GEOLOGICAL SURVEY OF GEORGIA

S. W. McCALLIE, State Geologist

BULLETIN No. 29

A REPORT

ON THE

ASBESTOS, TALC AND SOAPSTONE DEPOSITS

OF

GEORGIA

BY

OLIVER B. HOPKINS, Ph.D.,
Assistant State Geologist

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LETTER OF TRANSMITTAL

GEOLOGICAL SURVEY OF GEORGIA,

ATLANTA, June 16, 1914.

To His Excellency, JOHN M. SLATON, *Governor and President of the Advisory Board of the Geological Survey of Georgia.*

SIR: I have the honor to transmit herewith the report of Dr. Oliver B. Hopkins, Assistant State Geologist of this Survey, on the Asbestos, Talc and Soapstone Deposits of Georgia, to be published as Bulletin No. 29 of this Survey.

Very respectfully yours,

S. W. McCALLIE,

State Geologist.

PREFACE

In the preparation of this report, I have endeavored to present a description of the occurrence and possible commercial value of the Georgia deposits of asbestos, talc and soapstone, minerals which have attracted the attention of so many of the citizens of this State; but further than this, I have attempted to bring together information of a general nature relating to the subjects under discussion which is not easily obtainable where library facilities are not available, as well as to present the facts of a scientific nature, especially those relating to character and alterations of the basic dike rocks, in a convenient form for those who may be interested in that phase of the subject.

The work of this report was begun by Mr. Otto Veatch, formerly an assistant state geologist of Georgia, and it is to him that I am indebted for the following: a list of the localities at which asbestos, talc and soapstone are known to occur, a collection of minerals and rock samples from the various localities, and the use of his field notes in the description of the individual deposits. All the localities, with the exception of the J. H. Cantrell, Joseph L. Chambless, J. A. R. Camp and Leila Beasley properties, were revisited, additional collections were made and the localities were redescribed.

For helpful information in regard to the subject under discussion, I am indebted to two reports more than to any others, namely: "Chrysotile Asbestos, Its Occurrence, Exploitation, Milling and Uses," by Fritz Cirkel, and the "Corundum and Peridotites of Western North Carolina," by Joseph Hyde Pratt and Joseph Voltney Lewis.

Finally, I am indebted to Dr. Edgar Everhart, acting chemist of this department, for all the analyses in this report not otherwise accredited.

OLIVER B. HOPKINS.

ATLANTA, GA., June, 1914.

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GENERAL GEOLOGY OF THE STATE

Based on the nature and age of the underlying rocks, Georgia may be divided into three parts: the Coastal Plain, the Paleozoic and the Crystalline areas. Since the nature of the rocks determines to a certain extent the surface form, these divisions are physiographic as well as geological.

THE COASTAL PLAIN

The Coastal Plain comprises the southern part of the State, and occupies a greater area than the other two divisions combined. Beginning at the Fall Line, a sinuous line connecting Columbus, Macon and Augusta, with an average elevation of from 300 to 400 feet, it slopes gently to the southeast at a rate of three to four feet per mile to sea level. This area is underlain by unconsolidated deposits of gravel, sand, clay, and limestone which vary in age from Cretaceous to Pleistocene, overlapping the southern edge of the Crystalline Area and dipping at small angles to the southeast. These rocks are only slightly folded or faulted and stand in sharp contrast to the series of intricately folded and faulted granites, gneisses and schists of the Crystalline Area.

THE PALEOZOIC AREA[1]

The area of non-crystalline Paleozoic rocks forms the northwest corner of the State and is divisible into two physiographic provinces:

[1] This term is rather unfortunate since there are rocks of Paleozoic age in the Crystalline Area.

the Appalachian Valley and the Cumberland Plateau. The Appalachian Valley lies between the highlands of the Appalachian Mountains on the east and the Cumberland Plateau on the west. It is formed of minor ridges and valleys which trend northeast and southwest. The Cumberland Plateau is represented in Georgia by the extreme northwest corner of the State, and is characterized by escarpments and flat topped hills, such as Lookout Mountain.

The Appalachian Valley is formed by a series of sedimentary rocks, sandstone, shale, and limestone, which have been compressed into folds and, at places, faulted. The rocks dip at high angles. This area gradually merges to the west into the Cumberland Plateau, where the close folds give place to the broad undulations which characterize that area and give rise to its physiographic features.

The rocks of the Paleozoic Area of Georgia range in age from Cambrian to Carboniferous. The oldest are found, in general, in the southeast part of the area, while the youngest cap the tops of the hills in the extreme northwestern part of the State.

THE CRYSTALLINE AREA

LOCATION

As in the case of the Coastal Plain and Paleozoic Area, the Crystalline Area in Georgia represents a small part of a great belt which stretches from Alabama northeast to New York. In Georgia the Crystalline Area disappears to the south and east under the sediments which form the Coastal Plain, and to the northwest it is separated from the Paleozoic Area by the Cartersville Fault. It occupies the entire northern part of the State, with the exception of the northwestern corner, as mentioned above. (See map opposite page 14.)

PHYSIOGRAPHY

Within the Crystalline Area are found the most diversified topographic forms in the State. Like the Paleozoic Area to the west, it is divisible into two physiographic provinces, the Appalachian Mountain and the Piedmont Plateau. The former with its bold, rugged ridges and steep, narrow valleys, stands in sharp contrast to the flat, monotonous plain of the Piedmont Plateau. The average elevation of the Appalachian Mountain Province is approximately 2,000 feet, with 28 peaks which rise to more than 4,000 feet. The highest peak in the State, Sitting Bull Mountain, is located in this area and has an elevation of 5,046 feet above sea level.

To the southeast the Appalachian Mountains gradually merge into the Piedmont Plateau, a level plain with few elevations that interrupt the horizontal sky line. The elevation of this plain near its northern limit is about 1,200 feet, from which it slopes gently to the Coastal Plain where it has a general elevation of from 300 to 400 feet. Consequently, its average slope to the southeast is approximately 8 feet per mile; but near the Fall Line its slope has been estimated at from 25 to 50 feet. This plain has been exposed to subaerial erosion for a long period of time, and in such a position that disintegration of the underlying rocks has progressed more rapidly than their removal, hence a heavy mantle of residual soil has accumulated. In more recent time this plain has been elevated and the rivers and streams have cut through this soft material and flow in narrow valleys, and often over hard rocks. Above the general level of this plain stand a few elevations, such as Stone, Kennesaw, Graves and Burt mountains, which represent monadnocks upon the Cretaceous or Tertiary peneplain.

STRATIGRAPHY

The rocks of the Crystalline Area vary much in both origin and age. A large part, represented by granite, granite-gneiss and basic intrusives, are clearly of igneous origin; another, represented by graywacke, mica schists, graphitic schists, quartzites and exceptionally by limestones, are undoubtedly of sedimentary origin; while a third large division, composed of gneisses and schists of varying composition, are of doubtful origin, their distinctive characters having been lost during the many periods of metamorphism which they have suffered. Generally speaking, the oldest rocks are exposed toward the southeastern part of the region, and the more recent ones to the northwestern; however, this simple relationship has been largely obscured through the deformation of the rocks, which has led to the alternation of the older and younger beds in a northwest-southeast direction.

In general, the same types of rocks are found in both the Appalachian Mountain and the Piedmont Plateau provinces; the difference between them consists in the amount of degradation they have suffered. Base leveling began most actively southeast of the present position of the Fall Line and progressed toward the northwest. Had this process continued sufficiently long before subsequent elevation, the Appalachian Mountains would ultimately have been reduced to form a continuation of the Piedmont Plateau.

Based on the age and nature of the rocks, the Crystalline Area may be divided into two parts: the metamorphosed Paleozoic rocks and the pre-Cambrian rocks. Sufficient work has not been done on this area to make a complete separation on this basis; but an attempt to make this division is shown on the map opposite page 14.[1]

METAMORPHOSED PALEOZOIC ROCKS

Within the so-called Crystalline Area two general belts of metamorphosed Paleozoic rocks have been generally recognized; besides these, there are other areas of rocks of doubtful age which will be considered later.

The largest area of metamorphosed Paleozoic sediments is found occupying a belt along the western border of the Crystalline Area separating the pre-Cambrian rocks from the non-crystalline Paleozoic rocks to the west. In other words, these metamorphosed rocks of Paleozoic age, formerly known as the semi-crystalline rocks,[2] form a transition between the area of less altered Paleozoic rocks on the west and the pre-Cambrian crystalline rocks on the east. This belt is bounded on the west by the Cartersville Fault.

[1] The data for the construction of this map were taken largely from reports by the Geological Department of Georgia and the United States Geological Survey.

[2] King Francis P., Corundum Deposits of Georgia: Bull. Geol. Survey of Ga. No. 2, 1894, pp. 58-59.

The Cartersville Fault extends from Tennessee southwest across the northwest corner of Georgia, passing east of Cartersville, Rockmart and Cedartown, and entering Alabama near Esom Hill. On account of the superior hardness of the rocks on its eastern side, the position of the fault is clearly marked by an almost continuous line of bluffs which rise from 100 to 300 feet higher than the valley to the west. Through this fault all formations from Cambrian up to the Carboniferous age have been brought into contact with the overthrust, metamorphic rocks on the east. The rocks immediately to the east of the fault show the greatest amount of metamorphism from near Rockmart northeast to near Pine Log. To the north and south of this area the amount of metamorphism diminishes so that at Esom Hill, as well as near Chatsworth, there is little difference in the degree of metamorphism on the two sides of the fault plane.

East and southeast of the Cartersville Fault, the amount of metamorphism increases and the semi-crystalline finally give way to holocrystalline rocks of unknown origin. This belt of sediments east of the fault, formerly known by the name of Ocoee series, through its relationship to less metamorphosed, fossiliferous rocks to the north, is now considered to be of Cambrian age; and while it contains no fossils itself, it represents the lower part of a great group of rocks exposed further north which yields fossils, near its middle part, of lower Cambrian age, chiefly *Olenellus*. In Fannin County, where it reaches its greatest width in Georgia, this belt of rocks is known as the Great Smoky formation. Here it consists of conglomerate, graywacke, mica gneiss, biotite gneiss, mica and graphitic schists.

This belt continues to the southwest into Alabama. Its eastern limit passes east of Blue Ridge, Ellijay, Canton, Allatoona and Buchanan. In its northern part, particularly in Fannin and Gilmer counties, the Great Smoky formation contains in a faulted synclinal area a long, narrow strip of later Cambrian rocks, the entire series of which has been divided into the following formations:[1]

[1] See Ellijay Folio No. 187, Geol. Atlas U. S. Geol. Survey, 1913.

Cambrian.........	Nottely quartzite Murphy marble Valleytown formation Brasstown schist Tusquitee quartzite Nantahala slate Great Smoky formation

In this narrow belt are found the important marble deposits of Georgia, the Murphy marble. It occurs as a series of rather small, isolated areas extending from North Carolina south through Fannin, Gilmer, Pickens and Cherokee counties. Marble which appears to be the southwestern continuation of the Murphy marble, occurs in Haralson County in the neighborhood of Buchanan.

Rocks of igneous origin are found somewhat sparingly in this area. There are two long, narrow dikes in the northern part near Copper Hill, and other small ones along the strike to the southwest. Pegmatite dikes are also present over a small area.[1]

Within this belt is enclosed a large granite mass, the Corbin granite. It is exposed only in Bartow and Cherokee counties, and represented, according to Hayes, an island in the ancient sea around which the surrounding sediments were laid down. This relationship is demonstrated by the presence of detritus in the sediments which clearly came from the central granite mass; this relationship is so striking that some of the coarse sediments can be distinguished with difficulty from the mass of gneissose granite.

