the report of Professor W. S. Bayley on the Tate Quadrangle to be published as Bulletin Number 43 of this Survey.

I would add that it was only by the liberal contribution of Col. Sam Tate, President of the Georgia Marble Company, to the State Geological Survey, that it was enabled to co-operate with the Federal Geological Survey in the preparation of an up-to-date topographic map on which the areal and the structural map accompanying this report was worked out. The contribution here referred to was approved June 9, 1926, by the Advisory Board of the Geological Survey.

Very respectfully,

S. W. McCALLIE,

State Geologist.

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PREFACE

The field work upon which the following report is based occupied 11 weeks in the summer of 1925, about 4 weeks in August of 1926 and 10 days of June in 1927. The office work was done at the University of Illinois at such time as could be spared from University duties.

During the first summer the author was ably assisted by Mr. Charles Milton, graduate student at the University of Illinois and Mr. R. H. Haseltine, graduate student at the Johns Hopkins University. During the second summer he was accompanied by Mr. A. N. Murray, graduate student at the University of Illinois, to whose careful surveying much of the value of the accompanying geological map is due. In June, 1927, Mr. A. Keith of the United States Geological Survey visited the field and examined certain critical areas in company with the writer. With the help of Mr. Keith the problem of the faulting that caused the peculiar distribution of the white marble belts is believed to have been solved. The author wishes to express his appreciation of the generous way in which Mr. Keith's long experience in unraveling the complex geology of the Southern Appalachian region was placed at his disposal.

The writer wishes also to thank the officials of the Georgia Marble Company for their unfailing courtesy to him during the progress of the work, especially for the many favors granted him while in the field, and to Mr. S. W. McCallie, the State Geologist of Georgia, for his ever-ready willingness to furnish all the help needed in the study and for the patience with which he waited for the completion of the report.

W. S. BAYLEY.

University of Illinois, Urbana, Ill., July 21, 1928.

GEOLOGICAL DEPARTMENT

BIENNIAL FINANCIAL STATEMENT

December Thirty-First, Nineteen Twenty-Eight.

Advisory Board, Geological Survey of Georgia:

Gentlemen: I beg leave to submit the following financial statement covering the receipts and disbursements of the State Geological Survey for the years 1927 and 1928:

Receipts

Balance in Treas. January 1, 1927	$ 351.52		
Balance in Bank January 1, 1927	461.97		
Appropriation for 1927 and 1928	30,000.00		
			$30,813.49

Disbursements

Geologists Salaries:			
State Geologist (2 Yrs.)	$ 9,000.00		
Asst. State Geologist (2 Yrs.)	5,175.00		
Special Asst. (Part time 2 Yrs.)	508.00		
		$14,683.00	
Office Salaries:			
Chemist	$ 2,874.00		
Clerk	2,384.16		
Custodian of Museum	1,779.00		
Porter	1,050.00		
Secretary of Board	200.00		
		$ 8,287.16	
General Expense:			
Postage	$ 194.38		
Freight and Express	35.43		
Telephone and Telegraph	185.59		
Printing and stationery	3,212.80		
General Expense	151.52		
Library	62.00		
Travel—Mileage	337.69		
Travel—Expense	1,545.86		
Field Equipment	302.97		
Laboratory Expense	792.73		
Office Expense	439.49		
		$ 7,260.46	
Balance in Treas. Dec. 31, 1928		444.49	
Balance in Bank Dec. 31, 1928		138.38	
			$30,813.49

Respectfully submitted,

S. W. McCallie,

State Geologist.

GEOLOGY OF THE TATE QUADRANGLE

By W. S. Bayley, University of Illinois

INTRODUCTION

LOCATION

The Tate quadrangle occupies an area in northwestern Georgia that is bounded by the parallels 34° 15′ and 34° 30′ N. and the meridians 84° 15′ and 84° 30′ W. (Fig. 1.). It is the northwestern quarter of the Suwanee quadrangle which was mapped in 1887 on the scale of about 2 miles to the inch and with a contour interval of 100 feet. Since that time so many new roads have been built in the area, and, since the establishment of the rural free delivery system, so many of the old post offices have been abandoned that the old map is now useless. Consequently a new survey of the northwest quarter of the Suwanee quadrangle was undertaken in the summer of 1926 and a new map was drawn on the scale of one mile to the inch and with a contour interval of 20′. This was given the name Tate, after that of the settlement in the center of the quadrangle. The field work was done by members of the United States Geological Survey, the expense being borne partly by this Survey and partly by the Geological Survey of Georgia.

The Tate quadrangle includes the eastern part of Pickens County, the northeastern quarter of Cherokee County, a narrow strip along the west side of Dawson County and a small area in the northwest corner of Forsyth County. It is crossed in a generally north-south direction by the Knoxville Branch of the Louisville and Nashville R. R. which enters the quadrangle near its southwest corner, bends toward its center and leaves it near its northwest corner. All the large settlements in the quadrangle, Jasper, Tate, Marble Hill, Nelson and Ball Ground, are on or near its right of way and Canton, the largest city in the neighborhood, is just south of the southern boundary of the quadrangle, also on the railroad.

The greater part of the inhabitants of the quadrangle are farmers who are fairly well distributed over all of its area except its northeast corner which is occupied by Grassy Mountain and its spurs.

The principal industry of the district is the quarrying and finishing of marble. Georgia contests with Tennessee the position of the second largest producer of marble among the States of the Union, being exceeded, as a rule, in the value of this product only by Vermont. Most of Georgia's marble comes from the small area in the neighborhood of Tate and Marble Hill where there is a row of quarries that have furnished stone for some of the most notable structures and some of the most famous pieces of sulpture in the United States.

TOPOGRAPHY

According to La Forge[1] the area included in the Tate quadrangle lies mainly in the Piedmont Upland. (See Fig. 1). A small portion of its northern part is in the Appalachian Mountains district.

The Piedmont Upland, which is that portion of the Piedmont Plateau that crosses the State, is divided into two parts called Midland Georgia and Piedmont Georgia. The Midland division lies southeast of the Piedmont division. It is characterized by possessing little diversity of relief. Its surface is interrupted by very few residual hills (monadnocks) and its drainage is for the most part directly into the Atlantic Ocean. Piedmont Georgia, on the other hand, has considerable diversity of relief. Its surface is broken by scattered monadnocks rising 100 to 1,000 feet above its general level. Its drainage is southwestward and westward to the Gulf of Mexico. The Tate quadrangle is mainly in Piedmont Georgia, and in those topographic subdivisions

[1] La Forge, Laurence and others, Physical Geography of Georgia: Geol. Survey of Ga., Bull. 42, p. 57-61, 1925.

of this division which have been called the Dahlonega and the Atlanta plateaus. The former comprises a belt of country that skirts the southern edge of the Appalachian Mountains. (Fig. 1.) "It is a belt of hilly country scarcely recognizable as part of the upland, so many and large are the residual mountains that stand above the general level, and so deep and sharp are the valleys that are cut below it." The Atlanta Plateau is southwest of the Dahlonega Plateau and extends from this to the northern edge of Midland Georgia. It is a broadly rolling area, containing a few residual mountains, most of them rather large and high, and is traversed by several deep but rather flaring river trenches.[2]

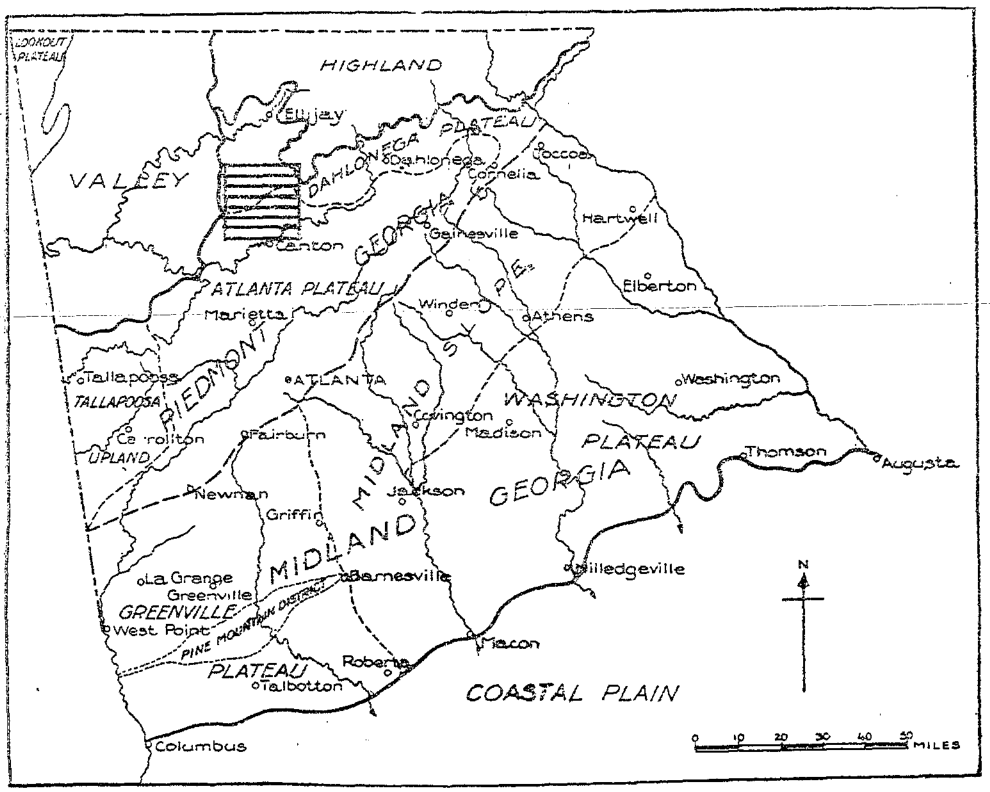

Fig. 1. The topographic divisions of the Central Upland of Georgia. Small rectangle shows the location of the Tate Quadrangle.

Except for the small area of mountains in the northeast corner of the quadrangle, the northern part of the Tate quadrangle is in the

[2] La Forge, L., Cooke, W., Keith, A., and Campbell, M. R., Physical Geography of Georgia: Geol. Survey of Ga., Bull. 42, pp. 93-114, 1925.

Dahlonega Plateau and its southern part in the Atlanta Plateau. (Fig. 1.) The vague boundary between the two divisions enters the quadrangle on its west side just south of Sharp mountain, runs northeast of Jasper and thence southeast, leaving the quadrangle on its east side at about the northern margin of the valley of the Etowah River.

The only part of the Appalachian province that is represented in the Tate quadrangle is the small area in its northeast corner that is occupied by Grassy Mountain and its spurs. With its steep slopes, deep valleys, high peaks and long, narrow ridges it exhibits the characteristic Appalachian topography, but its area is so small that these features are recognized only when they are projected northward into the Ellijay quadrangle. (Plates I and III B). The only distinct peak in the quadrangle is Grassy Mountain with an elevation of 3,290 feet. (Plate II A.)

The mountains are well wooded and are very scantily populated. (Plate I.)

GEOLOGY

The whole quadrangle is in crystalline rocks except for the presence of quartz veins, which though numerous in some places, do not cover much of its area. Most of the rocks are schistose. They are intruded by a few dikes of diabase or basalt that are massive and by peridotite, granite and pegmatite which at a few places exhibit only traces of schistosity. Most of the granite and pegmatite is gneissoid. Some is markedly schistose. All the rocks other than marble, granite, pegmatite, peridotite, diabase and the quartz of quartz veins, are crystalline schists. Some are the ordinary types of hornblende schists, garnetiferous mica schists, amphibolites, greenstone schists and gneisses. Others are comparatively fine-grained micaceous and garnetiferous schists that are metamorphosed graywackes. These occur in the eastern half of the quadrangle. They are regarded as pre-Cambrian.

In the western half of the quadrangle are fine-grained mica schists, many of them rich in garnets, some containing staurolite and others containing kyanite, quartz schists, graywacke schists, a few schistose conglomerates and black or dark-gray carbonaceous schists, of which most contain mica. All of these represent sedimentary rocks.

In many places the sedimentary schists can be seen to occur in distinct beds. They are cut by quartz veins, pegmatite, granitic and dioritic rocks, which for the most part are distinctly schistose. Interbedded with them are fine-grained, bluish-gray and comparatively coarse-grained white and pink marbles. The entire coterie of rocks in the western part of the quadrangle is believed to represent a series of sedimentary beds that have been metamorphosed and intruded by veins and bosses of igneous magmas. They are regarded as a part of Safford's[3] Ocoee group, which is now believed to include beds of various ages earlier than the end of Paleozoic time. Most of the members present in the Tate quadrangle, if not all of them, are believed to be Cambrian, since they can be traced northeasterly through the Ellijay into the Nantahala quadrangle. Here their Cambrian age is pretty well established by comparison with the rocks in the Cranberry quadrangle, where the upper beds of the Erwin quartzite, immediately under the Shady limestone, contain sparse lower Cambrian fossils of the Olenellus fauna.[4] The rock beds in the Nantahala quadrangle have not been traced directly into those of the Cranberry area, but their nature is the same in both areas and their sequence is similar, so that there appears to be little doubt that they are of the same age. As the Olenellus fossils were observed in a sand rock that is well up in the series it is possible that its lower members should more properly be regarded as Algonkian, but this has not yet been proven to be the case.

All the rocks in the Tate quadrangle are so thoroughly metamorphosed that the surface of demarkation at the top of the pre-Cambrian has been obliterated, and consequently the boundaries between the Cambrian and pre-Cambrian areas cannot be indicated with any very close degree of accuracy. The line on the map separating them is only approximately correct. It is based mainly on slight differences in the

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[3] Safford, J. M., Geology of Tennessee., Nashville, 1869.
[4] Keith, Arthur, U. S. Geol. Survey Geol. Atlas, Cranberry folio (No. 90), p. 5., 1903.

intensity of the metamorphism to which the rocks on opposite sides of the line have been subjected.

THE PRE-CAMBRIAN FORMATIONS

CHARACTERIZATION OF THE PRE-CAMBRIAN FORMATIONS IN GENERAL

The pre-Cambrian rocks in some parts of the United States and in Canada have been divided into two systems, which, according to the nomenclature employed by the U. S. Geological Survey, are denominated the Archean and the Algonkian. The Algonkian rocks are defined as a great system of rocks usually separated from the Cambrian system above by a distinct unconformity. "This system consists dominantly of rocks deposited under substantially the same physical conditions as those which obtained during the Cambrian and later periods. That is these rocks are chiefly shales, sandstones, and limestones, and their metamorphosed equivalents. Associated with this system of rocks, both as intrusives and extrusives, are igneous rocks, precisely as is the case with the later systems. In some regions this system is represented by two or more series of rocks, separated by unconformities. While scanty fossils have been found in the Algonkian rocks of a few areas, as yet they have not been discovered so dis-distributed and in such abundance as to serve the purposes of correlation of the series from province to province."[5]

Beneath the Algonkian rocks is another series which is believed to be much older. This series constitutes the Archean system, which in most places is so thoroughly metamorphosed that it now consists of gneisses and schists cut through and through by granites, gabbros, pegmatites and other intrusive rocks, all so closely folded that in most regions they form a complex which has not been satisfactorily unravelled.

The Archean rocks are characterized by Wilmarth[6] as follows:

"Below the Algonkian, and separated from it by a profound unconformity in the majority of regions, is another system or rocks of radically

[5] Wilmarth, M. G., U. S. Geol. Sur. Bull. 769, p. 103, 1925. Quotation from U. S. Geol. Sur., 24th. Ann. Rept., p. 26, 1903.

[6] Ibid., p. 127. Quoted from U. S. Geol. Sur., 24th. Ann. Rept., p. 26, 1903.

different character. This system consists dominantly of schists and gneisses, the chemical composition of which, so far as tested, corresponds with igneous rocks rather than with sedimentary rocks. The lithologic variations of these schists and gneisses are exceedingly complex. Usually accompanying this lithologic complexity is exceeding intricacy of structure. In this matter of unparalleled intricacy of structure the system is unique. Many masses of igneous rocks belonging to later systems are intrusive in the ancient schists and gneisses. In various parts of the world minor masses of metamorphosed sediments are intimately associated with the remainder of the system."

Because of the profound metamorphism to which the rocks in the Southern Appalachian region have been subjected there is great difficulty in distinguishing between those belonging in the different systems, and consequently they have not been differentiated, but have all been grouped in the Archean. It has been recognized that Algonkian rocks have probably been included with Archean rocks in the mapping, but it has been thought that the latter are in great excess and that it is impracticable to separate them.

In the Tate quadrangle pre-Cambrian rocks which were originally different, if there were such, are now so similar in character that they cannot be distinguished and all are therefore classed together. That two groups are present is indicated by the fact that some of the conglomerates which are classed as pre-Cambrian contain pebbles of hornblende schists, like some types of the Roan gneiss, which must have existed as hard rocks before the conglomerates were formed. But, as a rule, the conglomerates are so involved in close folds that they cannot be separated successfully from the other rocks with which they are associated.

THE PRE-CAMBRIAN FORMATIONS IN NEIGHBORING QUADRANGLES

In his discussion of the geology of the Nantahala quadrangle in North Carolina Keith[7] divides the Archean in this district into the Carolina gneiss and the Roan gneiss. These are intruded by granites,

[7] Keith, A., U. S. Geol. Sur. Geol. Atlas. Nantahala folio (No. 143), pp. 2-3, 1907.

pegmatities, pyroxenite, dunite, serpentine, and basalts. Some of the intrusions are of Archean age, but others are probably much younger.

Carolina Gneiss

La Forge and Phalen[8] in their description of the geology of the Ellijay quadrangle, which lies immediately north of the Tate quadrangle, define the Carolina gneiss in that district as consisting of an immense series of interlayered mica gneiss, garnet-kyanite gneiss, mica schist, quartz schist, garnet schist, conglomerate, kyanite-graphite schist, and fine granitoid layers. Layers of granite material and lenses of pegmatite are abundant in some parts of the formation.

The pebbles of the conglomerate beds are as a rule small and more or less scattered, and the rock ought perhaps to be called pebbly sandstone or sandstone with pebbly layers. The genuine pebbles are composed of quartz, but many beds contain apparent pebbles of feldspar which are uncrushed and probably of later origin than the groundmass of the rock, and which are believed to be due to impregnation of the rock by a granite magma.

The schists are composed largely of quartz, with which is associated some sericite and as a rule some biotite and a little feldspar. Some varieties are composed almost wholly of quartz, some contain much biotite, and others include a great deal of garnet. As a rule they are fine-grained and of even texture, with the minerals uniformly distributed, and they show marked schistosity. The beds range from a few inches to many feet in thickness.

The gneisses are generally rather fine-grained but are well banded, the layers averaging less than an inch thick. Some of the granitoid layers are composed of quartz and feldspar only, but most layers contain more or less biotite and some muscovite.

In some parts of the quadrangle are also layers of blackish, dark-gray or bluish-gray schist so involved in the Carolina gneiss that they are regarded as part of that formation. The individual beds split up and taper off between layers of the gneiss, so that it is difficult to map

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[8] La Forge, Lawrence and Phalen W. C., Description of the Ellijay quadrangle: U. S. Geol. Sur. Geol. Atlas. Ellijay folio (No. 187), p. 4, 1913.

them separately. For this reason they are shown on the map without definite boundaries. They are composed largely of quartz, with a very little feldspar and some mica, and in most places enough carbonaceous material to give them a distinctive dark color. Garnet appears in many beds, and in places kyanite is abundant, the largest crystals measuring an inch or more in length. The schists are characterized by a silky luster and generally by a fine curly or crinkly texture, with a marked schistosity. In some places the carbonaceous matter is nearly or quite wanting and the schist is brownish or yellowish.

In other places a garnet-kyanite gneiss is interbedded with conglomerate and gneiss. It is a coarse-grained, dark-gray gneiss, with numerous small garnets, generally less than one-eighth inch in diameter, and abundant kyanite crystals, the largest one-half inch or more in length. It is very tough and exceedingly resistant to weathering, so that it has produced some of the roughest topography in the quadrangle.

In the Ellijay quadrangle, except for the intercalated granitic layers, nearly the whole of the Carolina gneiss appears to be of sedimentary origin, but in a belt several miles wide, in the southeastern part of the quadrangle, the rock may be of igneous origin.

Whatever the origin of the formation, its members have been subjected to at least two periods of extreme deformation. In the first period their mineral character was thoroughly altered, metamorphic minerals were formed, and foliation was produced; in the second the earlier structures were deformed and in places new foliation planes were superposed on them.

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

Roan Gneiss

The Roan gneiss consists of a series of hornblende gneiss, hornblende schist and schistose diorite with some intercalated mica schist, garnet schist and mica gneiss, that are identical with the corresponding rocks in the Carolina gneiss. Like the Carolina gneiss they are cut by granite and pegmatite. The hornblendic layers are dark-green or black. The hornblende schists are composed almost entirely of hornblende, with very small amounts of biotite, feldspar and quartz; the hornblende gneiss consists of layers of quartz and feldspar alternating with layers of hornblende schist. In some places the rock is nearly massive diorite or quartz diorite, in many places containing garnet.

The Roan gneiss, like the Carolina gneiss, has been subjected to great deformation and metamorphism. In all probability it was originally a series of diorites or hornblendites, of much the same mineral composition as at present. The minerals now composing the rocks of the formation are, however, largely of secondary origin and are arranged in parallel layers or with their longer diameters parallel, causing the schistosity. The planes of schistosity are deformed, and the rock gives the same evidence as does the Carolina gneiss of having passed through at least two periods of considerable deformation. The bands of quartz and feldspar in the hornblende gneiss were evidently formed after the earlier and before the later deformation.

The Roan gneiss generally occurs in long narrow lenticular or sheet-like bodies inclosed by Carolina gneiss. These bodies range in thickness from a few feet to several hundred yards and some of them have a length of several miles. Many are branched, some branches at length reuniting, and in places the sheets are complexly folded. Their dike-like form and their positions in the Carolina gneiss suggest that they were intruded into it, but the rocks of both series are so much metamorphosed that their contacts throw no light on that point.

Intrusives

Both the Roan gneisses and the Carolina gneisses, in the Ellijay quadrangle are intruded by pegmatite, granites and peridotite. The peridotite and some of the granites are believed to be pre-Cambrian.

The peridotitic rocks occur in small bodies within the Roan gneiss. In quadrangles farther northeast they appear to cut the layers of this formation, but because of the close association of the intruding and the intruded rocks and their lithological affinities, it is thought probable that the two sorts of rocks are nearly of the same age and that they may be differentiates of the same magma. Furthermore the periodotitic rocks have been as greatly deformed as the Carolina and Roan gneiss, and consequently are regarded as pre-Cambrian.

The peridotitic rocks in the Ellijay quadrangle include pyroxenite, picrite, diorite and serpentine. In other areas soapstone also occurs. The most common variety is a rock composed chiefly of monoclinic pyroxene with subordinate amounts of enstatite, olivine and magnetite. By alteration of the olivine and pyroxene, serpentine results.

The pre-Cambrian granite is a medium-grained biotitic rock composed of quartz, orthoclase, and biotite, with some plagioclase and magnetite and in some occurrences augite. The rock has been thoroughly metamorphosed and made schistose. The granite is believed to be pre-Cambrian because it has been intruded only in the Carolina and Roan gneisses and has undergone the same deformation and substantially the same amount of metamorphism as the gneiss. Other granites that exhibit much less strongly the effects of metamorphism are believed to be much younger.

The pegmatite which occurs abundantly, especially in that portion of the Ellijay quadrangle that is mapped as Carolina gneiss, is in veins and lenses from a foot to over a hundred feet wide. The veins, as a rule, are parallel to the foliation of the gneisses, but in many places they cut obliquely. The pegmatite is made up of coarsely crystalline quartz, feldspar, muscovite, and biotite; at some places the micas are lacking, at others muscovite occurs in sheets several inches in diameter.

Since the pegmatite bodies have been crushed and sheared, but have not otherwise been strongly metamorphosed it is thought that they have not been affected by the pre-Cambrian deformation to which the Carolina gneiss has been subjected. They are believed to belong to the same period of intrusion as the Whiteside granite of the Cranberry area, and like it to be of post-Cambrian age.

THE PRE-CAMBRIAN FORMATIONS IN THE TATE QUADRANGLE

General Character

In the Tate quadrangle the rocks regarded as pre-Cambrian occupy its eastern and southern parts. Their western boundary enters the quadrangle from the north at a point about 1 mile west of Sharp Top Mountain, runs a little east of south and south to a point near the bridge over Long Swamp Creek, 1½ mile southeast of Nelson, and then south westerly, leaving the quadrangle at its west margin a short distance north of its southwest corner.

The rocks of the area comprise mainly a coarse-grained garnetiferious mica gneiss and a strongly micaceous graywacke which in many places is so completely metamorphosed that it might well be called a mica schist. Some layers of the mica gneiss contain kyanite, others staurolite, and many of them both of these minerals. The graywackes contain garnets in some places, but except for the garnet and the mica are otherwise free from metamorphic minerals easily visible to the naked eye. A few of the graywackes were probably conglomeratic. Moreover, in several areas there are dark rocks which are correlated with the Roan gneiss of Keith and in one area the predominant rock is a white granite. This granite is intrusive into the gneisses and graywackes and has partially assimilated certain layers of them to form granitic gneisses. Other parts of the granite have been much squeezed and have had impressed upon them a gneissoid structure, which in a few places is so well developed as to have produced micaceous schists. The only other rock that occurs over a comparative large area in the eastern part of the quadrangle is a carbonaceous mica gneiss forming a narrow belt extending across its southeast corner from near the center of its south margin to the center of its east side. The rock is characterized by the presence in it of large garnets which are so numerous that they literally cover the roads that cross the belt. Its relations to the pre-Cambrian gneisses have not been discovered. In appearance it so closely resembles some phases of the Hiwassee slate, which in the Tate quadrangle is a carbonaceous mica gneiss, that it is thought that it might be a portion of this formation that may have been brought to the present surface by folding. For purposes of discussion it is called the Canton gneiss.

Nearly all the rocks of the pre-Cambrian area can be assigned to one or the other of the types referred to in the last paragraph. There are a few, however, that are different, but they occur in such small quantities that they are not mapped. Pegmatities are common, but only in narrow dikes or veins, and quartz veins are abundant. These are naturally younger than the rocks they cut, but most of them have been greatly sheared and crushed and consequently are regarded as pre-Cambrian. Others, however, are only slightly deformed. These are regarded as younger.

In the area in which the pre-Cambrian rocks predominate are also a number of trap dikes. But since they have not been affected by any of the deformational processes to which the other rocks have been subjected they are thought to have been intruded much later than the rocks they cut.

For purposes of discussion the pre-Cambrian rocks of the quadrangle have been classified, in accordance with the scheme proposed by Keith, into the Carolina gneiss, the Roan gneiss and intrusives.

The Carolina Gneiss

The Carolina gneiss in the Tate quadrangle is a composite formation which is made to include the light-colored quartzose schists and gneisses, and the schistose graywackes and conglomerates that are regarded as pre-Cambrian in age, because they have suffered more profound metamorphism than any of the rocks that have been placed in the Cambrian formations. (Plate IV). Some of the gneisses and coarser grained schists were originally igneous rocks, but others, including all of the graywackes and conglomerates were sedimentary. As a rule those of sedimentary origin occupy the western and northwestern parts of the area mapped as pre-Cambrian, whereas those of probable igneous origin are mainly in its southeastern part. The line between them is parallel to the belt of Canton schist and a little farther south. Along it, here and there in the stream channels, have been found exposures of a coarse conglomerate containing many schistose granite pebbles. It is possible that this line may mark a division between Archean and Algonkian rocks. At present, however, the separation between the two divisions of the pre-Cambrian cannot be established and all the pre-Cambrian lighter colored schists are classed together, although it is recognized as incongrous to group well-bedded graywackes and well-defined coarse gneisses as members of a single formation. It is possible that some of the gneisses were originally sediments, as the graywackes certainly were, but if this is the case the former have been subjected to much more metamorphism than the latter and probably therefore are of greater age. However, no proof of the correctness of this view can now be cited, and consequently all are grouped together.

The principal members of the Carolina gneiss are a coarse-grained garnetiferous mica gneiss, a fine-grained micaceous and schistose quartzose rock that is believed to be a metamorphosed graywacke or arkose, a few conglomerates and a few thin layers of quartzite. These are intruded by granite, peridotite, pegmatite, and basalt and are cut by quartz veins.

Garnetiferous Mica Gneiss

The coarse-grained garnetiferous mica gneiss is a gneissoid rock containing much quartz, large garnets, and an abundance of white mica. Smaller amounts of feldspar or its decomposition products are present in most of it, and in some places there are large flakes of black mica, especially in the neighborhood of the garnets. This rock is more widely distributed through the pre-Cambrian area within the quadrangle than any other. It is best seen in the hills south of the Marble Hill belt of marble, east and northeast of Tate post office, and in the country to the south and southeast. It is less commonly met with further north and is absent from the mountainous area to the north and northeast.

The principal type of the rock is a mica schist composed almost exclusively of plates of gray mica and small dodecahadral garnets with diameters that are rarely over a millimeter. A few flakes of biotite, a very few grains of some opaque mineral and a little quartz make up the balance of the rock. Most of the garnets show no elongation and the mica plates weave around them. The other components are scattered between the mica lamellae. There is no layering observable. (See plate IV). The rock weathers to bronze-yellow flakes, and upon further weathering becomes a mass of brownish-yellow micaceous sand. In some places the cracks developed in the rock by weathering are filled with a pink or orange, dense, clay-like mass of gibbsite and in some other places the whole rock is changed to pink clay probably of the same character.

An analysis of the orange clay in the cracks of an otherwise apparently fresh mica schist obtained from a well-opening on the hill southwest of Tate post office yielded to Dr. Edgar Everhart the figures:

Composition of orange-colored clay in crevices of garnetiferous mica schist

SiO_2	Al_2O_3	Fe_2O_3	MgO	CaO	FeO	MnO	Na_2O	K_2O	TiO_2	H_2O+	H_2O-	Total.
7.92	54.42	3.12	.08	.00	.00	.00	.08	Tr.	.18	32.00	2.21	= 100.01

The theoretical composition of gibbsite ($Al(OH)_3$) and the composition of the orange clay, after excluding silica, soda and titanium oxide, are:

	Gibbsite	Orange Clay	
Al_2O_3	65.41	60.77	64.25
Fe_2O_3		3.48	
H_2O	34.59	35.74	

Another type of the mica gneiss differs from that just described in containing feldspar and quartz. All gradations exist between the two. In some places there is a little granulated quartz and feldspar fairly evenly distributed between the mica plates and in others these two minerals are in lenses which are in some specimens so flat as to be more nearly of the nature of scales.

In thin section, one specimen of this type, from the hill just west of Cherokee quarry near Tate post office, shows streaks of crushed quartz and others of muscovite, as the preponderant components. Scattered between these are many cellular garnets, an occasional grain of staurolite, many small crystals of rutile, a few of apatite and of colorless needles of kyanite grouped in loose bundles. Biotite plates are common near the borders of the quartz-streaks where they are in contact with the muscovite. Epidote is also present in nests throughout the rock, but more particularly in the garnets and around their edges.

With increase in the quartz and feldspar the rock becomes layered and approaches in character the garnetiferous micaceous graywackes to be referred to later. On surfaces across their schistosity they have the appearance of fine-grained graywackes containing parallel lines of flattened garnets. On surfaces parallel to the schistosity, the rocks resemble garnetiferous mica schist. On all shearing surfaces muscovite and garnets are strongly developed. By increase in the sandy components, the gneiss apparently grades into micaceous graywacke. In many places the two rocks are plainly interbedded.

Where the shearing is intense and the rock is crushed into tightly crowded small folds it is changed throughout to a fine-grained mica schist, composed of extremely small flakes of muscovite and biotite and quartz. The quartz occurs mainly as lenses filling the turns of the folds. One such exposure is on the railroad track about 1 mile northeast of Canton. In the specimens from this exposure are a few fragments of tourmaline.

In some places the kyanite and staurolite, such as are found in small rods in the thin sections of many specimens of the gneiss, are developed on a large scale. In the hills on the east side of the valley in which is the Cherokee quarry and in the strip of country east of the railroad track south of Ball Ground are a few exposures and many fragments of a coarse mica gneiss that contain large crystals of staurolite and rods of kyanite. (Plate V A). In some of the exposures the staurolite-crystals are from 1½ to 3 inches long and from ½ to 1½ inches wide. Most of them are coated with muscovite and include numerous inclusions of quartz. In some places staurolite is the more abundant and in others kyanite. The layers in which the kyanite is present appear to be denser and more feldspathic than most layers, as though they had been saturated with aplitic material. Moreover, the kyanite is particularly noticeable in the neighborhood of mica prospects in pegmatite, and there is nearly always associated with it some tourmaline, which is a common component of pegmatites and quartz veins. Furthermore, in the Valleytown formation, where the kyanite is developed on a large scale, the beds containing the mineral are either cut by quartz veins or are saturated with quartz. It appears probable therefore that the kyanite has some genetic connection with siliceous intrusions.

A third distinctive type of the garnetiferous mica schist is a much more massive rock than either of the first two types. It contains a large quantity of feldspar, much more quartz and the garnets in it are larger. All the components except the garnet are lenticular, and these are elongate. The quartz lenses are so long and thin as to approach plates. In the lenses the minerals are crushed to mosaics. The structure of the rock is very much like that of a gneissoid granite, suggesting that it has been subjected to intense deformation since its constituents were developed.

The one specimen examined in thin section is seen to be composed of plates of muscovite and biotite, apparently in equal amounts, streaks and lenses of quartz mosaic, a few lenses of feldspar and an abundance of elongated garnets with very ragged outlines. A few apatite crystals and some magnetite dust are the only other components. Everything is arranged with parallel elongation and the structure is much more plainly schistose than in the hand-specimen. The garnets have the cellular, or sieve, structure characteristic of minerals produced by metamorphic processes.

In the gneiss of many exposures there is a noticeable tendency for the mica to be grouped into little knots. As the grouping becomes more marked the mica aggregates become larger and assume a lenticular shape like compressed pebbles in a conglomerate. On the weathered surface the gneisses of this kind look very much as though studded with couvex scales from some ganoid fish like the sturgeon or garpike. The first rocks in which these lenses were seen were thought to be squeezed conglomerates, but the nature of the supposed pebbles precluded that probability. The gradation of the pebble-like aggregates into others with irregular outlines and the fact that some of the lenses are complete crystals with rounded edges indicate that the mica was formed by crystallization in place, much as were the cellular garnets referred to above. In many of these rocks there are also lenses of granulated quartz, but there are no means of learning whether these are crushed pebbles or segregations that have been shattered.

Under the microscope the pebbles of a specimen from the road crossing Darnell Creek about ¾ mile southeast of Long Swamp Church appear to be aggregates of muscovite plates 2-3 mm. in diameter with ragged interlocking outlines. Most plates contain rod-like tiny crystals resembling sillimante and larger crystals of a strongly pleochroic tourmaline in green and tan colors. The aggregates appear to have accumulated around tourmaline.

It is probable that the "fish scale" gneisses were sediments that had been invaded by granitic juices before they were deformed, or during their deformation, and that the mica "pebbles" were formed during the process of deformation, probably by reactions between the original components of the sediment and the intruded granitic material. The presence of crystals of tourmaline in the aggregate suggests the action of igneous emanations.

Another gneiss differs from that just described in being spangled with large crystals of black biotite. Unlike the muscovite groups in the "fish-scale" schist, however, the biotite crystals lie across the planes of schistosity and apparently were produced after the first deformation, but before the last one, since their greatest elongation is always parallel to the schistosity. The rock is apparently like the spangled gneiss of the Ellijay quadrangle, which however is assigned by La Forge to the Great Smoky Formation which is Cambrian.

Graywackes

The graywackes in the Carolina formation are on the whole, dark and light-grey, fine-grained more or less schistose and heavily bedded rocks, which in cross-section appear quite massive. (Plate VI A). On surfaces parallel to their schistosity they sparkle with many tiny flakes of biotite. Along their bedding planes, where their shearing has been intensified, they have developed a great deal of mica, so that when viewed on these surfaces they appear to be well-defined mica schists. Where the shearing has been distributed fairly evenly throughout the layers the entire rock is a mica schist, in many places containing small garnets.

Most of the graywackes are in massive layers from a foot to several feet in thickness that are separated from one another by thin sheets of mica schist, in many of which are garnets. Series of beds of graywacke are interlayered with thick masses of garnet-mica gneisses, so that, whereas in some areas graywackes are the preponderating rock, in others the gneisses are in great excess, in some places to the complete exclusions of the graywackes. In other areas the two kinds of rock alternate in about equal proportions. The very thin layers of mica schist between the graywacke layers appear to be the result of shearing along bedding planes, but thicker layers probably represent a different kind of sediment, perhaps originally more argillaceous than the sands that gave rise to the graywackes, though some of the thick layers of fine-grained mica schist interleaved with the graywackes may be beds of arkosic sand in which differential shearing has affected the bed throughout.

In a few places the graywackes are thinly bedded. Thick layers are composed of almost paper-thin lamina that are emphasized by differences in weathering. In some the laminations may be a secondary structure due to shearing but in others they represent original differences in sedimentation.

The graywackes are composed essentially of quartz, plagioclases, biotite and muscovite with smaller amounts of orthoclase and the decomposition products of feldspars. Apatite, sphene, epidote and magnetite are also present in nearly all samples. Different beds may consist of rocks of slightly different colors, due to slight differences in the proportions of their components, but on the whole the graywackes are rather uniform in appearance. All of them are hard, tough and compact and most of them ring clearly under hammer strokes.

The lighter colored graywackes contain a greater abundance of feldspar than the darker varieties and many layers are micaceous arkoses rather than micaceous graywackes. In the lighter colored varieties the schistosity is generally more pronounced because the decomposition products of the feldspar are compressed into little lenticular masses.

Some graywackes are very fine-grained, almost black rocks, the dark color of which is due largely to an abundance of extremely fine flakes of reddish-brown biotite. Some are only slightly schistose, whereas others are so markedly schistose that they are now well-defined biotite schists composed predominantly of small grains of quartz, plagioclase and possibly orthoclase and small plates of brown biotite. In some places interlayered black and light-colored graywackes are common, the differences in the layers being due mainly to the presence in them of large or small amounts of brown biotite and magnetite. Large poicilitic garnets occur here and there in both kinds of layers, and small crystals of tourmaline are fairly abundant in each.

On the other hand a few of the graywackes are almost white. They are made up principally of quartz and feldspar with only specks of garnet and biotite. Some of them contain also small, white masses of feldspar that may be crystals or larger grains. In all the very light-colored varieties traces of bedding are nearly always noticeable. Where strongly sheared the light-colored graywackes become silver-white mica schists.

In thin section most of the graywackes are seen to be composed of quartz, plagioclase, biotite and muscovite, and smaller amounts of orthoclase and a little apatite, sphene, epidote and magnetite. The quartz is in comparatively large crushed masses and the feldspar in irregular sharp-edged grains. These are embedded in a fine-grained matrix composed mainly of the same minerals and micas. The micas are in plates, of which those of muscovite are much larger than those of biotite. All the muscovite and the crushed quartz are elongate in a parallel direction. The biotite flakes, which, as a rule, are smaller than those of muscovite, are also for the most part parallel to the muscovite and quartz but many plates are sharply inclined to the schistosity and some of them are perpendicular to it. Some of the crushed quartz masses have the outlines of rounded sand grains. Since all the minerals are clear and fresh it is believed that they have been recrystalized. In many sections both the muscovite and the biotite have the sieve structure indicating their secondary origin. Tourmaline in large fragments and small crystals is present in some specimens, small quantities of zoisite or clinozoisite, rutile and zircon are in others, and garnet is in a few.

The principal differences in the different graywackes are in the proportions of their constitutents. Some contain much more feldspar than others, in some cases so much that the rocks are more properly arkoses, and some contain much more biotite and magnetite, but otherwise they are similar. All are compressed and all show shattering of their components under the microscope. In some, however, all the mica is elongate in the direction of the schistosity, whereas in others much of it is inclined to the elongation of the quartz lenses. The muscovite flakes on the other hand always lie in the schistose directions. The feldspar is usually fresh but in some specimens there is a development of sericite and zoisite on the borders of their grains.

One member of the graywacke series deserves special mention, because it may throw a little light on the nature of some problematic rocks to be mentioned later. This member is a nearly white rock spotted with dull-gray chloritized specks that are distinctly elongated. When thoroughly sheared the rock becomes a very light muscovite schist. There is rarely any evidence of lamination in the unsheared rock but in a few places there are little knots of white feldspar that are drawn out into tiny tails giving the rock an appearance that suggests a squeezed rhyolite.

A typical specimen taken from the road side about 3¾ mile E. 15° S. of Gober is composed essentially of irregular grains of quartz, and a great many crystals and grains of colorless epidote, a few flakes of brown and green biotite, a few grains of chlorite, and an extremely fine-grained interstitial mass of fine-grained quartz and decomposition products of feldspar. The epidote is arranged with parallel elongation, but the quartz as a rule is equi-dimensional and many of the rounder grains apparently show crystal enlargement, and there are no pressure shadows in them. The rock in spite of its lamination and its presence in a strongly sheared area has apparently escaped crushing. At the same time its feldspar has been changed almost completely to epidote.

Three analyses of graywackes from the Carolina areas furnished to Dr. Everhart the results below. In line I is the composition of a specimen of moderately micaceous graywacke from well layered exposures in the bed of Long Swamp Creek, at road-crossing about ¼ mile southeast of Sharp Top Church. The figures in line II show the composition of a specimen taken from the road cut ¾ mile west of Long Swamp Church. Those in line III record the composition of a specimen from the north bank of Long Swamp Creek just east of the ford where the old road running north from Tate crosses the stream. This is from a bed in the Valleytown formation, which is inserted here for comparison.

Analyses of graywacks in the Carolina gneiss, Pickens Co., Ga.

	SiO_2	Al_2O_3	Fe_2O_3	FeO	MgO	CaO	Na_2O	K_2O	TiO_2	MnO	P_2O_5	Ign	Total
I	77.86	12.23	.23	2.25	Tr.	2.54	1.68	.70	.80	.04	.84	.84	99.44
II	69.40	18.76	3.53	2.33	.04	.00	1.86	1.68	.72	.17	.50	.78	99.77
III	73.50	12.58	3.34	3.52	Tr.	2.00	2.06	.78	.85	.20	.28	1.36	100.47

The first is a light-grayish feldspathic (orth. and plag.) phase, containing a fair amount of biotite, the second a very dark-gray variety with abundant biotite, and the third a dark-gray variety, containing only a moderate amount of biotite. The principal difference between the three is in the Al_2O_3, the K_2O, the CaO and the Fe_2O_3, which is presumably due to the greater proportion of biotite and magnetite in No. II, and the greater quantity of plagioclase in No. III.

A group of rocks intermediate in appearance between graywackes and conglomerates is represented by a large number of exposures scattered throughout the northeast quarter of the quadrangle. These rocks differ from platy, micaceous graywackes in that they contain many little lenses of white or pink feldspar and streaks and plates of crushed feldspar, all, of course, with broad surfaces in the planes of schistosity. They differ from conglomerates in the fact that they contain no visible quartz lenses. They may be thoroughly squeezed granites or more probably graywackes that have been injected with feldspathic juice (Sederholm's "ichor"). They probably belong to Sederholm's "migmatities[9]" and to that division which he calls "arterites," though the Georgia rocks have suffered extreme metamorphism since their injection and consequently the vein-like character of the injection has been obscured. In a few places narrow pegmatite veins follow the schistose planes for a few feet or only a few inches, and in these rocks nearly all gradations can be seen between well-defined mica pegmatite streaks and rows of lenses of feldspar, micas or quartz. It seems plain that the pegmatite was injected along the foliation and was later squeezed out into lenses of its component minerals and finally into plates or scales.

The study of thin sections of these rocks adds little to the information that can be gotten from the hand-specimens. A dark-gray, very schistose biotitic variety is seen to be composed of large crushed masses of quartz and large grains of plagioclase embedded in a finer grained matrix of green biotite, quartz, plagioclase, orthoclase and crystals of colorless epidote. Much of the quartz is drawn out into streaks. A few small irregular particles of magnetite are the only other components present.

Another specimen from a ledge on Long Swamp Creek about 1 mile southwest of Sharp Top Church, near the north side of the quadrangle, contains abundant feldspathic pebble-like masses. In thin

[9] Sederholm, J. J., On migmatites and associated pre-Cambrian rocks of southwestern Finland. Bull. Com. Geol. de Finlande. No. 77. p. 136, 1926.

section the large feldspars are microcline, partly crushed. The matrix is a mixture of plagioclase, orthoclase, quartz, bright-green biotite, and a little muscovite, and everything except the mica is crushed.

The rocks of this kind are found as streaks in graywackes which elsewhere are of the usual types. They probably represent coarse layers in otherwise uniformly fine-grained sediments. They may be found at any horizon in the bedded series and have no structural significance. Like the finer grained graywackes they have been saturated by solutions from which feldspar was crystallized. Some of the larger pebble-like masses of feldspar are apparently crushed feldspar crystals.

Conglomerates

At a few places undoubted conglomeratic graywackes or mica schists occur interbedded with non-conglomeratic varieties. The most striking exposure of an unquestionable conglomerate is about 1¼ miles from Keithsburg alongside the road running southeast. It is a pile of closely packed slender lenticles lying parallel to one another and separated by thin films of micaceous sand. Most of the lenses are flattened, but a few are nearly circular in cross-section. Their lengths vary between ¼ inch and 3 inches, and their cross-sections have their shorter diameters varying between 1-3 and ½ inch and their longer ones between ¼ and 1¼ inch. Most of them consist of crushed quartz, but a few are composed of a pinkish or yellowish feldspar showing good cleavages where broken. The feldspathic masses are less lenticular than the quartz masses, some of them being almost spherical. The quartz lenses are certainly crushed pebbles that resemble the lenses of quartz described by McCallie from Gilmer County.[10] The feldspar masses, however, may in part have been formed in place by crystallization. The compact rock shows a very sparse arkosic sandy matrix in which the lenses are embedded. In this are scattered

[10] McCallie, S. W., Stretched pebbles from Ocoee conglomerate: Jour. Geol. Vol. 14, 1906, p. 55; Some notes on schist conglomerate occurring in Geor-gia: Idem. 15, 1907, p. 474, and A preliminary report on the marbles of Ga: Geol. Sur. vol.of Ga., Bull. No. 1., 1907, p. 33 and pl. II and III.

La Forge, L., in U. S. Geol. Sur. Geol. Atlas Ellijay Folio (No. 187), 1913, p. 9, accounts for the pebble-like masses of quartz described by McCallie by the close folding, crushing and fracturing of richly quartzose rocks and the rolling of the fragments under great pressure.

here and there a few black lenses of hornblende schist, probably representing pebbles of Roan gneiss and a few small crystals of feldspar. In the few places where the matrix is more abundant it has the character of the common graywacke.

This conglomerate can be traced for a short distance from the road by the elongate pebbles in the soil, but it is soon lost. The rock is interbedded with a dark biotitic graywacke containing eyes of quartz. The conglomerate is exposed for 360 feet and is followed to the southeast by 50 feet of graywacke and 100 feet of alternating graywacke and conglomerate beds.

Another conglomerate of a different type is just north of the bridge over Long Swamp Creek one mile and a quarter north of Tate post office. In this rock, which outcrops on the road running along the west side of the creek, the quartz pebbles are crushed to streaks and plates and the feldspar masses are spherules, which on cross-sections resemble the eyes in an augen-gneiss. The matrix is a gray, sandy and platy graywacke, the shearing surfaces of which contain abundant muscovite plates. Small black plates of biotite are abundant in parts of the matrix. The rock is distinctly schistose.

A third type of conglomerate is from a ledge in the channel of Town Creek, about 1¾ miles east of Canton and a short distance south of the south border of the quadrangle. It is described by Mr. A. N. Murray who made the traverse of the stream as forming a bed 100 feet thick in the midst of garnetiferous mica schist. Other beds, but much thinner were observed also interlayered with mica schists farther east. Murray describes some of the pebbles as being at least 4 inches long. Some are very much flattened quartz pebbles and others are fairly coarse-grained boulders of decomposed granite. The garnetiferous mica schists associated with the conglomerate are evenly laminated, and, in many places, sharply contorted rocks very much like the micaceous graywackes that have already been discussed. The mica is confined almost exclusively to coatings along shearing surfaces, and consequently on these surfaces the rocks look like well-defined mica-schists. On cross fractures, however, they are seen to consist mainly of arkosic sand in which are embedded flattened quartz and granite pebbles.

It is probable that the existence of this bed may have an important bearing upon the problem of the relative ages of different parts of the pre-Cambrian complex. It is above an erosional unconformity of some kind since granite pebbles would not have been present in it unless some granite mass had been deeply eroded to furnish them. It is possible that this conglomerate may mark a break between two pre-Cambrian series of rocks. Unfortunately it could not be followed into the Tate quadrangle because of the soil covering, and its extent is therefore unknown. It seems, however, to point clearly to the fact that some portion of the pre-Cambrian rock series is much older than the series of graywackes with which the conglomerate is associated.

Mica Schists

The mica schists in the Carolina formation are of two types. One consists of fine-graded aggregates of quartz, feldspar and muscovite, containing large garnets and in many places also staurolite and in some places kyanite. The second is a very coarse mixture of quartz and muscovite, with here and there a garnet crystal and in many places fragments of tourmaline.

The finer grained rocks were apparently graywackes that are sheared throughout. They differ from the micaceous graywackes that have been described, in that whereas these yielded to stresses along definite planes separated from one another by portions of the rock that had not slipped, in the mica schists the slipping planes were so close together that practically slipping was produced nearly uniformly throughout the mass. On cross-sections it can be seen that the rocks are made up of very thin edges of crushed and elongated feldspar and quartz grains, separated by layers composed almost exclusively of muscovite, instead of an aggregate of the three minerals uniformly distributed. The garnets, staurolite and kyanite crystals were made later than the muscovite, as they lie in all azimuths in the rocks, many of them extending across the layers indiscriminately.

The coarse-grained schists are greatly squeezed and sheared pegmatites. In these there is little evidence of layers, but on the other hand their constituents are distributed quite irregularly. In these also the garnets are a later production.

Quartzite

In a few places some of the rocks that have been called white graywackes are so quartzose that they might better be designated quartzites. It is difficult, however, to distinguish between the most quartzose of these and shattered quartz veins. Since all the veins run parallel to the general strike of the graywackes, and are so thoroughly crushed that they resemble crushed and sheared quartzites.

One layer that may be a quartzite forms a little ridge projecting from the west a short distance into the valley of Long Swamp Creek, about ¾ mile south of the Cherokee quarry. In thin section, crushed quartz, a few spicules of muscovite and a very few small areas of feldspar are the only components visible. The "quartzite" is light brown and apparently slightly schistose, but is cut by a white quartz vein which is crushed, and which grades gradually into the quartzite. On the strike of this ledge and about a mile and a half distant is another rock of the same kind except that it contains much more muscovite and grades into a mica schist.

The Roan Gneiss

General Features.—Keith places in the Roan gneiss all the hornblende schists, hornblende gneisses and schistose diorites that occur as narrow lenticular and sheet-like bodies within the Carolina gneiss, and suggests that they are igneous rocks that were intruded into the Carolina series and later were much metamorphosed. He regards them all as pre-Cambrian.

In the Tate quadrangle rocks of the kind described by Keith occur in the neighborhood of the Creighton gold mine and the Standard pyrite mine. They possess the features ascribed to the Roan gneiss by Keith and are regarded as portions of his Roan gneiss series. There are other rocks very similar to these, that are associated with the marbles at Marble Hill, on the east side of the Long Swamp Valley, southeast of Tate post office and on Sharp Mountain Creek, 2 miles west of Ball Ground. In the first two places the hornblendic rock is in contact with the marble and between it and rocks believed to be parts of the Carolina gneiss. In the area west of Ball Ground, it apparently is on the strike of the marble, in the midst of mica schists and graywackes of the Valleytown formation. The relation of the hornblende rock and the marble is not clear, but in a few places, notably on the east side of the valley of Long Swamp creek east of Tate post office and south of the New York quarry near Marble Hill, there are streaks of the hornblende rock in the marble. These streaks are for the most part hornblende schists and lenses of chlorite, but they suggest strongly sheared intrusions. There are also many other streaks and vein-like masses of the black rock in the marble but that they are genuine intrusions of the black rock in the marble is not certain. It is possible that they may be portions of the marble or of other calcareous sediments that have been metamorphosed, like the amphibolites described by Adams and Barlow[12] in the Haliburton area in Canada and by Bayley[13] in the Raritan and other quadrangles in New Jersey. Hornblende rocks of the same kind as those associated with the marble occur also as dikes, or possibly sills, in the Carolina gneiss and in the Great Smoky formation.

The hornblendic rocks in the Great Smoky are evidently at least as young as Cambrian and therefore are not members of the Roan gneiss series as defined by Keith. Those associated with the marble may also be Cambrian or younger, as may be also some of those involved with the Carolina gneiss. The dike-like masses in the Carolina gneiss may also be Cambrian or later, since they are identical in character with the intrusives in the Great Smoky beds.

From the facts outlined above it is reasonable to conclude that all the hornblendic rocks in the Carolina area are not pre-Cambrian, but that some of them are Cambrian or later. Only those of pre-Cam-

[12] Adams, F. D., and Barlow, A. C., Geology of the Haliburton and Bancroft areas, Province of Ontario: Canadian Geol. Survey, Memoir No. 6., 1910, pp. 25, 104-127, 164.

[13] U. S. Geol. Survey Geol. Atlas, Raritan folio (No. 191), p. 7, 1914.

brian age should properly be classed with the Roan gneiss. They are intrusions that entered the pre-Cambrian schists along their bedding planes, or other structural planes of weakness, and were sheared during the movements that compressed them into the close folds in which they now occur. The Cambrian hornblendic rocks were also intrusive into the pre-Cambrian schists, but they passed through these into the overlying Cambrian beds after the deformation that so profoundly altered the underlying rocks and escaped some of the shearing to which the earlier intrusives had been subjected. Since it is impossible to distinguish the earlier from the later hornblendic intrusives in the pre-Cambrian area they will all be grouped together as Roan gneiss.

Distribution and Character.—The most conspicuous belt of Roan gneiss in the Tate quadrangle crosses the Etowah River near the east margin of the quadrangle and extends for some miles to the southwest. It encloses the Standard Pyrite Mine[14] and the Creighton Gold Mine[15]. The pyrite mine is on a belt of siliceous material which is bordered on both sides by a laminated dioritic rock and the gold mine on a hornblendic schist cut by granite and quartz veins.

In all the dark rocks within this area there is abundant evidence of crushing. Their components are pale-green hornblende in large poicilitic plates, biotite, epidote, quartz, orthoclase, and plagioclase. The biotite is in reddish-brown plates and the epidote in very light-green grains and prisms. Both are closely associated with the hornblende. Some of the light components are embedded in the hornblende but their greater part forms streaks and lenses between the hornblende plates. The streaks and lenses are aggregates of small grains, some consisting exclusively of quartz, others of feldspar and others of a mixture of feldspars and quartz. Most of the grains are apparently fragments of larger grains that have been shattered and recrystallized, but some, especially some of the feldspar grains, are new crystallizations. A few

[14] Shearer, H. K., and Hull, J. P. D., A preliminary report on a part of the pyrites deposits of Georgia: Geol. Sur. of Ga., Bull. 33, pp. 165-179, 1918.

[15] McCallie, S. W., The Creighton mine: Geol. Sur. of Ga., Bull. 4-A, p. 175-182, 1896.

of the quartz grains exhibit strain shadows. All of the minerals are of metamorphic origin, having been produced from preceding ones after or during the time the rocks were undergoing the changes that made them schistose.

In some places the hornblendic rocks are characterized by a distinct lamination. They are extremely fine-grained and consist of alternating black and gray layers, the latter of which in places swell out into white lenses, around which the black layers bend. Some of the occurrences suggest very strongly a hornblende schist intruded by thin veins of granitic material.

Probably the best occurrence of the laminated rocks is in the neighborhood of the Standard Pyrite Mine and the Creighton Gold Mine, where they can be seen on the dumps of several shafts. The layering is due to the presence of overlapping flat lenses of quartz and epidote with very little hornblende and biotite and others in which hornblende and biotite predominate.

Near the gold mine the hornblendic schists are cut by small dikes of granite, some of which are from ½ to several inches wide. All the dikes run parallel to the schistosity of the schists, and are themselves schistose in the same direction, but their sch'stosity is due partly to residues of the schists that have not been completely assimilated. The granite shows the effect of the influence of the schists by the presence in it of small garnets, which are absent from the large masses of granite of the same kind farther east. From the wider dikes in many places tiny veinlets wander off into the schists and many of these are less than 1/20 in. wide. Similar tiny veins are abundant elsewhere in the schist, and all gradations in width can be seen until the veins become so small as to be indistinguishable from the small light-colored lenses in many specimens.

Nearly all specimens of the Roan gneiss that were examined microscopically showed clearly that their components are secondary, i. e., that they are of metamorphic origin, but in a black gneissic rock near Yellow Creek just beyond the east boundary of the quadrangle all the constituents are so fresh that the rock might well be called a quartz-diorite schist. It is made up mainly of hornblende and plagioclase with some microcline, some quartz, a great deal of sphene and some nearly colorless epidote, often in positions suggesting reaction rims around plagioclase. A little magnetite completes the list of compounds.

At the pyrite mine the siliceous rock that occurs as a layer in the dark gneiss is for the most part, where exposed, a friable, slightly laminated, very fine-grained, often porous, sandy rock. Where fresher, it is denser and more distinctly quartzose and is cut by quartz veins parallel to the lamination. The freshest specimens are dark-gray and extremely dense, resembling very closely gray chert. The ore is a granular pyrite that for the most part occurs as veins in the siliceous rock following its lamination, but here and there crossing it in definite fractures.

The dense chert-like rock in which the ore occurs is a fine mosaic of quartz through which are scattered a few grains of magnetite, a little chloritized biotite and an occasional zircon crystal. In ord nary light quartz grains are seen to be embedded in a cloudy yellow matrix, which, between crossed nicols, breaks up into a fine-grained mosaic of quartz and an albitic feldspar. Here and there are sparse feldspar phenocrysts.

It appears probable that the quartz rock is a silicified belt of the dioritic rock and that the silicification of this rock and the deposition of the pyrite were parts of the same process.

The old Creighton deposit is of a different type. Here the ore was also pyrite, but it contained a notable quantity of gold. The country rock is hornblende schist or gneiss. On the dump of the old shaft near Broadtree creek and south of the road are many fragments of an evenly layered white gneiss, which under the microscope is seen to be a fine aggregate of quartz, feldspar, brown biotite, many magnetite grains and a few spicules of hornblende, forming a matrix through which are scattered a few lenses of coarser quartz and others of a quartz-orthoclase aggregate.

At the main shaft of the mine on the Etowah River the dark schist, or gneiss, is cut by granite and pegmatite dikes and by abundant quartz veins. Toward the east the granite increases, until in the neighborhood of Settingdown Creek it is the only rock observed. The quartz veins, which on the whole are parallel to the foliation of the schist, are mostly straight and evenly thick, except where the schist is contorted, but in some places the quartz is in lenses, as though squeezed out veins. The quartz is the usual white vein quartz, here and there containing a little pyrite. The pegmatite veins are biotitic. They are more apt to be bordered by pyrite than the quartz veins. There are also on the dump fragments of fresh olivine-diabase, which is probably an intersecting Triassic dike. (See also p. 113.)

The only other large area of hornblendic rocks in the quadrangle borders the strip of Murphy marble east of Tate post office and that of the Marble Hill belt, near Marble Hill, and its extension south to the Amicalola mine. There are a few small areas of hornblende schists scattered through that portion of the quadrangle covered mainly by the Carolina gneiss, but most of them are not large enough to be indicated on the map.

The black rock associated with the marble is, as a rule, more massive than are the rocks near the pyrite and gold mines, and has much more the appearance of an igneous intrusive. It exhibits many phases, but in all of them brown biotite is in much smaller quantity than in the rocks near the mines.

The most common phase is a heavy, black, schistose rock in which nothing can be detected by the naked eye except hornblende. In some varieties only a slight schistosity is noticeable. In others the schistosity is very marked and the rock is a well-defined hornblende schist, which is cut here and there by small veins of epidote.

When their thin sections are studied the rocks exhibit considerable variety. The rock on the east side of the marble in the valley east of Tate post office is a very fine-grained black hornblende schist. Its thin section shows mainly an aggregate of pale, blue-green hornblende, a little epidote, a few grains of plagioclase and many grains of yellow rutile, and in limited areas large plates of brown-green biotite. The rutile is scattered indiscriminately throughout the section, but is generally associated with magnetite, either being in parallel growth with the magnetite, or in mantles with magnetite centers. The biotite is found only in circumscribed areas in which the epidote grains are much larger than elsewhere.

A thin section from the large mass of very fine-grained rock in the hill back of the old Kennesaw quarry differs from the rock near the Tate post office in the absence of rutile, and the presence of some quartz and a little calcite, epidote, magnetite, leucoxene and plagioclase, which together form a fine-grained matrix in which the hornblende lies. The specimen shows a slight lamination which is due to alternating lenses in which matrix or hornblende predominate. The quartz in the matrix is in a mosaic and all the other components appear to be crushed.

On the steep slope back of the old Southern marble quarry the marble is in contact with a hornblendic rock of a somewhat different variety. This is a very platy and strongly schistose rock that resembles in the hand-specimen a black biotite schist. The plates of hornblende are very large, some of them perhaps an inch in length and width. Nothing but hornblende can be detected in the hand-specimen, but in thin sections large plates and crystals of compact green hornblende containing much magnetite are seen to be separated from one another by a matrix of brown biotite, quartz, small plates of hornblende, numerous magnetic grains, and crystals of rutile. The quartz is commonly in small grains, but in places there are mosaics of large grains that have a vein-like character. Both the hornblende and much of the biotite have a poicilitic structure, but nevertheless the hornblende appears to have been granulated on its edges, where much of the biotite was developed. The rutile is abundant in the hornblende and the biotite. It occurs in individual grains and in groups of grains with magnetite. Many grains are also composed partly of magnetite and partly of rutile.

One other phase at Marble Hill is a schistose hornblendite streaked with flat lenses of feldspar and quartz. It is obscurely layered, with some layers containing only a few white streaks and others so many that the white streaks predominate over the glistening black hornblende. The layering suggests an interlamination of very basic and less basic flows, that have been squeezed. The darker portions of the rock consist almost entirely of green hornblende though there are usually present in them a very small quantity of a rather basic plagioclase, an occasional shred of biotite and a fair amount of evenly distributed ilmenite grains surrounded by sphene. The lighter portions are mainly crushed quartz and plagioclase.

Another phase of the black rock is a fairly coarse-grained gneiss, in which black hornblende and white feldspar are the only constituents noticeable in the hand-specimen. Some contain a predominance of hornblende and others of feldspar. They are essentially like the gneissic phases occurring near the Creighton Gold Mine.

In addition to the large masses of hornblendic schists and gneisses in contact with the marble and separating it from the coarse garnetiferous mica schists farther up on the slope of the hills south of the Marble Hill belt, there are within the marble dark layers, streaks and segregations of hornblende and other dark minerals, some of which appear to be undoubted intrusions. Others may be concretionary masses formed at the time of its metamorphism from the impurities in the calcareous deposit from which the marble was made, or they may be secretions emanating from the dioritic rock. Since the segregations are found only near the dark rock it is probable that they have some genetic connection with it. If the hornblendic rock is younger than the marble the segregations may partake of the nature of contact products. The stringers, or dike-like streaks in the marble apparently extend from the large masses lying south of the marble, but no one has been traced back to its source.

Some of the stringers consist simply of coarse hornblende or of a mixture of hornblende, a little calcite and a few grains of magnetite, but most of them present features that suggest reaction between the marble and a dioritic rock like that back of the quarries.

A specimen from a mass of hornblende schist in contact with the marble is an aggregate of a light-green, almost colorless hornblende, between the grains of which are large areas of interstitial material that is probably epidote. Scattered through the section are masses of opaque ore that give tests for chromium and a good deal of green isotropic substance that is probably picotite. The green material is especially abundant around the chromite. Here and there are veinlets cutting through the aggregate, and these are filled with crushed material cemented by calcite.

Another stringer is a mass of very tiny plates of a dark greenish-gray micaceous mineral, that cuts irregularly through the marble at the Creole quarry. The material was not seen in place, but was found in a fragment on a pile of rejected rock from the quarry. The vein, which is about two inches wide is bordered by large garnets. A sample of the micaceous mineral was submitted to Dr. C. S. Ross, of the United States Geological Survey, who kindly examined it, and reported it to be a chlorite, approaching amesite. It possesses a perfect cleavage, and an extinction parallel to this. Its optical character is positive and it's optical axial angle $2V = 16°$. The indices of refraction are $\alpha. \beta. = 1.60$, $\gamma = 1.612$. Larssen gives $\alpha, \beta. = 1.597$ and $\gamma = 1.612$ for amesite.

An analysis of material separated by a heavy solution yielded to Dr. Everhart the result indicated below in line I. In line II is the analysis of a sample of amesite [16] associated with corundum at Chester, Mass. In line III is the calculated composition of a chlorite composed of 40% amesite ($H_4Mg_2Al_2Si_2O_9$), 10% iron-amesite ($H_4Fe_2Al_2Si_2O_9$), 25% serpentine ($H_4Mg_3Si_2O_9$) and 25% iron-serpentine ($H_4Fe_3Si_2O_9$),

Analysis of chloritic material in vein cutting Creole marble, Tate, Ga.

	SiO_2	Al_2O_3	Fe_2O_3	FeO	MgO	CaO	Na_2O	K_2O	H_2O+	H_2O-	MnO	NiO	CoO	Total
I	27.50	17.95	.00	17.85	23.10	.00	.38	.14	12.64	.00	.05	Tr.	Tr.?	=99.61
II	21.40	32.30	-----	15.80	19.90	----	-----	----	10.90	-----	-----	----	----	=100.30
III	29.25	17.65	-----	18.71	22.38	----	-----	----	11.87	-----	-----	----	----	-------

[16] Pisani, F., Compt. rend. 1876, 83, p. 166.

Other stringers in the marble show clearly the effect of the assimilation of the marble by the black rock. The material of a stringer in the marble of the New York quarry looks very much like a coarse diabase since it shows more or less lath-shaped white areas in a fine-grained black matrix. Under the microscope, however, the dark groundmass is seen to be composed of large poicilitic light-green hornblende plates containing numerous inclusions of colorless epidote, sphene and rutile and nests of calcite, and the white masses to be aggregates of vesuvianite, epidote, quartz and calcite.

Dike Forms.—Some of the Roan gneiss exists as distinct dikes, as for instance that north of Canton cutting Carolina gneiss alongside the road, that ¼ mile north of Orange, that on Grassy Knob and that 1¾ miles southwest of McConnell. All are medium-grained, greenish-black, rather massive rocks showing in the hand-specimen nothing but numerous little plates of black hornblende with a tendency to parallel arrangement. They all consist mainly of hornblende, pleochroic in yellowish and bluish-green colors, but most of them contain also subordinate amounts of quartz, epidote, biotite, apatite, rutile and magnetite or ilmenite. Much of the little quantity of epidote present appears to have been formed from the hornblende, with which, in places, it is intergrown with a parallel orientation. The small amount of brown biotite present also appears to be an alteration of the hornblende. In some specimens is a very little plagioclase with a wavy extinction. In some there is a little sphene.

The dike-like mass on Grassy Knob cuts mica gneiss on the spur which is about two miles east of the peak. There is no appearance of schistosity in the section, which shows a medium coarse-grained aggregate composed mainly of light-green and brown amphibole, a little quartz and plagioclase. A little magnetite, a few grains of epidote associated with the plagioclase and a little brown hornblende replacing the green hornblende around its edges are the only other components. The quartz and plagioclase show the effects of pressure, and the feldspar is commonly poicilitic.

The dike cutting mica gneisses near Orange does not differ from that last described except that it contains a little sphene and no magnetite or epidote.

All the dike masses are essentially alike and are different from the larger masses that are interleaved with the Carolina gneisses, in containing larger quantities of fresh plagioclase.

INTRUSIVES

Hightower Granite

There are two areas of granite in the quadrangle, one in its western part and the other in its southeast corner. The latter occupies an area which extends eastward along Settingdown Creek and is best developed around Hightower in Forsyth County. Its distribution is best outlined by the white soil it produces. Very few outcrops have been seen. The rock is very thoroughly kaolinized, in many places to a mixture of kaolin and quartz without any other components. The area is mapped as though it were underlain by solid granite. As a matter of fact, however, there are several small masses of black Roan gneiss in the midst of the granite, just as in the Roan gneiss area at the Creighton mine there are small areas of granite. Near the Creighton mine the granite is plainly intrusive in the dioritic rock, and in the granite area the black rock appears as lenticular inclusions in the granite.

The granite is everywhere in contact with mica gneisses or graywackes, and sends apophyses into them, as it does into the Roan gneiss, and consequently its boundary on the map is largely conventional; on one side granite predominates, on the other graywacke or gneisses. In the exposures on the Etowah River and on the lower courses of Settingdown Creek granite and hornblende schist are uniformly interlayered forming exposures that are beautifully striped in alternating black and white bands about an inch or two wide.

The Hightower granite is a light-gray or white gnessoid biotite granite, varying greatly in coarseness of grain and in the proportion of biotite present. In many places especially in its border phases biotite is present in such small quantity that the rock is almost white.

In some places muscovite replaces the biotite but in many of the dikes extending into the surrounding rocks both micas are absent and the only components present are feldspar and quartz.

One of the border gneisses studied under the microscope is rich in quartz. In addition there are present irregular grains of kaolinized feldspar, prismatic grains of colorless epidote, small flakes of brown biotite, a few grains of colorless plagioclase and a few groups of platy muscovite. The epidote is in streaks, and much of the quartz is in lenses of coarse mosaics suggesting crushed grains. Sections of other specimens show that much of the plagioclase is oligoclase.

In many specimens a part of the feldspar is lenticular, forming eyes around which the schistose aggregate of quartz and plagioclase bends. Those eyes in the specimens examined are orthoclase.

The Roan gneiss in the fragments enclosed within the granite is not essentially different from that found elsewhere. The only specimen examined microscopically is a quartz diorite in which the plagioclase (oligoclase-andesine) has been changed along cracks and around its edges to an isotropic substance which appears to be a nearly colorless glass.

An analyses of a fairly fresh specimen of the granite taken from a few rods east of the east margin of the quadrangle and about 1½ miles a little north of east of Creighton was made by Dr. Edgar Everhart of the Georgia Survey with the result shown below. The rock is a medium-grained, light-gray, gneissoid variety.

Analysis of Hightower granite

SiO_2	Al_2O_3	Fe_2O_3	FeO	MgO	CaO	MnO	Na_2O	K_2O	H_2O-	H_2O+	TiO_2	SO_3	P_2O_5	
67.96	18.94	.39	2.54	.06	3.98	.12	4.04	.52	.23	.01	.54	.18	.64	=100.15

The rock is a soda granite with the norm:

Q = 34.15; or = 2.78; ab = 34.06; an = 18.12; hyp = 3.58; mag. .70; ilm .91; apa = 1.34 and cor. = 5.81. Its formula is 1, 3–4, 3, 5, which is that of a vulcanose.

Some of the granites cutting the pre-Cambrian rocks of the southern Appalachian are very old; others are thought to be as young as late Paleozoic. The Hightower granite is younger than much of the Carolina gneiss and some of the dark rocks that have been classed as Roan gneiss, but is probably not older than the Salem church granite in the western part of the quadrangle. Both are about equally deformed and both show about the same degree of crushing. The Salem church granite is intrusive in the Great Smoky formation which is believed to be Cambrian. It is therefore not older than Cambrian, and if the Hightower granite is of the same age it is also not older than Cambrian. On the other hand the Hightower granite is much more gneissoid than some of the other granites in the southern Appalachians and is probably therefore older than these. While it is impossible to fix accurately the time of its intrusion, it was probably early in the Paleozoic.

Other Granites

A few doubtful rocks that are believed to be old granites not connected genetically with the Hightower granite occur at various points. They are much more gneissic than the Hightower rock and consequently are believed to be much older. They are now fairly fine-grained gneisses of different compositions. Some are hornblendic and others biotitic, but all are so much weathered that their exact composition has not been determined. At any rate they do not form any surface deposits of kaolin as does the Hightower granite.

The biotitic forms resemble very closely the biotite graywackes. They are, however, more schistose and there are no areas in the thin section that suggest grains. Their components are more thoroughly shattered and the biotite, which is dark-brown, is in more sinuous lines. There are also present in some of them a few large plates of muscovite. One of the best exposures of these rocks is at the Tate Power site on Amicalola Creek about 3 miles east of Holecomb, just beyond the east boundary of the quadrangle. Here is a broad expanse of interlayered graywackes, hornblende schists and granites cut by pegmatites, that is drawn out into streaks of coarse gneiss. The pegmatite is in very crooked layers, but the granite layers are so perfectly parallel with the schistosity of the rocks they penetrate that the whole assemblage resembles a sedimentary series. Another exposure of gneiss that may be an old granite is at the Frogtown bridge over the Etowah River near Hightower, just east of the east margin of the quadrangle. It is a fine-grained, dark-gray, biotitic gneiss cut by pegmatite and aplite dikes. The dark gneiss consists of dark-brown biotite, untwinned and twinned andesine, oligoclase, some orthoclase, some quartz, a little apatite in large crystals, a few needles of pale-green hornblende and a few flakes of muscovite.

Some of the rocks which are regarded as belonging among the older granites are gray schists composed of a fine-grained matrix streaked with white lines, and containing very narrow lenses of white feldspar suggesting drawn-out grains. Others have large crystals embedded in the matrix as though the original rocks were porphyries. In the thin section of one of these rocks taken from an outcrop on the road 1¼ miles a little north of east of Yellow Creek Church the matrix is a schistose aggregate of quartz, plagioclase, unstriated feldspar, large plates of muscovite, small plates of brown biotite and a few small irregular garnets. Some of the phenocrysts are quartz mosaics and others grains of microperthite.

Other supposed granites are light-gray, nearly white, fine-grained rhyolitic-looking phases with a schistosity emphasized by little parallel streaks of quartz and biotite. Under the microscope one of these showed a schistose aggregate of interlocking quartz and orthoclase, with interstitial grains of plagioclase and microcline in small quantity. Through this are scattered large flakes and small scales of biotite, many particles of plagioclase and microcline and large masses of crushed quartz and feldspar. The rock might properly be called an aplite.

Pegmatites

The pegmatites in the Carolina formation are very coarse aggregates of quartz, feldspars and muscovite. Some of them are rich in muscovite and others are composed mainly of feldspar and quartz. Many of them, especially those rich in quartz, contain black tourmaline crystals, some of which are 18 in. to 2 ft. long. The feldspar that has been determined is either orthoclase or microcline. So far as seen all the pegmatite streaks follow the schistosity of the rock in which they occur.

One of the best exhibitions of a tourmaline-rich variety is on the secondary road leaving the main highway between Tate and Marble Hill a few rods west of Darnell Creek crossing. The outcrop is on the side of the road about ¼ mile from its junction with the highway.

Another occurrence worthy of mention is a loose block found near the Kennesaw quarry. It is stained with bright-green, thin films of a green substance the nature of which has not been determined. Since the stain is deepest near mica flakes it was first thought to be due to fuchsite, but Dr. Everhart, who kindly tested the substance reported the absence of chromium but the presence of a trace of nickel. Under the microscope tiny particles covered with the green stain show a pleochroism in blue and yellowish-green tints. Near the place where the loose block was found are exposures of a much sheared and contorted pegmatite containing large lenses of clear feldspar. Its thin section shows abundant remnants of pale-green, slightly pleochroic augite, much dark-green hornblende, apparently derived from augite, abundant epidote, some sphene, nests of calcite and a comparatively little plagioclase.

Many of the pegmatites exhibit only slight effects of crushing. Their mica plates may show a tendency to a parallel arrangement, but otherwise the rocks have the usual aspect of unsheared pegmatites. There are many others, however, that are crushed and sheared, some to very coarse-grained mica gneisses, others to fine-grained platy sericitic gneisses, or schists, and others to pencil-like aggregates of crushed feldspar, quartz and muscovite, with here and there a garnet. In a few places narrow veins are intricately contorted as the result of the close folding of the schists with which they are associated. Nearly all these pegmatites are too far gone to furnish much evidence as to their original character. (Plate VII A.) They are muscovite varieties, without exception so far as noted, but the character of their feldspar has not been determined, as it has been almost completely changed to sericite or kaolin. Many of the thinner layers of coarse mica gneiss that occur in the midst of other members of the pre-Cambrian complex are crushed pegmatites that were probably intruded during pre-Cambrian time. The uncrushed pegmatites are similar in structure to many of those in the Cambrian rocks, and are, in all probability, of Cambrian or later ages.

Peridotite

Small areas of periodotites and pyroxenites have been described as occurring in the Ellijay quadrangle and in other parts of the pre-Cambrian areas in North Carolina and Georgia. In the Tate quadrangle only one occurrence has been noted. This is on the road crossing the stream about a mile west of Long Swamp Church. Here the rock, which is heavy, coarse-grained and purplish-gray, forms a layer in a quartz schist on the east side of the stream-crossing.

In thin section it is seen to consist of large interlocking, poicilitic plates of green hornblende separated from one another by small areas of granular quartz, and in some places by crushed plagioclase. The hornblende plates enclose much colorless zoisitic epidote, a few remnants of pyroxene, a few large garnets, crystals and grains of sphene, and nests and veinlets of calcite.

The rock was apparently originally a pyroxenite. Because of its very pronounced metamorphism it is regarded as of pre-Cambrian age.

Other rocks of the same character are known to exist a few miles south of the Tate quadrangle near Hickory Flat where they have been worked in a small way for asbestos.

Quartz Veins

Quartz veins are common in the Carolina gneisses and graywackes, but apparently are not as numerous as they are in the Great Smoky formation. Most of them are approximately 4 or 5 ft. wide, but there are many others of less widths and a few that are wider. Nearly all run parallel to the schistosity of the rocks they intrude. A few small ones and many tiny veinlets cut across the structure, but these appear to be younger than the major part of the veins. The quartz of some of the veins is well crystallized, but that of most veins is crushed to a mass that is difficult to distinguish from a fine-grained quartzite that has been silicified. The only mineral besides quartz noted in any of the veins is tourmaline but this occurs in some places in large crystals some of which measure 10 inches, or a little more, in length and 5 inches in diameter.

The badly shattered veins are believed to have been formed before Cambrian time. The others which are less shattered show about the same degree of deformation as those in the Great Smoky and are supposed to have been intruded in Great Smoky (Cambrian) time.

THE CANTON SCHIST

Across the south-east part of the quadrangle a narrow belt of carbonaceous, or graphitic, garnetiferous mica schist extends uninterrupedly from its southern to its eastern margin. It is bordered on both sides by the characteristic mica schists and micaceous graywackes of the Carolina gneiss into which it grades by inter-layering. There is no way of determining whether it is an integral part of the pre-Cambrian complex or is a younger formation that has been brought to its present position by downfolding or by faulting. It is, however, so remarkably similar to the Hiwassee schist, which is also a strongly carbonaceous garnetiferous mica schist, that the two are thought to be parts of the same formation. Nevertheless, because the two schists are so widely separated from one another this correlation cannot be depended upon and therefore it seems desirable, for descriptive purposes, to call the southern belt by the distinctive name the Canton schist, since the best exposures are in the neighborhood of Canton, at the southwest corner of the quadrangle.

The Canton schist enters the quadrangle at its south border, about 4 miles from its southwest corner. It extends as a continuous belt across the quadrangle and leaves it at its east margin about 4½ miles north of its southeast corner. At its southern end the main belt is about ½ mile wide. It, however, gradually diminishes in width to the northeast, being only about 1/5 mile wide where it leaves the quadrangle at its east margin. The strike of the rock within the belt is about the same as the trend of the belt and the dip is everywhere to the southeast conformably with that of the micaceous graywackes by which it is bordered. The contacts are usually not sharp but the Canton schist and the graywackes pass into one another through mica schists that contain only small quantities of carbonaceous material, or beds of graywacke and Canton schist are interlaminated, the dark schist being predominant toward the main mass of the schists and the graywackes predominating away from it.

Exposures of the schist are scattered here and there throughout the area underlain principally by graywacke but they cannot be traced into distinct, interlaminated beds. On the south side of the main belt as mapped, the carbonaceous schists are more common than on its north side. In some places they cover comparatively large areas some of which seem to project as offshoots from the main belt, whereas others appear to cover lenticular areas entirely isolated from the main belt. The repetition of the schist may be due to close isoclinal and cross folding.

Throughout its entire extent the Canton schist has a uniform character. It is a very glistening bluish-gray mica schist containing many garnets, which in many places are from ¼ to ½ in. in diameter, and most of which are distorted dodecahedrous. (Plate V B.) The garnets are so abundant that where the rock is broken down the ground is covered with them, and most of the dirt roads crossing their exposures are so thickly strewn with them that they appear to be built of loose garnet gravel. On foliation surfaces the rocks show large curved and crinkled silvery areas broken by dull spots where the garnets protrude. In cross-section a very marked crinkling is noticeable and in many specimens there are many paper-thin interlaminations of mica and sand layers, that weave in and out between the garnets, which evidently were present before the foliation was produced.

The best exhibitions of the Canton schists are along the railroad south of Canton between the crossing of the road to Hickory Flat and the bridge over Town Creek, and on the old abandoned road about ½ mile east of the Canton post office, and connecting the Hickory Flat road and the road to Cuming. On the railroad the most striking exposure is on the side of Town Creek under the bridge, but there are other good exposures in the cuts near the water tank. Most of them are of the usual graphitic mica schist, but just north of the tank are interlayered beds of micaceous graywacke, containing small garnets and little lenses of quartz. The schistose surfaces of the graywacke are covered with silvery mica, but any notable quantity of carbonaceous matter is lacking. In the old road cut east of Canton there is a section over a mile long through a series of silvery and graphitic mica schists, coarse garnetiferous mica gneisses, and fibrolitic hornblende gneisses. The graphitic mica schists predominate but there are stretches in which the silvery mica schists are the only schists exposed. These differ from the graphitic mica schists solely in the absence of graphite. Both contain garnets in great numbers. In some places they are small but in others they measure as much as ½ inch in diameter.

Under the microscope thin sections of the Canton schists reveal no features which differentiate them from other graphitic schists that are regarded as of different ages, nor do they give any hint as to their origin. The few sections studied show masses of fibrous muscovite interwoven with a fibrous substance with a low birefrigence, suggesting serpentine, and in the meshes between these lenses of quartz. Here and there are little areas of sericite and little clumps of grains of rutile, grains of ilmenite and sparse tourmaline crystals, a few grains of zircon and a few crystals of calcite. Portions of the sections are stained by limonite and streaks of this mineral stretch through it, and its whole surface is besprinkled with tiny irregular particles of an opaque substance taken to be graphite, tiny flakes of hematite, biotite and a few of rutile. Large crystals of garnet are imbedded in this matrix and masses of bright-red hematite replace the margins of some of these and send veinlets into them. Hematite also stains the matrix around most garnet grains and around ilmenite, magnetite and in some places around epidote. In places the graphite is so thickly crowded that the section is opaque. In some sections are large grains and crystals of yellow-green epidote.

A specimen taken from an exposure under the railroad bridge spanning the west branch of Town Creek, about a mile south of the railroad station at Canton was analysed by Dr. Everhart with the following result:

Analysis of Canton schist near Canton, Ga.

SiO_2	Al_2O_3	Fe_2O_3	FeO	MgO	CaO	Na_2O	K_2O	TiO_2	S	P_2O_5	Ign	H_2O-	Total
69.16	18.42	4.24	1.55	.71	.58	.07	2.16	.54	.12	.01	2.14	.02	=99.72

The analysis indicates the presence of about 20% sericite, 23% kaolin, 46% quartz, a little serpentine and a few other constituents. Dr. Everhart[17] reports that the loss on ignition is due mainly to the burning of organic matter which is not graphite.

The Canton schists have been described as a belt, but in many places it is impossible to indicate the limits of the belt, since its borders are not sharply defined. The lines of demarkation on the map are drawn where the graphite schists appear to be less prominent than the interbedded non-graphitic schists.

Since the graphitic schists all contain much less quartz than the non-graphitic varieties, it would appear that they represent a set of aluminous beds in a series of more sandy ones—perhaps a series of shales containing organisms interbedded with argillaceous sandstones.

THE CAMBRIAN FORMATIONS

THE CAMBRIAN FORMATIONS IN NEIGHBORING QUADRANGLES

In the Nantahala quadrangle, where Cambrian beds are well developed, Keith has mapped the following formations beginning with the oldest: Hiwassee slate, Great Smoky conglomerate, Nantahala

[17] In a letter to the State Geologist Dr. Everhart states that he repeated the test for graphite in another specimen of the schist selected for this purpose and found that it lost 5.54% on ignition for six minutes in a closed crucible, while the residue in an open, inclined crucible lost only .02% more. The color changed from the dark-gray of the original schist to a light greenish-gray in the ignited material. Moreover he was unable to make from the schist any graphitic acid. His opinion is that the dark coloring matter in the rock is 'volatile organic matter'.

slate, Tusquitee quartzite, Brasstown schist, Valleytown formation, Murphy marble, Andrews schist and Nottely quartzite, and beneath the Hiwassee slate in some other quadrangles he recognizes another formation which he calls the Snowbird formation, which so far as known is the basal member of the Cambrian in the southern Appalachians.

In the Ellijay quadrangle the Hiwassee slate is missing. If it occurs beneath the Great Smoky conglomerate it lies to the west beyond the western margin of the quadrangle. The Great Smoky conglomerate is the lowest member of the Cambrian series in the area. As one passes south in the Ellijay quadrangle he notes that the Tusquitee quartzite and the Brasstown schist are cut out by faulting and disappear, as do also the Nottely quartzite and most, if not all, of the Andrews schist. The Murphy marble is also cut out at most places by the great Whitestone fault that runs along its east side, but it is found here and there in comparatively small patches on the west side of the fault line.

THE CAMBRIAN FORMATIONS IN THE TATE QUADRANGLE

All the Cambrian formations that occur in the southern part of the Ellijay quadrangle cross over into the Tate quadrangle, and in addition the Hiwassee slate makes in from the west and occupies a curving belt in its western part. There may also be small areas of the Snowbird formation west of the belt of Hiwassee slate but if so it is so intricately involved with granite that its presence cannot be established with certainty. It is known, however, that a conglomerate series lies west of the Hiwassee slate in the Cartersville quadrangle in the position in which the Snowbird formation should be found if it lies below the slate.

The Cambrian beds in the Tate quadrangle are intruded by a mass of white granite which has been called the Salem Church granite, because of many large exposures in the neighborhood of the church, and is cut by masses of hornblendic rock identical with some forms of the Roan gneiss, by pegmatites and by quartz veins. There are also, scattered over the Cambrian areas, many boulders of the fine-grained rock, which has been described by La Forge and others under the name "pseudodiorite." So far as known there are no dikes of basalt in the area.

The Snowbird Formation

Members of the Snowbird formation which is believed to be at the base of the Cambrian series in the southern Appalachians may be present in the extreme western part of the Tate quadrangle on the northeast slopes of Sharp Mountain, but if so they are so intricately intruded by the Salem Church granite (see p. 103), and so closely folded that they cannot be identified with certainty. In some places the granite is involved with a very schistose rock that contains large lenses of quartz and feldspar that may represent pebbles, but in most places the feldspar lenses are so greatly in excess of those composed of quartz that it appears more probable that the schists are squeezed dikes of porphyritic granite. These problematic rocks have been seen only in little patches near the borders of the granite between the Hiwassee schist and the granite, which elsewhere is entirely surrounded by the schist. Some of them have the appearance of augen-gneisses, except that they are distinctly layered, with thin layers of a black micaceous schist separated by layers of feldspathic rock which for the most part are as thin as the dark layers, but which here and there swell into lenses of feldspar and quartz. In some places the light-colored layers are studded with crystals of feldspar (orthoclase). These light layers are plainly thin intrusions of granitic material into a schist which may be portions of the Hiwassee schist.

The Hiwassee Schist

The rock into which the Salem Church granite is intrusive is a garnetiferous graphite schist resembling very closely the Canton schist. It differs from this in being more platy and less gneissic, in containing fewer and very much smaller garnets, commonly about ¾ mm. in diameter and in many places more sandy material. Near the granite it is cut by distinct layers of granite and at a greater distance from it is interlayered with flat lenses of feldspar and it contains here and there grains of quartz. These phases resemble fairly fine-grained biotite gneisses. The rock at greater distances from the margin of the granite is very fine-grained and platy and resembles a graphitic shale.

The schist when not intermingled with granite is more uniform in composition than the Canton schist. Most specimens examined are so fine-grained that it is impossible to identify all their components. Their coarser portions are mainly a very schistose mass of muscovite with a little kaolin and quartz, the whole bespattered with tiny carbonaceous granules and particles of iron oxides, a few grains of zircon and a rare one of tourmaline, that are accumulated sparsely and thickly in alternating layers. A few much larger grains of the carbonaceous material and a few small garnets are the only other minerals seen in thin sections.

In some sections there is a good deal of fibrous chlorite intermingled with the muscovite and filling the little areas at the ends of elongated garnets and especially between neighboring garnets. The schistosity bends around the garnets in some places, but in most places is not deformed the least by their presence. Many of the garnets are beautifully zonal, and around them are little aureoles free from dark components.

This graphitic schist extends as a continuous curved belt from a half mile to 1½ miles wide surrounding the granite. (See map). Near the intrusive thin sheets of the schist are interlayered with thicker sheets of granite. With increasing distance from the granite margin the granite diminishes in proportion to the schist until it disappears in a distance of from ¼ to ½ mile. At its other margin the schist belt is in contact with graywacke, quartzite and mica schists that are correlated with the Great Smoky formation farther north. This contact, however, is never sharp but the two formations grade by interlaminations. At the boundary as marked on the map the dark schists predominate, but at greater distances from it, on the Great Smoky side of the contact, the schists become less and less conspicuous, small lenses appearing here and there in the midst of the Great Smoky series, especially in the northwest portion of the quadrangle. Whether the dark schists scattered throughout the Great Smoky area are parts of the Hiwassee slate that have been brought up by close folding, or a carbonaceous deposit laid down in the midst of the Great Smoky series has not been established. The strikes of the layers in the Great Smoky series are so varied in direction and the dips so different in amount, that there can be no question of the complicated folding in this formation. In the carbonaceous schists, however, the dips and strikes cannot be depended upon as guides to the folding, as most of them are taken on structures that may be schistosity rather than bedding. Both series are closely folded and it is possible that the exposures of the schists outside of the main area occupied by them may have been brought up by folding.

The existence of the Hiwassee schist is not known in the Ellijay quadrangle, but a small area of Hiwassee slate has been described by Keith in the northwest corner of the Nantahala quadrangle[18], which is northeast of the Ellijay quadrangle, and larger areas underlain by the Wilhite slate are described by Hayes in the Cleveland quadrangle[19], which is northwest of the Ellijay quadrangle.

The Hiawassee slate is regarded as the oldest sedimentary formation in the Nantahala quadrangle, where "it consists of blue and gray banded slate and sandy shale, which in other areas contains beds of limestone and limestone conglomerate. Along the southeast side of the sedimentary series, and between this and the Archean schist there is no slate exposed, but this lack is thought to be due to the fact that the slate was never deposited as it has been observed that in the Guyot quadrangle the slate is lacking between the Archean gneiss and the Great Smoky conglomerate in places where it has not been cut out by faulting." The Hiwassee is therefore regarded as the oldest post-Archean sediment in the quadrangle, lying immediately beneath the Great Smoky formation.

In the Roan Mountain quadrangle Keith[20] describes the Hiwassee slate as occupying many narrow bands in the Cambrian belt, between the Snowbird formation, which is a series of interstratified beds of

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[18] Keith A., U. S. Geol. Survey Geol. Atlas, Nantahala folio (No. 143), p. 3, 1907.
[19] Hayes, C. Willard, U. S. Geol. Survey Geol. Atlas, Cleveland folio (No. 20), p. 2, 1895.
[20] Keith, A., U. S. Geol. Survey Geol. Atlas, Roan Mountain folio (No. 151), p. 5, 1907.

quartzite, arkose and conglomerate and a few thin layers of gray slate, and the Cochran conglomerate, which is a series mainly of conglomerates and quartzites, that is correlated with the Great Smoky formation elsewhere. The Hiwassee slate is thus older than the Great Smoky conglomerate (there represented by the Cochran conglomerate) and younger than the Snowbird formation. In the Roan Mountain quadrangle the Hiwassee formation consists mainly of slate like that in the Nantahala quadrangle but in addition there are interbedded sandstones, quartzites and a few layers of conglomerate, which in some places entirely replace the slate, and the formation loses its slaty character and becomes a quartzite. "In many of the layers mica in fine scales is a noticeable constituent."

In neither the Cleveland nor the Roan Mountain quadrangles has the slate been greatly metamorphosed. A slaty cleavage has been produced, but not to such an extent that the bedding has been obliterated. "Only in a few places has the deformation been sufficiently extreme to produce mica shist." In these few places, however, "the slates have been altered to dark-bluish or black schists."

The Wilhite slate in the Cleveland quadrangle is correlated with a similar slate in the Knoxville quadrangle where it has been placed immediately on top of the Archean and at the base of the overlying sedimentary series which is regarded as probably Algonkian. The slate is described in nearly the same terms as are used by Keith. It consists in the main of dark-blue or black slate, containing "lenses of gray siliceous or argillaceous limestone, which merge gradually into the calcareous slate." There are also in the formation beds of coarse limestone conglomerate and others of sandstone and quartz conglomerate. In an unpublished map Hayes traces one belt of his Wilhite slate, which here is carbonaceous and in part garnetiferous, to the east margin of the Cartersville area where it joins the belt of Hiwassee slate as mapped in the Tate quadrangle. On this same unpublished map Hayes indicates the presence of a conglomerate series which is so situated with reference to the slates as to suggest its lower stratigraphic position.

For these reasons it is assumed that the graphitic schists of the Tate quadrangle in the belt under consideration are to be correlated with the Wilhite and Hiwassee slates of other quadrangles, but that because of the greater deformation to which the slates have been subjected in the Tate quadrangle they have become more schistose and have had much micaceous substance developed in them.

The analysis of a brillianty shining, platy specimen from the south slope of the ridge extending northeastward from Sharp Mountain was made by Dr. Everhard who found:

Analysis of sample of Hiwassee schist, Tate Quadrangle, Ga.