In this belt of metamorphosed Paleozoic rocks are found the important talc deposits of the State. There are two distinct types of deposits present; those associated with the Murphy marble and those of Murray County, probably of igneous origin. The talc deposits of the first class are most prominently developed in the northern part of the area, from the northern boundary of Fannin County south to the Gilmer County line near Blue Ridge; further south only a single locality is known—that west of Ball Ground in Cherokee County. Just the reverse is true of the marbles, from a commercial point of

[1] It is possible that the area containing pegmatite should be classed with the Carolina gneiss.

view; they are much more important in the southern part of the belt, and more particularly in Pickens County.

The Murray County talc deposits lie on the western side of the belt of metamorphic rocks, and are associated with quartzite and graywacke. They are found best developed along the western slopes of Fort and Cohutta mountains. No definitely recognizable igneous rocks are found in this region. The talc and its associated serpentine rocks occur at various stratigraphic horizons over a range of not more than 1,000 feet. At places there is a sharp contact between the talcose rocks and the country rock, which is usually a graywacke or arkose, but at others the gradation seems to be perfect.

The second area of metamorphosed Paleozoic sediments occupies a narrow belt extending from North Carolina through the extreme northwestern corner of South Carolina and southwest through Georgia from east of Clarkesville to the Chattahoochee River near Atlanta. Slates of this belt are well exposed at Chattahoochee Station on the eastern bank of the river. This belt in the area of the Pisgah Folio, North Carolina, has been called the Brevard schist and is considered Cambrian in age. In Georgia this belt contains schists, slates, quartzites and limestones. In Habersham County the limestones reach a thickness of as much as 61 feet. As in North Carolina, this belt forms a narrow synclinal area, representing only a small remnant of the original area covered by these sediments.

Other areas of sedimentary rocks are found in the Crystalline Area, but their age is obscure. Among these may be mentioned the belt of quartzites and associated schists, which forms the prominent elevation called Pine Mountain, extending from the west central part of Harris County northeast near Hamilton, Bullochville and Woodbury, and further on into Pike County; the prominent belt of slates and schists which extends through the southern part of Lincoln County and southwest into adjoining counties; and the quartzite of Graves Mountain, which is described in this report. (See Lincoln County.)

In this connection it may be of interest to mention the fossils which were discovered north of Cleveland, White County. The fossils were found in the stream gravels which were being worked for gold, on the property of C. L. Coffin, near Parks. They were identified at the United States National Museum as follows: *Camerotochia,* several species; *Spirifer* sp (?); *Corals* (?). While these remains were somewhat water-worn, they had not lost their external configuration, and it seems impossible that they should have traveled far. Their presence in this locality is at least suggestive.

PRE-CAMBRIAN ROCKS

Pre-Cambrian, or holo-crystalline rocks of older terminology, occupy the greater part of the Piedmont Plateau and Appalachian Mountain provinces, and differ widely both in nature and origin. For convenience of description they will be divided into four groups, as follows: the Carolina gneiss; the Roan gneiss and associated basic dike rocks; the granites and related pegmatite dikes; and finally the diabase dikes.

In the following pages a brief description of the nature and occurrence of each of these divisions will be given, and in the following section particular attention will be called to the basic dike rocks, as it is with them that this report is especially concerned.

CAROLINA GNEISS

Carolina gneiss, so named because of its wide distribution in the Carolinas, where it has been most extensively studied, is the predominant type of rock in the Crystalline Area of Georgia. It has a wide distribution over the area; and, broadly speaking, it may be considered the country rock into which the others were intruded, since it is the oldest and most deformed rock in the region. It may be correlated roughly with the Baltimore gneiss and Wissahickon mica gneiss of Maryland and Pennsylvania, and the Stanford and Fordham gneisses of New York.

The Carolina gneiss includes mica gneiss, mica schist, quartz schist and graphitic schists, etc., interbedded in layers of varying thicknesses. In these rocks the component minerals are more or less segregated into layers with their long directions parallel to the schistosity, thus producing a pronounced banded appearance. Some parts of the series resemble some of the metamorphosed Paleozoic rocks to such an extent that they are practically indistinguishable in themselves, but may be recognized often by the presence of ancient intrusive rocks. This close resemblance, the fact that the one type grades into the other, as in the Ellijay quadrangle, and the presence of quartzites and graphitic beds at places, demonstrate conclusively that a part of this series is sedimentary in origin, and not far different in age from the metamorphosed Paleozoic rocks to the west. This series of rocks has suffered a greater amount of metamorphism than any other in the area by means of orogenetic movements, as well as by the intrusion of more recent rocks.

ROAN GNEISS SERIES

The Roan gneiss and associated peridotites and pyroxenites are found cutting the Carolina gneiss at widely separated points over the Crystalline Area. The Roan gneiss occurs in elongated sheet-like or dike-like masses enclosed in the Carolina, with which it is folded and faulted. At places it is found in lense-shaped or elliptical masses without pronounced schistosity. Under the head of Roan gneiss are included hornblende gneiss and hornblende schist and variously altered diorite and gabbro. Some of these larger areas appear to be of somewhat more recent age than the elongated, dike-like masses.

Usually more or less closely associated with the Roan gneiss, but often cutting the rock of the Carolina series, are found numerous dikes of peridotite and pyroxenite. These are considered, as a rule, later in origin than the Roan gneiss, since they cut it; but on account of their close association they are believed to be genetically related to it. While these rocks are seen cutting the Carolina and are consequently somewhat younger, they are, in turn, cut by the oldest granites in the area, within which they are, at places, included.

GRANITES AND PEGMATITE DIKES

The granites[1] and associated pegmatite dikes are found in Georgia distributed over practically every one of the sixty-one counties forming the Crystalline Area. The granite industry is confined, however, to ten of the counties of the Piedmont Plateau.

The Georgia granites may be grouped as even-granular granites, porphyritic granites and granite gneisses. Notwithstanding the wide distribution, the large size of the masses, and the differences in structure, they all have very nearly the same chemical and mineralogical composition. Chemically, they are characterized by their high soda content, which allies them with the quartz monzonites. Mineralogically, they are composed of feldspar, quartz, and biotite, with more or less muscovite. Hornblende is entirely absent, and muscovite predominates over biotite at only a few localities, of which Stone Mountain is the most important illustration.

The size of the granite intrusions varies within wide limits; the larger masses outcrop at the surface over one hundred or more acres. The Stone Mountain granite mass, for instance, has a circumference of approximately 7 miles; these masses vary in size down to dikes of a few feet, and even to narrow veins only a fraction of an inch in width. In the cases of the banded gniess, the granitoid layers vary in thickness from one inch to an eighth of an inch and alternate with the layers of schist. The granite bands, composed of feldspar and quartz with more or less biotite and muscovite, are generally considered of igneous origin. This type of rock, the banded gneiss, has a wide distribution over the Crystalline Area of Georgia.

Of somewhat larger size than the granitoid layer of the banded gneiss are the granite dikes which cut the schists and gneisses of the Carolina and Roan series. These vary in width from a few inches up to many feet, and cut through the enclosing rock in all directions, usually about vertically. In part, at least, they represent apophyses from larger granite masses.

[1] Watson T. L., Granites and Gneisses of Georgia: Bull. Geol. Survey of Georgia No. 9-A, 1902.

The pegmatite dikes differ from the true granite principally in texture, but also to a greater or less extent in the ratio of the minerals present and in their arrangement. Like the granites they are composed of feldspar, quartz and more or less muscovite and biotite. They vary in texture from very coarse-grained to the texture of ordinary granites, thus showing all gradations from pegmatite dikes to granite dikes. In thickness they vary from a fraction of a foot up to 30 feet or more, but usually they are not more than 5 or 6 feet. As a rule the large dikes are finer grained than the small ones and contain a greater variety of minerals. Some of the smaller ones appear to be deposited from mineralized waters, as in the case of true veins; this fact is occasionally shown by the presence of indistinct banding of the minerals, and by the fact that they are sometimes completely surrounded by the enclosing schist or gneiss. The pegmatites have their greatest development near the contacts of the Carolina and Roan gneisses.

In age the granites have been shown by Watson[1] to vary widely; some are certainly pre-Cambrian; especially is this true of the granite gneisses; while the true granites are, in part, as late as Carboniferous. The pegmatites appear to belong to the eruptive period of some of the later granites.

DIABASE DIKES[2]

The diabase dikes, consisting essentially of plagioclase and augite, but often containing hornblende, magnetite and olivine, are found in the Crystalline Area of Georgia at numerous places, but probably are most important in its southern part. They are characterized by their fine-grained texture, their dark color, their hardness, and their superior resistance to surface weathering. The dikes are often remarkably uniform in thickness and, on account of their resistance to erosion, commonly form ridges. They are later than all the other

[1] Op. cit.

[2] McCallie, S. W., Roads and Road Building Materials of Georgia: Bull. Ga. Geol. Survey No. 8, 1901.

types of rocks with which they are associated, since they cut them all. They have been considered as probably Jura-Triassic in age.

STRUCTURE

The structure of the Crystalline Area increases in complexity from its western limit to the southeast. The metamorphosed Paleozoic sediments, though highly folded and faulted, contain beds which are traceable and recognizable, and by them the intricate structure can be more or less completely unraveled. When thus studied, this series is seen to be closely folded into synclinal and anticlinal areas with the folds commonly overturned to the west and often accompanied by thrust faulting on the western or stretched limb. Such faults, usually dipping at high angles, may be found to continue over considerable distances, as in the Ellijay quadrangle.

The structure of the pre-Cambrian crystalline rocks is much obscured, even when studied in detail, by the absence of any distinctive beds which can be recognized from place to place. That both folds and faults are abundant is obvious, but their location and reconstruction is very difficult, if not impossible, at many places. On account of the small amount of work that has been done on this large area, little is known of the details of its structure.

As a whole, the rocks of the region strike northeast-southwest at variable angles, but usually about 25°; they dip, with many local variations, to the southeast at high angles, approximating 45° or more. In general, the igneous rocks, especially those of the Roan series, as well as the granites, conform to the general strike of the region. The general absence of northwestward dips shows that the series of northeast-southwest folds, into which these rocks have been thrown, have been with few local exceptions overturned to the west. The truncation of the crests of these folds leaves the great series of rocks striking and dipping approximately uniformly, and showing, where not obscured by faults, two limbs to each flexture; by this means the same series of rocks is doubtless repeated a number of times, but the metamorphism which the region has suffered obscures the differences in the beds and makes their differentiation impossible. The Roan gneiss is involved in the folding of the Carolina gneiss, while some, at least, of the granites have been later than the orogenetic movements which affected the older rocks, as they are seen to break through those structures.

METAMORPHISM AND AGE

Through a study of the amount of metamorphism which the different rocks have suffered, and the relation of the various types to one another, the relative age of each may be determined. The absence of fossils, and the fact that the rocks of the Crystalline Area of Georgia do not show conformable relations with other rocks of known or determinable age, makes it impossible to work out their absolute age in this State. The heavy mantle of residual soil and the depth of decay hide from view or obscure the relationships of the various types of rocks, so that the study of them is often unsatisfactory.

The oldest rocks of the Crystalline Area give evidence of two great periods of deformation; others of more ancient date probably affected these rocks, but their record was nearly, if not entirely, blotted out by the later ones. During the earliest period of deformation the mineral composition of the rocks was changed, and the gneissic or schistose structures were produced. During the second period the cleavage planes were deformed, accompanied by much folding and faulting. Thus the structures observed in the rocks today are largely those which were formed during this second and later period. In general, the Roan and Carolina series are equally deformed, but the dike-like form and other indications of igneous origin of the former indicate that it was intruded into the latter, and consequently somewhat younger.