SiO_2	Al_2O_3	Fe_2O_3	FeO	MgO	CaO	Na_2O	K_2O	TiO_2	P_2O_5	S	SO_3	Ign	H_2O-
49.56	29.90	1.60	3.53	.44	.04	.36	3.90	.54	.15	1.56	.74	8.22	.05

Total = 100.59—O =.78 =99.81.

If we disregard the minor constituents and consider the loss on ignition as due mainly to water the results of the analysis indicate a mixture of about 40% sericite, 38.5% kaolin and 14.5% quartz.

The Great Smoky Formation in the Ellijay Quadrangle

The Great Smoky formation in the southwestern portion of the Ellijay quadrangle is mapped as occurring in two areas, one of which occupies about 4 square miles in its southwest corner and the other a belt about half a mile wide crossing its south margin about 5½ miles from the corner. In the western area the formation is described as consisting of sandstone, graywacke, mica schist, etc., and in the more easterly area mainly of conglomerate and a mica gneiss which is designated by La Forge and Phalen[21] as spangled biotite gneiss.

According to these authors the Great Smoky formation where fully developed in the Ellijay quadrangle consists of "a variety of rocks, including conglomerate, graywacke, sandstone, quartzite, slate, mica

[21] La Forge, L. and Phalen, W. C., U. S. Geol. Survey Geol. Atlas, Ellijay folio (No. 187), p. 5, 1913.

schist, garnet schist, staurolite gneiss, and biotite gneiss. The original character of the beds is sufficiently plain in all the varieties, except possibly the staurolite gneiss, but it is plainest in the conglomerates and sandstones. The beds of the various sorts of rocks range in thickness from a foot to 50 feet, and all except the slate are decidedly gray, becoming lighter or whitish on exposure by the weathering of the feldspar that they contain."

Conglomerate is rare in the southern part of the quadrangle, adjacent to the Tate quadrangle, but it is fairly abundant farther north. Where it occurs its enclosed "pebbles are small, few of them over one-half inch long, and almost invariably much flattened by pressure. Although pebbles of white quartz predominate, feldspar pebbles abound, and some beds contain a few small pebbles of blackish slate."

"The staurolite gneiss has a rather fine-grained schistose matrix of quartz and mica, colored with some dark material and crowded with staurolite crystals, averaging rather more than 1 inch long by about two-thirds inch wide and one-third inch thick. So abundant are the crystals that the residual soil along the outcrop of this rock is composed largely of them."

The upper portion of the series is described as consisting of a spangled biotite gneiss interleaved with conglomerate. The spangled gneiss has "a fine-grained ground-mass which is a network of small grains of quartz and flakes of muscovite, with some magnetite, a little feldspar and biotite, and alteration products. Embedded in this matrix are many small garnets, a few small scattered crystals of staurolite, and a great number of crystals of biotite. The biotite crystals are in general from one-tenth to one-eighth inch in diameter, a few having a diameter of one-fourth inch or more." They occur in tabular or in prismatic forms with a thickness approximately the same as their diameter and lie in all positions in the rock instead of being oriented parallel to the schistosity or to the bedding planes. Both the biotite and the garnet crystals have surrounded and inclosed many grains of quartz and magnetite exactly like the grains of the groundmass, and both are regarded as having been formed during the final stages of the rock's metamorphism.

The matrix of the comparatively fresh rock is grayish-brown, and as the biotite crystals are shining black or dark-brown, they are very conspicuous and give the rock a characteristic spangled appearance. The matrix of the weathered rock is as a rule yellowish-gray or of a creamy tint and the biotite crystals weather brassy-yellow.

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

The base of the western area of the Great Smoky formation is no where exposed in the Ellijay quadrangle, but it is found farther northwest, in the adjacent quadrangle, where it is marked by a massive conglomerate. No Carolina gneiss is known in that area however, the conglomerate being underlain by the Hiwassee slate.

All the rocks of the formation are described as being greatly metamorphosed, so that many of the beds have lost nearly all traces of their sedimentary origin. Sericite, staurolite and garnet have been produced and a marked schistosity developed. The pebbles of the conglomerates nearly everywhere have been flattened and at several places have been greatly elongated. "Throughout wide areas all vestiges of the original bedding planes are nearly or quite obliterated, and in places later secondary structures are superposed on earlier ones. The beds were folded and schistosity was developed. A later deformation folded and crinkled the planes of schistosity and produced a marked slaty cleavage, and last of all joints that cut the rock at various angles were formed."

THE GREAT SMOKY FORMATION IN THE TATE QUADRANGLE

Distribution

The areas in the Tate quadrangle that are occupied by the Great Smoky formation are the southern extensions of those in the southern part of the Ellijay quadrangle. The largest and the one showing best the characteristic features of the formation surrounds the belt of Hiwassee slate as a crescent, entering the quadrangle at its northwest corner and leaving it at about the center of its western margin. Its width varies between 2 and 4 miles, being narrowest about opposite Tate and widening to both the north and the south. The variation in widths appears to be due mainly to folding. In that portion of the belt opposite Tate the strikes are with few exceptions a little east of north, which is the general direction of the major structure in this portion of the quadrangle, and the dips are comparatively high (between 35° and 60°) and to the eastward. Exposures are not sufficiently numerous to enable one to work out the folding in detail, but the impression produced is that the folding is in general monoclinal, with axial planes over turned to the west. In the southern part of the belt exposures are scarce, but in its northern part they are sufficiently abundant to warrant the conclusion that the great width of the formation in this portion of the belt is due to the repetition of open folds, with strikes and dips in all directions. A section along Talking Rock Creek shows preponderant strikes between a few degrees east and a few degrees west of north, but there are some beds that strike northwest, others northeast and others east-west. The recorded dips are generally to the east but there are a few that are westerly. The section for ½ mile north of the Philadelphia road is through flaggy graywackes striking N. 35°-60° W., interlayered here and there with thin beds of conglomerate striking a few degrees east of north. The rocks are folded into rather open folds, and are repeated over and over. The width of the belt is plainly several times greater than the thickness of the beds.

The only other area in the Tate quadrangle that has been mapped as Great Smoky is the southern extension of the eastern belt in the Ellijay quadrangle. This area covers only a few square miles in the northern part of the quadrangle. Only a few exposures have been seen in it, and these are so similar to the exposures of Carolina gneiss farther east, that the boundary separating it from the area of the Carolina gneiss is drawn arbitrarily. A fault is believed to separate the two formations in the Ellijay quadrangle. This fault is projected southeasterly into the Tate quadrangle and southerly until it merges with the fault on the east side of a belt of Valleytown formation, thus limiting the Great Smoky area on the east and south. The accurate position of this fault is not known, and it is not certain that there are no members of the Great Smoky formation to the east of the fault as mapped. It is possible that the exposed width of the formation is greater than shown on the map and that the fault is lacking. However, as there seems to be no way of distinguishing between the rocks belonging in the Great Smoky formation and those belonging in the Carolina formation, the boundary between the two formations must be drawn arbitrarily in such a position as will express a reasonable interpretation of the geologic structure. It is quite certain that the Great Smoky formation does not extend very far into the Tate quadrangle, but that its southern end is where it is indicated to be on the accompanying map is questionable.

In the Tate quadrangle as farther north the formation consists of a distinctly bedded series of graywackes, conglomerates, mica schists, usually containing garnets and a minor proportion of staurolite schists.

Graywackes

The graywackes are fine-grained to medium-grained, gray or purplish rocks exhibiting in all cases more or less schistosity. Nearly all are micaceous and many contain small garnets. Most of them are divided into slabs by distinct cleavage partings following the bedding and schistosity which are parallel. (Plate VI B.) The surfaces of the partings show distinct evidences of movement and in all cases they are coated with a layer of mica, so that when the rocks are viewed on these surfaces they resemble mica schists. When viewed on their cross-sections they appear granular, resembling a fine-grained sediment, and here and there they are banded as though layered. Their slight schistosity is due to the presence of abundant biotite plates, which though invisible on the cross-sections are very prominent on surfaces parallel to the bedding.

In thin sections the graywackes are rather monotonous in their characteristics. Most of them consist mainly of quartz, feldspar and biotite with an occasional flake of muscovite and small grains of rutile, zircon and sphene. Much of the quartz and some of the feldspar is in fragments that have rounded outlines suggesting sand grains, but most of both minerals are intercrystallized. The quartz is in general more or less cracked and in streaks is crushed to a fine-grained mosaic. Orthoclase is apparently more common than plagioclase but the two together are not as abundant as quartz. The biotite is a reddish-brown variety, occurring between the quartz and feldspar grains like a matrix. In ordinary light flakes of biotite appear to outline areas of colorless minerals that suggest sand grains. The only evidence of schistosity in the thin sections is the slightly greater diameter of the grains in a parallel direction and a general tendency of the biotite to be orientated in the same direction. Here and there are larger grains of feldspar, which when present give the hand-specimen a speckled appearance like that of many arkoses.

In the most schistose phases all constituents are flattened. The quartz and feldspar are badly cracked and many grains have been broken into flat lenses of mosaics and the biotite is in streaks that, while in wavy lines, nevertheless extend in a general parallel direction. The quartz and feldspar are all characterized by shadowy extinctions. Moreover in most sections there are a few large muscovite plates and here and there long narrow needles of a colorless mineral resembling sillimanite. These extend across the rock's schistosity and are sharply broken when the foliation planes cross them.

In other specimens the biotite is dark-green, and there are present very large flakes of poicilitic muscovite enclosing all other constituents. These are oriented irrespective of the schistosity, as many crossing this structure as lying parallel with it. There are also in these phases a great deal of colorless epidote in crystals and aggregates of crystals and a few small garnets. Most of the epidote is in nearly equidimensial grains but some grains are elongated in the direction of the schistosity. As a rule the phases with much epidote also contain considerable feldspar. With increasing coarseness of grain and at the same time increase in the proportion of feldspar in the rocks they become more definitely schistose and come to resemble in the hand-specimen rather fine-grained gneisses, differing from these mainly in exhibiting thin layering in addition to schistosity. In thin section they show large ragged fragments of orthoclase, plagioclases and lenses of quartz mosaic in a schistose matrix of small quartz grains, fragments of feldspar and wisps and plates of muscovite and biotite. All these lie in a fine-grained matrix of quartz which is in streaks where the crushing has been particularly severe. The whole rock appears to have been profoundly crushed and at the same time rather thoroughly silicified.

Most of the graywackes are of the kind described above, but many show other features some of which are noteworthy. Mention has already been made of the fact that some of them are garnetiferous. In a few the garnets are distributed uniformly through the rock, but in most they are crowded near the cleavage planes which separate the graywackes into slabs. The surfaces of these cracks are coated with biotite or with muscovite, and on both sides within ¼ to ½ inch of the crack the rock is very markedly schistose and full of garnets. Here micas and garnet make up nearly its entire mass. The quartz and feldspar, both of which are common elsewhere, have disappeared completely. Other beds are so full of biotite that they appear like layers of fine-grained biotite schist.

Many of the richly feldspathic graywackes are thinly and evenly laiminated, with light-colored feldspathic layers alternating with purplish-gray micaceous ones.

In some places the beds are coarser-grained than most of the graywackes and contain considerable feldspar, not only in small grains uniformly distributed through the rock but also in lenticular masses many times larger than the grains. The large lenses are usually limited to definite layers and the whole rock is more schistose than the less feldspathic phases and muscovite is apparently more abundant. These rocks look very much like sheared granites, but they are distinctly interbedded with mica schists and the usual micaceous graywackes and are involved in all the folding that characterize these. They have undergone the same kind of metamorphism as that to which the finer-grained graywackes have been subjected, and are now composed of the same minerals. They are apparently coarse-grained arkoses.

In a few places, however, there are interleaved with the graywackes sheared granites, aplites or rhyolites. These are extremely fine-grained purplish-gray rocks with a distinct pencil structure. On cross-sections they have the appearance of porphyritic felsites, in which the phenocrysts are feldspars, but on cleavage surfaces they show, in addition to their phenocrysts, parallel streaks of crushed feldspar and others of quartz. Micaceous components are not prominent. These rocks, which apparently are not very common suggest Keith's aporhyolites found in the Cranberry quadrangle.

A type of "porphyritic" graywackes noted at several places contains lenses of mixed quartz and feldspar and streaks of the same minerals joining neighboring lenses. They occur most abundantly near the belt of Hiwassee state, at the supposed base of the Great Smoky formation. In some of these there are pegmatite layers that are plainly intrusive. In others there are bunches of pegmatitic material in lines that are parallel to the rocks schistosity, and in others are bunches of quartz and feldspar and of aggregates of the two, connected by thin layers of the same composition. The gradations between these last phases and some of the conglomeratic graywackes are sufficiently complete as to leave no recourse but to conclude that some of the apparent conglomerates are very much squeezed graywackes that had, previously, been intruded by pegmatite parallel to a prior schistosity.

Conglomerates

The most distinct conglomerates are in thin layers in the more common graywackes. They usually consist simply of little layers with pebbles scattered through them. In some places the layers show a single line of pebbles on exposures, and in other places several lines. The best defined conglomerate seen in the formation occurs at the side of the road about ¼ mile east of the village of Sharp Top. It is nearly identical in appearance with the rock occurring in the Carolina at the road corner near the Bridge over Long Swamp Creek, about 1.1 miles a little east of north of Tate post office. The rock is composed of rounded fragments of feldspar and quartz in a sparse matrix of the usual biotitic graywacke, containing a few garnets. It exhibits a slight schistosity, by no means as marked as in the non-conglomeratic phases, possibly because of the abundance of the pebbles, many of which are ½ in. in diameter. Most of the quartz pebbles are flattened and crushed but those of feldspar are only slightly elongate and are free from all evidence of shattering.

Garnetiferous Mica Schists

Mica schists are not as abundant in the Great Smoky formation as they are in the Carolina gneiss, nor do they form thick layers. However, those that occur are very much like those in the Carolina gneiss. Like the older schists all of them are garnetiferous, but their garnets are, as a rule, not so large as they are in the Carolina series. Nearly all the garnetiferous schists are platy. They occur as comparatively thin layers interleaved with thicker layers of graywackes, and nowhere do they constitute the greater part of the formation. In all cases they appear to have been formed from the graywackes at and near shearing planes, which are usually the bedding planes separating neighboring beds. Here the adjustment of the beds in response to their deformation was more easy than elsewhere and as a result the rocks were more thoroughly sheared and more highly metamorphosed. Within the beds, away from the shearing planes, there was crushing and recrystallization but little differential movement. The material within the beds have retained some of their original characteristics, whereas that near the shearing planes have become well-defined schists.

The Nantahala Slate in Neighboring Quadrangles

The Nantahala slate is defined by Keith[22] and others who have worked in the quadrangles to the north as a formation lying between the Great Smoky conglomerate beneath and the Tusquitee formation above. In the Ellijay folio it is described by La Forge and Phalen as consisting of "blackish or dark-gray banded slate containing considerable finely disseminated graphite and iron oxide. It contains a few thin beds of white or light-gray quartzite and, at its base, a considerable thickness of banded garnetiferous and staurolitic quartz schists." This is

[22] Keith A., U. S. Geol. Survey Geol. Atlas, Nantahala folio (No. 143), p. 4, 1907.

its character north of Ellijay. South of this city it is less slate-like, "being chiefly graphitic schist with more or less staurolite throughout its thickness and containing few or no silicious beds." In the Nantahala quadrangle Keith describes the formation as "composed in the main of gray, banded slates and of schists, distinguished by mica, garnet, staurolite, or ottrelite. Most of the schists are near the base of the formation and strongly resemble the slate and schist beds in the Great Smoky conglomerate. * * * Many sandstones and conglomerate beds are interstratified with the slate near its base and form a transition into the Great Smoky. * * * Unimportant layers of graywacke or conglomerate are also found higher up in the slate. * * * Many of the slate layers are sprinkled with crystals of garnet and ottrelite, and with the increase of these and mica as a result of deformation the beds become almost entirely schists." The garnet and staurolite crystals are usually grouped in layers following the stratification, and neighboring layers may contain many crystals or none.

In the Ellijay quadrangle the Nantahala slate occupies narrow belts in its western part, separated by a belt of the Valleytown formation one mile wide, against which they are faulted. On their other sides both belts grade into the Great Smoky formation.

The Nantahala Slate in the Tate Quadrangle

In the Tate quadrangle the Nantahala formation also occurs in two distinct areas in its northern part. Both of these are southward extensions of the belts mapped in the Ellijay quadrangle. A third area is mapped as bordering the eastern belt of blue marble, called the Keithsburg belt (p. 95), which extends from the bridge east of Nelson over Long Swamp Creek to the southwest corner of the quadrangle.

The eastern belt in the north part of the quadrangle is about one mile west of Sharp Top Church, near the center of the northern border of the quadrangle. It is the southern end of the eastern belt in the adjoining Ellijay quadrangle. Where it enters the Tate quadrangle it is about ½ mile wide. It gradually diminishes in width to the south until at about 1½ miles from the northern margin of the quadrangle it terminates at a point and disappears, being cut off by faulting against the Valleytown formation on the west.

The western area in the north is the continuation of the western belt in the Ellijay quadrangle. It is a narrow belt, varying in width between one mile and one-fifth of a mile. It enters the quadrangle near its northwest corner with a width of about a mile and extends southeast to the latitude of Tate, where its width is scarcely 500 ft. and then south and southwest, leaving the quadrangle west of Hopewell Church with a width of about eight-tenths of a mile.

The contact between the graphitic slate and the underlying Great Smoky formation on the west is a transitional one through garnetiferous mica schists with a decreasing content of graphite to micaceous graywackes. The line limiting the Nantahala slate is drawn where the distinctly graphitic character disappears.

On the east side of the belt the contact is sharper. As one passes eastward the graphitic slate suddenly ceases, its place being taken by micaceous graywackes and mica schists of the Valleytown formation. Farther north, in the Ellijay quadrangle this contact is shown to be along a fault which cuts out the Tusquitee quartzite and the Brasstown schist, but there is no evidence that this fault extends through the Tate quadrangle. In the normal succession the Tusquitee and Brasstown formations lie between the Nantahala slate and the Valleytown formation, but they disappear at East Ellijay and do not reappear farther south. They continue for such a long distance to the north of East Ellijay with only minor interruptions that their absence in the Ellijay quadrangle south of East Ellijay and in the Tate quadrangle is thought to be due more probably to non-deposition than to faulting.

The area east of the Keithsburg marble belt is very narrow. It is marked by many exposures of graphitic and staurolitic and kyanitic garnetiferous mica schists such as characterize the lower portions of the Nantahala in the Ellijay and other quadrangles to the north. The boundary between the marble and the graphitic schists is sharp but that between the graphitic schists and the non-graphitic garnet-mica schists to the east has not been located. On the map this dividing line is drawn immediately east of the easternmost exposures of the graphitic schists, and the garnetiferous mica schists east of it are mapped with the Carolina gneiss.

The Nantahala slate in the Tate quadrangle is more like the schistose portion of the formation described in the Nantahala and Ellijay quadrangles than like its slaty portion, and much more like the rocks in the southern part of the belt in the Ellijay quadrangle than like that in its northern portion. Whether this is due to the fact that the areas in the Tate quadrangle are occupied only by the lower portion of the formation or to the fact that the rocks are much more deformed and metamorphosed than those farther north has not been determined. It is probable, however, that the difference is due mainly to differences in the degree of metamorphism to which they have been subjected. Staurolite and garnet are not present in most of the members of the formation in the Tate quadrangle. Garnet may be present in comparatively small crystals, evenly distributed through the schist, but staurolite is rare. The rocks on the whole are rather uniform in character. On cleavage surfaces they are glistening gray micaceous schists, but on cross-sections they show a dull-black slaty appearance, except where very schistose when they appear as a series of closely packed black platy layers.

The Nantahala slate in the Tate quadrangle is a very schistose, platy, graphitic mica schist resembling very closely the Canton and the Hiwassee schists. In general it differs from these in being much more slate-like and in containing fewer garnets, most of which are less than one millimeter in diameter. The rock of the formation is rather uniform in character, being made up of thin layers of a mixture of quartz and mica. The layers are closely folded into many small sharp folds in at least two directions, but the distinctly knobby appearance of the Canton and Hiwassee schists is not apparent. The Nantahala schist appears to have been a much more nearly uniform deposit of sandy silt than either the Hiwassee or the Canton schists which are characterized by "bulges" in its structure suggesting the former presence of large pebbles or of lenses of sand in an argillaceous matrix.

Under the microscope the sections of the Nantahala slates show only flat grains of quartz and plates of muscovite, with a few prisms of tourmaline and an abundance of graphite or other carbonaceous substance forming a matrix in which are scattered a few garnets, most of which are surrounded by alteration rims of hematite and limonite. The mica and quartz are not uniformly distributed, but the quartz is for the most part in lenses and streaks, surrounded by a mixture of quartz and mica, in which the mica predominates. The schistosity, which is determined by the parallel elongation of the quartz and mica is for the most part uniform except where it winds around garnets.

In some sections the mica is much less common than in others, which suggests an interlamination of sandy and argillaceous layers in the original deposit.

The carbonaceous material is in large irregular groups of grains in the more quartzose portion of the sections and scattered as small particles indiscriminately through those portions in which the mixtures of quartz and mica predominate. In these portions the graphitic material is not only between the grains but it occurs also as inclusions in the quartz, mica and tourmaline. It was not observed in the few garnets that were seen.

The anlaysis by Dr. Everhart of a specimen of a contorted silvery schist from near the southwestern end of the belt on the road about ¾ mile north of Hopewell church gave:

Analysis of Nantahala slate from Cherokee County, Ga.

SiO_2	Al_2O_3	Fe_2O_3	FeO	MgO	CaO	Na_2O	K_2O	TiO_2	S	P_2O_5	Ign	H_2O-	Total
44.70	41.18	2.20	1.47	.43	.04	.40	3.90	.79	.12	.02	4.53	.04	99.82

The most significant difference between this analysis and the analyses of the Canton (p. 46) and Hiwassee schists (p. 52) is in the very much higher percentage of Al_2O_3 shown by the analysis of the slate from the Nantahala formation. The figures are as follows:

	Canton schist	Hiwassee schist	Nantahala slate
SiO_2	69.16	49.56	44.70
Al_2O_3	18.42	29.90	41.18
K_2O	2.16	3.90	3.90

If the analysis of the Nantahala slate is calculated in terms of kaolin and sericite its indicated composition is 37.5% sericite, 58% kaolin, leaving an excess of 3.5% Al_2O_3 unaccounted for. These figures have little importance except that they indicate a more slaty character for the Nantahala rocks than for those of the Hiwassee and Canton formations.

The Valleytown Formation in Neighboring Quadrangles

The Valleytown formation in the districts north of the Tate area is very much better developed than in the Tate quadrangle, and for the most part is less metamorphosed. In the Nantahala quadrangle, where it is separated from the Nantahala slate below by the Tusquitee quartzite and the Brasstown schist, Keith describes it as consisting mainly of mica-schist and fine-banded gneiss in the vicinity of Valleytown. Farther north, where it is less metamorphosed, the mica schist passes into micaceous and argillaceous slates and the gneiss into graywacke and feldspathic sandstones. Numerous beds of coarse quartzite and graywacke occur in some places especially near the base of the formation.

Farther south where metamorphism is more pronounced mica schists are strongly developed, and are filled with small crystals of garnet and plates of ottrelite. The metamorphism, according to Keith[23] took place chiefly by the growth of new mica and quartz, and was particularly effective in the more argillaceous layers, where differential movements resulted in the development of new minerals in parallel layers. "Where the rocks were of uniform composition the schistosity bears no relation to the bedding planes. Where, however, the fine beds alternate rapidly with the coarse beds, the planes of motion were largely controlled by

[23] Keith, A., U. S. Geol. Survey Geol. Atlas, Nantahala folio (No. 143), p. 5, 1913.

the thick layers and the resultant schistosity is nearly parallel to the bedding." In many places the bands of secondary mineral as well as the sedimentary layers, are closely folded and faulted, indicating that the rocks were subjected to at least two deformations, the earlier one producing the secondary minerals and schistosity and the later one folding the schistose planes.

Farther south in the Ellijay quadrangle the rocks of theValleytown formation according to La Forge and Phalen[24] are biotite schist, sericite schist, andalusite schist and fine-banded, somewhat plicated mica-gneiss or graywacke, with a few thick beds of quartzite, arkose and fine conglomerate. South of Cherrylog the coarse beds disappear and the formation is a nearly homogeneous mass of sericitic mica schist and siliceous slate with some talcose material, with many graphitic schist beds in the upper part of the formation at some places.

In the belt crossing the southwest corner of the quadrangle and passing into the Tate quadrangle the rocks are said to be siliceous mica slates, curly phyllites and augen-gneisses, according to the coarseness of their grain. Talcose slate and thin beds of conglomerate are interbedded with the phyllite and augen-gneiss. On the whole the alteration of the members of the formation has been such that all the existing minerals are secondary, so that many of the beds have now little resemblance to sedimentary rocks.

The Valleytown Formation in the Tate Quadrangle

In the Tate quadrangle the Valleytown formation occupies a belt which is the southward extension of that crossing the southwest corner of the Ellijay quadrangle. It enters the quadrangle with a width of about one mile, being limited on both sides by belts of the Nantahala slate, against the eastern one of which it is faulted. At about 1½ miles farther south it splits into two parts enclosing a narrow belt of Murphy marble and extends south, with the same breadth, to the latitude of Tate. The eastern part, which is narrow, is faulted against the eastern belt of the Great Smoky formation as far south as this

[24] La Forge, L. and Phalen, W. C., U. S. Geol. Survey Geol. Atlas, Ellijay folio (No. 187), p. 6, 1913.

extends and then, farther south, against the Carolina gneiss to the latitude of Tate. The western part is bordered on the west by a belt of Nantahala slate.

At about Tate the two parts reunite and form again a single belt which widens, turns southwestward and leaves the quadrangle on its east side with a width of 4¼ miles. For about 3 miles of its length it encloses a narrow strip of Murphy marble, and at one place encloses a small portion of another strip. Its east side, south and west of Nelson is bordered throughout by a strip of Murphy marble.

Within the wider portions of the formation are many small lenses and short strips of graphitic mica schist identical in character with the prevailing phase of the Nantahala slate. It is thought that they may be portions of the Nantahala that have been brought up from under the Valleytown by folding. Most of the occurrences are too small to be represented on the map.

The Valleytown formation in the Tate quadrangle consists mainly of graywackes, arkoses and thinly layered, silvery, garnetiferous mica schists. The garnets in the mica schists are as a rule much smaller than in the corresponding schists of the Carolina gneiss series and the gneissic structure much less marked. Interbedded with these schists are thin layers of fine-grained, sandy graywackes, that are sheared along their bedding planes, the walls of which are so thickly covered with plates of muscovite that when viewed on their cleavage surfaces the rocks appear like mica schists. Indeed when the shearing planes are closely crowded the graywackes pass into mica schist just as do the graywackes in the Carolina and Great Smoky formations. Where very greatly sheared the Valleytown mica schists are thin plates of crowded mica flakes that readily break down and furnish a soil that consists almost exclusively of mica plates and a few garnets. Many of the micaceous schists contain abundant crystals of staurolite and of kyanite, and are in general identical with the staurolite schists found in the Carolina series.

The Valleytown beds, like those of the Great Smoky series, are traversed by quartz veins and by pegmatites parallel to their bedding, but these rocks are comparatively rare in the younger series.

Micaceous Graywackes

The graywackes in the Valleytown formation are evenly and thinly bedded rocks that are in no way different from the graywackes of the Carolina and Great Smoky formations except in that they split more readily into thin plates and ring less sharply when struck with the hammer. In many places they are so evenly bedded that they might furnish flagstones. Quarries have been opened at several points and excellent slabs have been shipped to Atlanta and elsewhere to be used for ornamental flagging. Close inspection of their cross-sections will show that the components of the Valleytown graywackes are not flattened to such an extent as those of the corresponding Carolina rocks and consequently the Valleytown rocks are not so schistose.

All the graywackes are distinctly gray rocks but some of them have a purplish-brown tinge.

Under the microscope the Valleytown graywackes are identical in appearance with those of the older formations, except that on the whole they are finer-grained and contain less tourmaline and sphene. Most of them consist of quartz, orthoclase, plagioclase, brown biotite and numerous small garnet grains, and small groups of grains and small particles of magnetite. Muscovite is absent from the body of the rocks, being confined merely to coatings on shear surfaces. The quartz and feldspars show no evidence of fragmental character. They are intercrystallized and are cut through by the biotite flakes. All the components appear to be of metamorphic origin. The rock at the flagstone quarry on Champion Creek, 1 mile northeast of Jasper, is a dark-colored graywacke, which is schistose and thin bedded but which is not separated into layers by seams of muscovite. Perpendicular to its cleavage it resembles a fine-grained biotite schist, but on cross-sections it looks like a slightly schistose gray sandstone. In some places in the quarry the graywacke is interlayered with thin seams of quartz, that are drawn out into flat lenses that are crushed to an extremely fine aggregate.

The darker varieties of graywacke contain muscovite, biotite, quartz, feldspars, a little epidote and nests of calcite, grains of rutile and sphene, and fragments of tourmaline crystals. The biotite is more abundant than in the lighter colored varieties, and it is this mainly that imparts the darker color. As a rule the parting planes of the dark graywackes are only thinly coated with muscovite and garnets are lacking.

Some of the graywackes contain white lenses that suggest sheared pebbles. These are well exposed in the bed of Champion Creek near where it is crossed by the road from Jasper to Grand View. The stream runs for some little distance over smooth ledges of micaceous graywackes alternating with thin layers of garnetiferous mica schists. Some of the graywackes contain lenses of quartz, others lenses of both quartz and feldspar, and others lenses of a mixture of the two. They vary between very small particles to lenses ½ inch long and ¼ inch thick.

The sparse matrix of the rock is like the material of the micaceous graywackes. In this are lenses of quartz mosaic and fragments of very much altered microcline and other feldspars apparently very much older than the clear feldspar of the matrix. That they represent old residuals is indicated by the fact that the matrix winds around them, in the same way that it does around crushed quartz pebbles.

A few beds in the Valleytown series consist of a muscovite-quartz schist that resembles a schistose quartzose sediment. Rocks of this kind are particularly noticeable on the east end of Hickory Log Mountain. They are associated with dark, fine-grained quartz rocks that certainly suggest sediments and garnet mica schists. Under the microscope nothing is seen except crushed quartz grains and scarce wisps of decomposed biotite flakes, through which are streaks of muscovite. Mr. Haseltine, who studied this portion of the area writes, "It seems that these rocks are pegmatites or quartz veins rather than sediments."

An anlaysis of a dark-gray micaceous graywacke from the Valleytown formation is quoted on p. 22. As might be expected there is no essential difference in chemical composition between this rock and the graywackes of the Carolina gneiss.

Garnetiferous Mica Schists

As in the case of the graywackes in the Carolina series most of those in the Valleytown formation contain muscovite coatings and numerous small garnets on their shearing surfaces. (See p. 19). With an increase in the number of shearing planes and the consequent increase in the platiness of the rocks they become more and more nearly garnet mica schists, until in those places where considerable thicknesses of the layers have been thoroughly sheared throughout they are typical schists studded with small garnets. The best examples of these mica schists are compact gneissoid rocks that consist of closely welded plates of silvery mica in which are embedded thousands of little garnets about 1/8 in. in diameter, and between the mica plates little lenses of colorless, crushed quartz.

Staurolite-kyanite mica schists

In certain layers the garnetiferous mica schists are so abundantly besprinkled with staurolite and kyanite crystals that they may well be described as staurolite-kyanite schists. (Plate V A). In some layers the kyanite predominates over staurolite and in others the staurolite is in excess. Garnets are always present. All of the rocks are strongly sheared. Excellent exposures that are easily accessible are in the bed of the little stream crossing the State highway at Keithsburg.

In most of the rocks the mica is in large aggregates of scales, resembling sericite, with a silvery gray luster. In this are blades of blue kyanite that vary in length from a fraction of an inch to several inches. Many of them are oriented with the schistosity but others lie athwart it.

The staurolite is commonly in slightly smaller crystals than the kyanite. Like the kyanite blades the staurolite is usually oriented parallel to the planes of schistosity, but with their longer axes inclined to the direction of shearing in this plane which is indicated by the elongation of the sericite plates. Where the kyanite is sparse the staurolite crystals are larger, in many places being over an inch in length and 1/3 in. in width.

Tourmaline is abundant in some specimens and in all are many poicilitic garnets. In some there are many biotite plates and in some a few plates that closely suggest ottrelite. The groundmass of all the staurolite-kyanite schists is mainly a felt of colorless or pale-green mica, a little quartz, a few wisps of biotite and some iron oxides, besides small tourmaline prisms. The biotite is characterized by numerous pleochroic halos.

In a few places the kyanite is in particularly large quantity. In a little pit on the east side of the road between Refuge church and Harmony school is a very cavernous staurolite-kyanite garnet schist in which the kyanite appears in little radiating bunches of plates in the pore openings, and in streaks through the schist. In the streaks the kyanite is sheared into masses of micaceous plates that look very much like masses of sericite except for their more distinctly blue color. Inspection of the walls of the pit suggests that the kyanite is grouped around quartz veinlets. It is true that blades of the mineral occur anywhere in the schist, but they are much more abundant and more thickly crowded near masses of quartz than elsewhere.

Moreover, in other places where kyanite is found in notable quantity, quartz veins are to be found near by. At several places quartz veins that cut mica schists are bordered by plates of sericitic mica and blades of kyanite, often with the addition of large garnets. The kyanite blades usually lie with their flat sides parallel to the directions of schistosity; but their elongation is in any azimuth in this plane. In some places large crystals of the mineral penetrate the quartz.

The best illustration of the relations of the kyanite to quartz is to be seen at an opening about 3½ miles a little south of west from Ball Ground. The opening which is on the west side of the road has exposed a portion of a 2 ft. wide quartz vein cutting mica schists. The schist in contact with the vein contains some kyanite, but the main mass of this mineral is in the quartz. (Plate VIII A.) The vein is roughly layered. The west layer, which is in contact with the schist, consists of quartz and large penetrating crystals or blades of kyanite. Next to this on the east is a barren layer of quartz, and next a little mica-kyanite schist and then another layer of quartz and kyanite. The kyanite seems to have grown from the outside inward. Along the borders it occurs in radiating aggregates that are in many places so compactly crowded as to appear massive. Usually, however, the masses are composed of large crystals of kyanite more or less divergently grouped with large plates and crystals of a white, glistening, micaceous mineral between them. This mineral resembles muscovite very closely, but is more brittle and apparently it grades into kyanite. At any rate large plates of the mica are mottled with bluish areas, which upon close study are seen to be masses of thin plates of kyanite. Here and there are large grains of quartz partially bounded by crystal planes and elsewhere in the mass are cavites like the gem-bearing cavities in pegmatites.

The flat surfaces of the kyanite blades are not smooth except where they are cleavage surfaces, but are covered with little wart-like projections. Many of the blades are bent and are marked by cross striations, or are broken across, and nearly all are covered by a scaly micaceous coating which appears to be a schistose kyanite.

Two analyses of the kyanite from this pit were made by Dr. Everhart. That in line I is of a powder separated by means of a heavy solution, and that in line II of a specimen in its natural condition. The theoretical composition of pure kyanite is shown in line III, but nearly all kyanite contains some Fe_2O_3.

Analyses of kyanite from near Ball Ground, Cherokee County, Ga.

	SiO_2	Al_2O_3	Fe_2O_3	FeO	MgO	CaO	Na_2O	K_2O	TiO_2	H_2O^+	H_2O^-	Total
I	36.08	60.66	1.68	.14	.00	.00	.43	.22	Tr.	.66	.08	99.95
II	42.54	51.72	1.08	.58	Tr.	.00	.78	1.34	.18	1.76	.14	100.12
III	37.02	62.98	------	-----	-----	-----	-----	-----	-----	-----	-----	--------
IV	58.44	23.94	3.55	1.17	.13	.06	.35	5.92	1.08	4.40	.22	99.75[1]
V	61.25	26.01	2.08	1.17	Tr.	Tr.	.68	3.11	.92	4.40	.08	99.78[2]

1. In addition, 0.30 MnO, 0.04 SO_3, 0.15 P_2O_5 and traces of NiO and CoO.
2. In addition, 0.07 P_2O_5 and traces of MnO and SO_3.

The first analysis indicates a mixture of about 94% kyanite and 6% muscovite; the second a mixture of about 67.3% kyanite, 24.4% muscovite, 5.8% quartz and 2.5% ilmenite, excess water and loss.

Where the masses of kyanite rock are exposed their surfaces are marked by ridges of divergent plates of a micaceous aggregate, which is plainly an alteration product of kyanite. (Plate VIII B.) Analyses III and IV are of these aggregates. The mass III consists of a mixture of 30% quartz, 55% muscovite, 6½% of residual kyanite and 9% of other constitutents. Mass IV contains 36½% quartz, 37% muscovite, 20% kyanite and 6½% of other substances.

There is not much evidence from which the manner of origin of the kyanite can be inferred but it appears clear that it has replaced the quartz, in consequence of reactions between the silica and the aluminous components of the schists. Where the quartz entered as a vein the crystals grew from its margins, where the schist was saturated with siliceous emanations the kyanite was produced irregularly through the mass near the intrusions.

The Murphy Marble in Neighboring Quadrangles

In the Nantahala quadrangle, at many places above the Valleytown formation, lies a strip of marble that is bordered on its east side for most of its extent by a fault known as the Murphy fault. Where the fault is absent the marble grades into a calcareous and quartzose schist containing small plates of a micaceous mineral suggesting ottrelite. This has been called the Andrews schist. The fault to the east of the marble strip separates it in most places from the rocks of the Valleytown formation, and in others from the Nantahala slate or the Brasstown schist. In some places the fault crosses the strike of the marble diagonally thinning the widths of its exposures or cutting out the belt completely. Consequently the marble appears as a series of long strips and isolated exposures in a line, the direction of which is approximately that of the strike of the fault. Folding east of the fault line brings the marble again to the surface and patches of it are found at several places where it is entirely surrounded by siliceous schists.

In the Ellijay quadrangle the exposures of the marble are more spotty. Small patches and narrow strips of its exposures occur along two lines that follow two nearly parallel fault outcrops. The western line, comprises a few isolated areas that lie against the Murphy fault, and the eastern line a long strip and a number of small areas that lie against a more easterly fault known as the Whitestone fault. Between the two faults are a few other small areas of outcrops that were brought to their present position by folding.

In the Nantahala quadrangle the Murphy marble consists entirely of marble which, for the most part is a rather fine-grained white rock. Associated with the white marble, however, are layers of a dark-gray or blue color and a few that are rose-red. Where its base can be seen the marble passes downward into the Valleytown formation by interbedding, and upward into the Andrews schist through several feet of alternating marble and schist layers.

Analyses show the marble to contain from 58 to 93 per cent of $CaCO_3$ and from 36 to 3 per cent of $MgCO_3$. In many places it contains sparingly garnet, tremolite and pyrite, and in the upper layers of the formation plates of a micaceous mineral that are described as ottrelite. The marble also in some places contains large and small lenses of talc, a few of which have been mined. All of these minerals were produced by the metamorphic processes that change limestone into marble.

In the Dalton quadrangle, the marble belt is well exposed at Whitestone, which is in Talona Valley, Gilmer Co., a few miles west of the western margin of the Ellijay quadrangle, where its upper portion is faulted against the Nantahala slate to the east. In the sections exposed by the various quarriest he upper portions consist of alternating layers of fine-grained magnesian marble and coarse-grained marble containing very little magnesia. Some of the most richly magnesian rock is used in the manufacture of carbon dioxide, epsom salt, and tarozo.

The low-magnesian phases of the marble are reported by La Forge and Phalen[25] to contain muscovite, tremolite, quartz, hornblende, biotite, graphite and hematite in comparatively small amounts, and chalcopyrite, galena and pyrite in minute amounts in some places.

Nowhere in the district is there a section from which can be determined the relation of the high-magnesian to the low-magnesian

[25] La Forge, L. and Phalen, W. C., U. S. Geol. Survey Geol. Atlas, Ellijay folio (No. 187), p. 14, 1913.

beds. They appear to be interlayered. In one section described by Maynard[26] a massive pink and white marble containing 9.66% of MgO is placed over a finely crystalline white marble containing 17.02% of MgO, and at another 30 feet of high-calcium marble lies above a bed of magnesian rock, but in neither of these sections can it be inferred that the marble beds increase in their magnesian content at lower horizons, since a portion of the formation has been sliced off by faulting.

The Murphy Marble in the Tate Quadrangle

General Distribution

In general the faults which determine the position of the Murphy marble in the Ellijay quadrangle continue southward and determine in part its distribution also in this quadrangle. But in addition there are long belts of marble in the Tate quadrangle that owe their positions to folding.

In the Tate quadrangle the marble occupies several areas separated from one another by schists that are entirely devoid of calcareous materials. Three of the areas are narrow strips many times longer than broad. Two of these lie toward the east margins of belts of micaceous schists of the Valleytown formation and one is well within this formation. For purposes of description these are referred to as the Long Swamp Creek belt, the Keithsburg belt and the Sharp Mountain Creek belt. A fourth area, which is crescentic in shape, extends northward from a point about ¾ mile south of Tate post office and then eastward to Marble Hill post office. At its east end it divides into two forks, one stretching southwest for a distance of one mile and the other eastward for a distance of two miles. A fifth area is outlined by a few pits and a number of drill holes near the mouth of a small branch entering Long Swamp Creek from the east, about one mile north of the head of Roberts Lake, which is a mile northeast of Ball Ground. The sixth area is in the valley of a stream entering Sharp Mountain creek from the east about ¾ mile north of the bridge about 2 miles west of Ball Ground. This, too, is a small area in which the marble is now exposed only in a few pits.

[26] Maynard, T. P., A report on the limestones and cement materials of North Georgia: Geol. Survey of Ga., Bull. 27, p. 121-123, 1912.

There are a few other isolated exposures, like the one on the side of the road between Marble Hill and Dawsonville, about 1½ miles southeast of Marble Hill, those near the spring south of the school house on Highway No. 5, at the south edge of Nelson, and a few places where marble has been encountered in well-digging or drilling, like the marble found in a ditch about ¼ mile west of Sharp Mountain Church, between Gober and Ball Ground, but these are regarded as portions of one of the larger areas, separated from it by a covering of soil or cut off from it by faulting. (Fig. 2.)

Long Swamp Creek Belt

Distribution and General Character.—The Long Swamp Creek belt of marble extends for a distance of 3 miles along the east slope of the valley of Long Swamp Creek from a point about 2 miles northeast of Jasper to a point 1¾ miles north of Tate station. The marble is exposed continuously through this distance in a narrow belt on the lower portion of an almost precipitous slope, the upper portion of which is in a very compact and moderately coarse garnet-muscovite schist, which is believed to be a part of the Valleytown formation. The upper margin of the belt is from 20 to 110 feet above the level of the creek. Its lower margin is at the base of the slope only a few feet above the creek. Its width varies between a few feet and 125 feet, but no estimate of its thickness can be given because of its extremely close folding.

Most of the marble in the belt is a fine-grained evenly granular white rock with a sugary texture and with only slight traces of bedding. In some places there is a suggestion of schistosity and here and there is an obscure lamination. Its general strike is in the direction of the trend of the belt and its dip between 25° and 30° northeast. For the most part the rock is a pure magnesian marble. (See analyses, p. 80). Most of it contains a few particles of white tremolite, grains and small lenses of quartz, and in some places numerous small bronzy-yellow plates of mica.

Slightly coarser-grained phases of the same rock are met with here and there but their relations to the finer-grained phases is not known, since exposures are not continuous, because much of the slope on which they occur is covered with talus. They, like the denser white marble, are magnesian. (See analysis, p. 80). At the Lincoln quarry, which is nearly due east from Jasper the marble is well exposed in massive beds that are very slightly schistose, though sharply folded into many plications that are overturned to the west so that their axial planes have very low dips to the east, in some places being nearly horizontal. (Plate IX A). The folds are marked by narrow blue streaks in the east and south walls of the quarry where they are easily recognizable. An attempt to photograph them was, however, not very successful. The very close folding of the marble makes it impossible to estimate its thickness and to determine the position of its bottom layers. It is believed that both the east and west margins of the belt are occupied by the lowest beds of the marble formation and that this formation is in a syncline overturned to the west with the Valleytown beds on both sides of the marble strip. At the east side of the Lincoln quarry the marble is in contact with a compact, coarse, hard garnetiferous mica schist along a crack that dips about 30° east and is filled with a micaceous gouge. A similar contact is to be seen again at another quarry about 1/8 mile farther north and at the old Ward's quarry about ¾ mile farther north. At the Ward's quarry the strike of the marble is N. 15° E. and its dip about 25° E. The rock west of the marble belt is a fine-grained garnetiferous schist characteristic of the Valleytown formation. It is more schistose than the schist east of the marble and more platy. The contact on the east is believed to be along a small slip, which has brought the marble in contact with a lower bed of the Valleytown series than that with which it is in contact on its west side. On the west side the Valleytown schist is below the marble, but on the east side is above it. This is due to the fact that both the Valleytown formation and the Murphy marble are compressed into folds overturned to the west.

Associated with the fine-grained white marble in some parts of the belt are layers of a coarse-grained white marble and others of a fairly coarse-grained light-blue-gray marble interlaminated with the white marble, but in general above it on the higher slopes. Unlike the finer grained white marble in this belt the coarse-grained marbles are almost free from magnesium. (See analysis I and IV, p. 80.)

At the old quarry at the base of the cliff on the east side of Long Swamp Creek alongside the road crossing the creek ½ mile south of the Lincoln quarry is a section through the formation which at this place is very thin. The rock in the old quarry is a fine-grained white marble containing a few streaks of bluish calcite. It is a little coarser than the greater portion of the rock at the Lincoln quarry, and is distinctly crystalline, but it is by no means as coarse as that in the Marble Hill belt. At about the middle of the exposure on the road is a narrow layer of a pinkish marble that resembles somewhat closely the pink Etowah marble. (p. 84). Its color, however, is due to an accumulation of flakes and little irregular lumps of a reddish-brown earthy substance that has resulted from the decomposition of some iron-bearing mineral, which during the process of alteration gave rise to solutions that stained the surrounding carbonate. Dr. Everhart reports that the rock consists of about 38% $MgCO_3$ and 59% $CaCO_3$, and contains besides 0.12% MnO which may account for the pink stain. In thin section the brown, earthy spots are seen to be a red stained fibrous or fine granular substance that apparently owes its present color to hematite. The original material was apparently a phlogopite or other mica. East of the pink marble is a layer of fine-grained bluish-gray marble like that over the white marble farther south. If the whole series is overturned the blue marble is at its bottom. A few rods east of the blue marble are mica schists, which a few feet from the contact are black with organic substance. This may be a thin layer of Nantahala slate which would indicate that the bottom of the Valleytown formation is a short distance east of the marble.

In thin sections of the white and bluish marbles very little can be seen beside polysynthetically twinned calcite grains. Here and there are a few crystals of tremolite, a few nests of quartz, a few flakes of phlogopite and of brown biotite, a few irregular masses of magnetite or some other iron compound and scattered opaque dust particles. The quartz is in round grains containing liquid inclusions, as though original sand grains. The biotite flakes also appear to be remnants but the phlogopite seems to be a new crystallization. Numerous small irregular clumps of zircon or almost colorless rutile are also observable and a few crystals of yellow rutile. The rocks are extremely pure marbles.