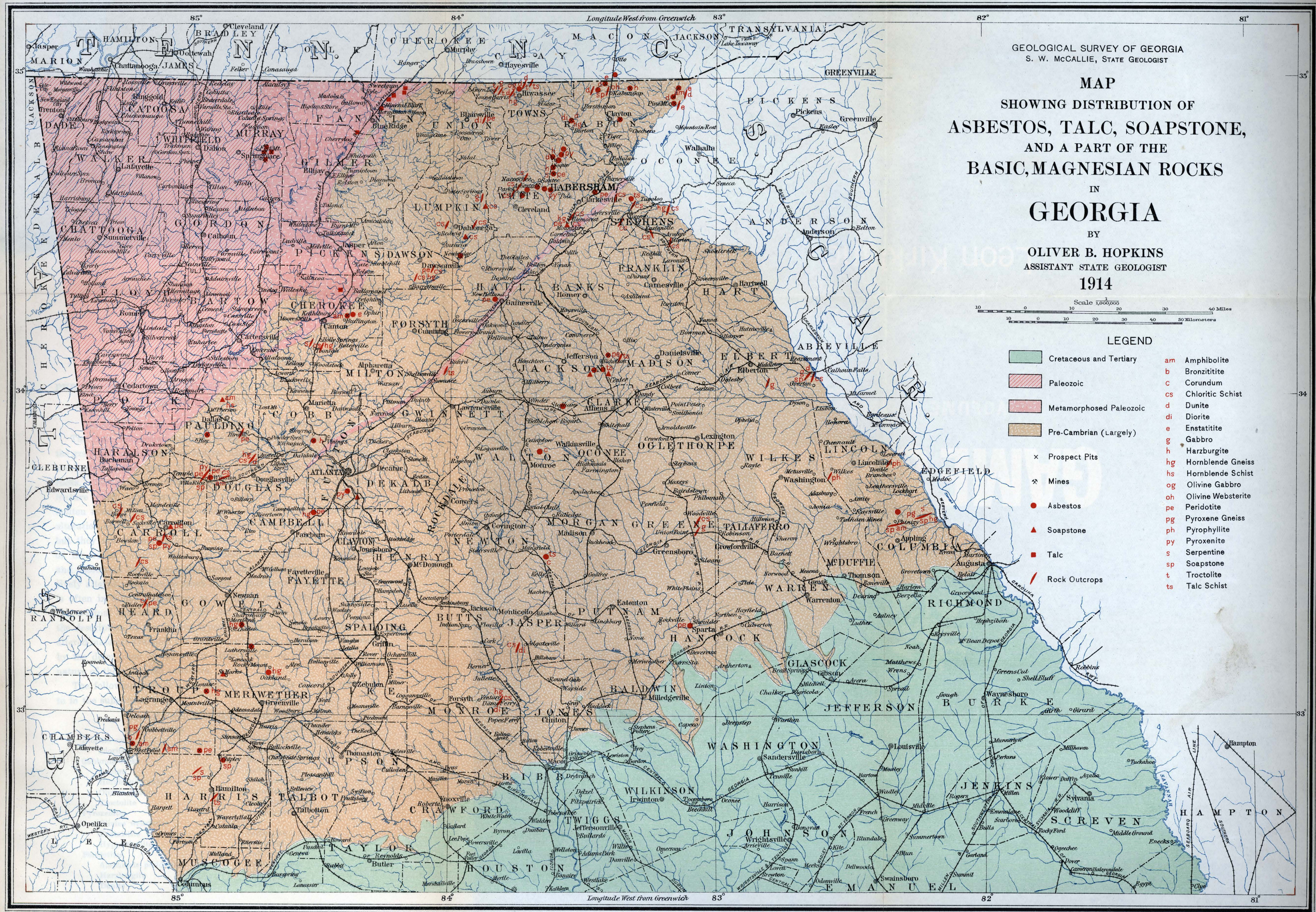
Probably all of the granites suffered part, if not all, of the latest great period of metamorphism—that accompanying the Appalachian revolution. That the granites, although practically identical in composition, were intruded at different periods and consequently suffered different amounts of deformation, is demonstrated by their difference in structure, some being massive and others distinctly gneissic. Some of the granites were then probably as late as Carboniferous in age, while some were doubtless pre-Cambrian. The intrusion of the granites not only disturbed pre-existing structures, but produced marked changes in the surrounding rocks; however, such changes are with difficulty recognized today.

The diabase dikes, being more recent in origin than the latest great revolution, have been little disturbed. They may be observed cutting all the rocks, with which they are associated; but since the age of the associated rocks is not known, the age of the diabase dikes must remain obscure so far as this region is concerned.

During the great periods of metamorphism which the Crystalline Area has undergone, certain changes have taken places which have produced mineral deposits of commercial proportions. Among others may be mentioned asbestos and talc. The most important alterations of the peridotites and pyroxenites led to the formation of amphibole, especially anthophyllite. The amphibole has either given rise to asbestos, or through a second alteration, after erosion had removed the superincumbent strata and exposed the material in the belt of weathering, has led to the development of talc or soapstone.

In the case of limestones and dolomites, of Cambrian age, silicates, particularly monoclinic amphiboles, were developed in favored places where sufficient silica was present or where it could be introduced through solutions. Under the conditions described above, the silicates were converted into talc, as in Fannin, Gilmer and Cherokee counties.

Just what was the original nature of the rock which gave rise to the talc deposits of Murray County can not be stated; but the part played by metamorphism in their development is unmistakable.


GEOLOGICAL SURVEY OF GEORGIA
S. W. McCALLIE, STATE GEOLOGIST
MAP
SHOWING DISTRIBUTION OF
ASBESTOS, TALC, SOAPSTONE,
AND A PART OF THE
BASIC, MAGNESIAN ROCKS
IN
GEORGIA
BY
OLIVER B. HOPKINS
ASSISTANT STATE GEOLOGIST
1914
LEGEND
Cretaceous and Tertiary
Paleozoic
Metamorphosed Paleozoic
Pre-Cambrian (Largely)
Prospect Pits
Mines
Asbestos
Soapstone
Talc
Rock Outcrops
am Amphibolite
b Bronzititite
c Corundum
cs Chloritic Schist
d Dunite
di Diorite
e Enstatitite
g Gabbro
h Harzburgite
hg Hornblende Gneiss
hs Hornblende Schist
og Olivine Gabbro
oh Olivine Websterite
pe Peridotite
pg Pyroxene Gneiss
ph Pyrophyllite
py Pyroxenite
s Serpentine
sp Soapstone
t Troctolite
ts Talc Schist
Longitude West from Greenwich

PERIDOTITES, PYROXENITES AND ASSOCIATED BASIC, MAGNESIAN ROCKS

CLASSIFICATION, DISTRIBUTION AND PETROGRAPHY

The basic, magnesian rocks of Georgia, which represent a part of the great belt stretching from central Alabama northeast into Canada, are best classified under two heads: primary rocks and secondary rocks. The primary rocks are those of hypidiomorphic, granular texture which have resulted from the original crystallization of a molten magma; while the secondary rocks owe their origin to the alteration of the primary ones. They may have a massive structure, but they are characteristically schistose. In Georgia a large part of the rocks included under the head of peridotites, pyroxenites and associated basic, magnesian rocks have been more or less extensively altered; some are so much altered that their original character is often in doubt. However, as a rule, it is possible to point out the original character and refer the rock to the proper type. In the description of the various types of rocks included here, the least altered material available has been described first; and that is followed by the description of the partly altered rock, as illustrative of the nature of the alteration processes.

The following table is a list of the various types of rocks referred to in the subsequent pages:

List of Rocks Described in this Report

PRIMARY ROCKS	SECONDARY ROCKS
Dioritic rocks	Anhydrous rocks
Diorite	Metaperidotite
Gabbroic rocks	Metapyroxenite
Gabbro	Gabbro-diorite
Hornblende gabbro	Pyroxene gneiss
Olivine gabbro	Hornblende gneiss
Troctolite	Hornblende schist
Pyroxenites	Amphibolite
Olivine websterite	Hydrous
Enstatitite	Serpentine
Hypersthenite	Soapstone
Peridotites	Talc schist
Amphibole peridotite	Peridosteatite
Harzburgite	Chlorite schist
Dunite	

The primary rocks named above are closely related chemically, and their arrangement is roughly in the order of decreasing lime, alumina and silica, and increasing magnesia. All of these rocks have not been found in a single locality, although two or more are usually found in association; thus the peridotites and pyroxenites are commonly associated over the entire belt which crosses the northern part of Georgia. The peridotites and gabbroic rocks are found associated and showing transitional types, especially in Towns County. The gabbroic type of rock in various stages of alteration, usually represented by hornblende schist and hornblende gneiss, is the most common and widely distributed of these rocks. It occurs over practically the entire area of pre-Cambrian rocks. The peridotites and pyroxenites are much more limited in their distribution and are, in general, confined to a narrow belt to be described later.

There are two kinds of alterations to which the primary rocks may be subjected; the development of schistose or gneissic structure, and a change in the mineral composition of the rock. A rock may undergo one of these changes without the other, but they are usually concomitant. Thus a dunite may be crushed until its massive structure is lost without an appreciable change in its mineral composition; or it may be altered to an amphibolite and still retain its massive structure. While these conditions are possible, they are not the rule. The change in mineral composition is the important one from the present point of view, as through it talc, soapstone or asbestos deposits may be formed.

In the following pages a brief description will be given of the distribution and occurrence of these different types of rocks, beginning with the anhydrous, secondary rocks, which constitute largely what is mapped under the name of Roan gneiss, because of their wide distribution; and finally, under the general heading of alterations, the general methods of alterations which lead to the production of the secondary rocks will be described.

HORNBLENDE SCHIST, HORNBLENDE GNEISSES, ETC.

DISTRIBUTION

The hornblende schists, hornblende gneisses, etc., have a wide distribution over the pre-Cambrian area of Georgia, being present in variable quantities in every county of the area. In general, these rocks are present in largest quantities in the northwestern and the southeastern parts of the area, while in the central area the granites and granite gneisses are prominent. The most important belt, and the one which contains the greatest number of different types of rock, is the northwestern; in it are found almost all of the peridotites and pyroxenites of this State.

The rocks of this group have not been mapped in detail within the State, except on the Ellijay Folio, and in a preliminary way in the neighborhood of Dahlonega.[1]

CHARACTER AND RELATIONS

The rocks of this series, included under the head of Roan gneiss, occur as a great series of beds composed largely of hornblende schist, hornblende gneiss, amphibole-pyroxene gneiss, diorite and altered gabbros. The most general type is hornblende gneiss and hornblende schist; in either case the rock is made up largely of hornblende with more or less quartz and feldspar and, at places, biotite. In general, the rock is from medium- to fine-grained, although the hornblende crystals may reach as much as one-half to three-fourths of an inch in length in some of the coarsely crystalline ones. The color of the hornblende varies from dark green to black. The arrangement of the minerals is such that their long directions are parallel, and in some specimens the minerals show segregations into layers; while in some of the fine-grained ones the arrangement is such that the rock gives the appearance of a "salt and pepper" mixture of the light and dark constituents.

[1] See map of Dahlonega district, 2d Report on the Gold Deposits of Georigia: Bull. Ga. Geol. Survey No. 19, 1909.

In the absence of the gneissic or banded structure, the rocks described above pass into diorite and gabbro.

The rocks of this series occur in long, narrow, sheet-like or dike-like bodies enclosed in the gneisses and schists of the Carolina series. The width of these bodies varies from a few feet to several hundred yards, although, in general, they range from fifty to a few hundred feet. These bodies usually lie parallel to the schistosity of the Carolina gneiss, with which they are folded and faulted. The relationship of the two series of rocks is so intimate that they can not be mapped so as to include the one and exclude the other, except on a very large scale map. Although this interbedding is very pronounced, the hornblende gneisses and schists are found to occur most abundantly along certain lines or belts forming the greater percentage of the country rock, up to 80 per. cent. or more, and at other places they decrease in abundance until they may be absent over limited areas. The dike-like bodies of the hornblende schist and hornblende gneisses appear to radiate from the larger bodies of less gneissic rocks, especially in the direction of the strike of the enclosing rocks.

PETROGRAPHY

A few typical rocks of this group will be described here as illustrative of the whole; also a few chemical analyses will be quoted showing the chemical relationships of these rocks to each other, and also to other rocks to be described later.

HORNBLENDE GNEISS

(Meckline Property, 1½ Miles North of Toccoa)

Megascopic characters.—In a hand specimen this rock resembles closely a diorite, and, in fact, might be termed a schistose diorite. It is a greenish-grey rock in which hornblende and feldspar can be clearly recognized. The medium sized grains of feldspar in the finer groundmass of feldspar and hornblende give the rock a slightly porphyritic appearance. When viewed in a section at right angles to the schistosity, the rock appears almost massive; while in any other section the hornblende, in particular, is seen to have a parallel arrangement, thus producing the schistosity. Segregation of the component minerals into separate layers is only slightly indicated. Near the surface the kaolin derived from the alteration of the feldspar is removed, leaving the rock with a pronounced pitted appearance.

Microscopic characters.—In thin section (No. H96) this rock is seen to contain porphyritic crystals of plagioclase, which have been more or less granulated around the edges, giving them a rounded, equigranular appearance. They are partly altered to form secondary hornblende, epidote and zoisite. The larger crystals of plagioclase appear to be the only original ones in the section. They are not fresh, but contain inclusions of dust-like particles and microscopic crystals of zoisite, etc. The plagioclase is basic labradorite. The hornblende is very similar to that of section 8 (a description of which follows), and is clearly arranged in bands, alternating with the feldspar. These bands are formed of aggregates of elongated prisms in roughly parallel arrangement. The hornblende is entirely secondary. Associated with the hornblende is a relatively large quantity of zoisite and a smaller amount of epidote. A single shred of biotite was observed, as well as numerous grains of titanite, pyrite and iron oxide.

This rock clearly represents a transition from massive diorite or gabbro to the very schistose hornblende gneiss. The larger crystals of plagioclase are the only ones that have not entirely undergone recrystallization. The original character of the ferromagnesian mineral or minerals can not be determined by a study of those present.

Hornblende Gneiss (Hessose), Meckline Property, 1 1/2 Miles North of Toccoa

CHEMICAL ANALYSIS[1]		NORMATIVE MINERALS	
SiO_2	49.28	Orthoclase	1.11
Al_2O_3	19.89	Albite	17.29
Fe_2O_3	1.60	Anorthite	44.48
FeO	4.39	Diposide	16.93
MgO	7.40	Enstatite	12.87
CaO	13.22	Olivine	2.78
Na_2O	2.05	Magnetite	2.32
K_2O	.24	Ilmenite	.61
H_2O-	.11	Pyrite	.24
H_2O+	.58	Water, etc	.73
TiO_2	.30		
P_2O_5	trace		99.36
S	.12		
Cr_2O_3	.04		
NiO	.00		
CoO	.00		
MnO	.22		
	99.44		

[1] In all the analyses quoted H_2O- is moisture at 100° C.; while H_2O+ is loss on ignition.

HORNBLENDE GNEISS

(Near Burton, Rabun County)

Megascopic characters.—This is a dark greyish-green rock, composed largely of hornblende and glassy feldspar; it has a well developed schistose structure and a very slightly banded character. The hornblende crystals can be seen to lie with their long directions in the same plane, and, in general, parallel, thus producing the schistose structure. The feldspar occurs in granular form, with the grains having a tendency toward segregation and arrangement along the plane of the schistosity. The rock is medium grained with the hornblende crystals not more than 2 to 3 millimeters in length. It is found in quite a fresh condition in sheet-like bodies of considerable size.

Microscopic characters.—Under the microscope a thin section (No. H8) of this rock shows a very pronounced schistose structure caused by the parallel arrangement of not only the hornblende but also the short grain-like crystals of plagioclase. The rock is seen to be made up largely of very small crystals of hornblende and plagioclase arranged in bunches. The rock gives evidence of complete recrystallization.

The section shows the following minerals arranged in the order of their abundance: hornblende, plagioclase, zoisite, epidote, titanite, pyrite, iron oxide (largely hematite). The hornblende occurs in elongated, irregular-shaped, often ragged, individuals, arranged in well defined bands where they mutually interfere, and as longer, better developed, prisms in the areas of plagioclase. It is highly colored, and has a well developed pleochroism varying from greenish-blue to yellowish-green to greenish-yellow. It is poikilitic in that it contains as inclusions titanite, pyrite, zoisite and fine dust-like particles. The crystals vary from subhedral to anhedral.

The plagioclase is composed of slightly elongated, anhedral granules, varying in size from one-sixth to one twenty-fourth millimeter in diameter. Twinning is rare although present at places. All the plagioclase is more basic than andesene, and is doubtless labradorite. A mixture of zoisite and epidote is found forming distinct masses and as scattered grains in the feldspar and hornblende. Their bunched arrangement is very striking, as is also their entire absence at places. They occur as equigranular or slightly elongated grains, in shape varying very little from the feldspar grains.

The bunching of the titanite is even more pronounced than that of the zoisite and epidote. At places areas of two millimeters square are seen to be composed of as much as 80 per cent. of titanite, while the surrounding area of many times as great contains practically none. Titanite occurs as confused masses of rounded grains. Pyrite is present in considerable quantity, usually showing an alteration rim of iron oxide, commonly hematite.

Hornblende Gneiss (Auvergnose), Near Burton, Rabun County

CHEMICAL ANALYSIS		NORMATIVE MINERALS	
SiO_2	46.77	Orthoclase	1.11
Al_2O_3	17.31	Albite	17.29
Fe_2O_3	2.24	Anorthite	35.86
FeO	6.48	Nephelite	1.70
MgO	10.44	Diopside	20.02
CaO	12.24	Olivine	18.13
Na_2O	2.40	Magnetite	3.25
K_2O	.21	Ilmenite	1.52
H_2O-	.01	Water, etc	.70
H_2O+	.69		
TiO_2	.81		99.58
P_2O_5	trace		
S	trace		
Cr_2O_3	trace		
NiO	none		
CoO	none		
MnO	trace		
	99.60		

AMPHIBOLE-PYROXENE GNEISS

(Near Hatcher Mountain, 5 Miles East of Phinizy, Columbia County)

Megascopic characters.—The least altered rocks found at this locality are uniformly fine-grained, and have a dark greenish-grey color. When examined with a hand lense, hornblende, feldspar, epidote, pyrite and rarely garnet may be recognized. They have the general appearance of a fine-grained diorite which has a slightly gneissic structure, a feature more apparent in some specimens than in others. Locally the rock consists of 50 per cent. or more of epidote. This rock is seen almost continuously from the Savannah River extending west and forming Burt (?), Dixie and Hatcher mountains to beyond Phinizy. The rock varies from a pyroxene gneiss to a hornblende-pyroxene gneiss and finally to a hornblende gneiss. It is altered locally to a greenish and yellowish serpentine, and peripherally to an amphibolite, which in turn has altered to a talcose rock of varying purity. It is closely associated with later granite. Owing to its superior resistance to weathering, it forms prominent elevations on the ancient peneplained surface. On weathering the rock is converted into a siliceous, cellular mass which is often encrusted and the cavities lined with quartz crystals, or more extensively into a dense siliceous rock.

Microscopic characters—This is a granular rock with allotriomorphic, poikilitic fabric, and a massive to gneissic structure. The rock appears to have completely recrystallized, with the development of a fabric not unlike that developed from original crystallization.

In thin section the following minerals have been recognized: hornblende, plagioclase, augite, epidote, zoisite, chloritic material, calcite, titanite, apatite, magnetite and pleonaste. The relative percentages of these minerals present varies considerably; in some, only remnants of plagioclase remain, their place having been given up to zoisite and epidote. With greater metamorphism more hornblende is present. The plagioclase is seen to enclose magnetite, augite and hornblende; the hornblende may be observed enclosing magnetite and augite; while the augite encloses only magnetite. Thus the order of crystallization has been magnetite, augite, hornblende, plagioclase.

The plagioclase is anorthite, and while it encloses numerous grains of the other minerals present, it is often found in a fresh condition, showing no evidence of alteration. In other sections the feldspar is almost completely altered to zoisite and epidote. Augite, occurring in anhedral grains of varying size, is present in variable quantities; in some specimens it is practically absent; in others it occurs in equal quantities with hornblende, while in still others it is the only ferromagnesian silicate present. It gives no evidence of alteration to hornblende, with which it is closely associated. Hornblende occurs as anhedral, equigranular to very slightly elongated individuals. On account of its distinct pleochroism it can be readily distinguished from the colorless to very faintly pleochroic augite. In the altered sections where augite is entirely absent it seems likely that the augite has given rise to hornblende, although some of the hornblende along with the augite was derived from the recrystallization of the rocks.

Magnetite is present in the fresh rock in subhedral to anhedral grains and elongated masses, usually included in, or in contact with, the ferromagnesian minerals, but exceptionally enclosed in the feldspar. In the more altered rocks pleonaste, titanite and more or less calcite and chloritic material are present. Pleonaste and titanite occur in considerable quantities as fairly large size masses in the zoisite-epidote areas, derived from the alteration of the plagioclase; titanite also occurs in smaller quantities in, or associated with the hornblende. The hornblende is seen in the process of alteration around its edges and along cleavage cracks to chlorite. Calcite is present in association with both the altered hornblende and plagioclase.

Epidote Gneiss (No. 1) and Hornblende Gneiss (No. 2), 5 Miles East of Phinizy, Columbia County

Chemical Analyses			Normative Minerals		
	No. 1	**No. 2**		**No. 1**	**No. 2**
SiO_2	38.45	41.40	Anorthite	62.83	39.48
Al_2O_3	25.00	16.38	Leucite	3.92	5.67
Fe_2O_3	9.08	7.16	Nephelite	2.84	1.70
FeO	1.73	4.90	Diopside	4.54	9.77
MgO	7.48	1.13	Wollastonite		28.65
CaO	15.00	25.62	Olivine	11.62	
Na_2O	.60	.40	Akermanite	.81	1.21
K_2O	.85	1.20	Magnetite	4.41	10.44
H_2O—	.02	.05	Hermatite	6.08	
H_2O+	.08	.30	Ilmenite	.91	1.22
TiO_2	.50	.60	Apatite	1.34	1.34
P_2O_5	.50	.54	Water, etc	.10	.35
S	.08	.04			
MnO	.08	trace		99.40	99.83
	99.45	99.72			

HORNBLENDE SCHIST

(Base of Findley Ridge, near Dahlonega)

Megascopic characters.—This specimen was described by Jones[1] in the following way: "The rock is a medium to fine grained schist of a dark appearance, but flecked with light colored specks. It is

[1] Jones, S. P., Second Report on the Gold Deposits of Georgia: Bull. Ga. Geol. Survey No. 19, 1909, pp. 70-71.

a typical specimen of the rock whose partly weathered product is locally known as 'brickbat.' "

Microscopic characters.—"In thin section it is seen that hornblende is the predominant mineral. Quartz and calcite are the next most abundant constituents. A small amount of plagioclase feldspar is present and pyrite with greater amounts of magnetite or ilmenite occur in rather large quantities for accessory minerals. A small amount of epidote is also present. The hornblende is of the common green variety and occurs as fibers, and elongated, ragged prisms with poorly developed cleavage. The calcite is generally associated with the hornblende and in some cases it can be seen to be an alteration product of that mineral. The quartz occurs as irregular interlocking grains. Much of it shows little or no undulous extinction and is probably secondary in origin. A small amount of plagioclase feldspar in the form of grains is mixed with the quartz. The origin of the rock is obscure. It may have been derived from a diorite. It will be noticed, however, that it is a decidedly more basic rock than a diorite of average composition."