Chemical Composition.—Analsyses of several specimens taken from this belt conform the results of the microscopic study. Specimen No. I was from an exposure in the cliff on the east side of Long Swamp Creek, 2 miles southeast of Jasper. It is a fairly coarse-grained white marble. No. II is the fine-grained white marble from the Lincoln quarry, east of Jasper. No. III is a fine-grained, sugary textured white marble from the south end of the belt. It is associated with the coarse gray-blue marble, No. IV. No. V is the coarse white marble at Whitestone, quarried at the first mine south of the railroad station. No. VI is the white, dense, flinty marble that is mined at Whitestone as a source of magnesium salts, and No. VII, a light grayish-blue marble interlayered with No. V. No. VIII is a black marble from a thin layer interbedded with the coarse-grained white marble at Whitestone. It was not seen in place, the specimen having been taken from the pile of waste at the quarry

Analyses of marbles in the Long Swamp Creek belt and at Whitestone, Ga.

Analyst: Dr. Edgar Everhart

	Long Swamp Creek				Whitestone			
	I	II	III	IV	V	VI	VII	VIII
Moisture	.02	.30	.02	.20	.00	.02	.06	.00
CaO	53.76	32.68	31.00	50.40	49.94	33.62	51.48	51.00
MgO	1.34	17.23	20.54	2.14	3.00	18.18	1.09	2.40
FeO	------	.56	------	.63	------	------	------	------
MnO	------	.07	------	------	------	------	------	------
CO_2	43.71	------	46.78	42.26	42.54	44.72	42.40	42.64
Al_2O_3	.00	.00	------	.20	------	------	------	------
Fe_2O_3	.15	.25	.79	1.00	.36	.38	.49	.55
Ign.	------	45.80	------	.20	------	------	------	------
SO_3, TiO_2, P_2O_5	.00	.00	.00	.00	.00	.00	.00	.00
Total sol. in HCl	98.98	96.89	99.13	97.03	95.84	96.92	95.52	96.59
Ignition	.35	------	.20	------	------	------	------	.68
Al_2O_3	.25	.79	Tr.	.98	.40	.12	.20	.16
Fe_2O_3	Tr.	.02	.15	.11	.18	.77	.10	.50
CaO	.03	.02	.11	.00	.00	.00	.00	.00
MgO	.01	.34	.03	.12	.00	Tr.	.06	.16
FeO	------	.14	------	.06	Tr.	.00	Tr.	Tr.
Na_2O	Tr.	.14	.02	.07	.09	.08	.07	.07
K_2O	.03	Tr.	.03	.21	.04	.02	.03	.02
TiO_2	.00	.02	------	.07	.02	------	Tr.	Tr.
SO_3, P_2O_5	.00	------	.00	.00	------	------	.00	.00
SiO_2	.36	1.40	.60	1.72	2.71	1.60	3.82	2.56
Total insol. in HCl	1.03	2.87	1.14	3.34	3.44	2.59	4.28	3.99
Total	100.01	99.77	100.27	100.37	99.28	99.51	99.80	100.58

I. Coarse-grained white marble. Exposure in cliff, east side Long Swamp Creek, 2 mi. S. E. of Jasper.

II. Fine-grained white marble, Lincoln quarry, 1 mile east of Jasper.

III. Fine-grained, sugary textured marble from cliff side, south end of belt.

IV. Coarse-grained gray-blue marble, from layer above III.

V. Coarse-grained white marble, quarry about one mile south of R. R. station, Whitestone, Gilmer County.

VI. Dense, flinty white marble, mined as a source of magnesium salts. Interbedded with V, at Whitestone.

VII. Coarse, bluish-gray marble interlayered with V, at Whitestone.

VIII. Black marble, from layer 16 to 18 in. thick, interbedded with V, at Whitestone.

A comparison of the analyses given above will show that the coarser marbles in this belt (I and IV), whether white or bluish, contain smaller amounts of $MgCO_3$ than the finer ones (II and III). This is in accord with the conditions at Whitestone where the finest grained bed (VI) is worked as a source of magnesium compounds. It will also be noted that the marble of the Lincoln quarry (II) is nearly as rich in magnesia as the famous rock at Whitestone (VI), and that the finer grained marble farther south contains over 2½% more of this oxide.

A calculation of the proportions of calcium and magnesium carbonates in the samples analysed gives the following results:

Proportions of $CaCO_3$ and $MgCO_3$ in the marbles of Long Swamp Creek and Whitestone, Ga.

	I	II	III	IV	V	VI	VII	VIII
$CaCO_3$	95.85	58.35	55.30	89.50	89.10	57.80	91.90	90.85
$MgCO_3$	2.81	36.18	43.10	4.49	6.30	36.83	2.29	5.04

Marble Hill Belt

Distribution and General Character.—The belt of marble that has been called the Marble Hill belt occupies in the main a hook-shaped area with its barb 1¼ miles north of Tate post office, and its stem extending east to Marble Hill post office which is 2¼ miles northeast of Tate. The curve of the hook between the barb and the stem extends at least a mile south of Tate post office. The area underlain by the marble varies in width from 400 to 2500 ft. It is from this area that most of the commercial marble of the district comes.

At the northwest corner of the area a very narrow belt of marble similar to that of the main belt leaves the main belt and stretches south and southwest for 1¼ miles to near the road between Tate station and Tate post office. It is marked by a few ledges on the steep slopes to stream valleys. The marble can be traced almost continuously from the road northward to Long Swamp Creek.

From the east end of the hook there are two narrow lines of marble exposures, one extending southwest about one mile along the little valley that terminates at the Amicalola quarry, and the other southeast about 1½ miles, following closely the road to Dawsonville. The first of these lines is marked by a few low ledges at the north end of the valley and by the openings at the quarry at its south end. The eastern belt is located by the opening of the Cowart quarry, a few small ledges well up on the slope over looking the railroad between the quarry and Marble Hill and another on the south side of the Dawsonville road ¾ miles east of the quarry. A few pits have exposed marble also in the valley of the East Branch of Long Swamp Creek, at the base of its north slope, and at many places in the bottom of the valley the Georgia Marble Company has explored by drilling and found the marble immediately under the surface.

The narrow streak of marble that extends northward from the road between Tate station and Tate post office is indicated by a few small exposures of a coarse-grained, white, glistening marble outcropping on the side of a ravine a few rods north of the old Tate Mansion on the north side of the road, a few outcrops of a light-gray marble a few score yards southwest of the large spring at the Williams house about 1/3 mile farther north, a small exposure in a cliff on the side of the road about ½ mile farther north and several exposures on the wooded slope overlooking the valley of Long Swamp Creek, about 1/3 miles farther north. Outcrops of marble are reported to be visible sometimes also in the channel of the creek, but they were not seen.

West of the marble are garnetiferous graywackes and garnetiferous mica schists striking about N. 15°-20° E., and dipping moderately to the southeast and on the east side are garnetiferous mica gneisses. The rocks on both sides of the marble are regarded as Valleytown. At the south the marble apparently strikes N. 8° W. and dips northeast and the schists beneath it strike N. 2° W. and dip 32° northeast. At the Williams house the gneiss overlying the marble strikes N. 17° E. and dips southeast, but the marble is probably not in ledges, as strikes varying between N. 32° E. and N. 25° W. are recorded, with dips both northeast and southeast. Farther north the marble occurs in thick, blue and white layers striking N. 21° E. and dipping 28° southeast.

Its vertical thickness is apparently 35 ft. On the slope overlooking Long Swamp Creek farther north, the ledge, which is a white marble strikes N. 16° E. and dips southeast.

The marble throughout the strip is coarser than that in the Long Swamp Creek belt and some of the darker beds are like some of the coarser-grained blue limestone of the Keithsburg belt.

The southernmost limit of the main area of the Marble Hill belt is not definitely established. The broad valley that extends 2¼ miles south from Tate post office is bordered on both sides by outcrops of marble for most of this distance. Near its south end, however, marble exposures are lacking and the slopes are comprised mainly of gneisses. The mapping assumes the existence of marble beneath the valley floor and the boundary between this rock and the gneiss is drawn near the base of the slopes.

Following north along the west branch of the area the west boundary of the marble is established by the openings of the Cherokee quarries, about a mile north of the south end of the area, and the openings of the Creole quarries from ½ to 7/10 of a mile farther northwest at Tate post office, and by exposures between these. The strikes of the marble follow closely the boundary as marked, increasing from N. 20° W. at the south to a general strike of N. 55°—60° W. at the Creole quarries. At the Cherokee quarries the marble is marked by blue streaks that apparently represent thin beds of blue-gray marble interlayered with the prevailing white variety, and at the Creole quarries comparatively thick blue and white marble are about equally interstratified. At the Cherokee quarries the rock is folded into flat, sharp folds overturned to the northeast, but at the Creole quarries the folding is so much more complex that it is difficult to discover any general system to the contortion. Where dips can be measured on individual folds they are generally to the southwest, all the folds being overturned to the northeast at moderately low angles.

West of the marble the bluffs consist of garnet-mica schist, the strike and dip of which are about parallel to that of the marble, though the dip is generally more uniform. The schist is believed to be part of the Carolina gneiss.

The presence of the opening of the Etowah quarry 1500 ft. northeast of the Cherokee quarries and of a small exposure of white sandy marble on the north slope of the hillock about 800 ft. farther east suggests that the marble is continuous through this distance. East of the exposure of sandy marble are mica graywackes followed to the east by mica schists and beyond by heavy ledges of marble. The little hillock south of the exposure is covered with a friable calcareous sandstone striking N. 10°—15° E. and dipping southeast, that resembles very closely a weathered form of the Andrews schist that overlies the Murphy marble in the quadrangles to the north. The relation of these exposures to one another indicates that the tongue of siliceous rocks that extends downward from the north and divides the area into its two branches ends at about this place. Farther south the marble is believed to underlie the entire valley from the lower slopes of the bluff on its west side to the lower slopes of those on its east side.

At the Etowah quarry which is near the center of the valley, but closer to its west than its east side, the rock is a pink variety with narrow blue-gray streaks. Like the white marble in the Cherokee quarry and the mottled marble in the Creole quarries the dark streaks are believed to indicate the bedding. If this opinion is correct the Etowah marble is closely folded like that in the Cherokee quarry into flat sharp folds with an average dip of 15°—20° for their axial planes. All the dips are toward the southeast and the folds are consequently overturned to the northwest. (See Plate IX B .)

At the Creole quarries the marble makes a turn westward into the head of Smoky Hollow, being exposed in a low ledge on the south side of the valley and in massive rough ledges in the bluffs on its north side. From the head of Smoky Hollow to the mouth of the East branch of Long Swamp Creek no exposures were seen, but marble is known to occur under the road running north along the west side of the valley. At the mouth of the East Branch, however, white marble outcrops for 90 ft. on the side of the road along the south side of the creek, and is overlain on the east by a garnetiferous micaceous graywacke. The marble, which strikes N. 10°—15° E., and dips 34° southeast, is a very fine-grained crystalline white magnesium marble (analysis VIII, p. 91) and a mediumly coarse-grained variety with a grayish cast interlayered with thin layers very rich in phlogopite. The coarser marble is distinctly contorted and the phlogopite marks shearing planes.

West of this exposure about 500 ft., on the west side of the creek, is a drill hole in marble, and about ¼ mile farther north is a low exposure 500 ft. long of marble interlayered with sandy micaceous beds, and folded into sharp corrugations, with pitches of 10°—20° southeast. The general strike of the beds at the southern end of the exposures is a little west of north, but in the stream bed farther north the strike is N. 25°—30° east. The most northerly exposure in this branch of the area is ¼ mile farther north on the little stream entering Long Swamp Creek at the exposure in the creek. It is a fine-grained white marble cut by little veins of coarse calcite. Overlying it is a very slaty mica shist with very small garnets scattered through it, and a short distance farther north at the head of the valley is a micaceous graywacke.

The rocks to the west of the marble are mainly micaceous graywacke, mica schists and mica gneiss. Near the bridge crossing Long Swamp Creek on the road to the mouth of the East Branch are conglomeratic mica schists and micaceous graywackes with strikes between N. 19° W. and N. 31° E. and with easterly dips. The conglomeratic mica schist is a sandy micaceous graywacke, containing small plates of white and black micas, thin streaks or lenses of quartz, a few garnets, a few large rounded masses and flat lenses of transparent quartz, and lenses and eyes of feldspar. It seems to be a sheared form of the "conglomeratic" rock found outcropping on the road ¼ mile east of Sharp Top village. All these siliceous rocks are regarded as Valleytown in age.

Beginning again at the south end of the area and following its East Branch one finds almost continuous ledges all the way to a short distance beyond Marble Hill post office, constituting a strip 7½ miles long, having a width varying between 800 and 2000 ft. except at the extreme south and east ends where it tapers to a point.

At its south end marble occupies the lower slopes of the bluff bordering the east side of the valley of Long Swamp Creek. The marble is the usual white, crystallized variety in heavy ledges. For the first 1½ miles it strikes N. 10°—20° E. and dips 26° to the southeast. On the east the marble is bounded by a narrow strip of a black basaltic rock which in many places has been sheared to a hornblende schist. Beyond this up to the slope are coarse mica gneisses. Opposite the Cherokee quarries marble and hornblende schist are interbedded. The hornblende schist is a very fine aggregate of amphibole, containing here and there little nests of green epidote and cut by veinlets of the same mineral. In thin section the rock shows an abundance of parallel pale blue-green hornblende, a little apatite, some brown biotite, in some places enclosing all other constituents, a little muscovite in large plates and many yellow rutile grains and crystals.

At 1½ miles from the south end of the valley the marble ledges become heavier for ½ mile and their strike changes to N. 18°—27° W. with dips of 28°—46° northeast. For the next mile north no exposures are seen, but an old quarry and exposures in the gulch back of the quarry show that the strip continues with its well-bedded layers striking N. 20° W. and dipping northeast. Here the marble is bounded on the east by garnetiferous mica schist striking about north and N. 13° W., and on the west by garnetiferous mica schist and gneiss, that outcrop on the side of the road between Tate and Marble Hill and on the hill to the west. The schists on the west and the schists and gneiss on the east are parts of the Carolina gneiss, those on the west forming the ridge that extends southward and divides the marble area into its two branches.

A short distance farther north the marble begins to turn eastward and follows the east branch of Long Swamp Creek without interruption to a few hundred yards beyond Marble Hill post office.

Its south edge is well defined by exposures on the lower slopes overlooking the valley of the creek and the numerous openings that have been made in the upper slopes for the production of building and monumental stone. Next above the marble on the slope is a strip of black rock that is apparently the same as that already referred to as east of the marble at the south end of the valley east of Tate Post Office, and above this, forming the upper slopes and tops of the hills, is the coarse garnetiferous mica gneiss that is one of the characteristic members of the Carolina gneiss.

The black rock varies in character from a very fine-grained massive "hornblendite" composed of interlocking spicules of pale-green amphibole, with interstitial epidote, calcite, magnetite, and other opaque substances, and some leucoxene, to a well defined coarse-grained hornblende schist that is described in the field notes as a "black, coarse, platy hornblende schist." It is composed of large plates of cellular, green hornblende containing numerous inclusions of quartz and magnetite, and an interstitial filling of brown biotite, granular quartz, a little calcite, or a mixture of these, and fine granular amphibole. Other phases of what are supposed to be the same rock are distinctly porphyritic and are intrusive in the marble. One of these intrusive stringers at the New York quarry is very similar to the dark rock in the Great Smoky formation west of Jasper. Other phases are rich in garnet, and another phase is an extremely fine-grained hornblende schist with thin streaks of quartz and small "eyes" of quartz and feldspar, as though it were a sheared amygdaloid.

Back of the Piedmont Crusher are great boulders of coarse muscovite pegmatite in the midst of the area believed to be underlain by the black rock. It is probable that the pegmatite intrudes the black rock, but no clear evidence of the relations was seen. Among the fragments are some that are marked in places by much bright green mica which according to Mr. Charles Milton contains chromium.

There are no outcrops by which the north boundary of the belt can be definitely determined. Ledges of pink marble resembling the Etowah marble outcrop in the East Branch a little west of the crossing of the road between Tate and Marble Hill but no other outcrops were seen. Drilling by the Georgia Marble Company, however, has shown that the valley is underlain by marble for its entire width to the base of the hills on its north side, and the numerous openings made by the quarries are evidence that the marble is continuous also through its length. With the exception of a few small pits farther west, the most westerly openings are those of the Piedmont and Kennesaw quarries, now abandoned. At the latter the strike is about E-W and the dip south. There is no evidence of close folding such as occurs in the Cherokee, Creole and Etowah quarries but there are present in the southeast corner of the more easterly of the two Kennesaw openings a few normal faults with down throws 3 to 6 inches on the west. A little farther east are the main openings of the New York group of quarries that produce the famous Georgia white marble of the district. Here the marble has a general strike that is about parallel to the contours of the topography, which is approximately N. 60° E., and an average dip of about 25° southeast, but there is much tight folding into little V-shaped folds that are overturned at low angles to the northwest.

The marble at the New York quarries is coarsely crystallized and is sparkingly white. On fresh surfaces it looks homogeneous as though composed of crystalline grains of a colorless calcite. On weathered exposures, however, the surfaces are rather rough and are marked by lines of colorless transparent crystals of tremolite. In certain places are thin, gray layers in which the tremolite is light-green. In addition to the tremolite these layers contain also a few flakes of phlogopite. Some of the tremolite crystals are at least 1 inch long, and a fragment picked up in the vicinity consists of a coarsely fibrous mass of tremolite crystals 2½ or 3 inches long held together by a sparse matrix of calcite. Under the microscope the white marble is seen to be composed of calcite, that is often turbid with tiny inclusions of liquids, and a few grains of tremolite.

A sample of the tremolite separated from the rock by treatment with hydrochloric acid and analysed by Dr. Everhart had the following composition.

SiO_2	Al_2O_3	Fe_2O_3	FeO	MgO	CaO	Na_2O	K_2O	Ign	TiO_2	Total
57.28	1.40	.08	1.17	32.65	7.20	.40	.05	.30	Tr.	100.33

which corresponds approximately to Mg_5 (Ca. Fe) $(SiO_3)_6$.

In the floor of the valley, about 160 feet below the most easterly of the New York group of quarries is a new opening which has developed a fine-grained white and flesh-colored mottled marble, the color of which is due to the presence of numerous tiny flakes of phlogopite. At this place the strike of the beds begins to turn more toward the east. At the quarry it is E-W, with the usual comparatively low dip to the south, and farther east becomes nearly southeast. Thus, east of the New York quarries, well up on the slopes of the hill, which is now covered with verdure, is an abandoned quarry in a white marble striking N. 35° W. and dipping southwest, and marble ledges striking N. 40°—50° west and dipping southwest extend at intervals for 3500 ft. beyond (S. E.) of the quarry where they apparently disappear, being cut off by a tapering wedge of the black hornblendic rock on the one side and by mica gneiss on the other.

The marble at the abandoned quarry is in contact with the black rock which apparently sends stringers into it. Near the contact the marble contains crystals of green hornblende and a few flakes of brown biotite.

At this point the belt divides into two forks, one of which stretches southwest and south through the narrow valley through which the railroad reaches the Amicalola quarry and the other extends southeast along the East Branch of Long Swamp Creek for about 1½ miles. On this was the Cowart quarry.

On the lower slope of the hill forming the east side of the valley leading to the Amicalola quarry are a pit and several exposures showing a very coarse, white marble about 25 ft. thick. The area underlain by the marble is narrow. It extends about 2,000 ft. up the valley and apparently ends. The rest of the valley all the way to the quarry is underlain by gneiss and schists striking northeasterly, and dipping to the southeast. The marble at the quarry appears to be in an isolated area separated from that to the north by the gneisses and schists referred to and is surrounded on all sides by a narrow belt of hornblende schists that separates it from the more common gneisses and schists. The strike of the gneiss to the west of the quarry is N. 15°—25° W., and its dip is high to the northeast.

The easterly fork is a direct extension of the Marble Hill belt. It follows the valley of the East Branch of Long Swamp Creek for 1½ miles, a few degrees south of east along the highway to Dawsonville. For the first three-quarters of a mile the marble lies south of the road and is separated from it by a knob of the black rock. At the east end of the knob the marble crosses the road and through most of the east portion of the strip is north of the road. There are, however, only a few surface evidences of the existence of marble beneath the area. A small exposure on the south side at the west end of the valley, a few outcrops in the channel of the stream occupying its bottom and a small exposure in the bluff on the south side of the railroad to the Cowart quarry, the opening at this quarry and a very small exposure 1½ miles farther east in the road cut on the south side of the Dawsonville road mark the southern limit of the belt.

Its northern boundary is marked by an outcrop of pink marble at the base of the hill just east of where the old road crosses the East Branch of Long Swamp Creek, about ½ mile north of the easternmost exposure on the Dawsonville road, and a few old pits at the base of this same hill about a mile farther west. A few drill holes and pits in the valley bottom and an outcrop in the stream are regarded as evidence that the entire valley is underlain by marble.

Only a few strikes and dips of the marble in this extension of the Marble Hill belt are measurable. On the hill south of the railroad track running to the Cowart quarry the strike is nearly E-W, being about N. 80° E. near the Cowart quarry. In the quarry there are noticeable the usual closed folds which in general are overturned to the northeast. The south side of the marble and much of its north side are bounded by hornblende schists. Its east end is limited by coarse mica gneisses and its northwest boundary by gneisses and graywacke schists. The strikes of the surrounding gneisses and schists are roughly parallel to the boundary of the marble area in such a way as to suggest that the marble and schists were folded together so forcebly that all evidences of the faults that must separate them have been obliterated, and the two series of rocks that are so widely different in age have been made to appear conformable.

Chemical Composition.—The composition of the marble in the Marble Hill belt is similar to that of the marble of the Long Swamp Creek belt. The coarse-grained varieties are almost pure calcareous varieties and the fine-grained varieties are magnesian. Both groups consist of rocks that are composed almost exclusively of carbonates. Only the dark bands in the Creole marble contain any large proportion of constitutents other than carbonates and the greater part of these is quartz (See analysis Ib.)

Analyses of marbles from Marble Hill area,
Pickens County, Georgia

Analyst: Dr. Edgar Everhart

	I	Ia	Ib	II	III	IV	V	VI	VII	VIII	IX
Moist.	------	.00	.04	.04	------	.02	.00	.10	.06	.54	.00
CaO	55.00	51.42	40.20	53.08	54.44	52.00	54.12	54.36	33.60	32.90	31.48
MgO	1.12	2.14	.98	.80	.46	.62	.28	.47	17.16	16.90	16.36
FeO	------	.42	1.26	------	------	------	------	------	------	------	------
MnO	------	.00	.00	Tr.	------	Tr.	Tr.	.14	------	------	------
CO_2	------	------	------	------	------	------	------	------	45.11	44.27	------
Al_2O_3	} .15	.00	.00	------	------	------	------	------	1.18	} .80	1.58
Fe_2O_3		.86	.04	------	.20	------	------	.25	------		.45
Ign.	44.16	42.08	33.60	42.20	43.35	40.94	43.00	43.58	------	------	43.14
SO_3	------	.00	.00	.00	------	.00	.00	.00	------	------	.00
TiO_2	------	.00	.02	------	------	------	.00	Tr.	------	------	Tr.
P_2O_5	------	.01	.21	.00	------	.00	.00	.00	------	------	.00
Total soluble	100.43	96.93	76.35	96.12	98.49	93.58	97.40	98.90	97.11	95.41	93.01
Ign.	------	------	------	------	------	------	------	------	.07	.05	------
Al_2O_3	------	.09	2.01	.55	.24	.75	.85	.21	------	------	2.00
Fe_2O_3	------	.02	1.32	.24	.44	.22	.38	.03	------	------	.01
CaO	------	.51	2.70	.31	.00	.42	.18	------	------	------	.16
MgO	------	.20	.19	.90	Tr.	.26	.08	------	------	------	.62
FeO	------	.14	.04	------	------	------	------	------	------	------	------
MnO	------	------	.00	------	------	------	------	------	------	------	------
Na_2O	------	.23	.08	.04	.09	.04	.05	.03[1]	------	------	.02
K_2O	------	.04	.04	.01	.01	.01	.01	.01[1]	------	------	.08
TiO_2	------	.01	5.40	Tr.	------	Tr.	.00	.01	------	------	Tr.
SO_3	------	------	------	.00	------	.00	.00	.00	------	------	------
P_2O_5	------	------	------	.00	------	.00	.00	.00	------	------	------
SiO_2	------	1.65	11.72	1.75	.66	4.44	.84	.68	------	------	4.11
Carbon	------	.30	.35	------	------	------	------	------	------	------	------
Total insol.	.35	3.19	23.85	3.80	1.44	6.14	2.39	.97	2.74	4.50	7.00
Total	100.78	100.12	100.20	99.92	99.93	99.72	99.79	99.87	99.92	99.96	100.01

[1]—Determined in a separate specimen.

Carbonates in the marbles of the Marble Hill belt, Ga., as indicated by the above analyses.

	I	Ia	Ib	II	III	IV	V	VI	VII	VIII	IX
$CaCO_3$	97.6	91.82	71.80	93.9	97.2	91.5	96.6	97.1	60.00	58.75	56.2
$MgCO_3$	2.35	4.49	2.06	1.7	1.0	1.3	.6	1.0	36.03	35.32	36.0
$FeCO_3$	-----	.67	1.76	-----	-----	-----	-----	-----	-----	-----	-----
$MnCO_3$	-----	-----	-----	-----	-----	-----	-----	.22	-----	-----	-----

I. Mottled blue and white marble. Creole quarry, Tate post office. S. W. McCallie, Marbles of Georgia: Geol. Surv. of Georgia, Bull. No. 1, p. 109, 1907.

Ia. Dark band in Creole marble.

Ib. Blue marble. Loose block at Creole quarry. Contains small inclusions of black hornblendic rock.

II. Georgia white marble. New York quarry, Marble Hill.

III. Silver gray marble. Cherokee quarry, Tate post office.

IV. White marble. Amicalola quarry, Marble Hill.

V. White marble. Cowart quarry, Marble Hill.

VI. Pink marble, Etowah quarry, Tate post office.

VII. Fine-grained white marble. Road-side, at mouth of East Branch Long Swamp Creek.

VIII. Fine-grained white marble. Road-side, at mouth of East Branch Long Swamp Creek.

IX. Fine-grained white and pale-pink marble with much phlogopite. Quarry in bottom of valley of East Branch Long Swamp Creek, near New York quarry.

Upon comparison of the analyses given above with those of the marbles from the Long Swamp Creek belt it will be noted that there is little difference between the rock of a similar degree of coarseness in the two areas. The last three analyses in the table above are of fine-grained rocks like those from the Lincoln quarry (analysis II, p. 80) and from the south end of the Long Swamp Creek belt (analysis III, p. 80). The other analyses of white marbles in both tables are of coarse-grained rocks. It is also to be noted that the dark streaks in the Creole marble (A & B) are similar to the coarse-grained gray-blue marble in the Long Swamp Creek belt (C) and similar marble at Whitestone (D), and that the pink Etowah marble from the Marble Hill belt (E) and the pink stained marble (F) from the Long Swamp Creek belt (see p. 78), contain small amounts of manganese carbonates. The only other marble in which manganese has been detected is that of the Lincoln quarry, one specimen of which gave .07% of MnO. Several other specimens of this marble gave no traces of manganese.

	A	B	C	D	E	F
$CaCO_3$	91.82	71.80	89.50	91.90	97.10	59.14
$MgCO_3$	4.49	2.06	4.49	2.29	1.00	38.01
$MnCO_3$	----	----	----	----	0.23	0.19
$CaCO_3$: $MgCO_3$	20.5:1	34.8:1	20:1	40:1	----	----
Other soluble constituents	1.29	1.53	2.03	0.49	0.25	.54
Insoluble constituents	3.19	23.85	3.34	4.28	.93	2.36

A Calculated from analysis Ia, p. 92.
B Calculated from analysis Ib, p. 92.
C Calculated from analysis IV, p. 80.
D Calculated from analysis VII, p. 80.
E Calculated from analysis VI, p. 91.
F Calculated from analysis of pink-stained marble in Long Swamp Creek belt.

Other Areas of White Marble

The only other three areas of crystalline white marble that need to be noted are those at Nelson, on the stream entering Long Swamp Creek at a point about 1 mile north of Roberts Lake, and in the valley of a small stream entering Sharp Mountain Creek about 2¼ miles a little north of west of Ball Ground.

At Nelson the exposure is a low ledge at the school-house spring on Highway No. 5. The rock exposed is a fine-grained, white, glistening marble cut by small veins of white dolomite and containing here and there rhombohedra of the same mineral about ¾ in. in diameter, and rather abundant flakes of phlogopite in thin layers in what are apparently bedding planes. Measurements of the obscure bedding gave a strike N. 5° W. and a dip of 53° northeast. The rock closely resembles that of the Long Swamp Creek belt. There are no other exposures near the marble except a large one of a dark graphite schist about 150 feet to the west. It is thought that the marble was brought to its present position by the minor fault which south of Nelson, passed into the syncline that is responsible for the Sharp Mountain Creek belt of blue marble.

The occurrence north of Roberts Lake has been uncovered by a pit and explored by drill holes near the mouth of the second stream below the foot bridge over Long Swamp Creek, about 2¼ miles southeast of Nelson. The marble is a mediumly coarse-grained, somewhat shistose variety, grayish-white in color and containing a great deal of light-brown phlogopite in streaks. It resembles very closely some of the white layers in the Creole marble at Tate. Drill cores that are said to have come from this locality show dark layers that suggest very strongly some of the dark layers in the Creole marble, and streaks composed of numerous flakes of dark green mica. The marble is underlain by black hornblende schist and coarse mica gneiss, and overlain by a silvery, sandy, mica schist with many small garnets. The underlying black schist strikes N. 35° E. and dips 30° southeast and the overlying mica schist strikes N. 55° east.

The thin sectionof the rock in one of the drill cores shows calcite enclosing a few grains of zoisite and pyrite and abundant plates of a light-colored mica that is probably phlogopite. There is also an occasional epidote grain between the calcite grains and much quartz in isolated grains and in nests and grains in the corners between neighboring calcites, and here and there a few masses of chlorite that may have come from hornblende. Sections across the dark and light layers reveal many long crystals of colorless epidote and a few bunches of grains of greenish epidote, an occasional flake of brown biotite and a few flakes of phlogopite. In the dark layers the biotite, zoisite and epidote are much more abundant. Quartz grains are common in both layers.

The presence of this small area of marble is thought to be due to a thrust fault, similar to that responsible for the Marble Hill belt. (See page 125). The exposure is probably a remnant of the marble near the thrust plane, which would account for its schistosity and the large amount of slipping noted in it.

The third small area in which white marble is known to occur is in the bottom of the little valley of the stream entering Sharp Mountain

Creek from the east about ¾ mile north of the bridge on the road between Ball Ground and Hopewell Church. The marble is exposed at several places in the little stream at the base of the slope on the south side of the valley, and formerly was exposed also in the bottom of Sharp Mountain Creek and at a spring between the creek and the highway on its west side. Pits dug west of the road have not encountered it. The marble is a mediumly coarse-grained variety with a silver-gray color. It contains a little talc and is tinged here and there with pink due to the presence of small phlogopite plates.

Except for the small ledges of marble in the creek the only exposures in the valley east of the main creek are mica schists and graywackes, striking N. 30°—40° E., and dipping southeast. West of the creek are numerous exposures of the same rocks, and on the road, about on the strike of the marble, is a low ridge of hornblende schist. The relation of the schist to the marble was not discovered.

The existence of the marble at this place also is supposed to be due to a fault. The presence of talc in it is believed to support this opinion.

Keithsburg Belt

Distribution and General Character.—The Eastern belt of blue-gray marble extends from the bridge over Long Swamp Creek, about 2 miles east of Nelson, southeastward across the quadrangle to its west margin about 2 miles northwest of Canton. The width of the belt varies between 2400 and 220 feet throughout most of this distance, but at its southwest end it narrows to less than 100 feet. The belt can be followed almost continuously since exposures are fairly common except at its west end where they are small and scattered.

The northernmost exposures within the belt are at the south end of the bridge over Long Swamp Creek. Ledges under the bridge and a short distance east on the south bank of the stream are of a badly contorted, fine-grained, blue-gray micaceous marble mottled with small aggregates of yellowish dolomite or ferruguious carbonate about ¼ inch in diameter. The rock is distinctly schistose through the parallel orientation of tiny mica plates that are so abundant on surfaces of foliation planes as to cause the rock to resemble a fine-grained mica schist. On the roadside other exposures appear weakly stratified, with the obscure stratification parallel to the schistosity. Here the strike is a little east of north and the dip about 30° southeast. The marble is overlain to the east by a coarse garnetiferous mica gneiss in some places and in other places by a graphitic schist. On its west it is underlain by very micaceous beds into which it apparently grades by interlaminations. The contact with the overlying mica gneiss is much like that between the two formations at the Lincoln quarry, i. e., it appears as a crack dipping moderately to the southeast and filled with gouge. The overlying rocks are believed to be members of the Carolina gneiss and of the Nantahala slate, and consequently, at this place the contact is believed to be along a fault plane along which the older rocks have been thrust over the marble.

Throughout the belt the marble that is exposed has nearly the same character. At a few places it is a rather massive gray or gray-blue sandy variety containing minute plates of light colored mica and a few little clumps of limonite. Most of it shows a distinct schistosity due to the presence of much mica, both dark and colorless, and weak evidences of bedding. On the cleavage surfaces many of the specimens resemble mica schist, but on surfaces across the schistosity they resemble more closely a fine-grained graywacke. Here and there are a few small garnets, and in many samples examined are nodules of white mica or of aggregates of white mica and calcite. The marble in many exposures resembles the micaceous graywackes so common in the Great Smoky formation, except that it shows on weathered projections the round edges characteristic of rocks containing a notable quantity of carbonate.

A few exposures are of alternating thin layers of white and blue-gray marble very much like the marbles of corresponding colors in the Long Swamp Creek belt, except that the blue-gray marble in the Keithsburg belt is not so coarse as that in the Long Swamp Creek belt.

The bedding of the marble in the Keithsburg belt is very much more distinct than that in the Long Swamp Creek belt. The beds strike with the trend of the belt and their dips are generally about 30° southeast. Here and there the dips are steeper and at a very few places they are lower. Nowhere are the layers as irregularly contorted as in the northern area nor are the folds observed as closely compressed.

In thin sections all the marbles in this belt are seen to be very impure. They are mainly granular aggregates of calcite, quartz, muscovite, phlogopite and biotite, and abundant rods and spicules of a colorless mineral with weak birefringence that is regarded as zoisite. The quartz contains many irregular inclusions of limonite, calcite, phlogopite and crystals of rutile and tiny rhombohedra of some carbonate. Small crystals of rutile are enclosed in the calcite. In some specimens granular feldspar is fairly abundant. Its grains enclose rutile and zircon crystals, grains of limonite, tiny masses of chlorite and long slender crystals of a light-colored mineral suggesting tourmaline. The calcite in some specimens consists of nuclei of old grains, with iron oxides and biotite in their cleavage cracks, surrounded by zones of clear, colorless calcite. In some specimens the quartz and feldspar are limited to round areas that resemble cross-sections of sand grains and some of the carbonate is more highly refractive than the rest suggesting that it may possibly be dolomite. Here and there scattered through some of the slides are fragments of tourmaline crystals, little bunches of pale-green chlorite, and a little kaolin and other micaceous decomposition products of various silicates. Distinct epidote crystals are observable in the most impure marbles. Although the rock of some of the beds included within the belt resembles calcareous micaceous graywacke, there nevertheless is no uniform gradation into the garnetiferous micaceous schists to the west or the gneisses to the east. There is very little difficulty in delimiting the boundaries of the marble belt where exposures are available.

Chemical Composition.—Analyses of four specimens of marble from the Keithsburg belt show that they differ very little from the marble in the Long Swamp creek area except in the presence of a much greater amount of silicates, which vary in the specimens analyses from about 16% to 74%. The limestone, from which the marble was made, was evidently an impure argillaceous deposit containing considerable quartz sand in some places. The proportions of calcium and magnesium carbonates in it vary between 7:1 and 32:1.

In the following table, in column V, is a record of the analysis of a dark-blue platy limestone which is apparently near the bottom of the formation at Whitestone. Its composition is very much like that of the blue-gray marbles in the Keithsburg belt.

Analyses of blue-gray marbles from the Keithsburg belt, in Cherokee County, and from Whitestone, Gilmer County, Ga.

Analyst: Dr. Edgar Everhart

	Keithsburg Belt				Whitestone
	I	II	III	IV	V
Moisture	.05	.10	.08	.08	.00
Ignition	.54	2.02	.85	1.55	1.18
CaO	29.96	30.20	9.10	39.72	26.72
MgO	1.80	.80	1.09	2.76	2.12
FeO	----	----	----	2.60	----
MnO	----	.00	Tr.	----	----
CO_2	25.36	25.86	7.96	35.95	24.00
Al_2O_3	4.00	.00	3.47	.52	.41
Fe_2O_3	2.55	1.90	3.69	.68	2.19
SO_3	Tr.	.00	.00	.00	.00
P_2O_5	.00	.00	.00	.00	.00
TiO_2	.02	.04	.14	----	1.40
Total soluble in HCl	63.69	58.80	25.45	82.23	56.84
SiO_2	26.41	21.37	45.75	9.99	32.29
Al_2O_3	5.23	10.58	13.84	1.83	7.70
Fe_2O_3	.50	1.96	2.69	2.60	.46
CaO	.99	2.48	5.08	.56	.00
MgO	.20	.01	.62	.02	Tr.
FeO	2.03	2.03	4.92	.42	.23
Na_2O	.23	.06	.11	.21	.44
K_2O	.46	.21	.59	.34	.23
SO_3	.00	.00	.00	.00	.00
P_2O_5	.00	.00	.00	.00	.00
TiO_2	.36	.29	.36	.29	.25
Total insol. in HCl	36.41	38.99	73.96	16.26	41.60
Total	100.69	99.91	100.34	100.12	99.62

I. Slightly schistose, fine-grained bluish-gray marble. In stream crossing road $1\frac{1}{4}$ miles southeast of Gober.

II. Bluish-gray, micaceous schistose marble at bridge over Long Swamp Creek, one mile south of east of Nelson.

III. Schistose micaceous blue-gray marble, near mouth of little stream entering Sharp Mountain Creek, $\frac{1}{2}$ mile west of Highway No. 5.

IV. Medium-grained, blue-gray marble interbanded with thin white layers. North end of belt, $1\frac{1}{2}$ miles southeast of Fairview Church.

V. Very fine-grained, platy gray-blue marble. West side of valley, south of road leading to Highway No. 5. Whitestone, Gilmer County.

Sharp Mountain Creek belt

Distribution and general character.—The marble of the Sharp Mountain Creek belt occupies a narrow strip of country extending 4 miles southwestward from a point midway between Fairview church and Ball Ground to a point one mile west of Lays school. The belt is not continuous. It is outlined by a number of small isolated exposures in a line, except where it crosses the road about a mile northwest of Ball Ground. Here it has a width of 400-500 ft. and is marked by several wide massive exposures. Another outcrop at a spring south of the school-house at Nelson may be in the same belt, but it is separated from the next exposure to the southwest by a distance of nearly 2 miles and is a rock of a very different appearance.

Most of the rock in this belt is not noticeably different from that in the Keithsburg belt. It is a fairly fine-grained, bluish-gray schistose micaceous marble, which in some places is so sandy as to suggest a micaceous graywacke. Here and there are segregations of coarse pink dolomite, or of colorless mica, and in other places are lenses and veins of white quartz and muscovite. At one place about 1½ miles northwest of Gober, where the road crosses Sharp Mountain Creek, the marble is very impure, some beds being apparently saturated with quartz and pierced by numerous spicules of a white striated mineral about 1/3 in. long, with many of the characteristics of wollastonite.

A few exposures consist of evenly bedded layers of a fine-grained white, schistose marble interlaminated with very thin layers of a blue-gray variety. The white layers, which vary in thickness from 1/10 in. to 1/3 in. are not different from the finer grained white marble in the Long Swamp Creek belt. The rock of the gray-blue layers is identical with the predominant blue marble which composes most of the belt. On exposed surfaces the blue-gray layers stand out as thin, black, rough, parallel lines against a smooth, gray background.

The structure of the Sharp Mountain Creek belt is very like that of the Keithsburg belt. The strike of the bedding throughout the entire belt is the same as the trend of the belt and the dip is uniformly to the east or southeast at angles of 20° to 30°. The marble is bordered on both sides by members of the Valleytown formation, and is therefore inferred to be the lower part of a closely compressed syncline overturned to the west.

Under the microscope the rocks of this belt are similar to those of the Keithsburg belt. They consist of calcite, quartz, phlogopite, with a little muscovite and biotite and in some sections grains and rods of zoisite and very pale epidote. Little rods of rutile, a few grains of tourmaline and a few particles of ilmenite are also noticeable in most sections, and in some are small masses of chlorite and in others grains of plagioclase.

Chemical Composition.—The results of analyses of two samples taken from the belt are given in the following table:

Analyses of blue-gray marbles from the Sharp Mountain Creek belt, Cherokee County, Ga.

Analyst: Dr. Edgar Everhart

	I	II
Moisture	.04	.06
Ignition	.10	2.56
CaO	19.49	31.40
MgO	2.20	1.20
MnO	----------	----------
FeO	2.11	.30
CO_2 (calculated)	17.50	25.90
Al_2O_3	9.09	4.04
Fe_2O_3	2.19	4.40
SO_3	.00	----------
P_2O_5	.00	.02
TiO_2	.07	.00
Total sol. in HCl	52.75	69.82
SiO_2	37.01	19.38
Al_2O_3	7.14	8.09
Fe_2O_3	.63	.31
CaO	1.25	.74
MgO	.08	.14
FeO	----------	.09
Na_2O	.18	.16
K_2O	.63	.59
SO_3	.00	----------
P_2O_5	.00	----------
TiO_2	.18	.43
Organic matter	----------	.22
Total insol. in HCl	47.10	30.15
Total	99.89	100.03

I. Schistose gray-blue, fine-grained micaceous marble, 2 miles northwest of Gober, where road crosses Murphy Creek.

II. Gray and blue-gray, fine-grained micaceous marble, 2 miles west of Ball Ground on Sharp Mountain Creek.

The proportions of calcium and magnesium carbonates indicated by these analyses are as follows:

	$CaCO_3$	$MgCO_3$
I.	34.40	4.53
II.	56.10	2.50

Comparison of the microscopic characters and the chemical composition of the marble of the Keithsburg and Sharp Mountain Creek belts indicates that the rocks are practically identical. The differences in the members of the two belts are no greater than the differences in different specimens of the same belt. All are essentially mixtures of carbonates with quartz, feldspar grains and secondary minerals derived mainly by the alteration of feldspar and certain iron-magnesium minerals that have now completely disappeared. Epidote and kaolin are among the principal new minerals that have resulted.

An appreciation of the lack of difference in the rocks of the two belts is perhaps obtained best if we arrange the 5 samples of the gray-blue rock studied in some definite order and compare the variations to be noted in their composition. In the following table the analyses of these specimens have been arranged in the order of their diminishing soluble components, and in the table beneath are their mineralogical compositions calculated from their analyses.

Analyses of marbles of the Sharp Mountain Creek and Keithsburg belts arranged in order of their diminishing soluble components.

	A	B	C	D	E
Soluble components	69.82	63.69	58.80	52.75	25.45
SiO_2	19.38	26.41	21.37	37.01	45.75
Al_2O_3	8.09	5.23	10.58	7.14	13.84
Fe_2O_3	.31	.50	1.96	.63	2.69
CaO	.74	.99	2.48	1.25	5.08
MgO	.14	.20	.01	.08	.62
FeO	.09	2.03	2.03	----------	4.92
Na_2O	.16	.23	.06	.18	.11
K_2O	.59	.46	.21	.63	.59
Ignition	2.56	.54	2.02	.10	.85

Approximate mineral compositions calculated from above analyses.

	A	B	C	D	E
$CaCO_3$	56.10	53.15	53.80	34.40	15.50
$MgCO_3$	2.50	3.76	1.68	4.53	2.18
$CaCO_3$: $MgCO_3$	22.5 : 1	14.1 : 1	32 : 1	7.5 : 1	7 : 1
Soluble constituents other than carbonates	8.66	6.78	3.32	13.70	7.77
Kaolin	15.20	2.25	11.75	11.50	2.00
Epidote	3.15	10.35	16.30	4.95	35.85
Feldspars	4.65	4.17	1.56	4.91	4.44
Quartz	7.86	18.44	8.23	26.40	27.61
Excess H_2O in analyses	.03	.00	.00	—.20	.15

A. Blue-gray marble, Sharp Mountain Creek belt. Analysis II, p. 100.
B. Blue-gray marble, Keithsburg belt. Analysis I, p. 98.
C. Blue-gray marble, Keithsburg belt. Analysis II, p. 98.
D. Blue-gray marble, Sharp Mountain Creek belt. Analysis I, p. 100.
E. Blue-gray marble, Keithsburg belt. Analysis III, p. 98.

INTRUSIVES

With the sedimentary rocks of the Cambrian formations are others that are igneous or that are so closely related to igneous rocks that they may be considered in the same category. Some of these are clearly intrusive in the bedded rocks, others are schists that were derived from igneous masses and others are in the form of veins that were deposited from fluids that originated in magmas.

Rocks of this class are present in all of the Cambrian formations, but some of them are most easily recognized when they occur in the Great Smoky formation, and consequently their descriptions are based mainly on these occurrences. Many of them are unquestionably identical with some of the igneous masses in the Caroline gneiss, but there are others in the pre-Cambrian area that have no equivalents in the Cambrian area. Moreover, there are a few in the Cambrian area that are much younger than others. The younger rocks have escaped the deformation which the older ones have suffered, and therefore, lack the marked schistosity which is common to most of the rocks in the quadrangle.

Salem Church Granite

In the central western part of the quadrangle is a granite mass which is quite distinct from that in its eastern part. It occupies about 8 square miles extending from about a little east of Sharp Mountain Creek to the western margin of the quadrangle. The granite is best seen at Salem Church and to the west and southwest, where excellent exposures occur and in the road running northwest from the church to its junction with the road running south, and alongside this road for a distance of 2 miles. Throughout most of the area the outcropping rock is a white or light-gray gneissoid granite, in which are dull-white and gray, glistening grains of feldspar, streaks and veins of bluish quartz and many tiny particles of limonite that have probably come from pyrite. In many places the granite is very coarse and pegmatitic, and nearly everywhere it is deeply weathered to a white mass of kaolin or sericite and quartz. This is strikingly noticeable at Salem Church and along the road running south about ¾ mile from the west side of the quadrangle. At many places along this road are little pits opened in the search for commercial kaolin. Some of these are in pegmatite but others are in the granite. Pegmatites cut the granite in a number of places. They are mainly muscovitic varieties, which at several places have been opened in the search for mica.