Hornblende Schist (Auvergnose), Base of Findley Ridge, Near Dahlonega

CHEMICAL ANALYSIS		NORMATIVE MINERALS	
SiO_2	46.00	Albite	19.91
Al_2O_3	15.65	Anorthite	32.25
Fe_2O_3	.03	Diopside	23.96
FeO	10.53	Olivine	15.08
MgO	6.31	Hypersthene	1.16
CaO	12.35	Ilmenite	2.74
Na_2O	2.35	Pyrite	.48
K_2O	.03	Water, etc.	5.21
H_2O-	.09		
H_2O+	1.40		100.79
CO_2	3.66		
TiO_2	1.38		
P_2O_5	.00		
S	.27		
MnO	.73		
	100.78		

AMPHIBOLITE

(Two and One-Half Miles East of Villa Rica)

Megascopic characters.—This is a greyish-green, slightly schistose rock composed almost exclusively of hornblends with scales of talc and chlorite. The arrangement of the hornblende needles with their long direction roughly in the same plane gives the natural cleavage to the rock.

The rock is harder than the surrounding gneisses and schists, and differential erosion causes it to form rounded ridges with ledges of the rock coming to the surface. It has altered to form an impure chloritic soapstone. (See description of T. J. Carnes' property.)

Microscopical characters.—In this section (No. H45) monoclinic amphibole, hornblende, and possibly some actinolite, with a very subordinate amount of anthophyllite are seen to form the greater part of the rock. The amphiboles lie with their long directions approximately in the same plane, but in that plane there is only a tendency toward parallelism, which is not strongly developed. The general habit of the amphibole is in the form of elongated prisms, but short, tabular forms are also present, especially in the case of those lying at right angles to the general direction of the longer needles.

The hornblende is only moderately pleochroic and shows maximum extinction angles from 19 to 22 degrees. Around the edges and in some cases the body of the crystal has been changed from pleochroic to colorless. Anthophyllite, in small quantities, can be recognized by its parallel extinction and non-pleochroic nature. Sphene is present in segregated masses of considerable size; magnetite is present in very fine grains. Talc and chlorite are present as decomposition products; and what is unusual in this type of rock, the talc is developed in greater quantities. In general, the formation of the talc appears to be somewhat later than that of the chlorite, while there is a very strong suggestion that the chlorite is at places altering to talc. Talc is found partly surrounding chlorite and showing gradations, well illustrated by the difference in the interference colors, from the one to the other. The talc is developed around the edges of the amphiboles and rarely projects into them except along cleavage lines. The zone of alteration is often quite narrow, but distinct. The alteration has progressed without the deposition of either magnetite or carbonate in appreciable quantities. In no case is the talc pseudomorphous after the amphibole, as is commonly the case in anthophyllite rocks.

Chlorite is present in numerous blade-like crystals, as well as ill-defined masses of a chloritic material which is non-pleochroic. The chlorite is very slightly pleochroic, showing the same colors as pennine, and is optically positive with a very small optical angle. It is formed not only around the edge of the hornblende, but as foliae projecting from one crystal into an adjoining one without regard to the structure of those minerals. The alteration to chlorite and chloritic material is accompanied by a gradual change in the pleochroism and especially in the birefringence, and often leads to the development of pseudomorphous forms, especially in the case of the latter.

DIORITES AND GABBROS

DISTRIBUTION AND GENERAL CHARACTERS

Although the diorites and gabbros are extensively distributed over the Crystalline Area of Georgia, there are four principal areas which stand out prominently and may be designated for convenience of description by the following names: the Elberton-Union Point-Monticello area; the Hiawassee-Dahlonega area; the Dallas-Carrollton area; and finally the LaGrange-West Point area. In the brief description of each of these areas which follows, it will be understood that they represent belts in which numerous more or less disconnected masses of these rocks occur and where they are more prominent than in the intervening regions.

ELBERTON-UNION POINT-MONTICELLO AREA

The first area mentioned above, occupies an elongated belt extending from east of Elberton southwest through Wilkes and Oglethorpe counties to near Union Point; and after a considerable break it is found continuing from near Monticello southwest through the northwestern corner of Jones, the southeastern part of Monroe and into Crawford County. This belt has been studied 7 miles south of Monticello, east of Union Point and east of Elberton, and rocks from these localities will be described later. The most general type of rock found here is a diorite or hornblende gabbro, which varies in texture from medium, even grains to porphyritic, and ranges in structure from massive to schistose. With an increase in the amount of hornblende the rock shows transitions to hornblende schist, or with the development of a schistose structure it grades into a hornblende gneiss. The rocks are characterized by basic plagioclase, ranging from labradorite to anorthite, and secondary hornblende.

The least altered masses consist essentially of plagioclase and augite or diallege, and more or less secondary hornblende. They are medium to coarsely crystalline and massive in structure, although the component minerals show the effects of crushing. There is a complete gradation from this type of rock into the more common one described above. The least altered rocks may be termed gabbro; the partially altered ones where augite and secondary hornblende are present may be termed gabbro-diorites; while those in which the augite has been completely altered to hornblende may be termed diorites, or more fittingly hornblende gabbros, because of the basisity of the plagioclase and the small amount of orthoclase present.

The belt as a whole is characterized by the uniformity in the composition of its rocks, as may be seen from the descriptions and analyses which follow. The pyroxenic phase is as conspicuously absent as the peridotitic, and in this respect this area stands in sharp contract to the Hiawassee-Dahlonega area.

These rocks occur both in large, elongated masses and in dikes of varying widths cutting the Carolina gneiss, and closely associated with,, and often cut by, granites and pegmatites. The relationship between the massive rocks and the typical schistose rocks of the Roan gneiss is not clearly shown; in general, the massive rocks appear to be somewhat more recent on account of their less altered character. The alteration of these rocks has lead to the formation of masses of impure chloritic soapstone, and more rarely to true soapstone; asbestos is found in limited quantities along shearing planes.

HIAWASSEE-DAHLONEGA AREA

The area of basic rocks which occupies a part of Towns, Union and Lumpkin counties, termed the Hiawassee-Dahlonega area, is characterized by the amount of differentiation that has taken place in the original magma, leading to the development of numerous rock types and especially of transitional varieties. Thus olivine gabbro and troctolite are found, the former representing a transition between normal gabbro and dunite, while the latter may be considered a transition between olivine gabbro and anorthite, or normal gabbro and dunite.

The most general type of basic rock found here, as elsewhere, is hornblende gneiss, which grades into more or less massive diorite. Aside from these, the most interesting rocks are the dikes of gabbro, olivine gabbro, troctolite, dunite, etc. These dikes are closely associated with the more schistose rocks, thus showing their close relationship; they cut the latter and thus are to be considered somewhat later in age, although belonging to the same period of intrusion. While not so extensively altered as the schistose rocks, under the microscope they are seen to have been extensively crushed and somewhat granulated, and in part extensively altered in composition. An interesting feature of these rocks, especially of the troctolites, is the corrosion mantles,[1] which are referred to under the description of that type of rock. Only the two types of rocks not found in the preceding area, olivine gabbro and troctolite, will be described here. Troctolite is described here with the gabbros because of its relation to those rocks as a transition type.

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[1] This feature has been extensively discussed by Pratt and Lewis; Corundum and Peridotites of North Carolina, N. C. Geol. Survey Vol. 1, pp. 146-151.

DALLAS-CARROLLTON AREA

A considerable area of basic rocks is found to extend from east of Canton southwest, past Blackwells Station, Dallas and Villa Rica to Carrollton. This area may be considered to be the southwestern extension of the Hiawassee-Dahlonega area, in which similar types of rocks are found to occur. Over this belt gabbros are most common near Dallas and Villa Rica, where they occur as dikes of varying width showing the same relations to the schistose rocks as has been previously described. Peridotites and, less commonly, pyroxenites are found here in the form of dikes of limited dimensions. Occasionally, what appear to be segregations of magnetite are found associated with these rocks, especially in the neighborhood of Dallas.

The basic rocks are here associated with ancient granite gneisses and are cut by more recent granites and pegmatites. These rocks have altered to form soapstones, chloritic schists and, to a small extent, asbestos. Soapstone is developed in considerable quanities near Canton, Dallas and Carrollton. It is evident from a study of the rocks that the formation of asbestos was interrupted by changed physical conditions before the process was completed.

LAGRANGE-WEST POINT AREA

A small, though conspicuous, area of basic rocks extends from west of LaGrange south to West Point. Within this area, which represents the southwestern limit of the belt of peridotites and pyroxenites in Georgia, are found gabbros and diorites in considerable quantities, besides hyperites, and hypersthenites and variously altered rocks. The more basic rocks are found most abundantly in the neighborhood of West Point, where they have been prospected for asbestos with little success. This belt is characterized by large quantities of orthorhombic pyroxenes, not only in the pyroxenites, but also in some of the gabbroic rocks.

PETROGRAPHY

The samples here described represent typical specimens of the various types of rocks under discussion. The analyses included are those of the rocks described; and in case the description covers more than a single specimen, the analysis was made of the least altered one.

A comparison of the analyses as well as of the descriptions of the rocks will reveal the fact that they are all very similar, the greatest difference resulting from the fact that they have been variously altered.

GABBRO

(Ogeechee Brick Plant, Union Point)

Megascopic characters.—This is a dark, massive, medium, even-grained rock with a granular appearance. When examined more closely it is seen to be composed largely of feldspar and green hornblende. The former has a greyish-lavender color which does not present much of a contrast with the hornblende. Small grains of pyrite also may be seen. The rock appears to have possessed originally a somewhat ophitic structure, but this feature is now obscured by the secondary development of hornblende; the plagioclase had a tedency to form elongated crystals, while the augite filled the interstices.

When further altered, the rock passes into a hornblende schist or gneiss which, in turn, gives rise to an impure chloritic soapstone, often of quite massive structure.

Microscopic characters.—In thin section (No. H92) this rock is seen to contain plagioclase and diallege as original constituents, with hornblende, chlorite, magnetite, carbonate and talc as alteration products.

The plagioclase (labradorite and bytownite or anorthite) is present in large tabular and prismatic crystals. It is not fresh, but contains dust-like particles and long, lath-shaped crystals which are visible only under high power lenses. Alteration has taken place to form hornblende and a small amount of chlorite. The latter is seen as small leaves and shreds projecting into the plagioclase around the edges and also following along cleavage lines into the center of the crystals. At places the feldspar appears to have given place entirely to leaves of chlorite arranged in rosettes. The chlorite is distinctly pleochroic: a and b showing light bluish-green and c a faint yellow tone. The pyroxene shows both 110 and 100 cleavages well developed, and is doubtless diallege; in large measure it is filling interstices between the plagioclase individuals, and appears thus to have crystallized somewhat later than it. It is largely altered to hornblende, leaving only central cores of the mineral unaltered. Alteration appears to have begun along the contact between the diallege and the plagioclase, and progressed inward toward the centers of the diallege crystals. The hornblende thus formed is brownish-green and stands in sharp contrast to the enclosed diallege. Beside this deeply colored hornblende, confused masses of colorless, slightly pleochroic amphibole are present in the form of much elongated prisms. Confused masses of talc, derived from the colorless amphibole, occur in small quantities. A small amount of apatite, magnetite and hematite, but no epidote, were observed.

Gabbro (Hessose), Ogeechee Brick Plant, Union Point

CHEMICAL ANALYSIS		NORMATIVE MINERALS	
SiO_2	48.42	Orthoclase	1.11
Al_2O_3	19.46	Albite	24.10
Fe_2O_3	1.44	Anorthite	37.81
FeO	4.22	Nephelite	1.99
MgO	8.69	Diposide	15.25
CaO	11.66	Olivine	14.12
Na_2O	3.29	Magnetite	2.32
K_2O	.18	Ilmenite	1.22
H_2O-	.08	Apatite	.34
H_2O+	1.06	Water, etc.	1.24
TiO_2	.60		
P_2O_5	.15		99.50
S	.10		
Cr_2O_3	.08		
NiO	trace		
CoO	trace		
MnO	.10		
	99.53		

GABBRO

(Eight Miles Southeast of Elberton)

Megascopic characters.—This is a light, greenish-grey rock composed largely of feldspar and hornblende, with the former greatly predominating. It is a massive, moderately coarse grained rock. The hornblende is dark green and evenly scattered through the rock; the feldspar is fresh and glassy. On account of the large percentage of plagioclase, which was found to be largely anorthite, this rock approaches an anorthosite.

Microscopic characters.—Approximately 80 per cent. of this rock (Sec. H79) is formed of anorthite, with subordinate amounts of hornblende, augite, zoisite, chlorite and magnetite, named in the order of their abundance.

The anorthite occurs in anhedral, tabular crystals of varying dimensions. It has been extensively twinned and cross-twinned, with the bands representing the albite twinning of variable width from fine lines to relatively broad bands. It shows three alteration products: hornblende, zoisite and chlorite. The hornblende has been developed largely at the expense of the augite, but also from the anorthite, particularly around the contacts of the latter, and as narrow rods entirely enclosed within it. Zoisite, and probably some epidote, is extensively developed in the anorthite, either in bunches or scattered along distinct lines, which appear to represent fractures in the anorthite.

Chlorite is found in conspicuous quantities both scattered through the plagioclase and in confused masses near its edges and projecting inward. The chlorite is distinctly pleochroic, and in some instances is strongly so. It clearly follows lines of fracture in the anorthite, and occurs usually near the contact of the plagioclase with hornblende. It has a small optical angle and is optically positive.

Augite is represented as small cores in the hornblende, which was formed from its alteration. Although there is no sharp line of separation, the alteration has progressed from the circumference toward the center of the augite. There is considerable difference in the appearance of the hornblende; in the case of the same individual, one part may be strong pleochroic while the other part is practically colorless. Its pleochroism is as follows: $\mathfrak{a}$ = greenish yellow; $\mathfrak{b}$ = dark to light yellowish green; and $\mathfrak{c}$ = greenish-blue. or blue. Magnetite and pyrite are present in small quantities, as is also hematite.

Gabbro (Corsase), 8 Miles Southeast of Elberton

CHEMICAL ANALYSIS		NORMATIVE MINERALS	
SiO_2	41.65	Orthoclase	6.12
Al_2O_3	26.54	Albite	1.57
Fe_2O_3	1.60	Anorthite	63.36
FeO	5.76	Corundum	1.84
MgO	7.20	Enstatite	6.31
CaO	13.48	Olivine	15.17
Na_2O	.20	Magnetite	2.32
K_2O	1.02	Apatite	1.34
H_2O-	.10	Water, etc.	2.10
H_2O+	2.00		
TiO_2	trace		100.13
P_2O_5	.56		
S	trace		
MnO	none		
	100.11		

HORNBLENDE GABBRO

(Bethlehem Church, 13 Miles East of Elberton)

Megascopic characters.—This rock outcrops at a number of places along the public road near Bethlehem Church, where it shows a wide variation in the amount of alteration. In a hand specimen, this rock is seen to contain green hornblende dotted regularly with a dull white mineral. It is a massive to very slightly gneissose rock of porphyritic structure. Hornblende phenocrysts as much as 12 millimeters in length occur here and there as equidimensional to irregular shaped grains. In the hand specimen the rock has the general appearance of a porphyritic diorite.

Microscopic characters.—In this section (No. H2) this rock is seen to contain the following minerals named in the order of their importance: hornblende, zoisite, epidote and plagioclase (bytownite or anorthite), titanite and a small amount of iron oxide. The amphibole, which shows a maximum extinction angle of 22°, occurs in large poikilitic phenocrysts enclosing titanite, epidote and exceptionally masses of partially decomposed feldspar, and also as small individuals arranged in all directions in respect to each other and mutually interfering with one another. It shows a pale-green body color and a moderate amount of pleochroism. It appears to be entirely secondary, and, in part, derived from the feldspar. Only traces of original feldspar crystals remain, their decomposition having given rise to epidote, zoisite and hornblende. The epidote and zoisite form masses of considerable size, which are composed of numerous irregular-shaped individuals; they are also contained as inclusions in the feldspar in the form of small particles. Titanite is present in much larger quantities than is suggested in the accompanying analysis; it occurs as fine grains scattered through the hornblende as well as included in the epidote-zoisite masses. It shows at no place its crystal outline and has been recrystallized, and at places segregated into masses of considerable size.

A rock from the same locality, although somewhat more altered from it original nature may be described as follows:

The rock is seen to be composed largely of hornblende, identical with that described in thin section No. H2, but it is in the process of alteration to chlorite and talc. The hornblende contains inclusions of titanite and magnetite, of which the latter was practically absent in the previous section. Chlorite occurs as small foliae arranged in all directions in the hornblende, from which it was derived, although showing a tendency toward arrangement of the long direction of the leaves in parallel position with the cleavage of the hornblende; it is optically positive with a very small optical angle; $\mathfrak{a}$ and $\mathfrak{c}$ = greyish-green, and $\mathfrak{b}$ = yellowish. Optically, the mineral is very close to pennine. Talc is in the process of formation from the hornblende; it occurs either as massses around its edge and more particularly as foliae along the cleavage lines of the hornblende where the cleavages of the two minerals are parallel. While the chlorite shows a sharp boundary separating it from the hornblende, the talc is separated from the latter by a transition zone and is later in origin than the chlorite, having the appearance of being, in part, derived from it. Besides the minerals mentioned above, a small amount of epidote was seen.

Hornblende Gabbro, Bethlehem Church, 13 Miles East of Elberton

CHEMICAL ANALYSIS		NORMATIVE MINERALS	
SiO_2	46.87	Orthoclase	8.90
Al_2O_3	14.36	Anorthite	28.63
Fe_2O_3	1.68	Leucite	1.31
FeO	6.05	Nephelite	5.40
MgO	11.10	Diopside	38.06
CaO	15.50	Olivine	13.44
Na_2O	1.20	Magnetite	2.32
K_2O	1.80	Ilmenite	.61
H_2O-	.10	Apatite	.34
H_2O+	.60	Water, etc.	.70
TiO_2	.30		
P_2O_5	.19		99.71
S	trace		
MnO	.10		
	99.85		

HORNBLENDE GABBRO (ALTERED)

(Bethlehem Church, 13 Miles East of Elberton)

Megascopic characters.—This rock is similar in general appearance to other diorites of the region except that it is more altered. It is medium to fine grained and massive to very slightly schistose. Light greenish grains of epidote appear to be second in abundance to the fine grains of almost black hornblende. Pyrite is quite abundant, while feldspar is scarcely recognizable.

Microscopic characters.—In thin section (No. H86) this rock is seen to contain the following minerals arranged in the order of their abundance: hornblende, epidote, plagioclase, quartz, zoisite, chlorite, pyrite, iron oxide and leucoxene.

The plagioclase is too much altered to permit the determination of its variety, but it belongs to the basic end of the series, and is probably labradorite. Its alteration has lead largely to the formation of epidote and zoisite, with the concomitant separation of silica in the form of quartz. Some hornblende was also formed from the plagioclase; it occurs as ragged poikilitic aggregates enclosing quartz from fine particles up to grains of fair size. It also encloses pyrite and iron oxide in large quantities. Its pleochroism is very strong: $\mathfrak{a}$ = bluish-green, $\mathfrak{b}$ = yellowish-green to dark green, and $\mathfrak{c}$ = pale yellow to almost colorless. It gives evidence of being entirely of secondary origin. The quartz occurs in anhedral, irregular-shaped grains enclosed in, and associated with, both the plagioclase and the hornblende. Its presence in such quantities is very exceptional in these rocks so far as studied. Epidote greatly predominates over zoisite, and the two are found evenly scattered with the quartz and hornblende through the rock section. Chlorite is sparingly developed in the form of spherulitic aggregates, as well as in foliae, and is formed from the alteration of hornblende. Pyrite, in the process of alteration to iron oxide, is very abundant.

HORNBLENDE GABBRO

(Seven Miles South of Monticello)

Megascopic characters.—This is a dark-green rock mottled with white spots. It is medium-grained and massive, with the very slightest tendency toward a gneissic structure. It can be clearly seen that dark-green to almost black hornblende and feldspar are the chief constituents of less altered parts of the rock mass; but with decrease in the amount of plagioclase it grades into a rock composed almost entirely of hornblende, which, upon alteration, passes into an impure, chloritic soapstone. The rock might be called a diorite, but for the basic plagioclase present, which suggests the term hornblende gabbro. Although the relationship here is not well displayed, further to the northeast at Union Point, the rock has been found to contain augite in the process of alteration to hornblende, and consequently the rock is considered an altered gabbro.

Microscopic characters.—This rock (Sec. H32, H78) is found to be composed essentially of hornblende and basic plagioclase feldspar with subordinate quantities of titanite, epidote, pyrite, and chlorite. The plagioclase (bytownite or anorthite) occurs as small grains and larger masses of anhedral crystals, which clearly show the effect of granulation. Both sets of cleavages are very prominently developed and twinning according to both albite and pericline laws is common. Long prisms of epidote are seen penetrating the small grains of plagioclase and often extending through more than one grain. Hornblende, which is entirely secondary, is developed around the edges of the plagioclase, commonly projecting into it. The jagged contacts of these minerals and the projection of the one into the other, and the fact that hornblende often encloses irregular masses of lagioclase, clearly shows that the feldspar has given rise to hornblende. The hornblende varies from equidimensional grains to tabular form; much elongated prisms are practically absent. The masses of hornblende are composed of numerous irregular-shaped grains, oriented in all possible directions. Small masses of plagioclase are at places seen entirely surrounded by a hornblende crystal, while some of the larger hornblende individuals are shot through with other smaller ones of a later period of growth. In a section of somewhat more altered rock, small laths of hornblende are seen included in the plagioclase, while the larger crystals of hornblende contain leaves and shreds of faintly pleochroic chlorite. The latter represents the incipient stage of the alteration of this rock to a chloritic soapstone which is found near by. Pyrite is quite abundant at places in the fresh rock, and in the more altered ones it is observed in the process of alteration to hematite.

OLIVINE GABBRO

(Hog Creek Corundum Mine, 2½ Miles West of Hiawassee)

Megascopic characters.—This is a hard, dark greyish-green rock of massive structure. When examined with the hand lense, olivine, feldspar, hornblende (?), and pyrite may be recognized. The weathered portion shows that the olivine was the first mineral to decompose and form ocherous spots, surrounded by the other minerals. The rock is of medium-grained texture.

Microscopic characters.—The original constituents of this rock (No. H48) are diallege, olivine, plagioclase and possibly a small amount of enstatite. Alteration which the rock has suffered has destroyed the relationship of these minerals to one another, as well as the structure and fabric of the rock.

The diallege contains the two cleavages characteristic of that mineral as well as numerous irregular cracks along which a green serpentinous mineral occurs. The diallege is filled with dust-like inclusions. It has altered directly to form pale greenish hornblende in small quantities. The plagioclase is much altered, and only remnants of its original masses are present; it is either bytownite or anorthite, in which epidote or zoisite have been developed to a slight extent. The olivine has been extensively fractured, and along the fracture lines altered to a slight extent to greenish-yellow serpentine and magnetite. The olivine seems to represent relatively large crystals which have been crushed and, in part, recrystallized.

Irregular-shaped, felted masses of fibrous, radiating minerals, surrounded, in general, by narrow bands of secondary enstatite and other minerals, are characteristic of this rock. These masses occur often in association with the altered plagioclase and the diallege or olivine; but also surrounding large plates of diallege when that mineral is surrounded by olivine. The secondary enstatite is commonly found fringing the olivine grains.

The felted masses appear to be made up entirely of enstatite and diopside. These minerals occur in rosettes or fan-shaped aggregates of slender prisms arranged in radiating form.

The enstatite can be easily distinguished from the diopside by its parallel extintion and lower birefringence. The diopside shows a positive character, a moderate sized optical angle and an extinction up to 40°. Hornblende can not be recognized in these masses, although it may occur. Diopside is the more abundant, and is found usually surrounding the decomposed plagioclase as well as with the diallege and olivine, where it is associated with enstatite.