The granite has been stated to occupy an area of approximately eight square miles. This is not literally the case, for within the area outlined as underlain by granite there are several layers of a black micaceous schist, identical with that which has been correlated with the Hiwassee slate of more northerly quadrangles. The two areas of this schist that are large enough to map are in the western part of the area. Other schists of the same kind are in increasing quantities near the margins of the area, where granite and schist are interlaminated. In some places the granite is in thick layers separated by equally thick layers of schist, but in most places the schist is in large excess and the granite appears only as very thin layers between the foliae of the schists, or as numerous isolated patches within it. In many places within ¼ mile, of the boundary between the two rocks, as indicated on the map, the schist appears to be saturated with granite material, and where the schistosity is marked, as it is in most places, the granite component is drawn out into lenses, or is even separated into its individual componenets, which are scattered irregular through the schist, giving the rock a strikingly close similarity in appearance to a conglomerate, except that the apparent fragments are of feldspar rather than of quartz. Under the microscope the conglomerate-like rock is seen to be a mass of interwoven biotite and muscovite, surrounding lenses of quartz mosaic and lenticular masses of plagioclase and orthoclase. Some of the feldspar lenses are single grains that have been rounded at their ends, and others are aggregates of fragments. Most of the plagioclase is oligoclase or andesine, and all of the feldspar is partly altered to kaolin. At the ends of the feldspar lenses and at some places between them and the surrounding mica is a mass of crushed feldspar, small quartz grains and small flakes of mica. The rock suggests a micaceous schist intruded by numerous veinlets of granite and then crushed and drawn out into a uniform schist aggregate.

Most of the granite is too much altered to furnish satisfactory material for analysis. The best specimen available, however, was submitted to Dr. Everhart of the Georgia Geological Survey in the hope that it might furnish some evidence that might be used to determine whether or not it is a part of the same magma that gave rise to the Hightower granite farther east. Unfortunately, however, very little such evidence was obtained, although the Hightower granite is shown to be strongly sodic and the Salem Church granite to be a soda-potash variety.

The analysis of a specimen taken from a ledge at the corner of the road about 1¼ mile southeast of Salem Church gave:

Analysis of granite from near Salem Church, Pickens County, Ga.

SiO_2	Al_2O_3	Fe_2O_3	FeO	MgO	CaO	MnO	Na_2O	K_2O	H_2O-	H_2O+	TiO_2	SO_3	P_2O_5	Total
74.60	18.28	.08	.60	.06	Tr.	.00	2.22	2.46	.40	1.20	.09	.00	.07	100.06

The norm corresponding to this is:

Q = 51.90; or = 15.01; ab = 18.34; hyp = 0.79; mag. = 0.23; ilm. = 0.15; cor = 11.93.

The high percentage of corundum in the norm is suggestive of kaolin and sericite. There are in the rock practically nothing but quartz, feldspar, kaolin and sericite.

The Salem Church granite differs from the Hightower granite in containing 0.68% of iron oxides as against 2.93%; a trace of CaO as against 3.98%; 2.22% of Na_2O as against 4.04% and 2.46% K_2O as against 0.52%. On the basis of the analysis the Salem Church granite contains 15.01% orthoclase and 18.34% albite, whereas these components in the Hightower granite are 2.78% and 34.06% respectively. The Hightower granite also contains 16.12% of anorthite in the norm, whereas the Salem Church granite contains none. It is possible that these differences may indicate a difference in the two rocks sufficiently great to warrant the conclusion that they were not parts of the same intrusion. The high percentage of water and alumina in the Salem Church rock indicate that it has been greatly altered and consequently that its original composition is not necessarily represented by its present composition. Soda and lime have probably been leached from it with the resulting concentration of potash, alumina and silica. The fact that the percentage of the alumina is no higher and of iron oxides is less in the altered Salem Church rock than in the Hightower rock, in spite of the fact that these oxides are usually proportionately increased in altered phases of nearly all rocks, suggests that the two granites were not erupted simultaneously, though perhaps they may have originated in the same magma reservoir. Since, however, the Salem Church granite differs markedly in different parts of the area occupied by it, any inference as to its general character that may be drawn from the analysis of a single specimen is untrustworthy.

Sericite-schist

Most of the Salem Church granite is strongly gnessoid. In many places the shearing has been so profound that very white mica schists have resulted. (Plate VII B.) These are for the most part aggregates of quartz, feldspar and plates of white sericitic mica. The schists are more or less platy and are intensely folded into many sharp crinkles, which are very noticeable on cross-breaks, where the schists can be seen to consist of thin layers of crushed feldspar in a mixture of crushed feldspar and quartz, and very thin sheets composed of many tiny flakes of sericite. The sericite coats slip-planes between the feldspar layers and is most abundant in places where the folding has been most intense. At many places there is no quartz observable in the hand-specimens which consist of only crushed feldspar and sericite, with the addition here and there of a little chlorite. In the southwest portions of the area, the granite appears not only to have contained much less quartz than elsewhere, but also to have been more severely sheared, yielding a fairly pure sericite, which has been mined.

Much of the sericite schist, which is commonly referred to as talc, is a light-gray or greenish-gray crinkled schist composed almost exclusively of sericite plates with only here and there fragments of broken feldspars and a very little chlorite, but all gradations can be seen between schists composed mainly of feldspar with a little sericite, and those in which sericite is the preponderating constituent.

Some mine-pits have produced a white schist that is almost pure sericite. This occurs in layers or lenses in the gray schist and is much purer. Associated with it are harder schists that show layers and streaks of feldspar. Some of the schists are platy, resembling very strongly talcose schists, but the purer varieties are smooth, soft and homogeneous masses of sericite that exhibit their schistosity only when fractured, when they break into thin plates. They show more or less crinkling on their cleavage surfaces but otherwise no signs of folding. Evidently this folding has been so close that it has become isoclinal and the schist is now made up of parallel layers of sericite.

A specimen of a white satiny schist taken from a pit was analyzed by Dr. Everhart who reported the result in line I below. In line II is the theoretical composition of muscovite and in line III the analysis of a second specimen of white or light-gray schist from the same region.

Analyses of sericite schists from south of Salem Church, Pickens County, Ga.

	SiO_2	Al_2O_3	Fe_2O_3	FeO	MgO	CaO	Na_2O	K_2O	H_2O+	H_2O-	TiO_2	P_2O_5	SO_3	Total
I	48.14	36.49	1.58	.49	.40	.40	.90	7.20	4.60	.08	Tr.	Tr.	.00	100.28
II	45.2	38.5	-----	----	----	----	11.8		4.5	------	----	----	----	------
III.	47.64	38.62	1.02	.71	.33	.00	.28	6.20	4.46	.48	.00	.03	.00	99.77

The figures in line I indicate that the rock consists of 72.73% of sericite, about 1.62% magnetite, 1.23% of talc, .88% of FeO and CaO, and a residue of 23.82% with the composition of approximately H_2O. Al_2O_3. 3 SiO_2, which in all probability represents a mixture of kaolinite and pyrophyllite. The figures in line III suggest a rock composed of a mixture containing sericite, kaolinite, quartz, and an excess of Al_2O_3. There appears to be no way of calculating the proportions of these constituents present, but the low percentage of potash indicates that the rock cannot contain more than 50% sericite, and the high percentage of Al_2O_3 as compared with water may indicate the presence of dehydrated aluminous or alumina-silica colloids.

Kaolin

The kaolin resulting from the weathering of the granite is very impure. At a few places where small pits have been dug into pegmatites small pockets of fairly good kaolin have been found, but most of it is mixed with quartz to such an extent that the mass is in reality a mixture, mainly of quartz sand with a very little sericite and kaolinite. Most of the supposed kaolin is sericite. The kaolin derived from the granite is even more impure. Some of it contains a little kaolinite, but most of it is so quartzose as to be valueless.

One of the best exhibitions of the "kaolin" is in a pit on the side of the road along the west side of Sharp Mountain Creek at a point about 1½ miles southeast of Salem Church. In the field notes it is described as a cut into a seam of kaolin 10–12 ft. wide in sericite schists. It was thought possibly to be an altered pegmatite. The material is a fine white powder which under the microscope is seen to be composed mainly of sharp-edged and rounded quartz grains with a very little intermingled sericite and shreds and flakes of leverrierite or some similar substance. No kaolin was detected. Another small deposit of white powder, which was described in the field notes as sericite was opened by a small pit on the property of Will Richards, about 2 miles northwest of Mineral Springs. This too when examined microscopically was found to be a mass of ragged quartz particles, a few small fragments of feldspar and a few shreds of sericite. There are many other small pits in a similar substance scattered throughout the southern portion of the granite area, but none of them produced merchantable kaolin.

AMPHIBOLITES

At many places in the quadrangle there are associated with the members of the Great Smoky formation masses of hornblendic rocks, which appear as dykes or as sill-like masses, and others that occur only as isolated exposures giving no hint as to their relations with the sediments. Both dikes and sill-like masses strike and dip with the bedded rocks, except locally where the dikes cut across their layers for short distances. The rocks are more or less schistose, those of the definite dikes apparently less so than those of the sill-like masses and isolated outcrops.

The dike rocks are nearly massive, black or dark purple, medium-grained and coarse-grained phases containing here and there large crystals of garnet, which are particularly abundant in those specimens in which schistosity is most marked. Under the microscope they show pale hornblende, a little plagioclase and less orthoclase, much quartz, a few grains of epidote, many grains of ilmenite and sphene and little nests of calcite and some rutile. Large poikilitic garnets are scattered through the section, having absorbed all the components into their bodies except sphene and quartz, which remain as inclusions. The rock of some other dikes contains much more epidote and that of others much more rutile.

The rocks that appear as sill-like mass are possibly deep seated intrusives that followed the bedding of the sedimentaries. Their material and that of those which occur in isolated exposures differ from the material of the dikes in being more schistose. A few of them were apparently porphyritic, but their phenocrysts are now flat lenses and streaks of feldspar and quartz. The rocks now are hornblende schists and hornblendic gneisses. Only one section was examined. The matrix of this consists of a fine-grained aggregate of quartz, feldspar and light-green hornblende. The phenocrysts differ from the matrix only in containing much epidote and no hornblende.

All the hornblende rocks have been badly crushed and recrystallized. Areas of fine-grained quartz mosaic lie in streaks between the other components and most of the quartz grains outside of the areas of the matrix show pressure shadows.

With the Murphy marble at some places are also associated masses of hornblendic rocks that are similar to those in the other Cambrian formations. At most places the relations of these rocks to the marble have not been determined, and because of their similarity with the Roan gneiss they are mapped as pre-Cambrian. At some places, however, as at the occurrence of white marble on Sharp Mountain Creek (p. 95) a hornblendic rock on the strike of the marble is included in the Valleytown. In the Tate post office area a hornblendic rock appears to be interlayered with white marble, and in the Marble Hill area black streaks, composed partly of hornblende occur in the marble. At these places the hornblendic rocks may be intrusions into the marble, though the evidence in favor of this view is not strong. (See p. 34.)

There is no essential difference between the amphibolites in the Cambrian formations and some phases of the Roan gneiss. The similarity is particularly striking in the case of the dike forms. It is necessary to assume that the hornblende schists and gneisses now in the Cambrian serias must have arrived at their present positions by passing through the Carolina gneiss and consequently it is natural to infer that some of the hornblendic rocks that have been included in the Roan gneiss are of Cambrian age and therefore are not properly to be grouped with the Roan gneiss which is defined as being of pre-Cambrian age. It is doubtful, however, if the hornblendic schists and gneisses that occur in pre-Cambrian areas in Georgia can ever be separated into two groups of different ages, since both groups would contain rocks of the same composition that had similarly been subjected to intense deformation.

Pegmatites

The pegmatites of the Great Smoky and Valleytown formations differ in no essential respects from those in the Carolina. Some of them are only slightly sheared, but most are more or less schistose, and are now composed of lenses of quartz and feldspar separated from each other by a clastic matrix of the same minerals, in which has been developed a great deal of muscovite. Most of them contain also notable amounts of tourmaline, and one vein seen in fragments scattered over the surface in the western part of the quadrangle about 2 miles southeast of Sharp Top village consist almost exclusively of tourmaline mixed with a small amount of quartz. The vein is about 2 inches wide and is near the contact between the Great Smoky and the Nantahala slate. One dyke which is typical of many others was noted on Rock Creek. It forms a layer 3 ft. thick traversing garnet-mica schists parallel to their schistosity, which is also the direction of bedding. This pegmatite is dotted with numerous black tourmaline prisms, which in the crushed portions between the lenses are broken into many pieces. Some of the pegmatites are much more crushed than others. In the most thoroughly crushed kinds muscovite has developed in such large quantity that the rocks are now muscovite gneisses. Some of them contain such large plates of muscovite that they have encouraged prospecting for commercial mica.

In a few places where the pegmatites were very feldspathic the resulting schist is a fine-grained, almost fibrous mass of thin quartz lenses in a matrix of granular feldspar. Usually the rocks of this kind are traversed by tiny veins of quartz running in the direction of the schistosity.

The pegmatites that are not strongly sheared are nevertheless somewhat crushed. Their feldspathic constituents are usually more shattered than the quartz and have had developed in them many small plates of secondary muscovite. Many of these rocks are coarse-grained and all are muscovitic. In some the muscovite is in plates that are large enough to offer promise to prospectors. Several pits have been put down on the pegmatites in the Great Smoky formation in the Tate quadrangle, but so far as known none have proven profitable.

Most of the pegmatites observed are in the Great Smoky beds. Only a few were noted in the Valleytown and these are like the less schistose kinds in the Great Smoky formation. There are some, however, that were not seen. One is somewhere in the hill just west of Sharp Mountain church, for on the old road leaving Highway No. 5 just south of the church were found hundreds of fragments of rutile crystals, some of which measured an inch in length and thickness, and nearly all of which showed cyclic twinning. With these lying loose in the road were also large fragments of quartz, many garnets and many fragments of staurolite and kyanite. The rutile crystals are so large that they must have come from a coarse grained rock, which the large fragments of quartz indicate was either a quartz vein or a pegmatite.

Quartz Veins

In some places scattered over the ground throughout the areas underlain by Cambrian rocks are great numbers of quartz or quartzite bowlders. They are particularly abundant over the areas underlain by the Great Smoky formation. Many of them come from masses that are evidently quartz veins cutting the formations parallel to their schistosity. These are usually small, ranging in width from the fraction of an inch to 5 or 6 inches. For the most part their material is shattered so that it has a distinctly clastic structure, but in some places it shows portions that are crystalline. These portions show shadow bands between crossed nicols. Most of the boulders are evidently from veins that were crushed when the rocks in which they occur were deformed.

There are other boulders, however, that are much larger. They are plainly from layers that are comparable in width with the graywackes with which they are associated. Their material is clastic, but the grains of which it is composed show very little resemblance to sand grains. They are subangular and entirely free from coatings. Moreover, the rocks are composed solely of quartz, with no admixture of grains of other minerals. Their layers are sharply separated from the graywackes and mica schists with which they are in contact, no gradation of any kind being observable. In the field these comparatively thick layers were thought to be quartzites, i. e. sandstones that had been crushed and recrystallized, but under the microscope their sections show the same features as those exhibited by the thin layers that are undoubtedly veins. Nothing is to be seen under strong magnification but quartz grains enclosing lines of glass inclusions, liquid inclusions and a few microlites. All of the grains are extremely irregular in shape and are interlocking, but here and there between the larger grains and in streaks through the mass are other grains of smaller size and in some little areas between neighboring grains are mosaics of still smaller grains. In many places too the mosaic lies as a narrow selvage between neighboring interlocking large grains, as though the large grains had been granulated on their edges and ground into a fine powder which had recrystallized. It is realized that an extremely pure quartz sandstone if crushed and recrystallized might exhibit all of these features, but it does not seem reasonable to expect a sediment to be composed so completely of a single mineral as are these quartzites. Further, no single layer can be followed for a long distance as should be possible if it represents a bed of quartz sand in a sedimentary series, consequently it is assumed that the thick layers like the thin ones are quartz veins that have been crushed to resemble clastic rocks.

BASALT DIKES

Scattered here and there through the pre-Cambrian area of the quadrangle are a very few dikes of basalt which because of their freshness and lack of deformational effects are regarded as parts of the Newark invasion that is best known in connection with the Palisades of the Hudson River. In New Jersey the intrusions took the form of great sills and large dikes. Farther south, in Maryland and Virginia large dikes are not uncommon, but in North Carolina and Georgia only small dikes were formed. In the Tate quadrangle one dike was discovered crossing the road a few hundred feet southeast of the Conn Creek School. The dike is about 50 ft. wide and trends N. 10°—30°W. Its length on the surface is not known. It was traced a few hundred feet both south and north of the road and then lost. About ½ mile north another exposure of the same kind of rock was encountered in the road to the Mackey School. It is on the trend of the dike to the south and may therefore be its extension. A second occurrence is in the old Creighton Gold Mine. This was not seen in place, but abundant fragments in the old dumps are abundant evidence of its presence. At a few other places small streaks of the same rock were noticed outcropping on the side of roads, but their dike forms could not be determined. The material comprising the dikes is a fine-grained, heavy, black rock, the thin sections of which show it to be a very fresh olivine diabase. Large fresh olivine grains, partially idiomorphic, lie in a matrix of fresh divergent plagioclase laths with an intersertal filling of granular augite. The olivine is only slightly serpentinized in some of the small pieces, and a few grains of the pyroxene are chloritzied, but the rock is remarkable fresh. It contains, of course, the usual magnetite particles and a few crystals of apatite. Measurements on one section indicate that the plagioclase is in the neighborhood of basic labradorite.

STRUCTURE

Folding

The entire area of the Tate quadrangle is underlain by rocks that have been closely folded and much crushed, and which in consequence have been greatly metamorphosed. Moreover, they have been fractured by a few great faults that have been recognized and probably by a number of minor ones that have escaped detection.

The Cambrian rocks in the area constitute in general the west limb of a synclinal basin the east limb of which has been cut off by a thrust fault in such a way that the highest beds of the Cambrian series have been brought in contact with pre-Cambrian rocks which originally must have been several thousand feet below the Cambrian beds. In the northern part of the syncline its structure is simple, its trough being under the marble at the east side of the Cambrian area. Farther south is is more complex, with two parallel troughs under the Keithsburg and Sharp Mountain marble belts, but there is no close correspondence between the troughs of the syncline and valleys as there is in the Ellijay quadrangle. In a minor way, however, the syncline is extremely complicated, since the materials of all of the different beds involved in the syncline have yielded to the stresses, that produced the major fold and have been intricately and commonly closely folded within their own limits.

The axis of the major syncline is curved, as a glance at the map will show. In the southwest portion of the quadrangle its strike is nearly east, but it gradually changes toward the northeast, north and northwest, and in the northwest corner is again east-west. The minor folds strike in the same direction as that portion of the major fold in which they are situated, but departures from this rule are not uncommon, especially in the northwest corner of the quadrangle, where cross folding particularly is noticeable. The dips of the beds are generally fairly high and are southeasterly, except in the northwest corner of the quadrangle where they are in many directions. It is evident that most of the minor folds are overturned to the northwest, and it is inferred that the major syncline is also overturned in the same general direction. The closeness of the folding and the consequent difficulty of following individual beds makes it impossible to judge of the thickness of the formations, or to work out the detail of the folding, but the variations in the directions of the strikes and in the magnitudes of the dips that are in the same directions leave no doubt of the existence of many close, overturned folds within the limits of each formation.

The severe folding to which all the rocks have been subjected has been attended everywhere with the production of schistosity. In general the strike of the schistosity is parallel to that of the bedding and in the more resistant beds it dips with the bedding, the adjustment to the stresses having been more easily effected along the bedding planes than elsewhere, but in a few places in the less resistant rocks, like the sericite schists and the micaceous schists of the Hiwassee and Nantahala formations, where the rocks are puckered by numerous small folds, the schistosity crosses the small folds intersecting their layers at various angles, but always with its strike parallel to the strike of the axes of the folds. Because most of the rocks in the quadrangle are strong the schistosity is nearly everywhere parallel to the bedding in the Cambrian rocks and to the layering in the pre-Cambrian rocks. Consequently, the schistosity is the most general structure in the quadrangle. Its strike is northeasterly over most of the area and its dip uniformly to the southeasterly at moderately high angles. In the Cambrian areas it can generally be distinguished from bedding, but in the pre-Cambrian areas the folding is so close and the difficulty of recognizing bedding is so great that the two cannot be distinguished with certainty in many places and consequently no attempt has been made to work out the folding.

Metamorphism

The constituents of most of the rocks in the quadrangle are not the same as those of which they were originally composed. Some of them, like the quartz veins and quartzite have retained their most important component, but there have been added to this other minerals that were made from the small quantities of other substances that were deposited with the quartz. Among the most common of these newly formed minerals are muscovite and biotite. Other rocks, like the hornblende schists originally contained augite, but this mineral has been transformed into hornblende and the plagioclase that may have been present has passed into epidote, quartz, micas, kaolin, and a few other less common minerals. These were formed when the rocks were at considerable depths beneath the surface and were being subjected to stresses, which changed the original minerals into new ones and forced the newly formed compounds to develop with their long axes in approximately parallel directions. When they were brought to the surface the minerals produced under pressure were no longer stable under the changed conditions, and chlorite, calcite, more quartz, more kaolin and a new set of compounds resulted. As a consequence the rocks now on the surface are unlike the original rocks, and the nature of these must be inferred from the character of their metamorphic products. The graywackes have now become schists composed of muscovite, biotite and the alteration products of feldspar, quartz and the argillaceous materials that once cemented the original sand grains. Where the argillaceous material was in large quantity garnets have been made and in some places staurolite and kyanite. The kyanite, however, was formed in greatest abundance where the rocks undergoing metamorphism were saturated with silica in the neighborhood of quartz veins. Similarly tourmaline was formed in some of the rocks adjacent to pegmatite dikes. With the exception of the tourmaline and some of the kyanite, nearly all the components of the Cambrian schists were made from the constituents of the sediments or of the igneous rocks, simply by a rearrangement of their chemical components into forms that were more stable under deep-seated metamorphosing conditions than those that were produced when the sediments were formed at the surface or those that crystallized from a molten magma.

The pre-Cambrian rocks are now completely crystallized and strongly schistose, but they have been so thoroughly crushed that their schistosity is always parallel to the boundaries between the different kinds of rocks, so that if faulting has occurred the fault planes cannot be distinguished from ordinary planes of schistosity. Because of the parallelism that exists between the schistosity, the faulting and the boundaries between the different layers, it has been impossible to decide whether the layering is the result of the folding of beds of different sedimentary rocks, or of the repetition of the same sedimentary beds by faulting, or of the crushing of a series of sediments intruded by igneous rocks. It is probable that the rocks that have been called micaceous graywackes and much of the garnetiferous mica-schist in the pre-Cambrian series were originally ordinary sediments, although at present they show no undoubted evidence of a sedimentary origin. With these, however, are interlayered mica-garnet gneisses, hornblende schists and hornblende gneisses, fine-grained aplitic rocks, coarse mica gneisses and other schists and gneisses that are very probably igneous rocks. They were forced into the pre-existing rocks along their directions of least resistance, which are now marked by their schistosity, and the whole complex was crushed under such great pressure that its different components were distorted into intricate folds, nearly all of which, whether small or large, were overturned to the northwest, indicating that the strongest thrust was from the southeast. (Cf. Plate VII A.) The dips of the layers are almost without except moderately high to the eastward. At a few places the dips of the layers and of their schistosity is south, and at a very few places is toward the northwest. At these places, however, there were massive buttresses of igneous rocks which successfully resisted the pressure and diverted the stresses from their normal directions, or there was faulting and consequent drag of the layers, which reversed the dips of the layers near the fault plane.

While the processes of crushing were active there was vigorous reaction between the crushed rock components. New minerals were formed, and since they crystallized under pressure, they were oriented in a general uniform direction which gave rise to the schistosity. When igneous rocks were nearby there was considerable addition of material to any sedimentary rock that may have been present and as a result a greater variety of new minerals was found than would have been possible if only a series of sediments had been metamorphosed. Not only did the material of the crushed igneous rocks contributed to the solution which saturated the complex and afforded an opportunity for interchange of chemical constituents and the production of new minerals, but the gases and thin solutions, emanating from the cooling magmas of intruding masses, passed out into the surrounding rocks and deposited tourmaline, rutile, magnetite, quartz and in many places feldspar, garnet, augite and other substance characteristic of igneous rocks, so that the resulting product lost all traces of any fragmental character it may have possessed and assumed more or less closely the features of igneous masses. The characters now exhibited by the pre-Cambrian complex are, therefore, probably the consequence of the alteration by dynamic metamorphism of a mixture of sedimentary and igneous rocks that had previously been affected by contact metamorphism. In those places where the metamorphosed series was invaded by later intrusions, like the Salem Church and Hightower granites, these also produced slight contact metamorphism in the already metamorphosed series and were themselves metamorphosed by dynamic processes, if their intrusion was prior to the end of Paleozoic time. If intruded later than the Paleozoic, like the Triassic basalt dikes, they had little effect upon the invaded rocks, probably because of their small size, and were not themselves metamorphosed.

Pseudodiorite

This peculiar rock which has been noted by all geologists who have worked in northwest Georgia and the neighboring portions of Tennessee and North Carolina has been met with at a number of places in the Tate quadrangle, more commonly over the areas underlain by the Carolina and Great Smoky formations. It is found as loose nodules on the surface, and as round masses embedded in graywacke or mica schist. In the Ellijay quadrangle the rock occurs also as sheetlike masses of rather uniform thickness, and with nearly parallel sides, that are generally conformable with the inclosing strata. The sheetlike masses appear at first sight to be intrusive, since in some places at the ends of the masses they have irregular branches that cross the bedding of the enclosing layers. The sheets range in thickness from a few inches to more than 50 feet. Most of them appear to be thin lenses.

The nodular masses lie in all positions in the beds in which they occur, but the longer diameters of most of them are roughly parallel to the bedding. Their contacts in most places cross the bedding, but in a very few places the bedding seems to be deformed about the nodules and to be parallel to their outlines.

The pseudodiorites are composed essentially of quartz, plagioclase, hornblende and garnet, but the relative amounts of these minerals differ greatly in different masses and in different parts of the same mass. In many places the rock contains a little muscovite, in some places considerable biotite or hornblende and in some places more or less orthoclase. Calcite and zoisite are present in some masses. Pyrite is a common constituent, and pyrrhotite and chalcopyrite are present in a few specimens.

In color the fresh rock ranges from nearly white, where there is little hornblende or biotite, to nearly black where these constituents are abundant. Masses containing much garnet are purplish. The most common phase is said to be a grayish rock resembling in general appearance a granite or quartz diorite, though this phase has not been noted in the Tate quadrangle. The pseudodiorites are generally dense and tough and they weather slowly forming small bowlders covered with a light brown crust. On fresh fractures the weathered rock is dirty yellowish-white or rusty-brown.

In texture the pseudodiorites are wholly crystalline and range in granularity from almost aphanitic to very coarse-grained, the coarsest type containing apparently phenocrysts of hornblende one-half inch or more long. The common phase is medium-grained, and in it the minerals are rather uniformly distributed. The garnet appears to have been formed last. Schistosity is rare, but a fairly well-defined zonal structure is developed, and in many places there is a marked striping of the surface due to the arrangement of the garnets in lines.

Generally the contact between the pseudodiorite and the surrounding rock is gradational. In some places the bedding of the graywacke passes more or less distinctly into or quite through the nodules or through portions of the irregular branching masses. In a few places, however, the contact is sharp.

Study of the pseudodiorite in the Ducktown region has led to the conclusion that the rock "was formed in place by a complete recrystallization of portions of the original sedimentary rock, as an extreme result of the regional metamorphism. Whether any part of the rock was actually melted under pressure is uncertain but seems rather improbable. It is believed that percolating solutions played the chief part in the recrystallization, and that its localization and generally very slight extent is due to its having occurred only in those parts of the rock in which the texture and composition were favorable to its formation." Because the specimens seen by La Forge and Phalen[27] lack schistosity and exhibit very little deformation of any kind, it seemed probable to them that the pseudodiorites "were formed during the closing stages of the latest great deformation to which the rocks of the region were subjected, and undoubtedly at a great depth."

In thin sections the specimens found in the Tate quadrangle were seen to consist mainly of interlocking quartz, garnet, pale-green hornblende and epidote, all strung out in lines. The garnet and quartz in some sections are equally abundant. The epidote, which is nearly colorless, is closely associated with the hornblende, in many places being intimately intergrown with it. The garnet is cellular. In some sections there are also a little plagioclase, sphene, zircon, apatite and magnetite. In all sections the minerals except the quartz are elongated in a parallel direction, but in most specimens the quartz shows no uniform orientation and no pressure phenomena. Some of it appears in streaks as though it had been infiltrated after most of the deformation had ceased.

An analysis by Dr. Everhart of a specimen of a garnetiferous variety occurring in the Great Smoky formation about 4000 ft. a little south of east of Cagle Mill, on a small branch of Sharp Mountain creek, showed:

SiO_2	Al_2O_3	Fe_2O_3	FeO	MgO	CaO	Na_2O	K_2O	Ign	MnO	TiO_2	P_2O_5	SO_3	Total
71.76	13.70	3.76	1.76	.36	6.90	.26	.10	.14	.16	.72	.54	.00	100.16

[27] La Forge, L. and Phalen, W. C., U. S. Geol. Survey Geol. Atlas, Ellijay folio (No. 187), p. 8, 1913.

Several of the pseudodiorites found in the Tate quadrangle show schistosity, and in these all the components are crushed, and elongated in one direction.

In the Tate quadrangle some of the pseudodiorites must have existed as such before the last great deformation, since all their constituents except the garnet are crushed and the rocks are distinctly schistose. Moreover, they appear to have been thoroughly silicified, much as have many of the graywackes in the Carolina gneiss series. It is possible that, instead of being among the last products of the metamorphic processes to which most of the rocks of the Tate quadrangle have been subjected, the pseudodioretes of this district may have been formed under static conditions during the earlier stages of the metamorphism, and that because of their rigidity they resisted the deformation to which the other rocks yielded and remain as residuals in a series of schists.

There is little difference observable in the pseudodiorites associated with the beds of the different formations. Those in the Great Smoky formation are in no wise different from those in the Carolina gneiss, so far as has yet been discovered. They perhaps contain a little more sphene and more plagioclase, but this appearance may be due to the fact that those found in the pre-Cambrian rocks are much more silicified than those in the Cambrian beds, and consequently, contain such a large proportion of quartz that the other components are noticeably less in comparison. Most of the quartz in the Great Smoky pseudodiorites has been strained or crushed and nearly all grains show strain shadows, and very little of it is in streaks, whereas most of that in the pre-Cambrian pseudodiorites is in streaks as though infiltrated and only a very little of this quartz exhibits strain shadows of any kind. Between the quartz streaks, however, there are other quartz grains scattered through the mass and these are strained. It seems plain that the pseudodiorites in both areas were originally similar but that those associated with the older rocks have been richly impregnated with silica, whereas those associated with the Great Smoky rocks have escaped this kind of metamorphism.

Faulting

The presence of belts of the Murphy marble in contact with pre-Cambrian rocks and with the schists of the Nantahala formation, and the crossing of strips of the Nantahala and Great Smoky formations by a belt of the Valleytown formation can be explained satisfactorily only by the assumption of faulting. No fault planes were seen and because of the uniform character of many of the rocks of most of the formations their positions could not everywhere be determined. Where the faults are between formations that differ in character their mapped positions are accurate, but where the faulting is between two formations of schists that are nearly alike their mapped positions are only approximate. It is probable that there are many small faults in the area, (See Plate X A) and possibly some large ones that have not been detected. All those that have been recognized are of the overthrust type, with the thrust from the east or southeast, crowding the older rocks to the east toward the younger ones to the west, resulting, in some places, in the actual overriding of the younger by the older rocks, thus reversing their normal sequence in position.

Three main faults are indicated on the map of the Ellijay quadrangle as passing over into the northern part of the Tate quadrangle. Of these the two most important are that on the east side of the western belt of Nantahala formation, and that on the west side of the eastern belt of the same formation.

The former has been called the Murphy fault and the latter the Whitestone fault.[28] Of these the Whitestone fault is believed to pass into the Tate quadrangle and to become the dominating cause of the distribution of most of the marble in this area. (See Fig. 1.)

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[28] La Forge, L. and Phalen, W. C., U. S. Geol. Sur. Geol. Atlas, Ellijay folio (No. 187), p. 9, 1913.

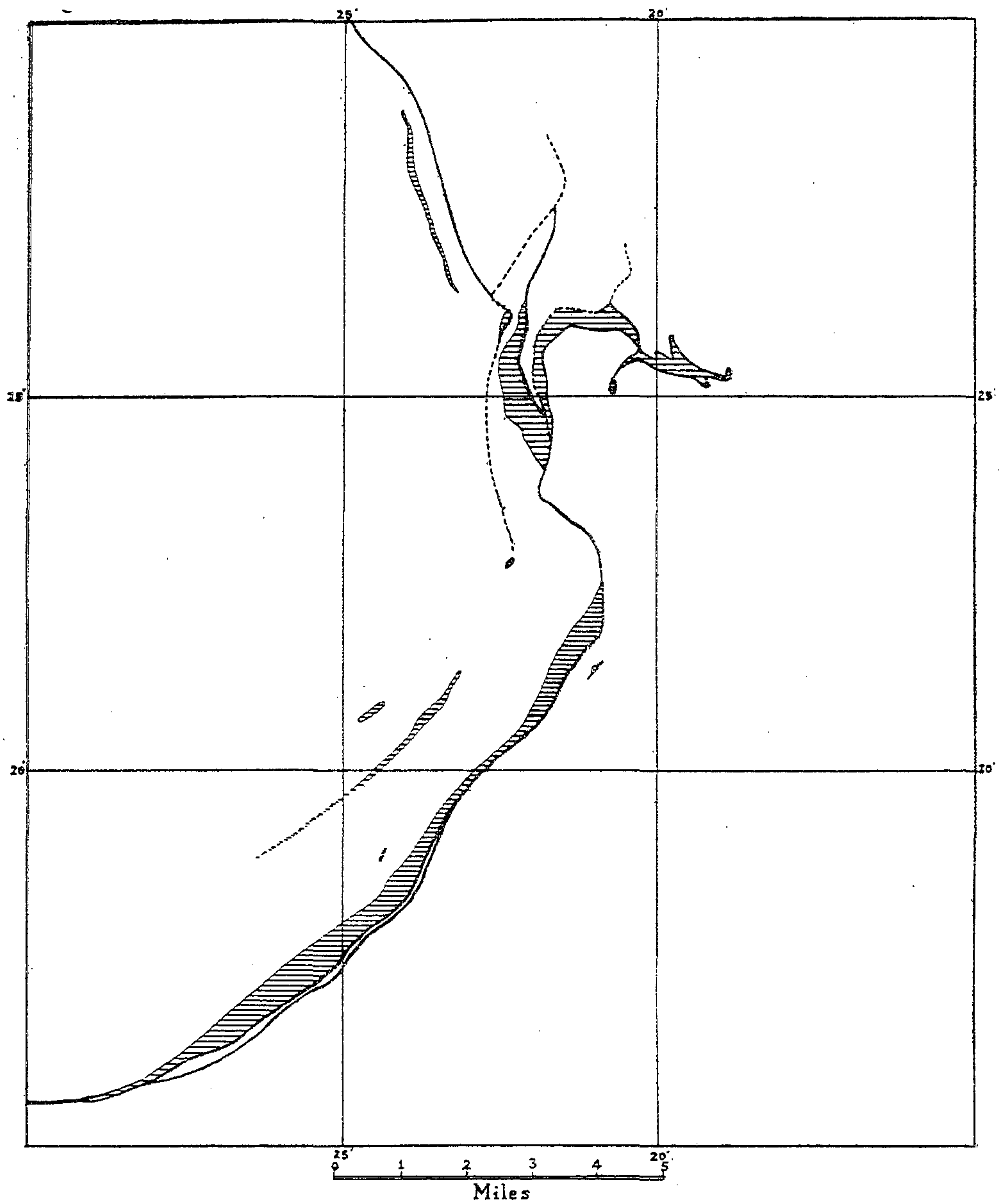

Fig. 2. PLAN OF MAIN FAULTS IN THE TATE QUADRANGLE.

The major fault (in heavy black) is the extension of the Whitestone thrust in the Ellijay quadrangle. Cross faults (in dash lines) intersect the major fault, which in the Marble Hill area is repeated on opposite sides of the valley by folding. Areas of the Murphy marble are shown by horizontal lines and by solid black spots.

The Murphy fault is described by La Forge as probably the second longest fault in the southern Appalachians, extending northeastward nearly to the east side of the Nantahala quadrangle, and southward across the Tate quadrangle and beyond. The reason for supposing that this fault extends into the Tate quadrangle is the absence of the Tusquitee and Brasstown formations from between the Nantahala and Valleytown formations, where they would naturally be expected to occur if they had been deposited in their ordinary sequence. However, in his description of these formations in the Ellijay quadrangle (p. 6), La Forge suggests that since neither of these formations occurs south of Ellijay their disappearance at this latitude may be due to the fact that they were never deposited farther south, in which case the Valleytown beds should be found immediately above the Nantahala beds. It is thought probable that in the Tate area the deposition of the Valleytown sediments immediately succeeded those of the Nantahala formation, and that in consequence there is no necessity for introducing a fault between the two formations to explain their juxtaposition. It has, therefore, been omitted and the Murphy fault is not indicated as passing into the Tate quadrangle.

The Whitestone fault, passes through Whitestone, a few miles north of the southwest corner of the Ellijay quadrangle and enters the Tate quadrangle 5 miles east of its northwest corner. To the northeast it extends into the western part of the Nantahala quadrangle, where it dies out a few miles northeast of Murphy. At Whitestone the Nantahala slate can be seen overlying the Murphy marble with a nearly horizontal fault contact. In the Tate quadrangle the fault plane dips below the marble, cutting it out and, continuing southeasterly across the Nantahala and Great Smoky formations and into the Carolina gneiss, brings them successively in contact with the Valleytown formation. At the great bend in Long Swamp Creek the major fault is cut by a cross fault striking a little east of north and its southern continuation is shifted to the east. The cross fault trends southward and passes into a syncline at about Nelson, where its position is marked by the exposure of white marble at the spring near the school-house.

That portion of the main fault that was shifted east runs south for about three miles to a point about opposite the Tate post office, bounding the east side of the great marble area that occupies the broad valley of Long Swamp Creek (Cherokee Valley) in this portion of its course. At this point another cross fault again shifts the southern extension of the fault to the east, for a distance of three miles, to a point on the north slope of the valley of the East Branch of Long Swamp Creek opposite the openings of the New York quarries. From this place the trace of the main fault follows a sinuous line around the valley of the East Branch returning to the valley of Long Swamp Creek near the Tate post office, and thence southerly and southwesterly along the east side of the Keithsburg belt of marble, leaving the quadrangle near its southwest corner. Between the south end of the Cherokee Valley and the northermost exposure in the Keithsburg marble belt at the bridge over Long Swamp Creek, east of Nelson, the position of the fault line has not been located with exactness. Its approximate position is indicated by a few exposures of contorted, bedded, colored clays that are exposed in gullies at the base of the slopes on the west side of the valley. South of the bridge east of Nelson the fault follows the contact between the Keithsburg marble belt and the Nantahala and pre-Cambrian schists.

At Whitestone the thrust plane has a very low dip to the east. It is assumed that the same low dip is maintained throughout the Tate quadrangle and that it is this feature that accounts for the distribution of the marble in the Marble Hill area. Here the fault plane and the rocks on both sides have been compressed into a major east-west syncline, with subordinate cross folds. (Compare curved fault, Plate X A). The intersection of the plicated fault plane with the surface explains its sinuous outcrop, and the fact that the rocks and fault plane were folded together explains the parallelism existing between the direction of the fault line and the strike of the schistosity in the adjacent schists. (See fig. 2, p. 123 and cross-section E-F on map 2.)

The third fault entering the Tate quadrangle crosses its north boundary a few miles west of Sharptop Mountain. So far as can be determined it separates the pre-Cambrian and Great Smoky rocks in the Ellijay quadrangle and continues south between the same formations in the Tate quadrangle for a distance of about 3½ miles, when it merges with the Whitestone fault and loses its identity as a distinct fracture.

MINERAL RESOURCES

The possible mineral resources of the Tate quadrangle include marble, dolomite, or magnesian marble, building stone, flagstone, road-making materials, garnet, kyanite, sericite, mica, graphite, gold and pyrite. Marble and the road-making materials constitute the most important of these resources, but flagstones, pyrite, sericite and kyanite are also worthy of serious consideration. Pyrite and sericite have been produced in considerable quantities and flagstones are quarried periodically. Gold was once a very important product but after the placers had become exhausted and the weathered portions of the vein deposits had been removed all gold mining ceased.

The mica and graphite deposits in the quadrangle do not furnish much encouragement to the miner, but garnet and kyanite give promise of future importance.

GOLD

Gold occurs in veins and in placer gravels associated with some of the streams.

Veins

The gold-bearing veins in the Tate quadrangle consist mainly of quartz and small quantities of native gold or of pyrite and other sulphides. In this quadrangle all the fold-quartz veins known are in the pre-Cambrian area where they conform to the trend of the inclosing schist or gneiss. The quartz of the veins is the usual milky variety. Generally the sulphides in it have been weathered and on their outcrops the vein material is stained brown by iron hydroxides. Although the gold is generally directly associated with sulphides, the absence of sulphides does not necessarily mean that gold is also absent, for some of the richer gold-bearing veins in the southern Appalachians contain only quartz and free gold.

The best known veins of this type are at Dahlonega, a few miles northeast of the northeast corner of the Tate quadrangle, where they occur near the contact of a mass of hornblende schist, or closely similar rock (Roan gneiss), with granite or gneiss. In the Tate quadrangle veins of the same kinds as those at Dahlonega were formerly worked at the Creighton, or Franklin mine on the Etowah River. The mine is now abandoned and the works are in ruins. The only evidence with reference to the character of the veins that can now be gathered is by a study of the old dumps. (See pp. 31-32.)

In addition to the Creighton mine there have been several other openings made in the Tate quadrangle that are reported to have yielded gold. Among them are a few that were worked as mines down to the water-level, when they were abandoned because of the expense of separating the metal from the unweathered pyrite.

The most important openings for gold were in Cherokee County. McCallie has listed the following: The Creighton mine, the Cox property, The Sandow mine, The S. R. Smith, The Richards, The Latham, The Thomason and The Burt properties.[29]

At the Creighton mine two parallel veins about 150 ft. apart were worked. The larger of these, known as the Franklin vein, strikes N. 60° E. and dips about 40° southeast. Its developed portion consisted of a series of chimneys, or shoots, connected by quartz stringers. The shoots were from 50 to 120 feet in length and had an average width of three feet. Their pitch was about 45° northeast. In 1896 the vein had been worked for about ¾ mile along its outcrop and to a depth, in some places, of 400 feet. The vein material is described as "a milk-white quartz and thin layers of mica-and hornblende-schist, all impregnated with auriferous pyrite," and the veins as alternating layers of quartz and pyrite. Many veins were broken by cross gashes filled with calcite.

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[29] McCallie, S. W., Cherokee County: A preliminary report on a part of the gold deposits of Georgia: Geol. Sur. of Ga. Bull. No. 4-A., pp. 174–188, 1896.

About ½ mile southwest of the main shaft of the mine a prospecting shaft 70 feet deep encountered a vein from 2 to 3 feet thick that was said to carry ore assaying from $15.00 to $20.00 per ton. About 1/3 of a mile farther southwest was another shaft (see p. 31), which struck a 3-foot wide vein at a depth of 72 feet containing fresh sulphides assaying from $20.00 to $30.00 of gold per ton.

In all these places the country rock consists of garnetiferous mica schists and hornblende schists with intercalated quartz veins.

The Sandow mine is on lot 741, 3rd district, between Fowler's and Smithwick creeks. There are two veins of which the one that is visible on the surface is 18 inches wide. Shafts, open cuts and three tunnels indicate that the mine was profitable so long as the work was confined to the exploitation of the weathered rock; when the water-level was reached the place was abandoned.

The Cox property is on lot 404, 3rd district, about 1½ miles west[30] of the Creighton mine. A tunnel, test pits and open cuts expose two porous and iron-stained quartz veins, 18 inches and 3 feet wide. The Smith property was on lot 701, 3rd district, adjoining the Sandow mine. Old excavations are said to have uncovered a rich pocket of ore which was soon exhausted. The vein was reported to occur in hornblende schist.

The Richards property was on the west side of Fowler's creek, opposite the Sandow mine, probably on the continuation of the veins on the Sandow and Smith properties. The great amount of work that was done on this property suggests that at one time it was profitable. At the junction of Fowler's and Smithwick creeks is a band of schist 2 or 3 feet wide that is impregnated with pyrite.

The Latham property is on the Canton road about 2 miles west of the old Orange post office, on lot 805, 3rd district. On the map it is placed about three miles west and a little north of Orange. Gold was first discovered here in 1852, and a few tons of ore were milled. About 30 years later a shaft was sunk to a depth of 50 feet, and in 1893 a stamp mill was erected, several new shafts were sunk and several tons of ore

[30] On the map that accompanies McCallie's report the "Cox prospect" is located about ½ mile north of the Creighton mine.

were milled. There are said to be three parallel veins on the property, the largest of which is 30 inches wide. A sample from this vein assayed $1.32 per ton, and one from a vein 18 inches thick, about 20 feet from the first vein, assayed $3.60 per ton.

When first opened all these operations are said to have been profitable.

The Thomason property is on lot 208, 3rd district, adjoining the Latham lot. On this a shaft 15 feet deep exposed a porous, iron-stained vein 2 feet thick, from which 10 tons of ore are reported to have been taken.

At the Burt property, a short distance northeast of the Latham property, is another old shaft about 35 feet deep, at the bottom of which there is said to be a gold-quartz vein, but nothing is known about it.

Origin.—The veins in the Tate quadrangle are in every respect like those in other portions of the southern Appalachians, which, before the discovery of gold in California, furnished most of the metal produced in the United States.

Graton[31] in his preliminary study of the gold ores of the southern Appalachians, declares that the pyritiferous-gold-quartz veins are not confined to any one kind of rock but occur in all the schists of the region. He concludes that they were formed at great depths and at high temperatures, from solutions that emanated from granites. His reason for this conclusion is the close similarity between the quartz-tourmaline veins in the tin-bearing areas and the gold-quartz veins in the gold-bearing areas, and the fact that some of the former contain small quantities of gold. The tourmaline-quartz veins are almost certainly derived from granite magmas; it is inferred, therefore, that the gold-quartz veins have a similar origin. The source of the ore materials was at great depth below the surface at the time the veins were made, but of unknown distance below what is the present surface. The veins now at the surface represent the deeply buried stumps of quartz veins which originally extended much higher. The numerous nuggets of

[31] Graton, L. C., Reconnaissance of some gold and tin deposits of the southern Appalachians: U. S. Geol. Sur. Bull. 293, pp. 58–75, 1906.

large size found in placer deposits may be an indication that the upper portions of the veins were richer than those portions now known. It is possible that ore exists far below the present surface, but that the individual bodies of pay ore known at present give out at comparatively small depths, to be succeeded farther down by other ore bodies, which however, may be difficult to find.

The general conclusions of Graton concerning the origin of the gold ores of the southern Appalachians are corroborated by Lindgren[32] as the result of his study of the Dahlonega deposits. The gold at Dahlonega is mainly as metal but with the native gold in many places are auriferous sulphides.