TROCTOLITE

(Brasstown Creek, 1¾ Miles North of Young Harris)

Megascopic characters.—This rock has a dark, yellowish-green color and a massive structure. With unaided eye it can be seen to be composed of yellowish masses of olivine grains surrounded by a fine-grained, greenish ground mass, the individual minerals of which can not be recognized.

Microscopic characters.—Olivine appears to be the only original mineral in this section (No. H37). It occurs as large grains which have been much crushed, and, in part, recrystallized. The fractures are filled with a central stringer of magnetite and separated from the olivine by greenish-yellow serpentine. At places the magnetite is collected into masses of considerable size. The olivine grains are commonly surrounded by a band of short, stocky, crystals of actinolite arranged with the crystallographic c axis sometimes parallel, but usually perpendicular to the surface of the enclosed olivine. A small amount of enstatite is present in the place of actinolite. In the spaces between the olivine grains, and enclosed by a layer of actinolite, are fine-grained, granular minerals, the exact nature of which could not be determined. These areas were formerly occupied by feldspar, only traces of which remain, and are believed to be formed of actinolite, enstatite, etc. Some large leaves of what appears to be chlorite are found associated with these fine-grained minerals. Both pleonaste and picotite occur, often forming the same individual.

A somewhat fresher sample of this rock has been described as follows:[1]

"The section is over half composed of olivine, which is slightly altered to yellowish serpentine, especially along the cleavage cracks. The serpentine contains numerous magnetite granules, particularly along the central portion, making the position of the original crack. Plagioclase feldspar (probably anorthite) occurs in only a few large remnants. Large areas of it have been entirely replaced by the corrosion products. Occasionally grains of translucent picotite occur.

"The corrosion mantles are only two-ply in this rock, and consist of (1) enstatite in broad plates next to the olivine, usually nearly colorless; (2) pale-green monoclinic amphiboles, in slender needles and narrow laths, usually slightly pleochroic in greenish and yellowish tones and always associated with much pleonaste in parallel arrangement and irregularly intermingled. As olivine preponderates over the feldspar in this rock, the latter is often entirely replaced by the corrosion minerals. In such cases, the 'nests' of minerals replacing the feldspar consist, in some cases, of enstatite alone; in others, enstatite forms the border next to the olivine, with amphibole in the center. Picotite grains surrounded by the corrosion minerals show a gradual transition from dark-brown color in the central portion to the light-green of the pleonaste about the borders; among the olivine, picotite does not show this character."

PERIDOTITES AND PYROXENITES

DISTRIBUTION

On account of their association with corundum, which was extensively prospected for some years ago, the distribution of peridotites and other basic, magnesian, dike rocks is fairly well known. The area in which these rocks are found was termed the "corundum belt;" but it may more fittingly be called the belt of peridotites and pyroxenites. It stretches from east central Alabama in a northeastern direction through Georgia, the northwestern corner

[1] Pratt and Lewis, Corundum and the Peridotites of North Carolina: N. C. Geol.. Survey, Vol. 1, 1905, p. 69.

of South Carolina, across North Carolina, Virginia, and Maryland, and with some interruption it continues north into Canada. This belt enters Georgia from the south in Troup and Harris counties, and passing northeast near Atlanta it enters North Carolina from Towns and Rabun counties. These basic dike rocks are relatively more numerous in the northeastern part of the belt than in the southwestern. Outside of this major belt, a number of small outliers are found to the east. The peridotites and pyroxenites are most important in Rabun, Towns and Habersham counties, and it is from them that the asbestos deposits have been derived.

While the peridotites and pyroxenites are closely associated, the peridotite type is much more common. The general distribution of these rocks may be seen on map opposite page 14.

CHARACTER AND RELATION

The basic dike rocks referred to here may be included under the two rock families, peridotites and pyroxenites. Mineralogically they are characterized by the presence of olivine and enstatite, which are present in variable proportions. Thus the rocks vary from those composed essentially of olivine, dunite, to rocks composed essentially of pyroxene, as in the case of enstatitite. Of the pyroxenes the orthorhombic varieties are by far the most common, and predominate over the monoclinic varieties in every rock studied, with a single exception. Of the orthorhombic pyroxenes, enstatite is the most common, but bronzite and hypersthene may also be present. As would naturally be expected, the end members of the series, those composed entirely, or almost entirely, of olivine or pyroxene, are not so usual as the intermediate varieties. Thus a rock composed of olivine and enstatite, harzburgite, is very common; in this, however, the olivine usually predominates. Corundum is often associated with these rocks, either as small crystals scattered through certain portions of the rock, or in massive form in well defined veins. Besides corundum, chromium, nickel and cobalt are often found in small quantities. Chromium occurs as chromite in grains scattered through the rock mass and in the form of small segregations; nickel, and probably also cobalt, occurs as silicates, derived through leaching from the rock mass, encrusting the walls of these rocks along jointing planes.

These rocks have been extensively altered both in structure and most conspicuously in mineral composition. As a rule the peridotites and pyroxenites have preserved their massive structure to a greater or less extent; but in some instances where the dikes are small, they have developed a schistose structure. From a microscopic study, it has been observed that all the rocks have undergone extensive crushing, which has lead to the fracturing of the component minerals, especially the olivine, and in a large number of cases, to granulation.

The alteration of both peridodites and pyroxenites has commonly lead to the formation of amphibole, which has later altered, to a variable degree, to talc. The development of large masses of serpentine, which are so common in connection with these rocks in Canada and the northeastern part of the United States, is the exception here. Serpentine is usually present, but in subordinate amounts.

In case the alteration to amphibole is complete, and the fibrous form is developed without the extensive development of talc and carbonate, deposits of asbestos are formed. The most general case, however, is where the development of amphibole has not been completed and where the rock has subsequently been subjected in the belt of weathering to the processes of hydration and carbonation; thus, an impure soapstone is developed which may contain original pyroxene or olivine, or both together with amphibole, talc, serpentine, magnetite and calcite or dolomite. Although the orthorhombic pyroxenes may give rise directly to talc, the process often has an intermediate step—the development of amphibole.

The peridotites and pyroxenites and their alteration products occur as dikes, usually associated with the hornblendic rock previously described, but in some instances they are included in schists and gneisses of the Carolina series, and exceptionally in more recent granites. Although usually much altered along their contacts, the bodies are well defined. They vary in width from a few feet to a few hundred feet; and in length from a hundred yards to a fraction of a mile. As a rule the dikes are small and much altered. When associated with hornblende schists and gneisses, they are sometimes seen to cut across those formations, indicating a somewhat later origin.

PETROGRAPHY

As in previous sections, typical specimens of this class of rocks are included here along with analyses of some of the freshest specimens. Practically all the rocks here described come from the northeastern part of the belt, since it is there that the least altered material is available.

HARZBURGITE

(John Martin Property, near Soque, Habersham County.)

Megascopic characters.—This is a fine-grained, yellowish to bluish-gray rock, in which olivine can be recognized as the dominant constituent. Coarser grained masses of light yellow pyroxene can be recognized, as well as long needles of amphibole and a few scales of talc and considerable magnetite or chromite.

On the weathered surface talc scales stand out prominently in a groundmass of ocherous grains of decomposed olivine. The transition is well shown in a single specimen, from the fresh, bluish-grey material to a light greenish-yellow band, and finally to the ocher-yellow surface.

Microscopic characters.—Olivine (Sec. H27) in the form of equidimensional grains, varying in diameter from two-fifths to one-twentieth of a millimeter and averaging approximately one-fifth of a millimeter, clearly shows the effect of crushing and recrystallization. The olivine grains have been cracked, and along these openings and particularly around the edges of the grains, colorless to pale yellow serpentine has been developed in small quantities. Along certain lines in the rock it is more abundant than at other places. The olivine contains numerous fine grains of magnetite, in subhedral or anhedral form. The grains of olivine are penetrated infrequently by long needles of anthophyllite.

The pyroxene is determined as enstatite. It occurs both in small, irregular-shaped grains and as larger poikilitic individuals enclosing grains of olivine. In a single instance, 50 per cent. of the total area covered by a large enstatite individual is occupied by olivine grains. Magnetite is also included in the enstatite.

Anthophyllite, as well as a smaller amount of cummingtonite (?), is present in the form of long needles penetrating the olivine as well as the enstatite. These needles are quite fibrous and show numerous cross fractures. These two minerals, and also the enstatite, are seen altering to talc. Confused masses of talc appear to form first; and later these are converted into broad foliae. A few shreds and leaves of very faintly pleochroic chloritic material were observed. In addition to the small irregular-shaped grains of magnetite in the olivine and enstatite, magnetite also occurs as large, anhedral crystals impressing its form on the surrounding minerals.

Harzburgite (Gordunose), John Martin Property, Near Soque, Habersham County

CHEMICAL ANALYSIS		NORMATIVE MINERALS	
SiO_2	46.00	Orthoclase	.56
Al_2O_3	.99	Albite	3.14
Fe_2O_3	2.19	Anorthite	.83
FeO	5.90	Enstatite	32.81
MgO	42.00	Olivine	57.08
CaO	.14	Magnetite	3.25
NaO	.42	Pyrite	.48
K_2O	.12	Chromite	.22
H_2O-	.15	Water, etc.	2.29
H_2O+	2.14		
TiO_2	trace		100.66
P_2O_5	trace		
S	.28		
Cr_2O_3	.12		
NiO	.16		
CoO	trace		
MnO	.08		
	100.69		

HARZBURGITE

(Ten Miles Northeast of Clayton)

Megascopic characters.—In this rock of light greyish-yellow color may be recognized olivine, enstatite, magnetite or chromite and a few scattered scales of talc. Along the joints in the rock encrustations of nickel silicate are present. The rock is massive and granular.

Microscopic characters.—In thin section (No. H61) this rock is found to be composed largely of grains of olivine, ranging from one to three millimeters in diameter. These have been badly fractured and in part granulated; but as a rule they have preserved their integrity better than in any other rock examined. It has been altered to a slight extent to serpentine. Enstatite is present as large poikilitic crystals enclosing grains of olivine. At places a large network of enstatite comprising a single individual surrounds numerous grains of olivine of varying sizes. A few short prisms of colorless, monoclinic amphibole of original character are present.

Yellowish serpentine is present in the fissures in the grains of olivine as well as in the enstatite. Leaves of chloritic material are present as an alteration product from the amphibole; and in some instances its association with olivine suggests its derivation from it. The crystals usually elongated parallel to its cleavage, show two straight, sharp sides, but their ends may be more or less jagged. Magnetite is present as anhedral or subhedral crystals in the olivine and enstatite.

Harzburgite (Gordunose), 10 Miles Northeast of Clayton

CHEMICAL ANALYSIS		NORMATIVE MINERALS	
SiO_2	44.83	Albite	1.57
Al_2O_3	1.40	Anorthite	.56
Fe_2O_3	1.30	Corundum	.92
FeO	7.83	Enstatite	30.64
MgO	42.04	Olivine	62.10
CaO	.08	Magnetite	1.86
Na_2O	.18	Pyrite	.48
K_2O	.05	Chromite	.22
H_2O-	.18	Water, etc.	1.79
H_2O+	1.61		
TiO_2	.00		100.14
P_2O_5	.04		
S	.26		
Cr_2O_3	.15		
NiO	.20		
CoO	trace		
MnO	.15		
	100.30		

HARZBURGITE

(J. H. Cantrell's Property, 1½ Miles South of Smyrna, Cobb County)

Megascopic characters.—This rock differs from the others described under the name harzburgite, in the ratio of the olivine to the enstatite. In the other specimens described olivine predominates over the enstatite, while in this one the two minerals are present in almost equal quantities. In this yellowish-grey rock, the olivine can be distinguished with difficulty from the enstatite, on account of the crushing and shearing the rock has suffered. Here and there may be recognized plates of enstatite in the finer-grained groundmass of olivine and enstatite grains. Some magnetite and scales of talc are also present. The harzburgite is represented at the surface by a talcose-chloritic rock. (See description of Cantrell property.)