Placers

The Etowah River and its branches, more particularly those entering it from the south, drain rocks in which are quartz veins containing native gold and others containing auriferous pyrite. In the weathered portions of the sulphide veins the pyrite is oxidized and the gold is left as the metal, which occupies portions of the cavities originally filled by the sulphide. The exposed portions of these veins and of the veins containing native gold are disintegrated and their debris is carried away by the streams. The gold settles with the coarser sand, whereas the finer sand is swept along until the currents become sluggish, when much of it also is deposited. The finest material is carried onward, some of it probably into the Gulf. The sands along nearly all the streams in the quadrangle upon careful panning will show more or less gold, but those flowing north into the Etowah River were particularly favored as sites for rich placers, since they carried the debris of rich veins. Because of their richness these placers have been thoroughly worked, so that there is probably little gold left in them for future prospectors. Other streams are also bordered by gravels containing gold, though the amount of metal in them is probably not sufficient to pay for separating it. Some portions of the channel of Etowah River might yield enough gold to be profitable if it were worked by a modern dredge, but it is very doubtful if a sufficient

[32] Lindgren, W., The gold deposits of Dahlonega, Ga.: Ib. pp. 119–128, 1906.

quantity of gold-bearing sand is available to warrant the cost of such a dredge and the expense of operating it.

PYRITE

Pyrite (FeS_2) is used as a source of sulphur in the manufacture of sulphuric acid. The residue after roasting is employed as a pigment.

Nearly all the pyrite deposits in the southern Appalachians are associated with the hornblendic rock known as the Roan gneiss, and generally occur within a fraction of a mile from its contact with granite.[33] The principal vein mineral is pyrite, but pyrrhotite, chalcopyrite, sphalerite and magnetite are present in subordinate quantities in some places. Although the pyrite is believed to have been deposited by emanations derived from cooling granite, just as was the gold in the gold-quartz veins (p. 129), it nevertheless is commonly free from all traces of the more valuable metal.

One of the principal belts of pyrite veins in the State crosses the southeast quarter of the Tate quadrangle, from Creighton to Canton. In this belt are a number of small pyrite deposits which can be identified by the red rust stain, or gossan, produced by their weathering, and a few larger ones, some of which have been opened.

Only two deposits in the Tate quadrangle have been mined, though several others have been prospected. The most important workings were at the Standard Pyrites Mine, a short distance southwest of the old Franklin Gold Mine. The mine is on a belt of siliceous material that is bordered on both sides by Roan gneiss. (See p. 29). The Roan gneiss is surrounded by Carolina gneiss and at a mile's distance is the northwest boundary of the Hightower granite. The siliceous material, which strongly resembles chert, is laminated, and is traversed by occasional veins of quartz. The pyrite follows the laminae. The vein therefore consists of alternating layers of chert-like rock, pyrite, and here and there layers of milky quartz. In some places the pyrite is in crystals scattered through the siliceous rock, in many others it forms thin solid layers of granular material without inclusions of other

[33] Shearer, H. K., and Hull, J. P. D., A preliminary report on a part of the pyrites deposits of Georgia: Geol. Sur. of Ga. Bull. 33, p. 21-23, 1918.

substances, and in other places the pyrite replaces the siliceous rock forming shoots that are described as being 9 ft. wide.

Shearer and Hull[34] state that there are on the Standard property three approximately parallel veins, 600 ft. apart, striking and dipping with the schistosity of the country rock, and in each vein are ore shoots pitching to the northeast. The working mine was on the northwesternmost of the three veins.

In 1917 the shaft had a depth of 400 feet on an incline of 39°. In the vein were two shoots, and the shaft was between them. The shoot southwest of the shaft had a workable length of 170 feet and a width of 11 feet, of which 9 feet were in pyrite. The second shoot, 70 ft. northeast of the first one, was 200 ft. long and had a maximum thickness of 5 feet. Both ore shoots were persistent in length, thickness and quality as deep as the workings extended. The ore removed was concentrated yielding 85:100 for the west vein and 70:100 for the east vein, with a sulphur content of 45%. The vein was reported to be underlain by quartzose schist, at least 20 feet thick, containing disseminated pyrite crystals and veinlets of pure pyrite an inch or more thick. The pyrite constituted about 20% of the whole mass of rock.

That portion of the vein removed contained little quartz or other gangue, but held inclusions of chlorite schist ranging from a fraction of an inch to more than a foot in thickness. Analyses of the ore gave the results shown in lines A and B.

Analyses of pyrite from the Standard Mine, Cherokee County, Ga.

	SiO_2 and insol.	Fe_2O_3	FeS_2	Moist	Fe	S	Cu	Au	Ag
A.	9.71	6.04	81.50	.09	42.16	43.57	.00	------	------
B.	10.33	5.03	83.89	.10	42.56	44.85	.00	.00	.00
C.	2.36	2.13	95.31	.03	45.85	50.95	.00	------	------

A. Average sample across 9-foot vein, 400-ft. level, exclusive of bands of chlorite schist.

B. Concentrates. Average of shipments in August, 1917.

C. Average sample from vein exposed in cut near Boardtree Creek.

[34] Shearer, H. K. and Hull, J. P. D., Ib. pp. 164–174.

The vein worked at the Standard mine has been traced both to the northeast and southwest of the shaft. In some places it shows only thin streaks of pyrite, but northeast of Boardtree Creek the vein was uncovered for a length of 172 feet beyond the creek where it pinched out. In this distance it had a thickness varying between one and three feet of exceptionally pure pyrite containing over 50% of sulphur. (See analysis C). The hanging wall is a quartzose schist impregnated with small pyrite crystals and the foot wall a "slaty chlorite and biotite schist."[35]

About half a mile southwest of the Standard mine shaft another vein was worked by two shafts at the Swift mine. This vein was supposed to be the middle vein on the Standard property and from it about 4000 tons of concentrates were shipped between 1906 and 1911. The ore body on the 270-foot level is reported by Shearer and Hull[36] to have an average thickness of between 30 and 36 inches throughout a length of 700 feet. It pinches rapidly to the southwest and is apparently cut off entirely at its southwest end by a fault. The ore is like that at the Standard mine. Its gangue consists of vein quartz and inclusions of the wall schists. The foot wall is a "finely banded schist made up of quartz, calcite, biotite and magnetite" and the hanging wall consists of the same minerals with the addition of hornblende and muscovite. It is estimated that 40,000 long tons of ore are blocked out above the 270-foot level of the old mine and that the concentration should yield at about the ratio 3:4.

Analyses of pyrite from the Swift Mine, Cherokee County, Ga.

	SiO_2 and insol.	Fe_2O_3	FeS_2	Moist	Fe	S	Cu	As
A.	25.62	3.88	62.74	.16	31.92	33.54	.00	.00
B.	2.03	1.44	87.62	.04	41.58	46.84	------	------

A. Concentrating ore from old dump. Contains vein quartz and wall rock inclusions.

B. Average sample across vein 7 feet thick. From 270-foot level, 600 ft. northeast of shaft.

[35] Shearer, H. K., and Hull, J. P. D., Ib. pp. 164–174.

[36] Ibid. pp. 174–178.

Two other developments of pyrite are a mile north of the Canton-Creighton road half way between Buffington and Orange and 7 miles east of Canton on the lands of the Thomas Dickerson heirs, and on the A. S. Smith land, adjoining the Dickerson property on the east and northeast. Pits and a shaft disclosed a gray "chloritic micaceous schist" with darker quartzitic members. The vein, varying in width between 8 and 36 inches, consisted mainly of granular pyrite in which were intermingled some quartz and mica. Copper is said to be present in some of the ore, but analyses indicate that it is rare. It is noticeable that there are no exposures of either granite or hornblendic rocks in the vicinity of the veins. Analysis of the lump ore from the Dickerson prospect gave:[37] SiO_2 and insol = 5.10%; Fe_2O_3 = 5.17%; FeS_2 = 87.39%; moisture = 0.15%.

The pyrite body on these properties is at least 175 feet long and 3 feet thick to a depth of 50 feet.

It is probable that not all the pyrite deposits in the quadrangle have been discovered. There are other places at which gossans are known, but in no other places is there any evidence that the deposits are of commercial value. Indeed with the increasing tendency to utilize sulphur in the manufacture of sulphuric acid the market for pyrite is gradually being depressed, so that at present it is only an exceptionally large and favorably situated deposit that might be profitable to work.

RUTILE

Many of the quartz veins and pegmatite dikes in the district contain small amounts of rutile (TiO_2) in minute crystals. In one or two places the crystals are large enough to be visible to the naked eye, but only on the old road running northwest from Sharp Mountain church, on Highway No. 5, about 1 mile north of Gober, were any crystals seen that are large enough to be of interest commercially. In the soil on the gentle grades, about one mile from the church, there were (in 1925) many fragments of quartz, staurolite, kyanite, garnet and other minerals that are common to the Valleytown schists, and in

[37] Ibid. pp. 160–163.

addition fragments of simple and twinned crystals of rutile measuring as much as 1½ inches in length and one inch in thickness. The source of the rutile was not discovered but it was undoubtedly one of the pegmatite dikes so common in the neighborhood.

Rutile of this type is not an unusual constituent of the pegmatites in the Appalachian Mountains[38], but nowhere has it been exploited because of the existence in Nelson County, Virginia, of great deposits of a rutile-apatite rock[39] and a rutile syenite from which rutile can be obtained more cheaply than from pegmatite, and because of the presence of large amounts of ilmenite ($FeTiO_2$) in the sands near Pablo Beach, Florida, from which the titaniferous compound can be separated easily by washing.

Titanium is used mainly in the manufacture of ferrotitanium and pigments, and to a smaller extent in the preparation of some grades of leather.

ROAD-MAKING MATERIALS

Road-making materials are as plentiful in the Tate quadrangle as they are in neighboring areas. In discussing similar materials in the Ellijay quadrangle Phalen declares that the Roan gneiss, and the pseudodiorite should make excellent material for roads. There is not much available pseudodiorite in the Tate area, but there is an abundance of the Roan gneiss and related hornblende rocks in the southeast part of the quadrangle and in the neighborhood of Marble Hill, and most of it would make good road surfacing.

The blue marble, which is so easily accessible to Highway No. 5, is worthy much more attention as a road material than it has heretofore received. The crushed rock has been used to some extent for surfacing, but has been employed on only a few comparatively short stretches of road. When compacted it should make a firm, hard, nearly dustless surface. The crushed rock should also be a satisfactory component for concrete.

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[38] Watson, Thos. L., Geology of a vein occurrence of rutile-ilmenite in a new locality: Jour. Wash. Ac. of Sciences, vol. 12, No. 20, p. 447–454, 1912.

[39] Watson, T. L. and Taber, S., Geology of the titanium and apatite deposits of Virginia: Va. Geol. Sur. Bull. III-A, 1913.

FLAGSTONES

Many of the micaceous graywackes in the Great Smoky and Valleytown formations are in sufficiently thin layers to split evenly, furnishing smooth surfaced blocks of almost any size desired. Their color varies in different shades of gray, bluish, purplish and greenish tones prevailing. Most of the rocks contain garnets, but there are layers in which the garnets are very small or are entirely lacking.

There is no difficulty in finding many places, especially in the Valleytown area, at which tough, fine-grained, and strong stones may be secured by using a little care. Flagstone has been quarried from the Valleytown formation on Champion creek, 1¼ mile north-east of Jasper, and from the Great Smoky formation about 1½ miles west of the same city. A few flags for local use have been obtained also at other places.

FLUXING ROCKS

The white marbles and quartz are both available as fluxes for the copper smelters at Ducktown. Most of the marble is of more value for other purposes, but nearly all of it might be utilized as flux if needed. A glance at the analyses on pages 80, 91 and 93 will show that some of it is an almost pure calcite marble, and that the rest contains a very little of any other component than magnesium carbonate. Silicates are present in very small amounts. Marble of this kind, which makes an excellent flux, can be obtained in large quantity in the Long Swamp Creek and the Marble Hill belts.

There are no great deposits of quartz in the Tate quadrangle comparable to those of the Tusquitee and Nottely formations farther north, but there are numerous pegmatite dikes and quartz veins cutting the pre-Cambrian schists and the rocks of the Great Smoky formation, and lenses of quartz, that may be quartzites, intercalated with them. These, when eroded, yield abundant quartz bowlders. Some of the veins are very large and the quartz lenses are in some places closely crowded, consequently in these places many bowlders are scattered over the surface. Those near the railroad are collected by farmers and carried to the stations for shipment. Perhaps the largest vein-like mass is exposed at the head of Talking Rock Creek, on the ridge running east from Sharp Mountain. Boulders are particularly abundant in the country east of Ball Ground, but they are also scattered in many limited areas over much of the country underlain by the Carolina gneiss and the Great Smoky formation and less abundantly over that underlain by the Valleytown formation. A very few of the pegmatites may yield quartz as a by-product if they are ever exploited for mica or kaolin.

SAND AND GRAVEL

Some sand and gravel are to be found in the deposits along the Etowah River and some of the smaller streams, but only small quantities have been used for local purposes.

BUILDING STONE

The Tate quadrangle is abaundantly supplied with rocks that are suitable for building stones, though none of them except some of the marble are of such beauty as to warrant their exploitation except for ocal use.

Marble

The handsome marbles of the Long Swamp creek and the Marble Hill belts are monumental stones of great value, not only because of their beauty and ease of work, but also because of their strength and durability. They are more particularly referred to in another place (pp. 147-156.)

The blue marbles of the Keithsburg and the Sharp Mountain Creek belts are compact, durable, fine-grained rocks that may easily be gotten out in large dimension blocks that might be used for all kinds of construction work. They are resistant to weathering, are strong and are fairly easily split, and there are many places in the quadrangle that would furnish excellent locations for quarries. Moreover, the Keithsburg belt is close to the railroad. The marble is well suited to rough masonry. It would make good foundations, and might be used for commercial and manufacturing buildings in which its dull color would not be objectionable.

Quartzose Rocks

The Great Smoky and the Carolina gneiss contain the greatest amount of stone suitable for construction. The graywackes and the mica gneisses might serve well for rough work such as bridge abutments and dams. Much of both rocks, however, contains pyrite which upon weathering would cause staining.

The two granites occurring within the quadrangle contain very few objectionable components and ought to wear well. They are both fairly coarse-grained and schistose. They could easily be quarried into rough blocks, but would not trim well or take a good polish. At no place have they been opened up, so that the character of unweathered material can only be inferred. Their light color might be a sufficient inducement to cause them to be employed for small ornamental buildings, but their principal use would be for rough masonry. Since, however, all the granite in both areas, is at a considerable distance from any railroad it is not likely to be utilized in the near future except locally.

Another rock which may become of importance if it can be found in large enough quantity to warrant exploitation is the pseudodiorite. It is dense, hard and durable and takes an excellent polish. Its beauty when polished and its durability should make it desirable as an ornamental stone. Unfortunately, however, it rarely occurs in masses that would furnish a slab more than 3 feet square.

CLAY

Clay occurs abundantly as a covering of the rocks along some of the streams and in the low places throughout the quadrangle. Some of it might be used for brick, drain, tile, etc., and certain coarse grades of pottery, but there is no great demand for these products within the area and the clay will not bear the cost of transportation to manufacturing centers.

Some sandy and gravelly clay has been used with good results on roads.

KAOLIN

Most of the kaolin produced in the United States comes from the mountains of North Carolina where it occurs in the weathered portion of pegmatite dikes. Lower-grade material results from the weathering of granite and other feldspathic rocks and, under the influence of special conditions, from the weathering of limestones, quartzites and shales.[40] There are other white clays occuring in beds that were deposited as sediments. Some of these are employed for the same purposes as the residual kaolin, but they possess somewhat different properties and are usually referred to as sedimentary kaolin. The most important white clays of Georgia are sedimentary kaolins. They occur in Lower Cretaceous deposits, in a belt that extends across the State on the northwestern margin of the Coastal Plain. At only a few places are residual kaolins known, although pegmatites are common. In North Carolina most of the pegmatites in the pre-Cambrian areas are more or less altered to kaolin, but in Georgia they appear to have escaped this process. A few deposits have been prospected in the southwestern part of the Ellijay quadrangle but so far as known no kaolin has been shipped.

In the Tate quadrangle no promising deposits of kaolin are known. In some places the soil over the granite areas is largely kaolin, but it is so mixed with other substances that it has little value. At other places the white decomposition product of the granite is a mixture of sericite and quartz (p. 108). At a few places pits dug into weathered pegmatites have uncovered masses of kaolin, feldspar and quartz, but in all cases that have been reported the dikes are small and the kaolin in them is in too small amounts to warrant the construction of washing plants and therefore is unavailable as a commercial product. With the coming of better roads it may be possible to work some of the larger dikes in the neighborhood of Jasper and Nelson, but the outlook for any large output from the district is not promising.[41]

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[40] Ries, H., Bayley, W. S., and others, High-grade clays of the Eastern United States: U. S. Geol. Sur. Bull No. 708, pp. 1–162, 1922.

[41] Cf. Galpin, S. L., A preliminary report on the feldspar and mica deposits of Georgia: Geol. Sur. of Ga., Bull. 30, pp. 151–3, 1915.

FELDSPAR

Many of the pegmatite dikes in the Tate quadrangle are richly feldspathic. Some of those in the Great Smoky and pre-Cambrian rocks contain enough feldspar of sufficiently good quality to be worthy of consideration as sources of the material. The greatest promise of value is offered by dikes that contain also mica and kaolin, of which a few have been reported from the Tate quadrangle. In Galpin's Report reference is made to the description by Watts of the Davis mica mine (see p. 142) in which the feldspar is said to be excellent. Unfortunately, however, the dikes are comparatively small.

KYANITE

Transparent kyanite ($(AlO)_2 SiO_3$) has long been employed as a blue gem, but only in small quantity. The mineral is now coming into use as a source of alumina in the ceramic industry, more particularly for use in the manufacture of spark plug porcelain. Its value depends upon the fact that when heated it changes to a mixture of glass and long slender needles of mullite ($Al(AlO)_5 (SiO_4)_2$) that serve as a bond in the finished porcelain.[42]

In most places kyanite occurs in comparatively small bladed crystals in metamorphic rocks so intimately mixed with their other components that it is separated from them only with difficulty. (Plate V A). It is known to be present in commercial quantities at but few places. In the Tate quadrangle it occurs in large quantity as a constituent in some of the pre-Cambrian and the Valleytown schists and on the borders of quartz veins cutting them. (See p. 71). Some of the groups of crystals on the sides of the quartz veins weigh several hundred pounds and many boulders composed of mixtures of quartz and kyanite scattered over the northeast corner of the quadrangle are even larger. Before the kyanite is suitable for use it must be freed from adhering quartz.

[42] Peck, A. B., Changes in the constitution and micro structure of andalusite, cyanite and sillimanite at high temperatures and their significance in industrial practice: Amer. Miner, vol. 10, pp. 253–280, 1925.

The most promising deposits of the mineral that have been seen in the Tate quadrangle are (1) a belt of Valleytown staurolite-kyanite-mica schists lying about ½ or ¾ mile west of the railroad and extending northeastward from Keithsburg to a point near Ball Ground, (2) a short belt of the same schist just east of the road between Refuge Church and Harmony School and (3) a quartz-kyanite vein on a secondary road about a mile west of the junction of Murphy and Sharp Mountain creeks. No openings have been made on the belt of schists west of the railroad for the purpose of obtaining kyanite, and it is not likely that any of the schists in this belt would be commercially profitable because of the small size of the kyanite crystals and the difficulty of separating them from the staurolite and other minerals with which they are associated. The belt at Refuge Church has been opened at one place about 1½ miles north of the church. The weathered schist is easily worked but here again the kyanite is in small prisms that would be expensive to separate from its valueless associations. The most promising occurrence is the quartz vein near Murphy creek. The relations of the kyanite to the quartz have been described on page 71 and analyses of the kyanite have been recorded. The vein can be traced for some distance by boulders, all of which contain large plates of kyanite. An opening made on the side of the road disclosed many large crystals of kyanite bordering and penetrating quartz in such a way as to allow them to be separated very easily from their matrix. (Cf. plate VIII A). A small shipment has been made from the deposit for experimental purposes but the result of the trial is not yet known.

It is probable that there are veins in the pre-Cambrian area in which there is more or less kyanite and it may be that in some of them the mineral is in as great abundance as in the vein just referred to, but they have not yet been discovered.

MICA

Muscovite, or white mica, is abundant in many of the rocks of the quadrangle, but in most of them only in flakes that are so small as to be of no commercial value. Plates large enough to be marketable occur only in pegmatites. In neighboring quadrangles muscovite-pegmatites are common, but at only a few places do they contain enough of the mineral to be profitable to work. The mountains of North Carolina have furnished large quantities of excellent mica from pegmatites, and in the Ellijay quadrangle, in Georgia, a few deposits have been opened.

In the Tate quadrangle there are many pegmatite masses, but only a few of them contain muscovite in merchantable size. Most of them have been crushed and whatever muscovite was originally in them has been shredded by the rock movements and is now in very small flakes. At a few places the pegmatites cutting the Great Smoky and Valleytown formations are fairly coarse-grained and contain moderately large plates of mica, but nowhere is the proportion of this mineral in them large enough to make them profitable to work. Here and there pits have been opened in pegmatites that have looked promising, but at no place has the quantity of good mica obtained been sufficient to warrant serious operations.

The pegmatites, where they occur, are in lenses and vein-like masses some of which run for long distances and others for only a few yards. Most of them, like the rocks in which they occur, have been shattered and broken and in nearly all cases their components have been fractured. The irregularity in the distribution of the pegmatite and of the mica within it makes the success of any mica-mining venture very uncertain, even where the rocks of the region are less deformed than they are in the Tate quadrangle. There is no place known in this quadrangle where the probability of successful mica-mining is favorable.

Galpin[43], in his preliminary study of the mica deposits of the State, records the existence of mica-bearing pegmatites two miles southeast of Ball Ground, on the farm of F. M. Cagle, 5 miles west of Nelson, on the Marion Davis farm, 4½ miles west of south from Jasper, on the Burgess Fowler and John Freeman properties, two miles east of Nelson, and on the Bozeman estate, one mile farther east, and at a number of other places not specifically mentioned. In some of these pegmatites the mica is in large enough pieces to furnish trimmed plates measuring

[43] Galpin, S. L., A preliminary report on the feldspar and mica deposits of Georgia: Geol. Sur. of Ga., Bull. 30, pp. 150–153, 1915.

6 x 8 inches, but in no case have the dikes proven profitable to mine partly because of the small amount of mica in them and partly because of the difficulty of transportation to the railroad. It is possible that when the pre-Cambrian area of the quadrangle is more thoroughly prospected pegmatites may be discovered that will be profitable to work after the grades of the country roads are improved, especially if the feldspar and quartz that accompany the mica in all the dikes are saved and marketed.

SERICITE

Sericite is a potash mica closely allied to muscovite ($H_2(K.Na)Al_3(SiO_4)_3$) if not identical with it. It has been urged as a source of potash, since much of it contains over 10% of K_2O.[44] When pure, sericite may be used as a component of heavy lubricants, as foundry facings, as an abrasive in soap, in the manufacture of lustrous wall-papers, to coat the surface of composition roofing, and for other purposes to which ground mica is adapted.

In the Tate quadrangle sericite occurs abundantly in the western and southern portions of the area underlain by the Salem Church granite, where it was formed by the metamorphism of the more feldspathic parts of the rock. (See p. 106). The material occurs in the form of a light-gray to white schist which in some places contains about 73% sericite (see p. 107 and plate VII B) and about 23% of kaolinite and pyrophyllite. In other places it contains in addition a little quartz, chlorite, an occasional garnet, and in others a little serpentine and remnants of unaltered feldspar. Analyses of two of the purer varieties are given on page 107. In these analyses only 6.2% and 7.2% of potash are shown, but in three other analyses of the same rock, quoted by Hopkins[45], 10.31%, 10.49% and 10.50% potash are recorded.

At the present time the sericite schist cannot be regarded as a practicable source of potash. It is, however, well adapted to many of the other uses for which ground mica is employed.

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[44] McCallie, S. W., High potash-bearing slates in Georgia: Eng. and Min. Jour., Vol. 104, p. 643, 1917.

[45] Hopkins, O. B., A report on the asbestos, talc and soapstone deposits of Georgia: Geol. Sur. of Ga. Bull. 29, p. 305, 1914.

GRAPHITE

Graphite, or a carbonaceous material closely resembling graphite, is present in large quantities in the Tate quadrangle only in the Canton schist and in the mica schists of the Hiwassee and Nantahala formations, and in these rocks it is usually so intimately associated with the mica that it is impossible to separate it. At a few places in the Hiwassee formation the rock is more like a shale than elsewhere. It is a fine-grained mixture of tiny mica flakes and carbonaceous material that possesses many of the physical properties of amorphous graphite. The material is not pure enough to be used for the purposes to which a good grade of graphite is usually put, but it is soft, and black and might be employed in the manufacture of a lubricant, or a paint, or as a coloring agent in fertilizers. A few pits have been dug in the Hiwassee schist near Mineral Springs, but so far as known no material has been shipped.

GARNET

Garnet is produced in the United States to the value of about $600,000 annually. It is used in the manufacture of garnet-coated papers and cloths and for polishing ornamental stones and plate glass. In 1926 the production was 6,397 short tons, valued at $523,875. All was obtained in New York and New Hampshire from rocks very like those in the crystalline areas of the southern Appalachians.

For the best abrasive purposes the garnet must have a hardness above that of quartz. When crushed it should break into sharp angular fragments without curved, flat or rounded edges. It should be so tough as not to fracture too easily and so brittle that under use the individual grains will break into sharp-edged pieces rather than become rounded. Furthermore the crushed grains should have a high attraction for glue, so that it will adhere to them strongly when they are being coated into paper or cloth. The crystals should break into clean and solid pea-size fragments with a minimum amount of fines.

Among the common types of deposits, those containing clear, unfractured individual red crystals, at least the size of a pea, should be suitable for abrasive purposes, and the ore to be commercially valuable should contain at least 10 per cent of garnet. Almandite, andradite and rhodolite, all iron garnets are the varieties in commonest use.[46] Almandite is $Fe_3Al_2(SiO_4)_3$, andradite is $Ca_3Fe_2(SiO_4)_3$ and rhodolite is a mixture of one part almandite to two of pyrope ($Mg_3Al_2(SiO_4)_3$).[46]

In the Tate quadrangle garnet is present almost universally, but it occurs in large quantities only in the Hiwassee and Canton schists. (See pp. 48 and 43). It is especially plentiful in the Canton schist, which is a graphitic mica schist thickly studded with garnet crystals measuring from ¼ to ½ inches in diameter. (Plate V B). A sample of the garnet separated from the rock by means of a heavy solution was submitted to Dr. Everhart for analysis. His result was as shown below.

Analysis of garnet separated from the Canton schist near Canton, Cherokee Co., Ga.

SiO_2	Al_2O_3	Fe_2O_3	FeO	MgO	CaO	TiO_2	Undet.	Total.
31.40	23.16	30.27	7.76	.81	4.40	.96	1.24	100.00

This apparently is a mixture of the almandite, andradite and several other garnet molecules, with perhaps some limonite and aluminous silicates.

In some places east of Canton the roads are covered with a gravel composed almost exclusively of garnet crystals set free from the rock by the disintegration of its matrix. At many places the proportion of garnet in the schist is as great as 25%. The garnet should be separated easily from the rock by mechanical means, but whether it would be a profitable undertaking can be determined only by trial on a comparatively large scale.

In North Carolina attempts have been made to produce garnet from rocks similar to those in the Tate quadrangle, but without striking success. In a letter from Mr. H. J. Bryson, then Acting State Geologist, it is stated that in 1925 almandite garnet was obtained from a garnetiferous hornblende gneiss on Penland Bold in Clay County, and in

[46] Eardley-Wilmot, V. L., Abrasives Pt. III. Garnet: Can. Dept. of Mines. Mines Branch. No. 677, 1927.

earlier years from a garnetiferous chlorite schist near Marshall, in Madison County. Some of the crystals in the hornblende gneiss are 2½ inches in diameter and those in the chlorite schist vary between 2 and 6 inches. The average content of garnet in the gneiss is about 10%. A third deposit reported to be "very large" is on Double Top and Sugar Loaf Mountains, about 2½ miles south of Willets, Jackson County. The garnet here is rhodolite. It occurs as disseminated crystals, many of which are an inch in diameter, constituting from 25% to 50% of a quartz-biotite gneiss. None of these properties were active in 1926, but it was expected that the plant in Jackson County would resume operations in the near future.

If the North Carolina deposits can be worked successfully there is no reason why some of the Canton schist might not also prove a profitable source of garnet, as the matrix of the schist could easily be separated from the garnet crystals.

The Hiwassee schist is very similar in character to the Canton schist. and in some places it contains a great number of comparatively large garnets, but at no place, thus far discovered, are the garnets so thickly crowded as they are in the Canton schist, and consequently, at no place now known, does the Hiwassee schist offer a very promising field for profitable garnet production.

In the Valleytown and Great Smoky formations are also beds of schist that are rich in garnets but most of them are comparatively thin and would prove expensive to mine. In many of the staurolite-kyanite schists garnets are well developed. Some of these are so situated that they might be cheaply mined, but the cost of separating the garnet from the staurolite and kyanite would be prohibitive, since the specific gravities of the three minerals are so nearly alike. The specific gravity of blue kyanite is 3.67, that of pure staurolite is 3.7 and that of the iron garnets is between 3.75 and 4.1.

MARBLE

Varieties and Their Distribution

General statements.—The marble occurring in the Tate quadrangle is of two kinds. One is a blue-gray, fine-grained, granular rock that occurs in distinct beds in two narrow strips, one along the Louisville and Nashville R. R., extending from near Nelson to a point about a mile northwest of Canton, and the other a strip parallel to the first, but about 1½ miles farther west. In both areas the marble is very impure, and quite hard. It contains a large quantity of quartz and silicates (see pp. 98 and 100) and consequently will not take a high polish. At present it is not utilized, except locally as a building stone, etc.

The second, and more valuable kind of marble in the quadrangle is the distinctly crystalline type that has made Tate famous throughout the country. Some of it is pure white, some is pink and some is mottled white and gray, white and green, or pink and green. Some of it is coarsely crystallized and some so fine-grained as to be almost structureless. The coarser grained varieties are nearly pure calcite and the finer grained varieties are magnesian. As a rule, the finer the grain, the more magnesium carbonate is present. The coarser grained varieties are used as building and ornamental stones, and the waste is ground for chicken grit. It might also be employed for terrazzo and for roofing. The magnesian varieties would furnish a cheap source for magnesium salts.

The marble of this type occurs in two main areas, one along the east side of the upper portion of Long Swamp Creek and the other east, southeast and northeast of Tate post office. The rock of the first belt is not now being exploited. All of the production at present is from the second area, which is divisible into two parts—the Tate area and the Marble Hill area. In the first, which is near Tate post office, occupying the valley of Long Swamp Creek, are the Creole, the Cherokee and the Etowah quarries. The Marble Hill area stretches along the valley of the East Branch of Long Swamp Creek for about 2 miles both east and west of Marble Hill post office. Just east of the post office a narrow spur extends south about 1½ miles. In this spur is the Amicalola quarry. The Kennesaw, the New York, and several abandoned quarries are on this belt west of Marble Hill post office and the now abandoned Cowart quarry on its eastward extension.

Exposures of the marble in the Tate area in the valley of Long Swamp Creek are at the base of the hills on both its west and its east sides, but the quarries, except the Etowah, are in the floor of the valley at the bottom of the slope on the west side. The Etowah quarry is near the center of the valley. The massive exposures on the east side of the valley have not yet been worked. The whole valley has been explored by test pits and drilling and is known to be underlain everywhere by marble. A few exposures occur at its extreme north end but elsewhere there is no sign of marble at the surface.

In the western portion of the Marble Hill area exposures are continuous on the slopes bounding its south side, and there is one ledge on its north side in the channel of Darnell Creek. All the quarries are well up on the southern slope except a new one just opened in the bottom of the valley at the base of this slope. There are no exposures on the floor of the valley, except in Darnell Creek, but explorations by drill holes have shown that marble underlies the valley everywhere. In the eastern extension of the belt the conditions are about the same as in its western part. There is a small exposure on the right-of-way of the railroad to the Cowart quarry, other exposures on the hills to the south, a large opening exposing marble at the quarry, and a small ledge on the side of the Dawsonville road, about 3/4 mile east of the quarry, all on the south margin of the valley. Near its north margin a few small pits have uncovered white marble between the channel of the East Branch and the base of the diorite-hill north of the valley, and there is a small exposure in the channel of the stream in its northwest corner. There is also said to have been an exposure of pink marble at the east end of the same diorite knob, but it is now covered. The rest of the valley has been explored by the diamond drill which everywhere entered marble.

At the end of the spur extending southwest from near Marble Hill is the Amicalola quarry, where a coarse, white marble has been uncovered by two large openings. A few exposures occur at the base and on the lower parts of the slopes on the east side of the railroad to the quarry, and between these exposures the marble has been shown by drilling to be continuous between them for a distance of about ½ a mile south of the junction of the Amicalola and Cowart quarry spur railroads.

In addition to these areas there is also a narrow strip of white and light gray marble running northward from the road between Tate station and Tate post office to a point on Long Swamp Creek. There are a few outcrops scattered along the strip, the most notable being on the side of the road about ½ mile north of the Williams house north of the Methodist church at Tate. Other white marble exposures are (1) near the school-house at Nelson, (2) near the mouth of a small branch of Long Swamp Creek about a mile north of the head of Roberts Lake, and (3) in the valley of a stream entering Sharp Mountain Creek about ¾ mile north of the bridge over this creek, 2 miles west of Ball Ground. None of these places but the last has been explored except in a desultory fashion. At the location last referred to there are a few small exposures in the little stream which flows at the south side of its valley. The valley north of the creek has been test-pitted and a few pits are said to have been dug in the westward extension of the valley on the west side of the main creek. All are reported to have entered marble. If the report is correct the marble covers several acres. It has been worked only for local uses. At the place north of Roberts Lake a few holes have been drilled into a coarse white marble, but there is no evidence to indicate that the deposit is to be of commercial importance. (See pp. 93-95 for details of these occurrences.)

The marble now being produced in the quadrangle is quarried by The Georgia Marble Company (Plate XI) from nine quarries with an annual capacity of a little over 1,000,000 cu. ft. Some of the older quarries have been operating for 40 years. Others were operated for a score or more of years but have since been abandoned. New ones are opened from time to time, and if the marble developed is of a type differing from that furnished by the older quarries they may become permanent contributors. Those quarries in which the rock is like that already available are held in reserve for future operation. The quantity of good material still remaining in the ground is very great, and, because all of it has been equally thoroughly metamorphosed and equally compacted by pressure it is likely that most of it is of as good quality as that which has been quarried. Unfortunately the contortion of the beds has been so great that no one layer can be followed for any great distance, and consequently the succession of beds has not been determined. It is known that the entire series has been sharply folded and overturned, but the folding has been so complex that the positions of individual layers cannot be prophesied in advance of development. Moreover, faulting has cut out some of the beds, and it is not known what portion of the series has been left. It is believed that in most places the marble extends below the depth of profitable quarrying and that its quality does not deteriorate as distance from the surface increases.

Commercial Varieties

Creole Marble.—The Creole type of marble differs from all other types in the quadrangle in its dark tone. It is a mottled dark-gray and white rock, known as light Creole when the dark mottling is subordinate and as dark Creole when more prominent. (Plate XIII). The dark streaks may be straight, or curved or they may be interwoven into intricate patterns. The interlacing of the dark streaks through the white background is due to the close folding of alternating thin beds of limestone, some containing carbonaceous material and others devoid of this component.

The Creole marble is quarried at the base of the hill, a few rods southwest of the Tate post office. There are here several openings from which this type of marble has been taken for many years.

The Creole variety is a little finer grained than most of the other utilized marbles in the quadrangle. A recent analysis of its white matrix is not available, but an old analysis (I. p. 92) shows 97.60% of calcium carbonate, 2.35% of magnesium carbonate and 0.5% of other components. Its darker bands are much more impure. The two analyses (Ia and Ib) on p. 91 show the presence of from 2% to 4.5% of magnesium carbonate and from 4.5% to 26% of other components including about .3% of carbon.

The marble consists mainly of twinned calcite grains from 1.2 mm. to 2.0 mm. in diameter, a few rounded grains of quartz about 0.2 to 0.4 mm. in diameter, occasional flakes of colorless and greenish tremolite and phlogopite, from 0.2 to 0.4 mm. in length, and a rare granule of carbon. The dark layers are like the light ones except that they contain more phlogopite and greenish tremolite and a much larger proportion of carbon grains. These may be enclosed in the calcite, but are much more abundant in the quartz and phlogopite and between the different grains. In many places carbon particles outline calcite grains. The dark color of the streaks in this variety of marble is plainly due to the carbon and green tremolite.

The Creole marble has been popular for grave stones, but is not now used for this purpose as extensively as heretofore. It is employed as a trim with the Georgia White and Silver Gray marbles on large buildings (Plate XII), and also as an interior finish of corridors, etc., in public buildings. Because of its distinct veining the Creole marble is beautifully adapted to the production of excellent effects in matched panels.

Cherokee Marble.—The Cherokee, or Silver Gray marble, from the Cherokee quarry (Plate XVI) in the Tate post office area, is a coarse-grained, grayish-white marble that differs from the Georgia White in possessing a grayish tone, and a remarkable degree of translucency. (Plate XX). Moreover, it is marked by a few light-gray and dark-gray streaks that are curved into designs that grade off into cloud-like masses of a very light-gray color. It is partly to the presence of these darker portions buried at various depths beneath the surface and indistinctly visible through the semi-transparent rock that its gray tones are due. The Silver Gray variety is free from streaks. The streaked and mottled types are distinguished as Cherokee. Two varieties of the Cherokee are recognized—Light Cherokee in which the veining is not very pronounced and the color of the veins is light-gray, and Dark Cherokee in which the veins are more abundant and are darker colored. The Dark Cherokee differs from the Creole in its more distinctly gray background.

These three varieties come from the Cherokee quarries, a short distance south of Tate post office. (Plate XIV.) The marble from these quarries is one of the purest of the calcite marbles in the quadrangle, containing as it does 97.2% of calcium carbonate, only 1.0% of magnesium carbonate and 1.64% of all other components. Although used for both exteriors and interiors of buildings, it is especially favored by sculptors for large groups. (Plate XV.)

Its grains measure between 2.5 and 4.0 mm. in diameter and are about equidimensional.

In a few blocks seen on the track near the Cherokee quarry the marble is differently marked from any other marble in the district. The rock has the color and granularity of the Georgia White but is streaked and clouded with a bright green mica, closely resembling fuchsite in appearance. The relation of the green-streaked marble to the common types is not known as none was seen in any of the quarries. It is evidently not common, but is probably limited to one or two places where shearing has been more pronounced than elsewhere. A similar bright-green mica has been noted in a pegmatite near the New York quarry, so that it is reasonable to assume that the mica is due partly to the effect of solutions emanating from some igneous rock. Some of the mica was separated from the marble and analyzed by Dr. Everhart with the following result.

Analysis of bright-green mica from block of marble on track near Cherokee quarry, Georgia

SiO_2	Al_2O_3	Fe_2O_3	FeO	MgO	CaO	Na_2O	K_2O	H_2O-	H_2O+	TiO_2	MnO	NiO	Total
47.44	29.68	.16	1.41	2.42	4.00	.95	6.75	1.76	4.68	.72	.10	.16	100.23

Through the kindness of Dr. C. S. Ross of the U. S. Geological Survey its physical properties were determined to be as follows:

$\alpha = 1.561$, $\beta = 1.587$, $\gamma = 1.592$; $2V = 42°$; dispersion $\rho > v$; elongation—.The mica is pleochroic with X = blue-green, Y and Z = yellow-green.

The mineral was first regarded as fuchsite, but a critical search for chromium by Dr. Everhart gave a negative result.

The only analyses of micas in which nickel is reported by Doelter are that of a philadelphite, from Philadelphia, in which .06% of NiO (CoO) are indicated, that of a reddish-brown biotite from Amador Co., Calif., in which .40% of NiO (CoO) was found, and that of a biotite from Port Henry, N. Y. Nickel is also reported from the alteration product of mica known as culsageeite, from the Culsagee mine, Corundum Hill, N. C. None of these, however, are like the green-mica in the Georgia marble, which is notable for its high content of lime and low content of magnesia.

Mezzotint Marble.—Georgia Mezzotint is a combination of a silver gray background and contorted streaks and irregular blotches of a light-purplish-gray color which in some places are sharply defined and in others are scarcely discernible against the white background. As in the Creole, the Mezzotint is a much folded series of layers alternately composed of calcite and a mixture of calcite and other substances. In the less pure layers phlogopite has been produced in comparatively large quantity, causing the darker streaks to have a purplish cast. In tone the Mezzotint is intermediate between the Silver Gray and the Light Creole. Because of its subdued tone it is much used for interior work. It is also employed in large buildings in which the nearly pure white of the Georgia White marble is not desired.

The Mezzotint marble is quarried at openings immediately east of the main Cherokee quarry near Tate post office.

It is a medium-grained rock, a little coarser than is the Creole, but not quite so coarse as the Cherokee. Its streaks are lighter than those characterizing the Creole, and are not as definite. They merge into the silver-gray background.

Etowah Marble.—The Etowah, or pink, marble is the product of the quarry of the same name, situated near Tate post office in the center of the Tate post office division of the Marble Hill area. This marble varies in color from old rose to deep pink. (Plate XVIII). It is crossed by greenish-black veins and is mottled with greenish-black and gray splotches, some of which are speckled with black dots, but blocks of a uniform pink color may be obtained by careful selection. Pieces showing layers containing much dark mica are rejected because of their tendency to split along the cleavage of the mica. The Etowah marble is a little finer grained than the Cherokee variety and like it is an almost pure calcite. In addition to the calcium carbonate, it contains only one per cent of magnesium carbonate and about one per cent of quartz and silicates. It is worthy of note that it contains 0.22% of $MnCO_3$, which may account for its color.

The average sample of the pink portion of the Etowah marble shows grains of calcite measuring 3 to 5 mm. in diameter. They are perfectly transparent as in the other marbles, but contain clouds of tiny liquid enclosures, a few minute opaque grains that may be hematite or carbon, an occasional large enclosure of hematite, here and there a grain of quartz and a small crystal of apatite. There is nothing in the thin section to suggest the cause of the pink color. The darker layers contain in addition to the calcite numerous plates of green biotite, many grains of greenish epidote, much of which is poicilitic, a few flakes of phlogopite and an occasional grain of zircon and quartz. Most of the epidote is enclosed in calcite, as is some of the biotite. The greater part of this mineral, however, is between calcite grains and is particularly abundant near the contacts between the pink and the dark-greenish layers.

The Etowah marble is especially favored for interior work, for the trim of buildings faced with Georgia White marble, for the construction of ornamental public buildings and sumptuous private residences, and for decorative structures, such as public fountains, (Plate XVII), etc. Its waste would make very attractive terrazzo.

Georgia White Marble.—The Georgia White marble is a coarse-grained calcite marble of an almost pure white color and possessing a sparkling luster. (Plate XX). It is marked here and there by vague streaks of a grayish-blue tone, which, however, are not distinct enough to do more than break the monotony of a solid color. The white marbles consist mainly of clear calcite. The three analyses (II, IV and V) given on pages 91-92 show the presence of very small quantities of magnesium carbonate (0.6% to 1.3%) and less than 6.25% of quartz and silicates. Their uniform grain, translucency and soft white color have made them favorite stones for monumental buildings (Plate XIX), ornamental structures (Plate XXI) and statuary (Plate XXII).

The Georgia White marble comes from the New York (Plate X B), the Cowart and the Amicalola quarries. That from the New York quarries is composed of perfectly transparent calcite grains from 2 to 3 mm. in diameter, an occasional crystal of colorless apatite, a few grains of colorless tremolite and scattered very sparsely through the calcite tiny grains of carbon. The calcite in places contains a few dust particles and numerous minute liquid inclusions.

The Amicalola marble resembles the rock from the New York quarries in its purity, but it is much coarser grained. The tremolite and the calcite are larger but the grains of tremolite are few. Many of the calcite grains have diameters of 8 and 9 mm. and in only a few are the diameters as short as 3 mm.

The rock of the Cowart quarry is one of the purest calcite marbles in the district. It contains only 0.6% of magnesium carbonate and 2.39% of quartz and silicates (see analysis V. p. 91). At present the quarry is not being worked.

Rosepia Marble.—The Rosepia marble is the finest-grained of the marbles quarried in the district. It is also the most highly magnesian. It is a white stone marked by amber streaks and scattered amber spots, that are due to the presence of transparent amber phlogopite. The general effect at a little distance is that of a very light-pink marble crossed by irregular streaks of a little deeper pink. It is composed of about 55.5% of calcium carbonate, 35.5% of magnesium carbonate and about 9% of quartz and silicates. It is from the quarry in the bottom of the valley at the base of the slope on which are the New York quarries.

The components of the Rosepia marble are rarely more than one mm. in diameter, though a very few grains measure 1.5 mm. in their largest dimension. Its only component other than the carbonate is phlogopite, which occurs in very small flakes embedded in the carbonates, which are crowded together in certain portions of the rock forming streaks and vague clouds of a pinkish amber color in the otherwise white marble. The flakes are so small and they are so irregularly distributed in the streaks that they should have very little effect on the strength of the rock.

The Rosepia marble should become a favorite for interior decoration.

White Marble in Small Isolated Areas

Although there is no commercial production of marble in the Tate quadrangle outside the Marble Hill belt, there are several other areas in which it is possible that a sufficient quantity of the rock may be present to be worthy of consideration in the future. The most promising of these is the narrow belt stretching from a point a little north of the old Tate mansion a little east of north to Long Swamp Creek. (See p. 81). The marble where exposed, is a white rock very much like that at the New York quarries. It is free from dark streaks, but in some places is slightly marked by vague clouds with the grayish color of the Silver Gray marble. In most of its course the streak is apparently very narrow but at its north end it widens and in the valley of Long Swamp Creek and the little stream entering it from the north there may be a deposit of reasonably large size.

Another promising area is in the valley of the stream entering Sharp Mountain creek, ¾ mile north of the bridge over this stream, 2 miles west of Ball Ground. (See p. 75). The marble is now exposed only in the bed of a little stream, but it is reported to have been found by test pits in the valley north of the stream. The rock exposed is a little finer grained than the Georgia White, has a grayish tinge and is marked here and there by streaks of amber phlogopite, so that it resembles in some respects the Mezzotint marble from the Cherokee quarries.

A third area of white marble that may prove of interest in the future is indicated by an exposure near the mouth of a little stream entering Long Swamp Creek from the east, about 2¼ miles southeast of Nelson. Specimens taken from a pile of debris alongside a pit show a fairly coarse-grained, grayish-white, schistose marble in thick layers alternating with thin dark-gray layers marked by numerous small plates of black mica, some of which plainly coats slipping surfaces. Through the marble is also a great deal of phlogopite much of which coats small slickensides. If the few specimens of the rock that have been seen are fair representatives of that underground it is not probable that the occurrence will furnish satisfactory stone for monumental work, or for ornamental buildings, though it may be drawn upon for ordinary constructional purposes, if the quantity of rock available is large enough to warrant the opening of a quarry.

The occurrence at the school-house spring at Nelson is exposed only by a low ledge of fine-grained white marble, containing layers rich in phlogopite and narrow veins and large crystals of white dolomite. If the size of its component grains are any criterion the rock is highly magnesian. There is no means of knowing whether the rock is of any commercial value or not until it has been explored by drilling.

There are a few exposures of coarse-grained marble also in the Long Swamp Creek area (see pp. 76-81), but most of the rock in this area is fine-grained and highly magnesian.

Magnesian marbles

The marbles characterized by a comparatively large content of magnesium occur in the Long Swamp Creek belt and at a few places in the Marble Hill belt.

Throughout the entire area of the Long Swamp Creek belt the principal marbles exposed are fine-grained, very white varieties, showing a few crystals of tremolite on weathered surfaces and only very rarely a flake of phlogopite. The marble is well exposed on the lower slopes on the east side of the valley and it has been quarried on a comparatively small scale at a number of places. The most accessible place at which it can be seen is at the old Lincoln quarry on Long Swamp Creek, about 2 miles east of Jasper. The marble here is dazzingly white and very fine-grained, the individual crystals rarely exceeding .2 mm. in diameter. In places it is crossed by thin, light-gray streaks that represent sharply folded layers of less pure marble than the great body of the rock. Thin sections show nothing but calcite and a few small grains of tremolite and quartz and small plates of phlogopite. Upon examination of analysis II on page 81 it will be seen that the Lincoln marble contains 36.18% of $MgCO_3$.

At the south end of the belt another marble exposed on the cliff-side just beneath a bed of a coarse, blue variety is as fine-grained as the Lincoln quarry rock. Its analysis shows 43.10% magnesium carbonate. The coarse, blue-gray marble above is a comparatively pure calcite marble, with only 4.5% of $MgCO_3$ shown in the analysis. Here and there are exposed a few ledges of coarse-grained marble, very similar to the Georgia White phase at Marble Hill. A specimen taken from a ledge on the east side of the creek, about 2 miles southeast of Jasper contains only 2.8% of $MgCO_3$. The rock differs from the Georgia White in being slightly schistose and less translucent.

The exposed portion of the Long Swamp Creek belt consists mainly of fine-grained white marble like that of the Lincoln quarry, and presumably all of it is magnesian. If most of it contains as much magnesium as the two specimens analysed there is an enormous reserve of magnesium marble in the belt, and most of it is probably as highly magnesian as the rock now being quarried at Whitestone for its magnesium carbonate.

Outside the Long Swamp Creek belt highly magnesian marbles are known in the Tate quadrangle at only a few places. Reference has already been made to the Rosepia marble in the Marble Hill area as containing about 35.5% of magnesium carbonate. Fine-grained white marbles also outcrop on the road at the junction of the East and Main branches of Long Swamp Creek and in the valley of the main branch about ¾ mile farther north. Their content of magnesian is about the same as in the Rosepia marble.

In the rock on the road the relative proportion of calcium and magnesian carbonates is 58.75% of the former and 35.32% of the latter and in the rock farther north 60.00% and 36.03%. It is probably safe to infer that there is a large amount of magnesium marble in the central and northern parts of the Marble Hill belt, and that at some places rock may be found with as high a content of magnesium carbonate as that in the magnesian marble in the Long Swamp Creek belt.

At the school-house at Nelson there may also be a deposit of magnesian marble. A small exposure of white rock with a grain that is as fine as that of the magnesian marble exposed at the junction of the East and Main branches of Long Swamp Creek, may indicate the presence of a bed containing about 35% of magnesium carbonate, or perhaps a little more, since the marble is cut by veins of coarse dolomite.

Physical Properties and Chemical Characters.

The only marble of commercial importance in the Tate quadrangle is the variety which has been called the crystalline variety to distinguish it from the dull, more or less dense, blue-gray variety of the Keithsburg and Sharp Mountain Creek areas, consequently it is only the crystalline variety whose physical properties are of significance. This crystalline marble is a white, a very light-gray, a light-blue or a pink variety which at many places is mottled with sinuous bands of a dark-gray, dark-green, bright-green or amber color. The amber streaks are due to the presence of amber mica, or phlogopite, the bright-green streaks to the presence of a bright-green nickeliferous muscovite, the dark-green streaks to the presence of actinolitic tremolite and mica and the dark-gray streaks to the presence of carbonaceous matter. The bluish variety contains an unusual quantity of iron carbonate and the pink variety a small quantity of manganese carbonate. (See descriptions of varieties, pp. 92 and 150-156.)

As a rule the marble in the Long Swamp Creek belt is comparatively fine-grained and most of it is very white though there are a few beds of a coarser grain variety that are blue. Most of the crystalline marble elsewhere is comparatively coarse-grained but a few exposures of fine-grained rock occur in the Tate post office and the Marble Hill areas, especially toward the ends of their northern extensions. The rock of the new quarry at Marble Hill is also fine-grained but nowhere else in the interiors of the two areas are there any exposures of the fine-grained variety.

All the fine-grained marbles are magnesian, whereas the coarse-grained phases are non-magnesian. Nearly all the coarse-grained marbles show distinctly many small plates of amber phlogopite. In most places they are scattered irregularly through the rock and are not objectionable. In some places, on the other hand, they are arranged in layers. In this form they are exceedingly objectionable since they constitute planes of weakness along which the rock splits easily. In a few places, where slipping has occurred a large amount of phlogopite was developed, and the rock is valueless for building or ornamental uses. The other common accessory minerals are tremolite and quartz. Both of these are white and transparent and neither is in large quantity. They fill the interstices between the carbonate grains and render the marble almost non-absorbent and harder than it would otherwise be. Moreover the tremolite has a perfect cleavage from the surfaces of which light is reflected with a brilliant sparkle. This adds to the beauty of the lighter colored marbles, whether employed in buildings or for statuary. Both the tremolite and the quartz are resistant to weathering and thus add to the durability of the rock. Less common constituents are biotite, graphite, hematite, magnetite, and various sulphides. The biotite is found only in shear zones where it usually accompanies phlogopite. It is objectionable not only because of the large size of its plates and their dark color, but also because it weakens the marble in consequence of its easy cleavage. The graphite, hematite and magnetite are present only in minute amounts. The former imparts a dark color to certain streaks in the white marbles causing the mottling which enhances their value for some purposes. The hematite and magnetite, if in notable quantity, would injure the rock for ornamental purposes. Both of these minerals are, however, present in such small quantities that their effect is negligible. The sulphides are at a very few places, especially near the contacts of the marble with hornblendic rocks or with pegmatites. They are all equally objectionable, since when they weather they form sulphuric acid which destroys polished surfaces, and iron oxides which cause reddish-brown stains. Blocks containing even small amounts of the sulphides are rejected and become waste. There are a few other minerals occurring locally, but they are exceedingly rare.

Tests on the crushing strengths of some of the marbles from this quadrangle give results that are highly gratifying. Some of the tests, it is true, were made many years ago when the quarries were not as deep as at present, but, since the rock now being quarried is similar to that quarried at shallower depths, it is probable that the results of the tests then obtained represent the minimum strength of sound blocks now being quarried.

The results of the tests on 3 cubes made at the Watertown arsenal, September 18, 1886, were as follows:

Results of strength tests on 3 cubes of marbles from the Tate quadrangle

	Dimensions (in inches)		Sectional Area (in sq. inches)	Ultimate Strength (in pounds)	
	Height	Compressed Surface		Total	Per sq. in.
Cherokee	6.04	6.01 x 6.00	36.06	395,800	10,976
Creole	6.03	6.00 x 5.99	35.94	434,100	12,078
Etowah	6.03	6.03 x 6.01	36.24	384,400	10,642

The most extensive series of tests ever made on the physical properties of marbles was undertaken by the U. S. Bureau of Standards and their results were published[47] in 1919. In this series 7 varieties of marble from the Tate quadrangle were crushed when dry and while wet. One set of tests was made with the blocks set on edge and another with them set on the bed. For most of the marbles the distinction between the strength "on edge" and the strength "on the bed" is not very important, since the Georgia marbles have been so severely compressed that the beds are greatly contorted and the material of most blocks is partly "on edge" and partly "on the bed."

[47] Kessler, D. W., Physical and chemical tests on the commercial marbles of the United States: U. S. Bur. of Stand. Technological Papers, No. 123, 1919.

The results of these tests are given in the table below:

Compressive strength of Georgia marbles

(In lbs. pr. sq. inch)

Specimen		Dry	Wet	After freezing
Amicalola:	On bed	10685–11339	11243–12766	12558–14661
	On edge	9851–9993	9312–10788	8180–9008
Etowah:	On bed	10919–12171	9414–11095	9569–11083
	On edge	9755–10643	10856	7383–9919
Creole:	On bed	11055–12217	8719–10233	9875–10583
	On edge	11244–12572	8350–8677 a	9336–10042
Silver Gray:	On bed	8709–9043 a	----------	8416–8888
	On edge	----------	10422–10907	7699–8166 a
Light Cherokee:	On bed	9127–11161	10067	11316
	On edge	8800–11033	7804	6703–8782
Mezzotint:	On bed	11398–12492	9355–9931	8675–8724
	On edge	10585	7856	9514
Georgia White:	On bed	10218–10697	12466–18672	17577–21521
	On edge	9079–9409	16447–17898	8547–9057

a. Direction of bedding not distinguishable.

The non-absorbtive character of a marble is well exhibited when it is subjected to freezing and thawing tests. Twenty-seven dry samples of Georgia marble broke when subjected to an average load of 12,865 lbs. per square inch. Twenty-five other samples were then frozen and thawed 30 times and again subjected to pressure. They were not crushed until the average load applied to them reached 10,533 lbs. per square inch. This result indicates that the marble, even when subject to the changeable climate of the north temperate zone, will resist disintegration even more effectively than many granites. (See table above.)

The strength of resistance to transverse stresses is not as important in marble as it is in stones that are used to span openings above which loads are to be borne. Nevertheless, tests on the marbles from the Tate quadrangle showed that they may be used as lintels with the assurance that they will support a reasonable load without danger of failure. In this test bars 3 by 1¾ inches in section and 6 to 12 inches in length were supported on knife edges at their ends, and the load was applied by a third knife edge at the center of the span. Half of the specimens tested were cut with the long dimension parallel to the bedding and the other half with the long dimension perpendicular thereto.

The transverse strength of the more important marbles was found to be as shown below:

Modulus of rupture of 7 marbles from the Tate quadrangle, Georgia

(In lbs. pr. sq. inch)

	Amicalola	Etowah	Creole	Silver Gray	Light Cherokee	Mezzotint	Ga. White
Paral. to bed	994–986	885–1567	624	507–1234a	---------	1325–1367	1290–1395
Perp. to bed	1488–1705	1433–1606	1320–1536	---------	1254–1279	1275–1769	1384–1412

a. Direction of bedding not determinable.

The resistance of an exposed stone to weathering depends partly upon its composition and partly on its porosity. In the crystalline marble in the Tate quadrangle there are no components that will decompose under the influence of the weather and cause disintegration and crumbling. Moreover there will be no decomposition products formed that will cause staining. All the marbles of the district, when properly finished, should retain their color almost indefinitely. Sharp corners will round in time but without discoloration and without spalling. The long life of the rock is assured by its density. Its specific gravity is about 2.715 or about 170 lbs. pr. cubic foot. This indicates its compactness and its lack of porosity. Prof. Johnson reports that a 3 inch cube of the Kennesaw marble after being soaked in water for 24 hours at a temperature of 60° had absorbed only six one hundredths of one percent of its weight. This compares very favorably with the ratio of absorption shown by the excellent granites and limestones of Wisconsin as given by Buckley[48].

Wisconsin granites..0.04% to 0.50%
Wisconsin limestones.....................................0.19% to 5.60%
Georgia marble...0.06%

[48] Buckley, E. R., On the building and ornamental stones of Wisconsin: Wis. Geol. & Nat. Hist. Sur. Bull. IV, pp. 400-402, 1898.

In the tests made by the Bureau of Standards cubes were dried at a temperature of 110° C. for 48 hours, were allowed to cool and were weighed. They were then placed in a shallow tray and gradually immersed in water. After 48 hours the cubes were removed from the water, were carefully dried with a towel and immediately weighed. The increase in weight represents the weight of the water absorbed. From this is calculated the volume absorbed.

Absorption of water by marbles from the Tate quadrangle, Georgia

(In percentages)

	Amicalola	Etowah	Creole	Silver Gray	Light Cherokee	Mezzotint	Georgia White
By weight	.069–.103	.089–.108	.080–.103	.115–.160	.091–.116	.119–.124	.099–.103
By volume	.188–.280	.243–.295	.218–.280	.312–.434	.246–.313	.324–.337	.269–.280

The low porosity of the marble from the Marble Hill area is largely the cause of its strong resistance to weathering. Much of the destructive effect of weathering is due to the chemical action of acid-laden water, which not only wets the exposed surface of a rock but also enters its pores and attacks the material with which it comes in contact. Plainly a porous rock offers a greater suface of contact than a non-porous one, because in the latter the part exposed to the attack is limited to its outside surface. One of the most effective weathering agents is carbonic acid. Two cubes of Georgia white marble when subjected to the action of carbonic acid for 70 days lost only .011% and .009% by weight, and 4 samples subjected to the same treatment for three months lost .0165%, .017%, .015% and.016%. Their surfaces were roughened slightly but no disintegration was observed.[49] Two cubes of the famous Carrara white marble subjected to the same conditions showed a loss of .021% and .023%.

In order that the record of the action of the marbles tested under different conditions might be complete the Bureau of Standards tested

[49] Merrill, G. P., Report on some carbonic acid tests on the weathering of marbles and limestones: U. S. Nat. Mus. Proc., Vol. 49, pp. 347–349, 1916.

(1) their tensile, or cohesive, strengths, obtained by pulling on bars cut parallel and perpendicular to their lengths, (2) their degree of permeability for air and (3) their susceptibility to staining by absorbed dyes. Their permeability was obtained by forcing air through a 2¼ inch cube for 15 minutes and noting the depression produced on the height of a column of mercury which at atmospheric pressure is about 30 inches. In the staining test a hole ¾ inch in diameter was drilled from the side to the center of a 2¼ inch cube, and filled with a 1:5000 solution of eosin. At the end of 6 hours the solution was removed from the holes and the cubes were sawed in half and the stained area was noted and measured.

The results of these tests and a few others are given in the table below.

Some additional physical data of marbles from the Tate quadrangle, Georgia

	I		II
	Tension tests (In lbs. pr. sq. inch)		Air permeability (Depression of mercury column in inches.)
	Parallel to bed.	Perp. to bed.	
Amicalola	408–534	735–802	20.0
Etowah	472–538	850–962	2.8
Creole	----------	586–683	1.2
Silver Gray	416–460a	----------	20.5
Light Cherokee	----------	781–988	12.8
Messotint	----------	----------	16.6
Georgia White	296–324	495–596	7.9

a. Direction of bedding not recognizable.

	III		IV	V
	Staining tests		Specific Gravity (Apparent)	Weight (Lbs. pr. cu. ft. Average)
	Area of stain (In sq. inches)	Appearance		
Amicalola	3.01a	Pink	2.715–2.723	169.9
Etowah	.87	Nearly invisible	2.725–2.727	170.4
Creole	.34	Nearly invisible	2.717–2.720	169.9
Silver Gray	3.53	Nearly invisible	2.708–2.714	169.4
Light Cherokee	3.11b	Nearly invisible	2.698–2.708	169.1
Mezzotint	2.83c	Pale Pink	2.714–2.716	169.7
Georgia White	1.04	Red	2.717–2.726	170.1

a. Stain reached 4 faces of cube in 30 minutes.

b. Stain reached 1 face of cube in 1½ hours.

c. Stain reached 4 faces of cube in 3 hours.

The tests applied to the Tate marbles prove them to be able to satisfy all the demands upon them as building and monumental stones, and their translucency and colors make them eminently suitable for ornamental purposes. Their extremely low absorption ratio preserves them against discoloration by dirty water and against disintegration by the freezing of absorbed moisture. The fact that they contain such minute quantities of easily decomposable components assures them against staining. Their strength is great enough to withstand all the pressure to which they may be subjected in even the loftiest structures. In short all of their different varieties are quite capable of meeting the demands of all architects and sculptors as media in which to express their ideas. Moreover, there is still enough first class material left in the ground to supply the needs of the market for several centuries at the present rate of consumption.

Uses

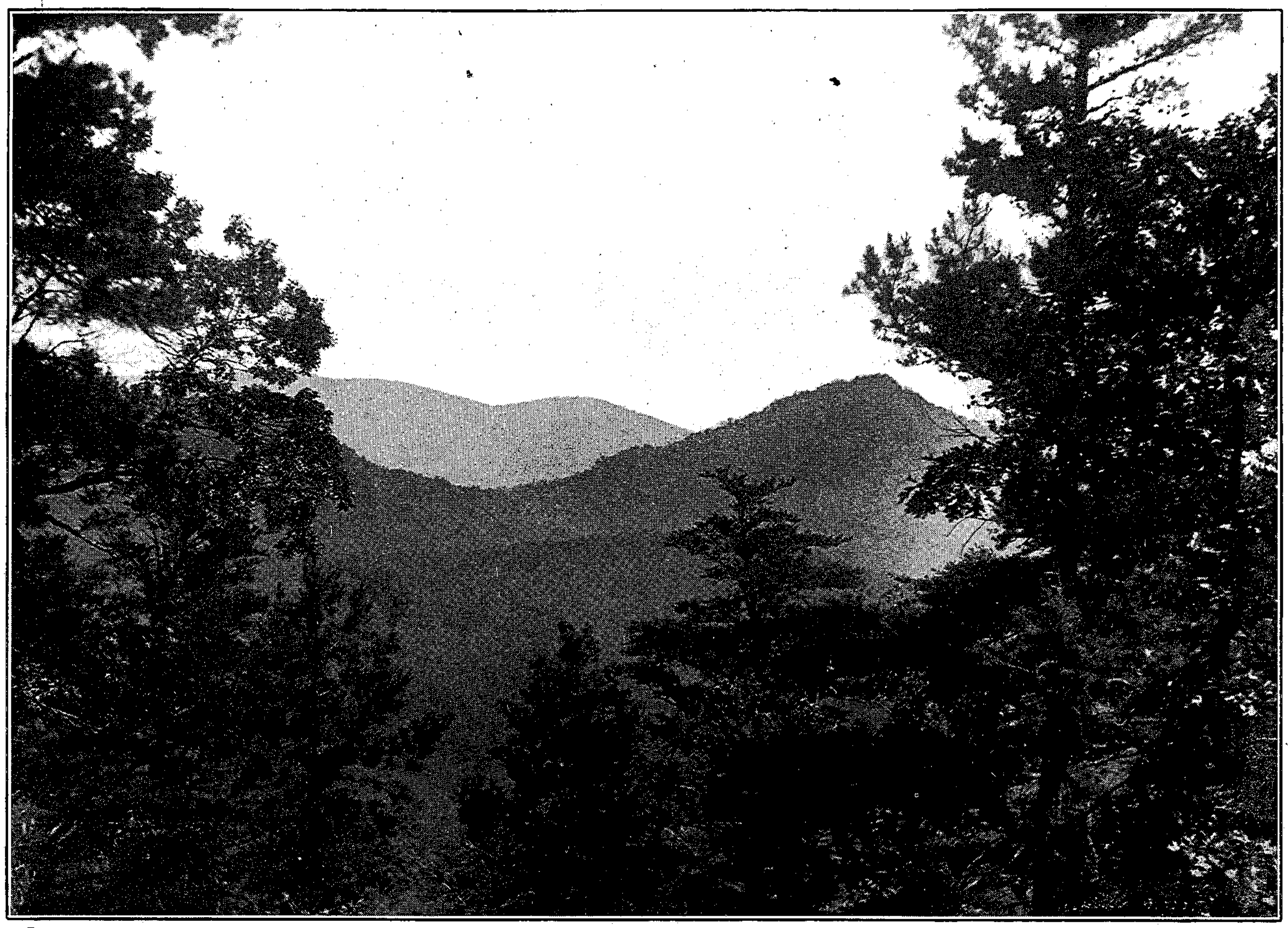
The principal uses of the marble from the Tate quadrangle have been as a building, an ornamental and a monumental stone. Nearly all the different varieties have been used in the construction of memorial and large public buildings and of dignified palatial residences. Much of the Creole and Etowah types have also been employed for interior decoration with excellent results. All varieties of the marble are well adapted to the manufacture of tiles because of their excellent wearing qualities and for the sculpturing of statuary because of their translucency. Some of the best known monumental figures have been cut from the Silver Gray marble of the Cherokee quarry.

The waste of all varieties has been crushed for chicken grit.

That not used for this purpose might be employed in the manufacture of attractive terrazzo, especially if care were taken to incorporate into the mixture a fair quantity of Etowah marble. Another quantity might be used as a fluxing stone or in a Portland cement mixture, but the value of the rock as a building or ornamental stone is too great to warrant its being quarried for these purposes.

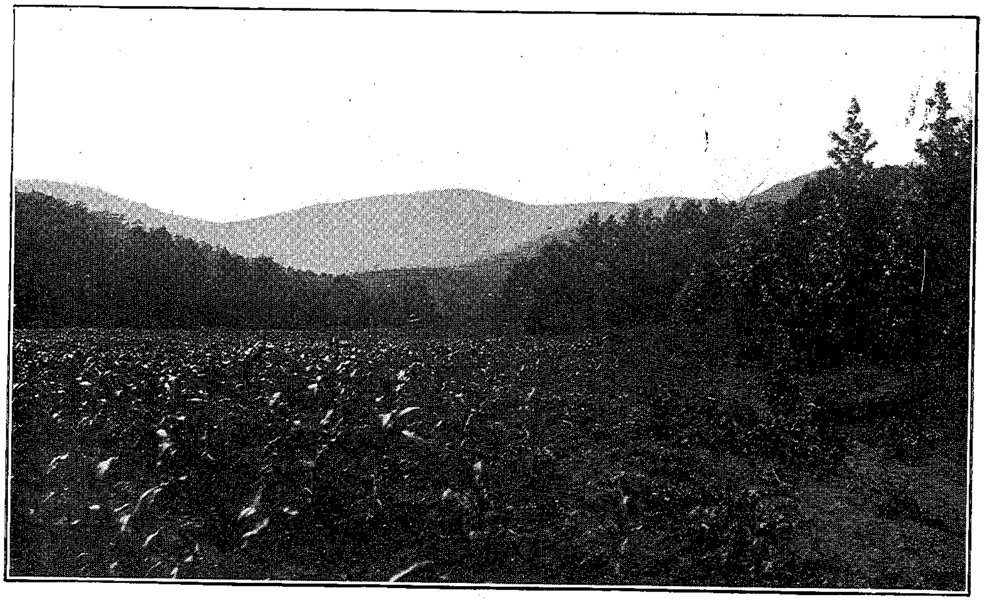
The highly magnesian types, such as occur in very large quantity in the Long Swamp creek belt, and in the central and northern parts of the Tate and Marble Hill areas will furnish an abundant source of carbonic acid gas and of magnesian salts, when needed. Some of the beds in both areas are composed of fine-grained white marble that contain as much magnesium as the well-known magnesian rock at Whitestone, and it is probable that a much greater quantity of the richly magnesian rock might be found if searched for. Most of it might be reached by short spurs from the Georgia Marble Company's private railroad. The demand for dolomite and magnesian marble is rapidly increasing. There is no reason why the deposits in the Tate quadrangle should not be called upon to satisfy a part of it.

INDEX



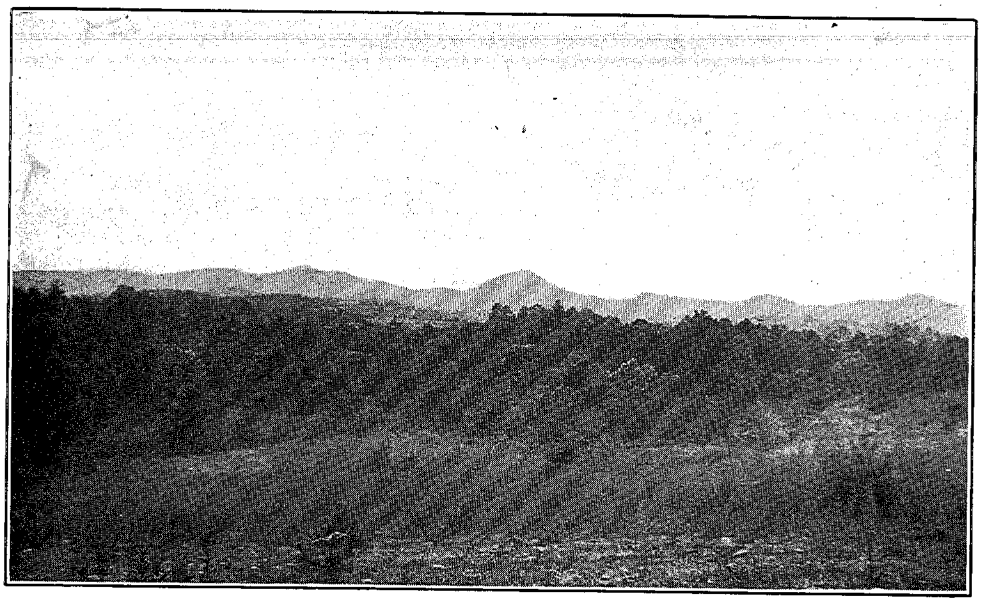
GENERAL VIEW IN THE VICINITY OF BURNT MOUNTAIN, NEAR TATE, PICKENS COUNTY, GEORGIA.

A



VIEW OF GRASSY MOUNTAIN TAKEN FROM A POINT IN A SMALL VALLEY NEAR TATE'S MOUNTAIN SCHOOL. LOOKING ACROSS THE DAHLONEGA PLATEAU.

B

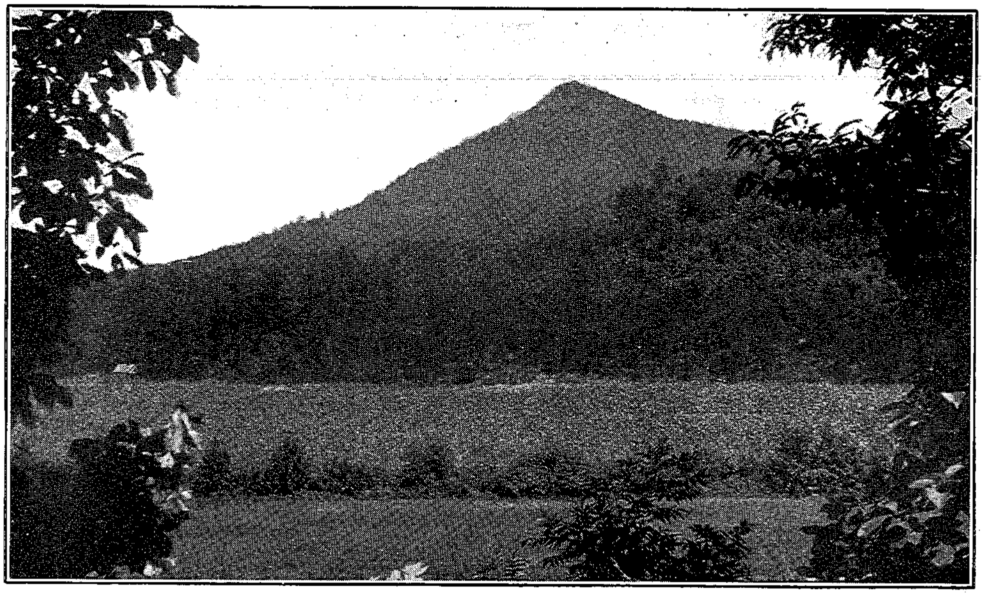


GENERAL VIEW OF SHARP MOUNTAIN LOOKING ACROSS THE DAHLONEGA PLATEAU.

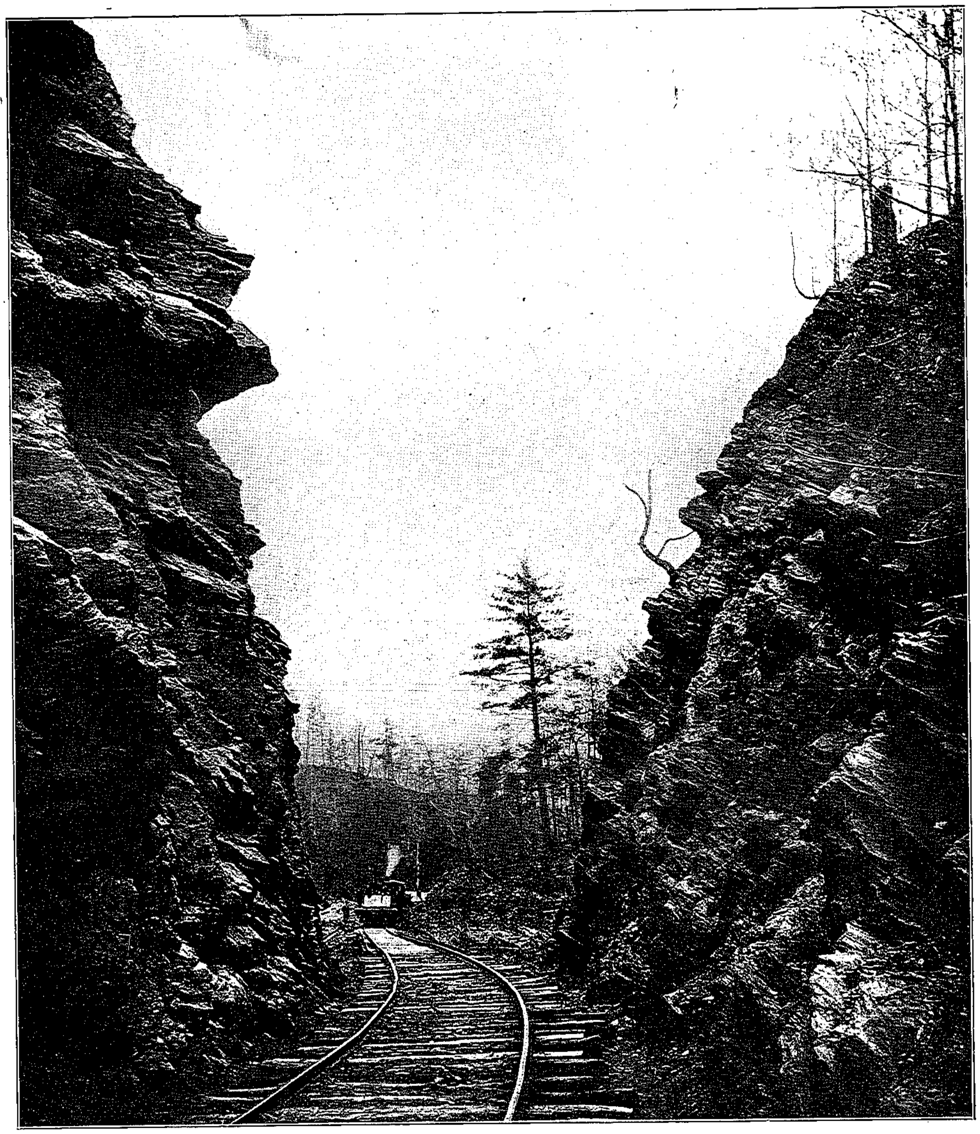
A

ROBERTS LAKE ON LONG SWAMP CREEK, EAST OF BALL GROUND, SHOWING CHARACTERISTIC TOPOGRAPHY NEAR WATER COURSES IN THE CAROLINA GNEISS.

B

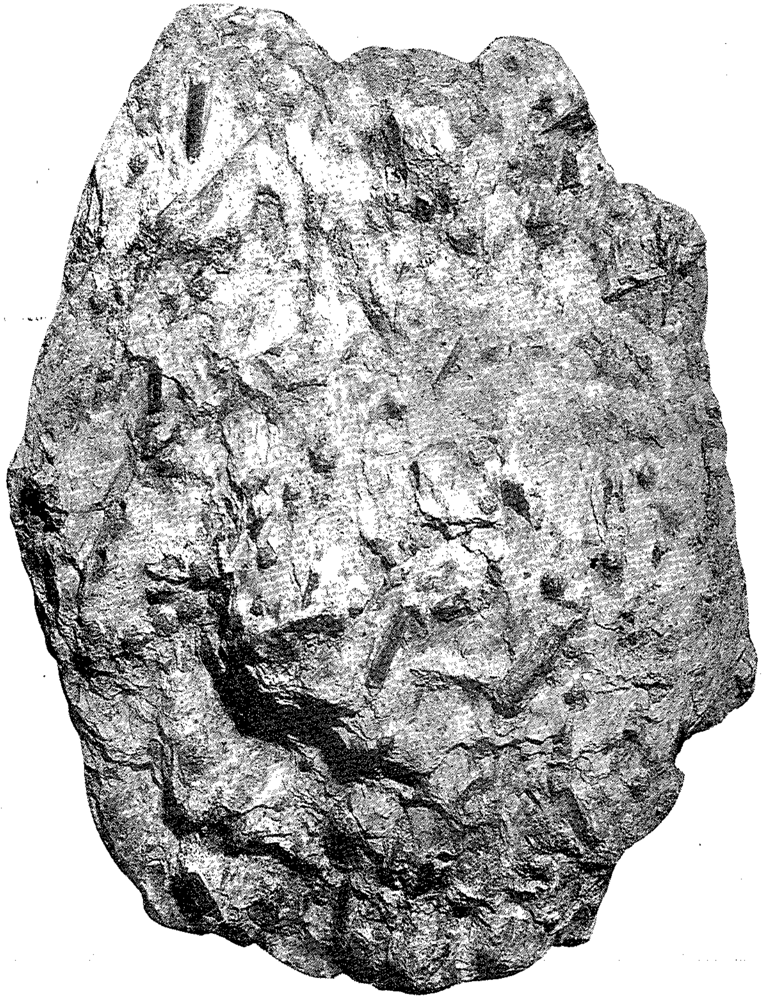


NEAR VIEW OF SHARP TOP MOUNTAIN SITUATED A SHORT DISTANCE BEYOND THE NORTHERN BOUNDARY OF THE TATE QUADRANGLE.



EXPOSURE OF CAROLINA GNEISS IN CUT ON THE OLD ABANDONED BALL GROUND-MARBLE HILL RAILROAD, NEAR FOUR MILE CREEK, PICKENS COUNTY, GEORGIA.

A

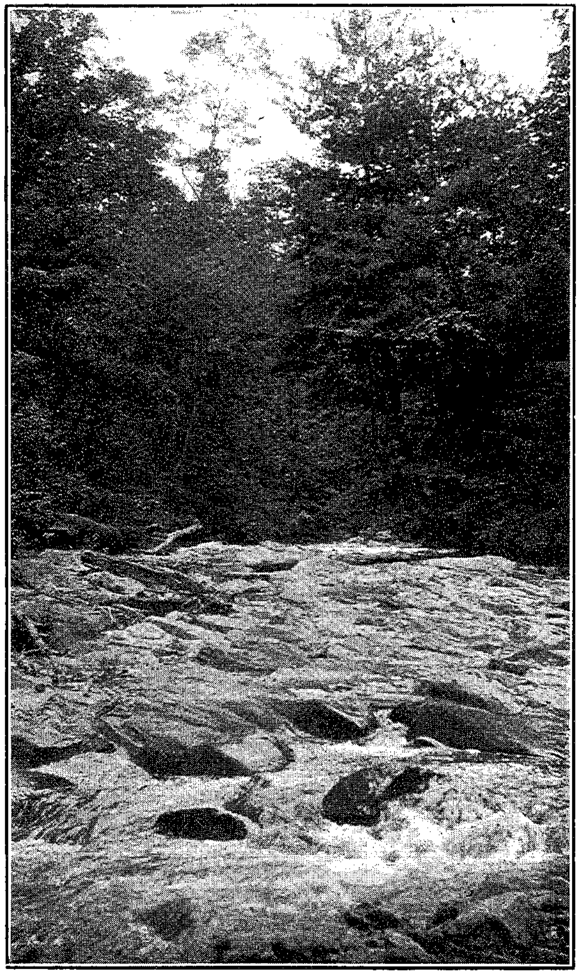


STAUROLITE-KYANITE SCHIST

B

CANTON SCHIST

A



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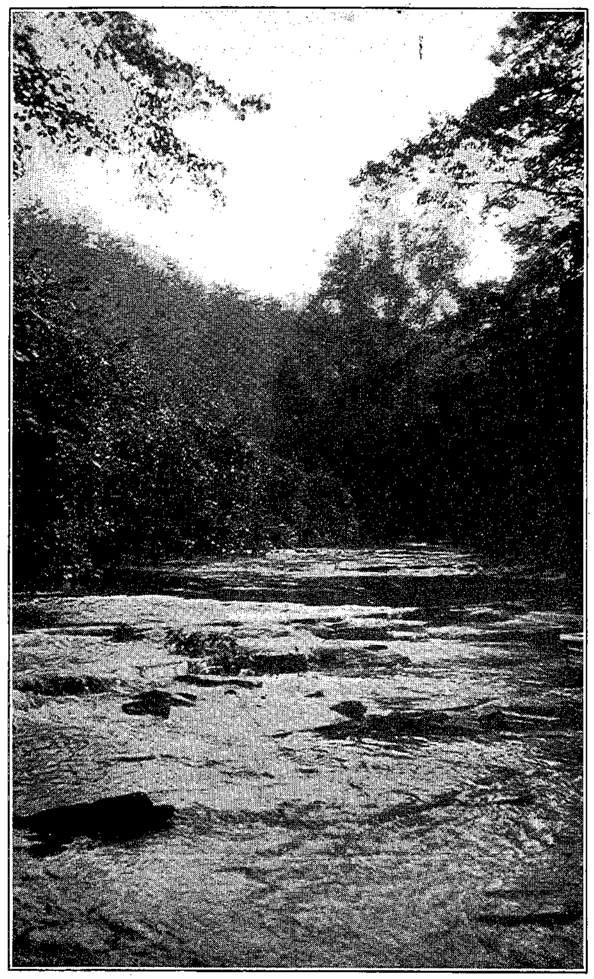
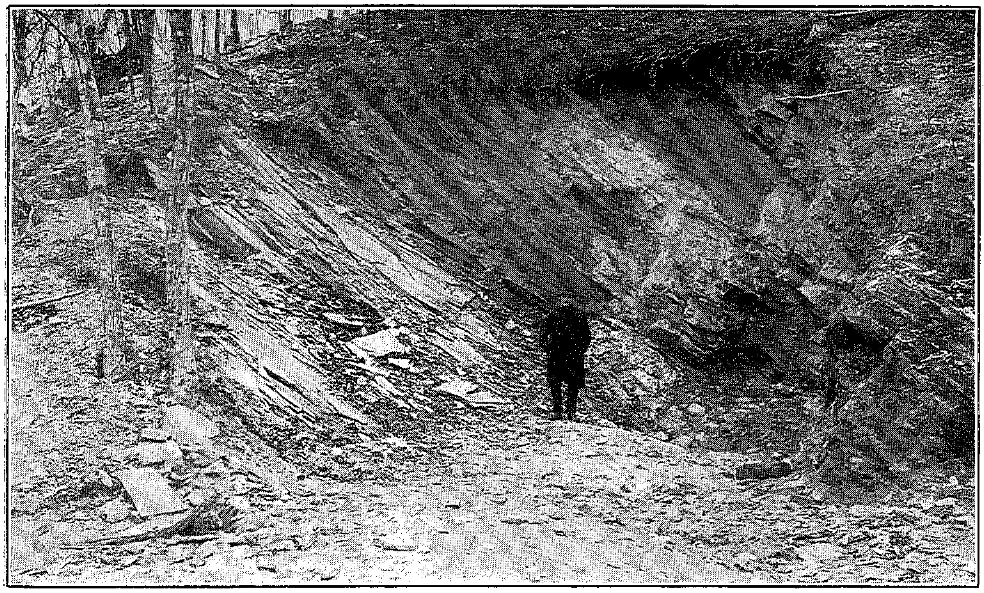


A—VIEW OF CHANNEL, EAST FORK OF LONG SWAMP CREEK, NEAR CORINTH CHURCH. BEDROCK IS CAROLINA GRAYWACKE.
B—VIEW LOOKING SOUTHWEST UP BLUFF CREEK NEAR JUNCTION WITH SHARP MOUNTAIN CREEK, SHOWING LAYERS OF GRAYWACKE AND MICA SCHISTS OF THE GREAT SMOKY FORMATION.

A

CONTORTED PEGMATITE AND QUARTZ VEINS IN CAROLINA GRAYWACKE AND SCHISTS. NEAR RUDICIL MILL, 4 MILES SOUTH OF ORANGE, IN THE NEIGHBORING QUADRANGLE.

B

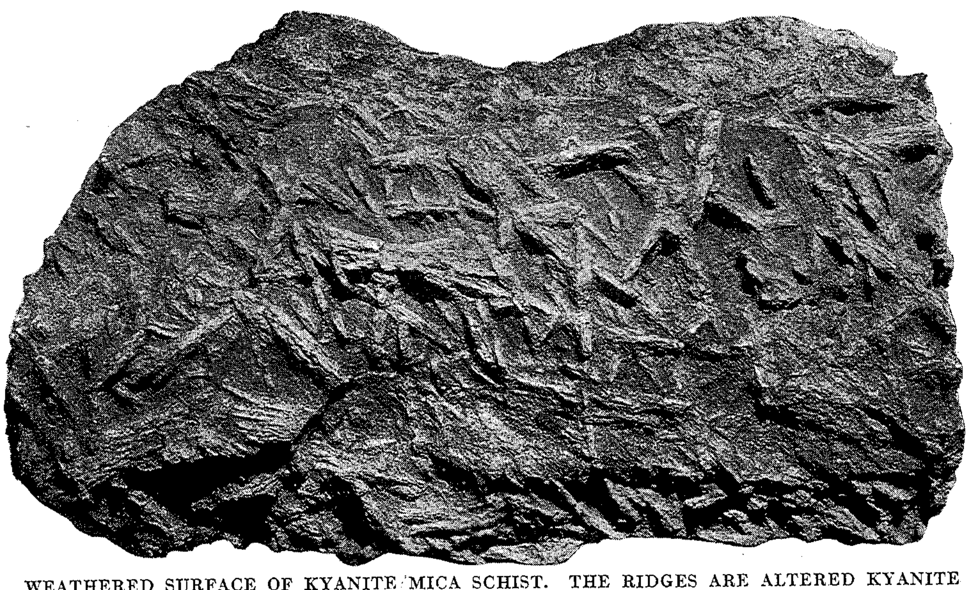


OPEN CUT SHOWING SERICITE SCHIST. LOT 120, 13TH DISTRICT, PICKENS COUNTY, 4 MILES SOUTHWEST OF JASPER, GEORGIA.

A

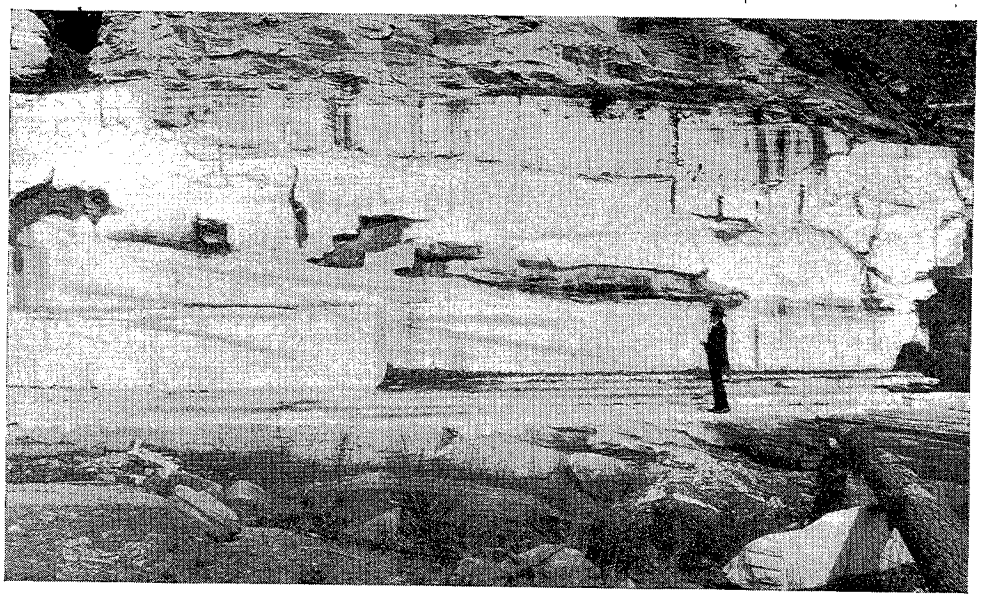
KYANITE CRYSTALS (BLADES) IN QUARTZ VEIN. ONE-THIRD NATURAL SIZE.

B



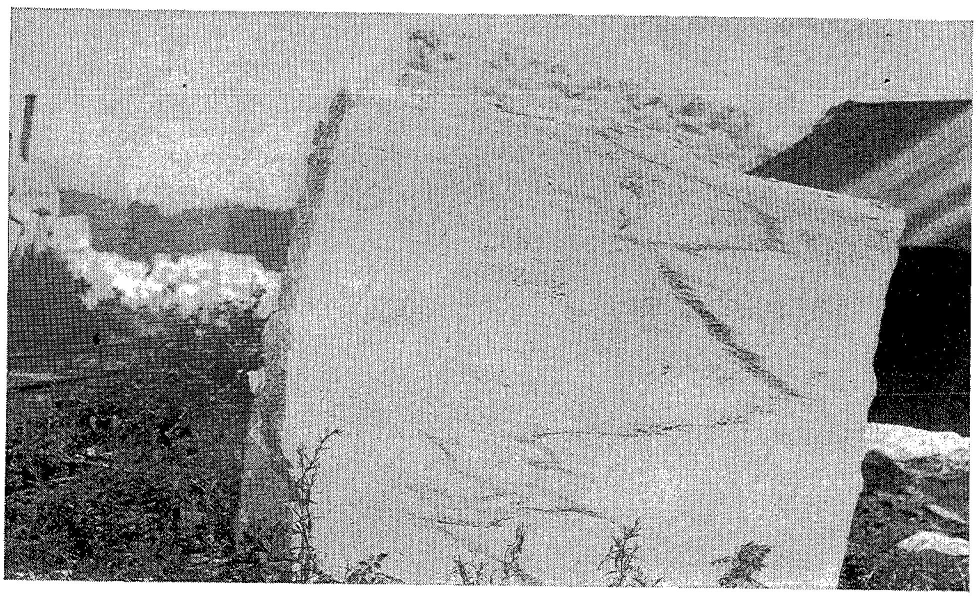
WEATHERED SURFACE OF KYANITE MICA SCHIST. THE RIDGES ARE ALTERED KYANITE PRISMS. ONE-HALF NATURAL SIZE.

A



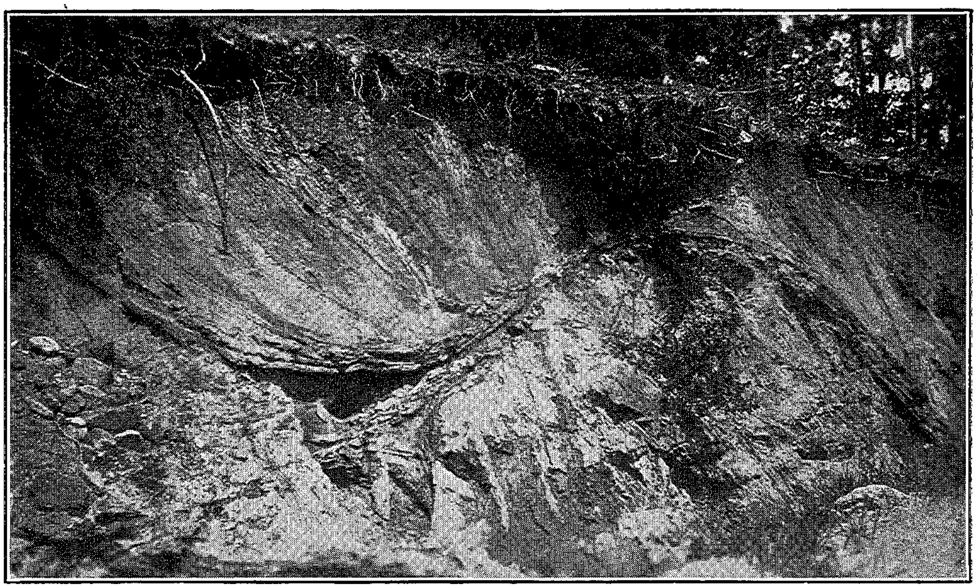
WALL OF LINCOLN QUARRY, NEAR JASPER, PICKENS COUNTY, GEORGIA, SHOWING NEARLY HORIZONTAL OVERTURNED FOLDS.

B



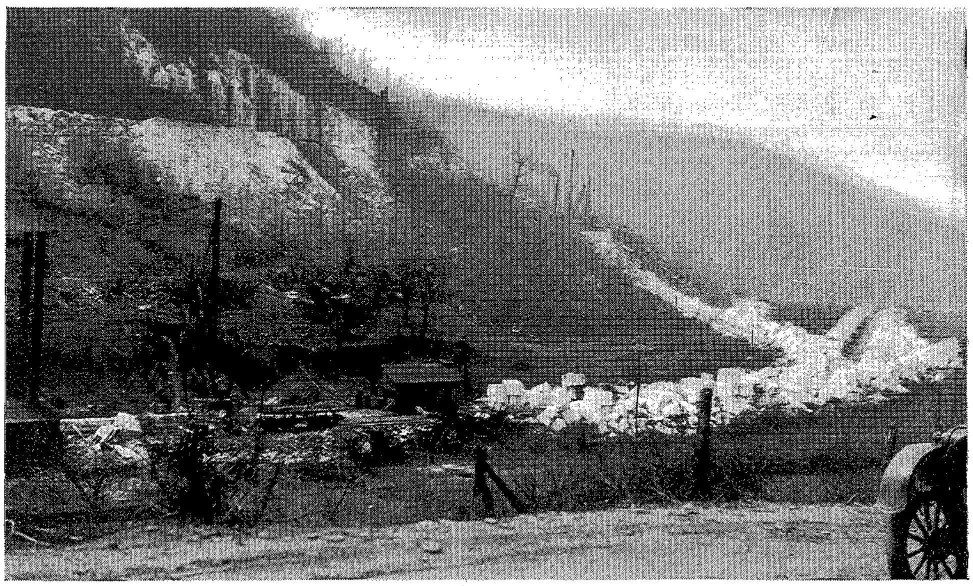
BLOCK OF ETOWAH MARBLE SHOWING FOLDS WITH MINUTE PLICATIONS.

A

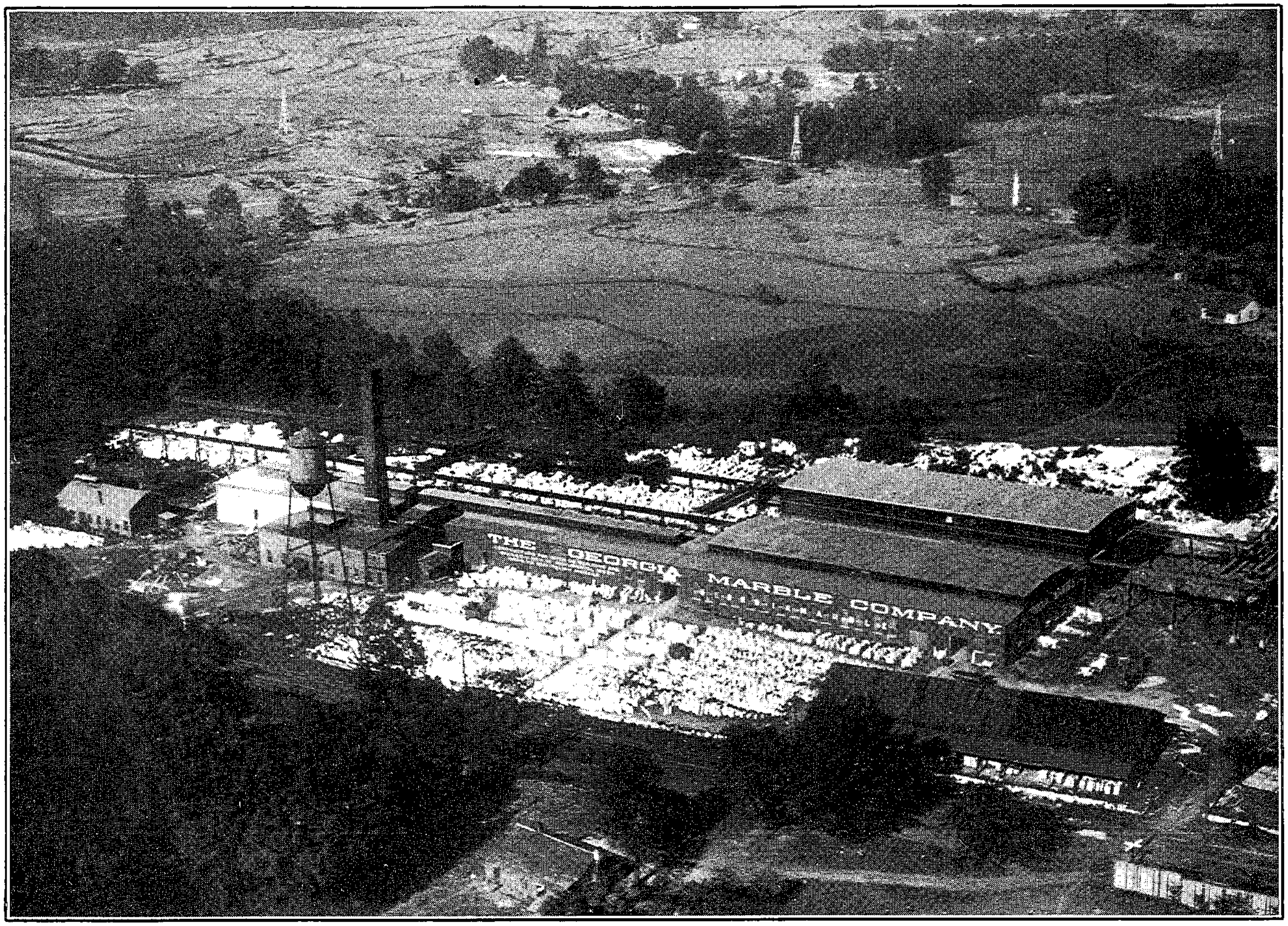


CURVED FAULT IN CAROLINA GNEISS ON ROAD BETWEEN LONG SWAMP CREEK AND CHERRY GROVE SCHOOL, ABOUT ONE-HALF MILE NORTHEAST OF BRIDGE OVER LONG SWAMP CREEK. VIEW LOOKING NORTH. THE DIP OF THE SCHIST IS ABOUT 50° NORTHEAST.

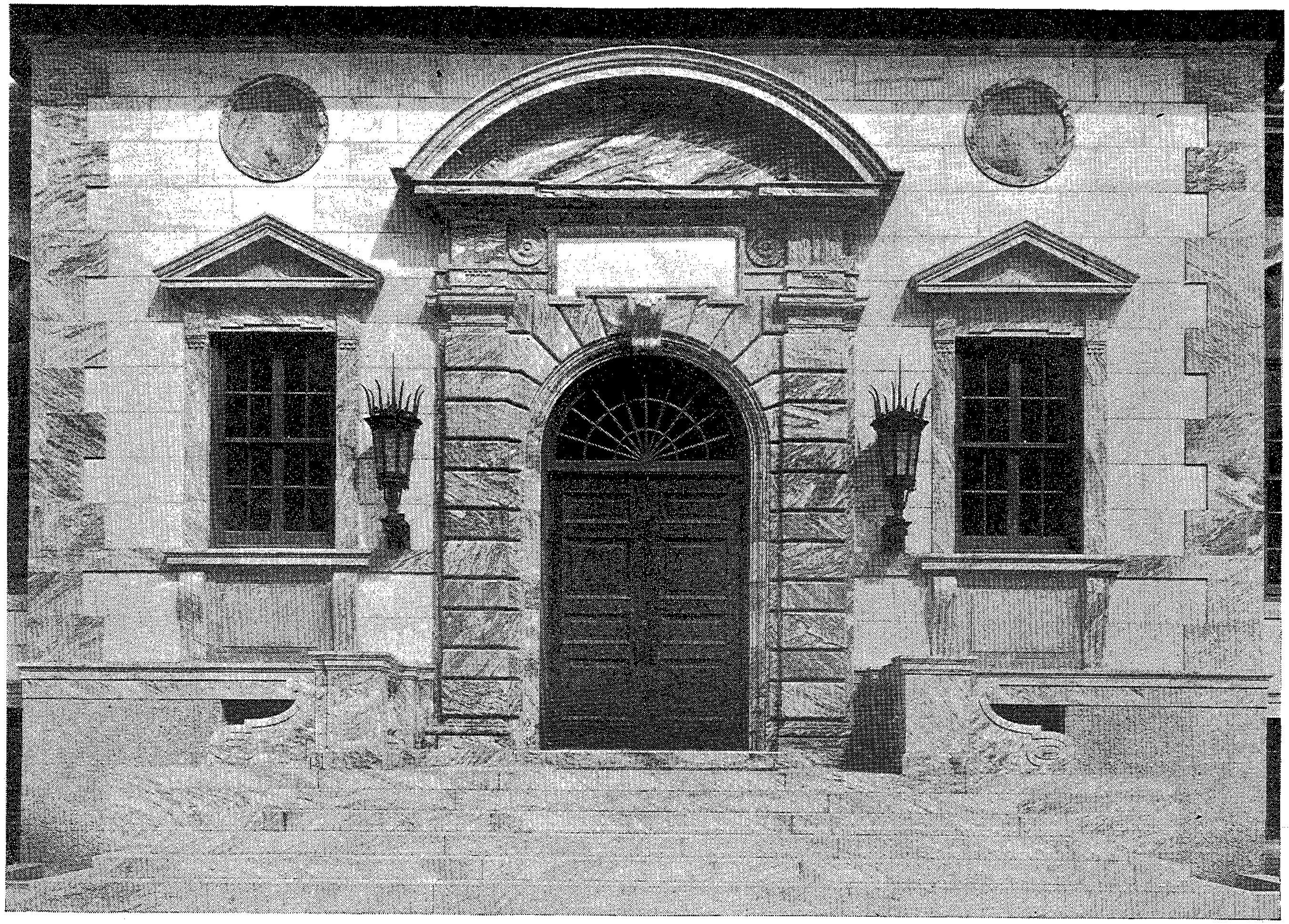
B



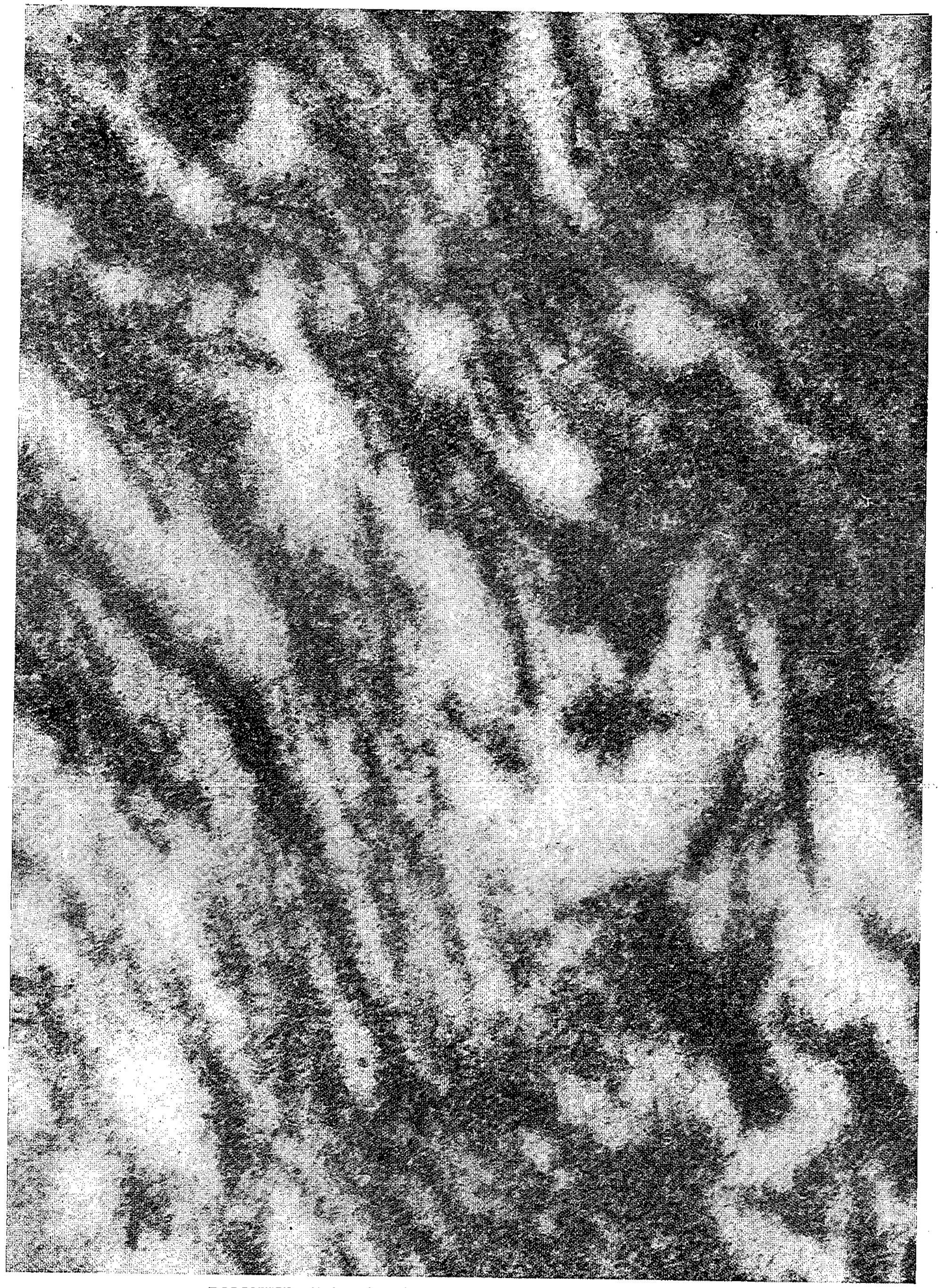
NEW YORK QUARRY, NEAR MARBLE HILL, TATE QUADRANGLE. THE HILL BACK OF THE QUARRY IS CAROLINA GARNET-MICA GNEISS.



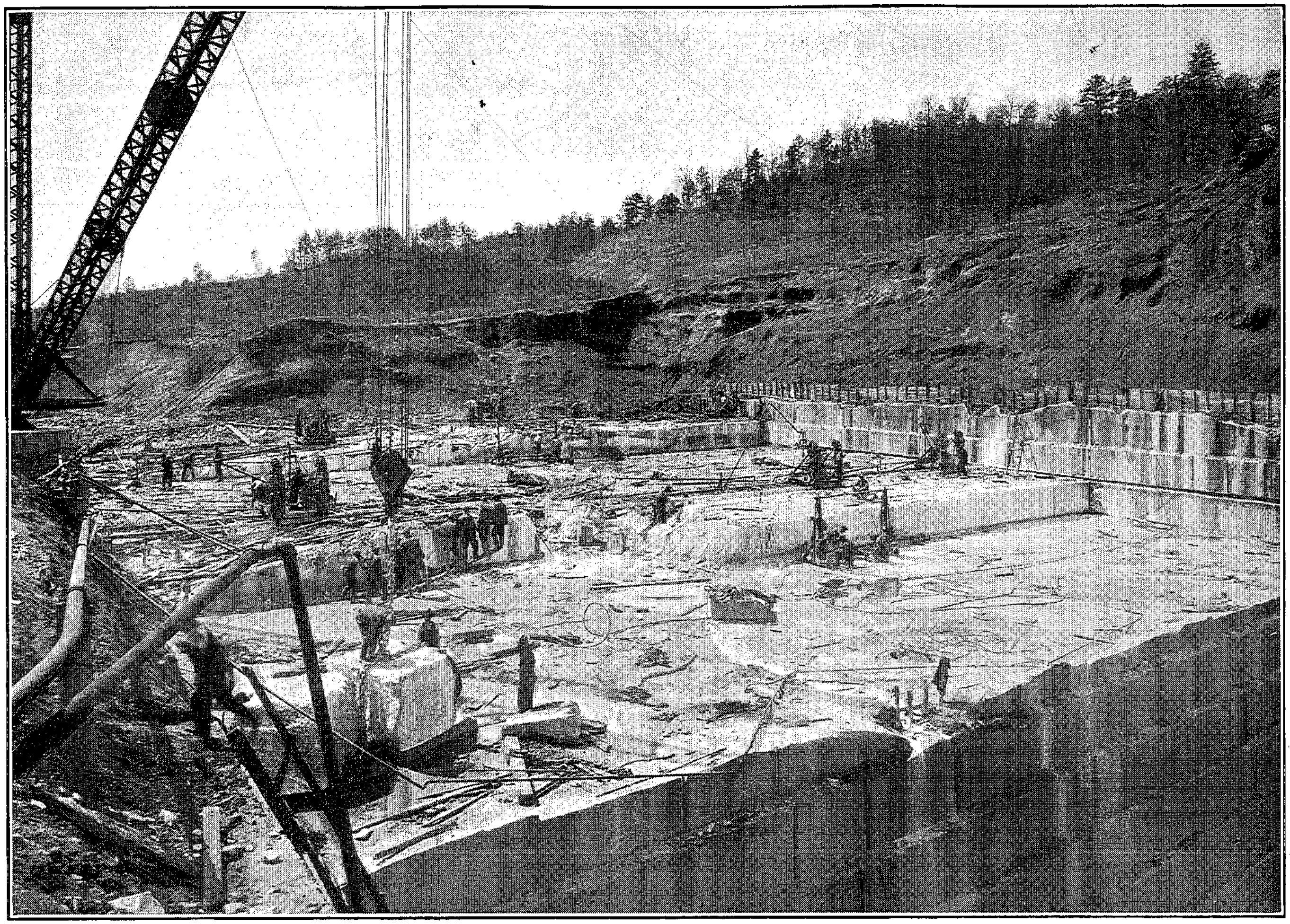
AIRPLANE VIEW OF THE GEORGIA MARBLE COMPANY'S PLANT, TATE, PICKENS COUNTY, GEORGIA.



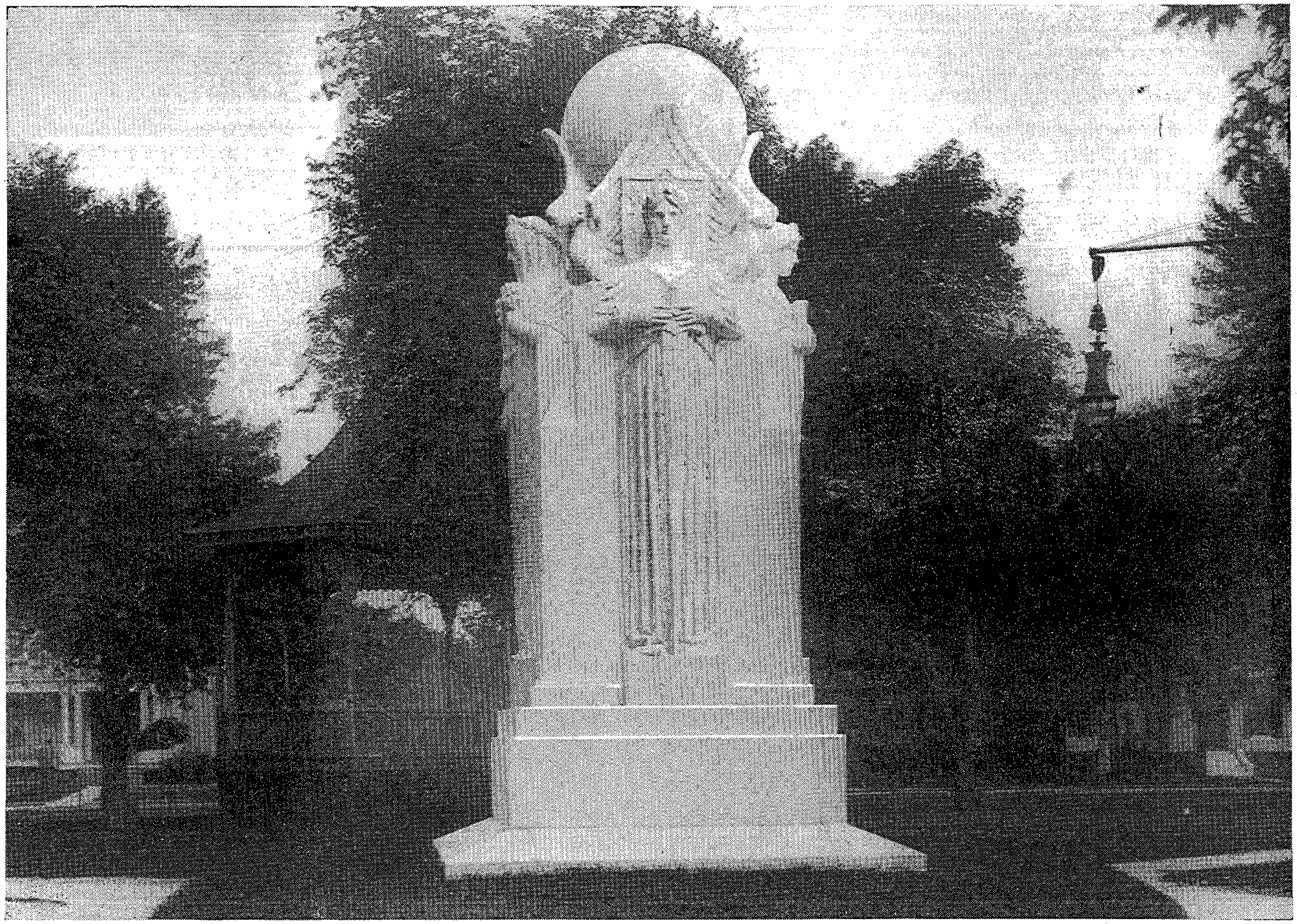
ENTRANCE TO DINING HALL, EMORY UNIVERSITY, ATLANTA, GA. THE WALL IS FACED WITH CHEROKEE MARBLE. THE DOORWAY AND TRIM ARE CREOLE MARBLE.



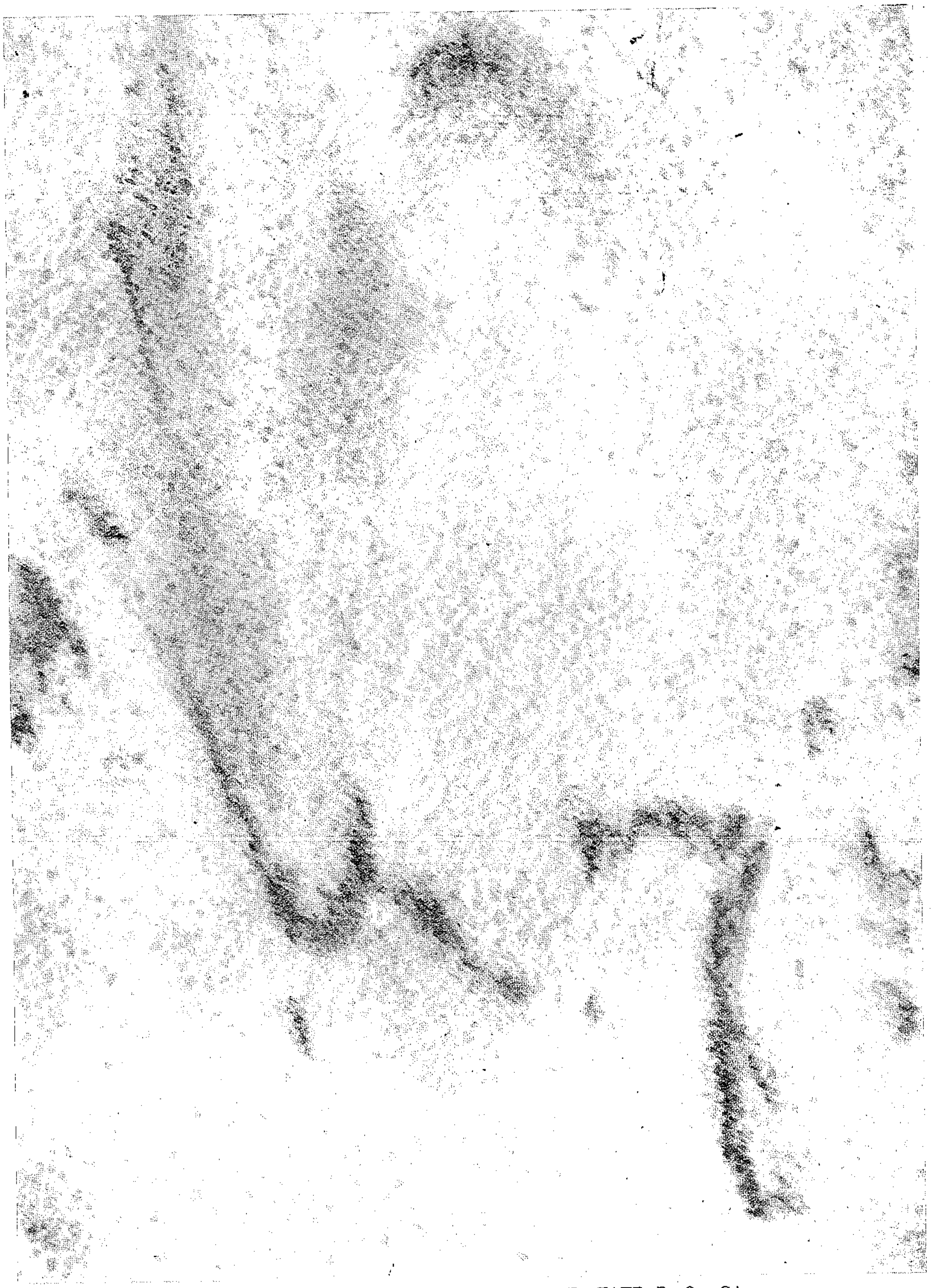
POLISHED SLAB OF CREOLE MARBLE, TATE P. O., GA.



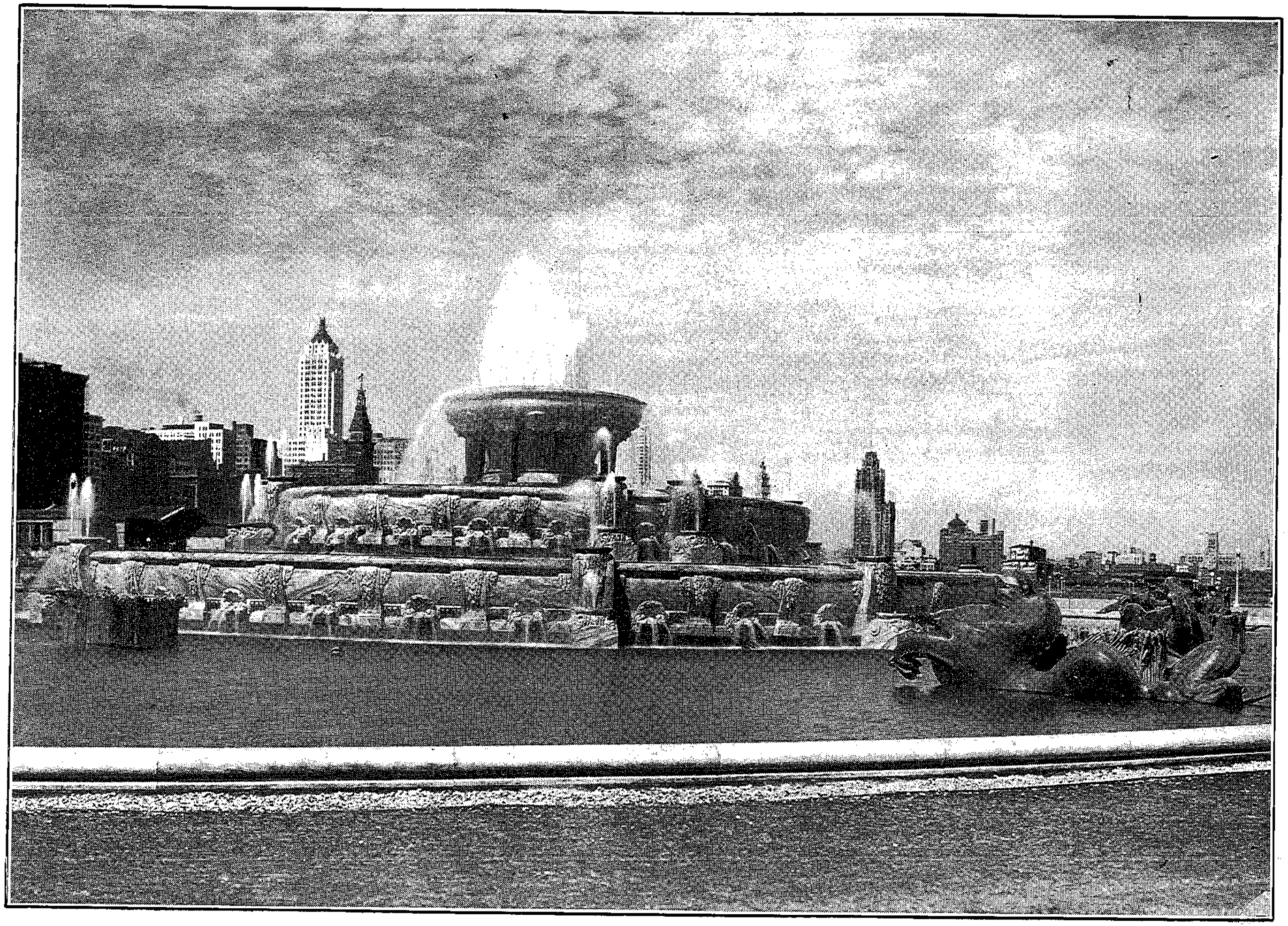
CHEROKEE QUARRY OF THE GEORGIA MARBLE COMPANY, TATE, PICKENS COUNTY, GEORGIA.



CENTENNIAL MEMORIAL, EDWARDSVILLE, ILL. (SILVER GRAY MARBLE.)

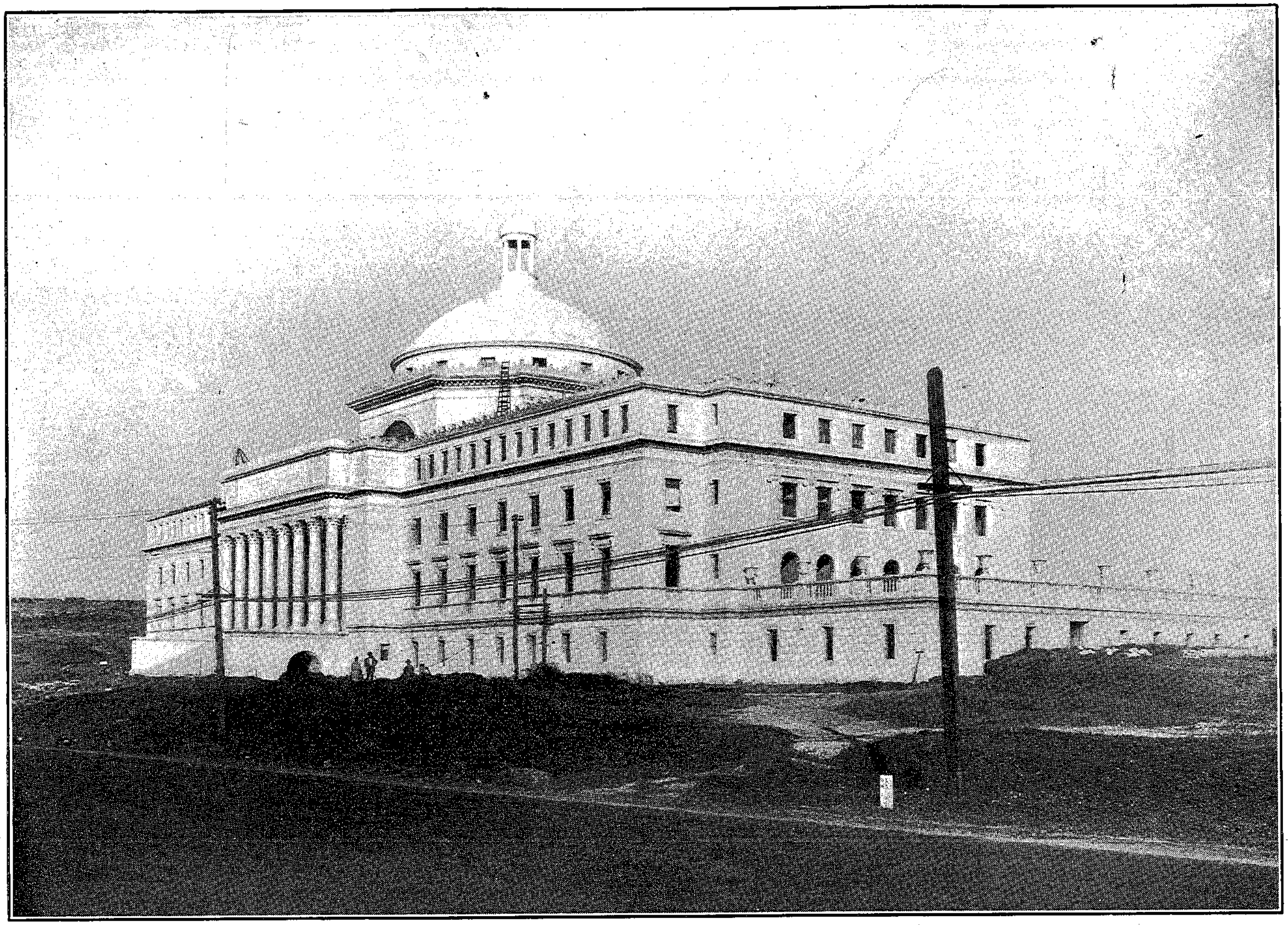


POLISHED SLAB OF CHEROKEE MARBLE, TATE P. O., GA.



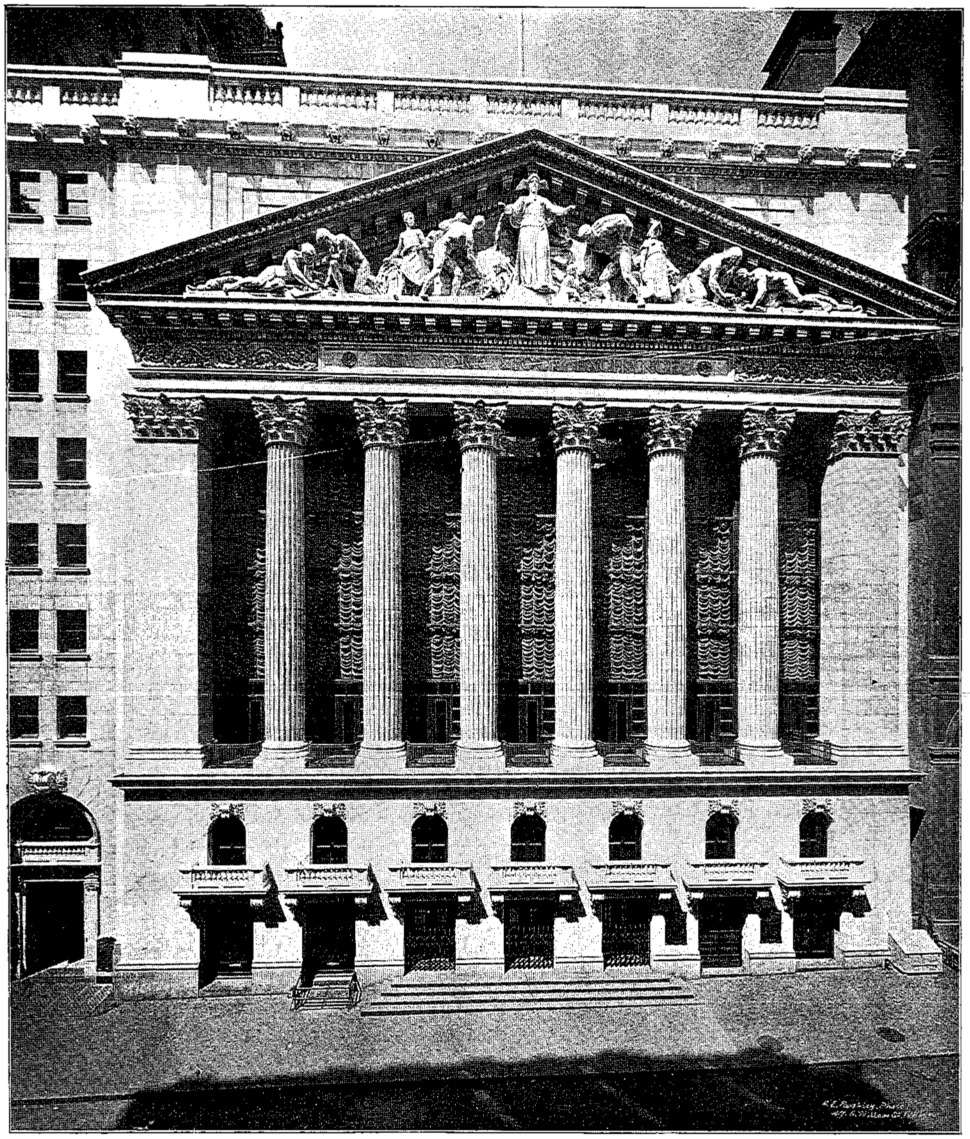
BUCKINGHAM FOUNTAIN, CHICAGO, MADE OF GEORGIA ETOWAH MARBLE.

POLISHED SLAB OF ETOWAH MARBLE, TATE P. O., GA.

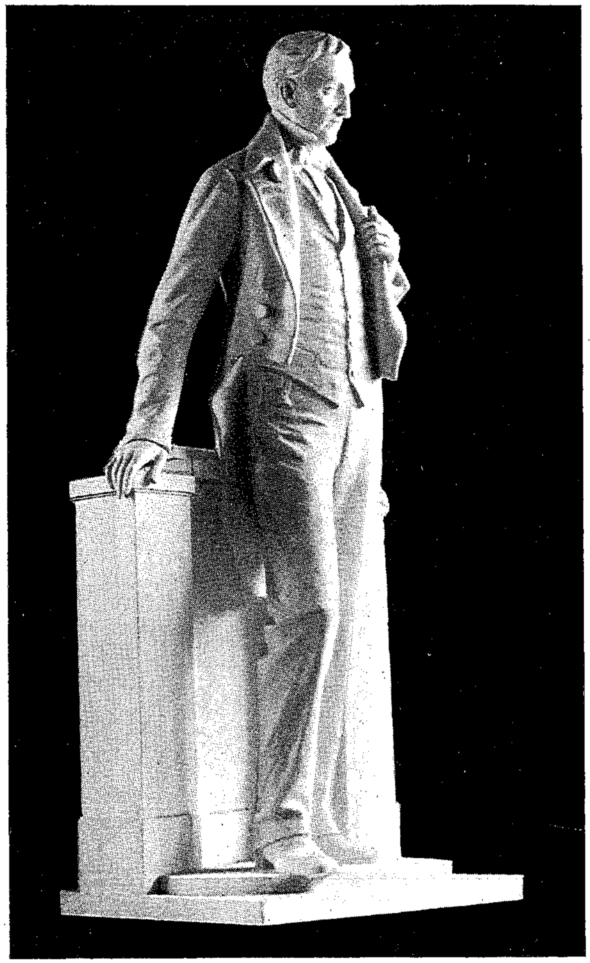


CAPITOL OF PORTO RICO MADE OF GEORGIA WHITE MARBLE.

POLISHED SLAB OF GEORGIA WHITE MARBLE, NEW YORK QUARRY, MARBLE HILL AREA, TATE QUADRANGLE, GEORGIA.



NEW YORK STOCK EXCHANGE BUILDING, MADE OF WHITE MARBLE FROM MARBLE HILL, TATE, PICKENS COUNTY, GEORGIA.



CRAWFORD W. LONG ALEXANDER H. STEPHENS
STATUTES IN HALL OF FAME, WASHINGTON, D. C., MADE OF GEORGIA WHITE MARBLE.

DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

STATE OF GEORGIA
GEOLOGICAL SURVEY
S.W. McCALLIE, STATE GEOLOGIST

GEORGIA
TATE QUADRANGLE

Topography by E. I. Ireland, B. A. Jenkins, and Crawford Dickey
Control by U. S. Geological Survey and U. S. Coast and Geodetic Survey
Surveyed in 1926

APPROXIMATE MEAN DECLINATION 1926

Scale 62500

5 Miles

20000 Feet

5 Kilometers

Contour interval 20 feet
Datum is mean sea level.

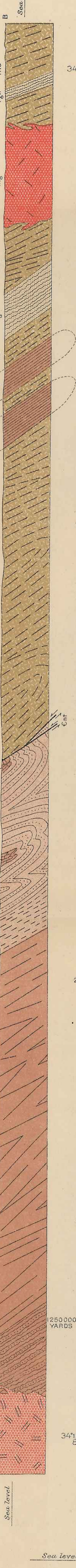
Polyconic projection. North American datum
5000 yard grid based upon U.S. zone system, B
THROUGH ROUTES
SECONDARY ROUTES

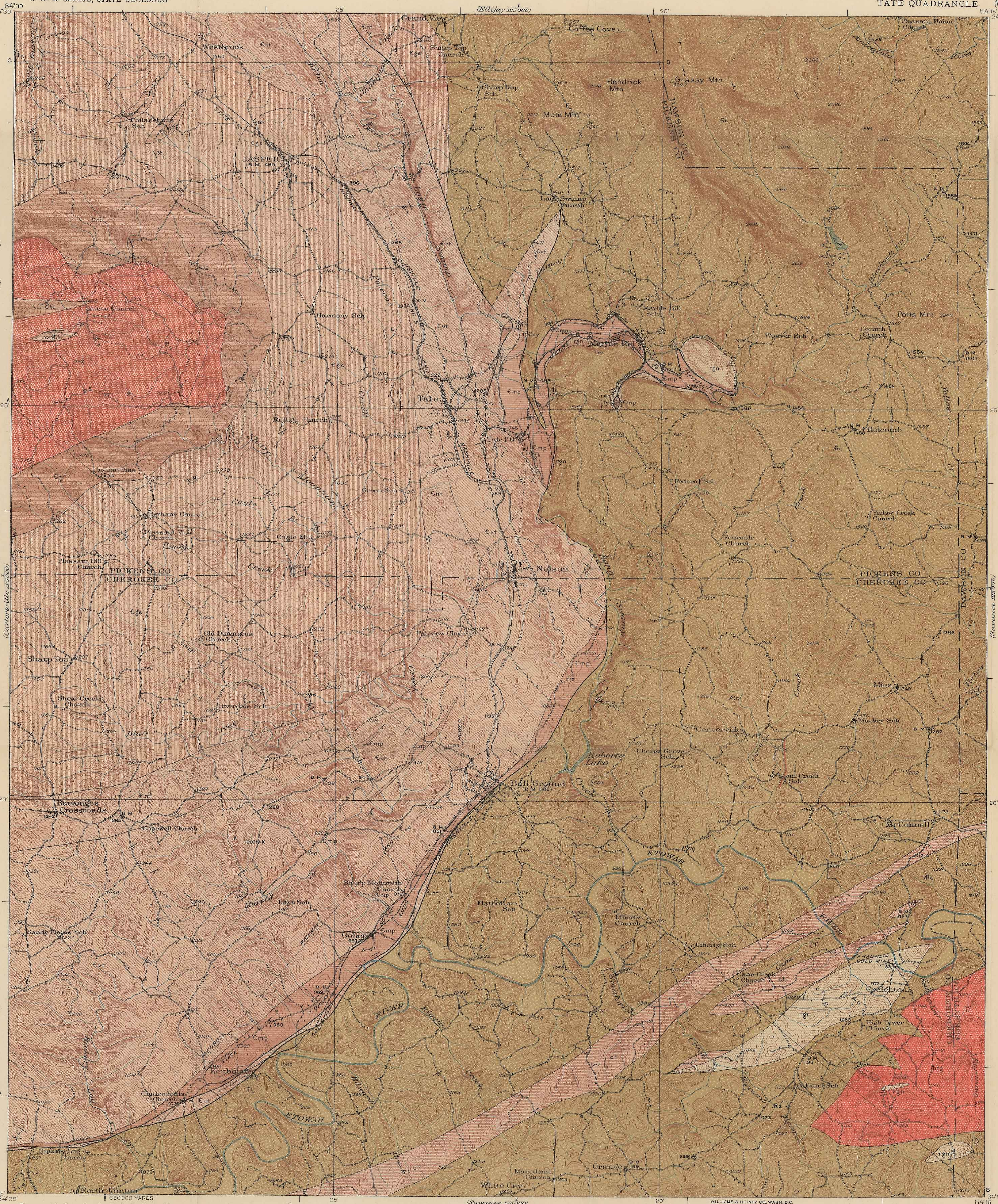
TATE, GA.
Edition of 1928

STATE GEOLOGICAL SURVEY
S. W. McCALLIE, STATE GEOLOGIST

AREAL AND STRUCTURAL GEOLOGY

GEORGIA
TATE QUADRANGLE





EXPLANATION

METAMORPHIC ROCKS

CAMBRIAN

Єny — Nottely quartzite (*white quartzite*)

Єmp — Murphy marble (*white and blue marble*)

Єvt — Valleytown formation (*micaceous graywacke and garnet-mica schist; in places with kyanite and staurolite*)

Єnt — Nantahala schist (*graphitic garnet-mica schist*)

Єgs — Great Smoky formation (*micaceous graywacke, garnet-mica schist and a few layers of graphitic schist*)

Єhi — Hiwassee schist (*graphitic garnet-mica schist*)

CAMBRIAN OR ARCHEAN

ct — Canton schist (*graphitic garnet-mica schist; possibly same as Hiwassee slate*)

ARCHEAN

Ꞧc — Carolina gneiss (*micaceous graywacke, mica gneiss and mica schist, in places containing kyanite and staurolite and granitoid gneiss*)

IGNEOUS ROCKS

POST-PALEOZOIC

Basalt

PALEOZOIC OR OLDER

scg — Salem Church granite (*white gneissoid granite*)

htg — High Tower granite (*light-gray gneissoid biotite granite*)

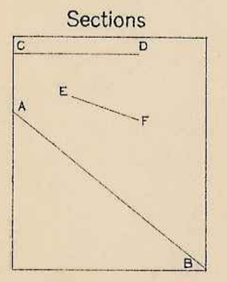
rgn — Roan gneiss (*hornblende schist, hornblende gneiss, amphibolite and gneissoid diorite*)

Faults

Quarries, mines, and prospects

- G gold
- K kyanite
- S sericite
- M mica
- F flagstone
- P pyrite

Sections



Topographic Base Map by U. S. Geological Survey

Scale 1/62500

Contour interval 20 feet
Datum is mean sea level

WILLIAMS & HEINTZ CO. WASH. D.C.

Geological map of the Tate Quadrangle with generalized structure sections by W. S. Bayley
Assisted by A. N. Murray, C. Milton, and R. H. Hazeltine