Microscopic characters.—As stated above, the rock (sec. H91) is composed essentially of olivine and enstatite in about equal quantities. Under the microscope evidence of shearing leading to the development of a somewhat gneissic structure, is quite plain. Both the enstatite and olivine are extensively fissured and traversed by veins of yellowish serpentine. Enstatite is seen to enclose grains of olivine, thus showing that it crystallized somewhat later. On account of the strong development of the prismatic cleavage, the enstatite has at places assumed a pronounced columnar structure. Chromite is present, as well as magnetite in both primary and secondary form. Besides the serpentine, which forms a network of veins in the olivine and enstatite, talc is also present as an alteration product of the latter. Faintly pleochroic chlorite with a very small optical angle and positive character is found usually in association with olivine as large, clean cut foliae. A small amount of dolomite (?) is present.

The amount of chlorite which has developed from this olivine-enstatite rock is worthy of note.

DUNITE

(Chromite Mine, 2¾ Miles Southwest of Hiawassee)

Megascopic characters.—This rock is a typical dunite in which olivine and magnetite (or chromite) can be recognized. It has a greenish-yellow color and a granular texture. This specimen represents the least altered rock of its kind found in the State.

Microscopic characters—It is a medium-grained rock (sec. H53) in which the olivine individuals, which are badly fractured, range up to one or one and one-half millimeters in diameter. Around the border of the olivine grains, and along the fractures in them, yellowish serpentine has been formed with the separation of magnetite. Associated with the serpentine are a few leaves and shreds of chloritic material which have very faint, if any, pleochroism. Chromite is present in considerable quantity, somewhat larger than is suggested by the accompanying analysis. It occurs in irregular-shaped grains and masses of considerable size, usually less than that of the olivine grains. Along thin edges it shows the characteristic coffee-brown color. The individual grains of the rock have been badly shattered and commonly granulated along the edges. The shattering, together with the granulation and formation of serpentine, has completely obscured the original fabric of the rock.

Dunite (Dunose), Chlorite Mine, 2¾ Miles southwest of Hiawassee

CHEMICAL ANALYSIS		NORMATIVE MINERALS	
SiO_2	41.20	Albite	2.10
Al_2O_3	1.19	Anorthite	1.39
Fe_2O_3	1.20	Corundum	.31
FeO	8.20	Enstatite	8.19
MgO	44.81	Olivine	83.42
CaO	.30	Magnetite	1.86
Na_2O	.27	Ilmenite	.15
K_2O	.04	Pyrite	.60
H_2O-	.03	Water, etc.	2.29
H_2O+	2.16		
TiO_2	.09		100.31
P_2O_5	trace		
S	.33		
Cr_2O_3	.06		
NiO	.38		
CoO	trace		
MnO	.10		
	100.36		

DUNITE

(Near Bethlehem Church, 13 Miles East of Elberton)

Megascopic characters.—This rock is so dense that the individual minerals can not be recognized even with a hand lense. It is a greyish-black rock of massive texture cut by veins of what appears to be yellowish serpentine.

Microscopic characters.—Under the microscope (sec. H83) this rock is seen to be composed of olivine and magnetite as the only original minerals, and a variable amount of alteration products. The olivine occurs as large crystals up to 4 millimeters in diameter and possessing an abnormally good cleavage. The large grains have been badly shattered with the subsequent development of serpentine along the fissures. Needles of colorless, monoclinic amphibole are seen penetrating the olivine crystals here and there. They have been extensively cross-fractured and in part altered to chloritic and serpentinous material, and, to a less extent, to talc. The amphibole occurs abundantly in places as a confused mass of needles in a serpentinous groundmass. Magnetite is present in large quantities as small granules in the olivine and also as stringers in the center of the veins of serpentine, and particularly as segregated masses in the alteration products. A small amount of carbonate is also present.

This rock is of particular interest in that it is far removed from the general belt of peridotites, and is the only rock of its kind found in that part of the State.

METAPERIDOTITE

(Wykle Property near Soque, Habersham County)

Megascopic characters.—This is a dense, dark-grey rock in which olivine may be recognized as the dominant constituent, together with magnetite and scales of talc. It outcrops in the form of rough, grey boulders on the steep mountainous slopes.

Microscopic characters.—Under the microscope this rock (sec. H10) is seen to contain about 50 per cent. olivine and almost an equal quantity of serpentine. In ordinary light the olivine grains stand up like islands in the sea of serpentine. The olivine was formerly present in large grains. These were subsequently shattered and partly altered to serpentine both around their margins and along the fissures.

The original size of the grains is in many instances represented by clusters of separated grains which extinguish simultaneously and show the same optical orientation. The serpentine is distinctly fibrous, with the fibers arranged at right angles to the crystal boundaries and the cracks. Forming the central part of the serpentine bands are grains and small masses of magnetite and occasionally a stringer of small grains of carbonate. Associated with the serpentine especially in the larger bands, as well as in the smaller, is developed a considerable quantity of talc. That the talc is derived from the serpentinous material is demonstrated by the following facts: The talc is always associated with serpentine and is never in contact with any other mineral except magnetite; the serpentine shows a gradation or a zone of alteration between it and the talc; and finally talc is seen associated with serpentine showing gradations into it when included in narrow cracks in a single individual grain of olivine.[1] At certain places in the rock where the olivine has been almost completely altered, large masses of talc occur surrounding numerous small grains of olivine, but separated from them by a band of serpentinous material. The progression of this alteration is clearly shown between crossed nicols by the increase in the interference colors from the grey of the serpentine through light grey to yellow to first order red, and finally through shades of blue and green of the second order to the delicate shades of red, yellow and blue of the talc. A few needles of anthophyllite are present showing alteration to both talc and serpentine. Magnetite, entirely of secondary nature, occurs as scattered grains and in large masses. A small amount of pyrite showing alteration to magnetite is also present.

This rock, while called an altered peridotite, gives every indication of being an altered dunite.

ALTERED DUNITE

(Darnell Property, 5 Miles West of Dillards, Rabun County)

Megascopic characters.—This is a massive, yellowish-grey rock in which olivine and long needles of amphibole can be recognized with the unaided eye. The amphibole needles range from microscopic size up to 2 centimeters long. They have the appearance of being compact crystals, but when crushed the fibrous structure is made apparent. The needles are straight and show no indication that they have suffered any distortion by movements of the rock mass. When closely examined, the needles are seen to have at places a well defined radiating form. This rock is considered to represent the initial stage of the alteration of a dunite to amphibolite, a process which if continued would, it appears, lead to the formation of

[1]Another explanation for this occurrence is that the olivine originally altered to talc and later to serpentine, thus causing the serpentine to enclose the talc.

mass-fiber anthophyllite. (For description of locality see Darnell property.)

Microscopic characters.—This rock (sec. H63) is found to contain olivine, pyrite, and magnetite or chromite as original minerals, and amphibole, magnesite, serpentine, chloritic material and talc as secondary minerals.

The olivine grains, which are irregular in outline, have been extensively crushed and, in part, recrystallized. Serpentine is developed in very small quantities, while chloritic material is present apparently as a direct alteration of the olivine. It is faintly pleochroic, optically positive with a small optical angle. The most characteristic feature of the slide is the development of amphibole, both of the monoclinic and orthorhombic types, the latter being by far the most abundant. The monoclinic variety is either tremolite or cummingtonite; and the orthorhombic variety is anthophyllite. In general, these amphiboles are long and needle-like and run through the olivine grains without regard to cleavages; frequently the same needle will penetrate consecutively as many as six or even eight olivine grains; and again, the amphibole needles may be entirely enclosed within a single olivine grain. As a rule, the needles are straight, but frequently they are gently curved. The curving is not due to movements within the rock subsequent to the formation of the anthophyllite, as the curving usually takes place within the olivine grains themselves. These amphibole needles run in all directions through the rock. At places they show alteration to talc and chlorite. Magnesite (?) is present at places in considerable masses. Confused felted masses of what appears to be amphibole needles, uralite (?), are present showing alteration to talc.

ENSTATITITE

(Pig Pen Mountain, One Mile Southeast of Pine Mountain, Rabun County)

Megascopic characters.—This rock is composed largely of coarse bladed crystals of enstatite oriented in all directions in respect to each other. Scales of talc and deep green chlorite are easily recognized, as well as small grains of magnetite or chromite.

Microscopic characters.—In thin sections (Nos. H64,, H111, H112) this rock is seen to be composed essentially of large poikilitic crystals of enstatite enclosing irregular masses of olivine and numerous grains of magnetite and chromite. The enstatite crystals are much elongated parallel to the vertical axis, while the basal sections show a moderately well developed prismatic cleavage. It is practically colorless and non-pleochroic. Some of the enstatite crystals show a well developed columnar structure. The relationship of the original minerals to each other shows the order of crystallization to have been as follows: magnetite and chromite, olivine, enstatite.

The olivine shows alteration to yellowish serpentine along the cracks. The enstatite is altered to a variable degree to talc, bastite and chlorite. Talc is formed from the enstatite both around its edges and also along cleavage cracks. At places plates of talc of considerable size are developed, while at others it occurs as an aggregate of fine scales. It is formed commonly along the prismatic cleavage, with its cleavage and long direction parallel to that of the enstatite; it may occur as variously oriented, separated scales. Often closely associated with the talc are foliae of chlorite; its arrangement in respect to the enstatite is not so pronounced as that of the talc. It is faintly pleochroic, showing the colors characteristic of pennine. Bastite is developed in considerable quantities in the cracks, and along the border of the enstatite; it is colorless and is oriented with the long direction of the fibers parallel to the vertical axis of the enstatite. Masses of magnesite (tested chemically) are seen enclosed in the enstatite or fringing its edge.

In three thin sections made from samples from this locality, no amphibole could be recognized, although in one of the hand specimens fibrous material could be seen along the weathered edge. This apparent absence of amphibole suggests strongly that the mass-fiber asbestos associated with the fresher rock is fibrous enstatite; but this is by no means demonstrated, as it is quite possible that anthophyllite is present, but has not been differentiated from the enstatite because of the absence of basal sections. In only one of the three thin sections a few enstatite individuals were seen showing the pyroxenic cleavage.

Enstatitite (Maricose), Pig Pen Mountain, One Mile Southeast of Pine Mountain, Rabun County

CHEMICAL ANALYSIS		NORMATIVE MINERALS	
SiO_2	53.16	Corundum	2.14
Al_2O_3	2.13	Enstatite	88.66
Fe_2O_3	4.56	Magnetite	6.73
FeO	1.66	Water, etc.	2.57
MgO	35.35		
CaO	.02		100.10
Na_2O	.00		
K_2O	.00		
H_2O-	.00		
H_2O+	1.77		
TiO_2	trace		
P_2O_5	.00		
S	.00		
MnO	.55		
Undetermined	.80		
	100.00		

Enstatitite (Maricose), Laurel Creek Corundum Mine, Near Pine Mountain, Rabun County

CHEMICAL ANALYSIS		NORMATIVE MINERALS	
SiO_2	55.77	Quartz	1.68
Al_2O_3	1.19	Corundum	1.22
Fe_2O_2	2.40	Enstatite	91.70
FeO	4.89	Magnetite	3.48
MgO	34.21	Pyrite	.73
CaO	.00	Water, etc.	1.66
Na_2O	trace		
K_2O	trace		100.47
H_2O-	.25		
H_2O+	1.20		
TiO_2	.00		
P_2O_5	.21		
S	.41		
MnO	trace		
	100.53		

ALTERED ENSTATITITE

(W. T. Worley Property, 7 Miles East of Canton)

Megascopic characters.—This is a typical coarse-grained, massive enstatitite, in which is developed amphibole needles. The amphibole needles are usually about the same color as the enstatite, but in rarer instances they are bright green. A small amount of fibrous material is present, but it can not be determined megascopically whether it belongs to the enstatite or the amphibole. Olivine may be recognized at places as aggregates of yellowish grains. Magnetite is quite abundant. Along certain planes this rock appears to have altered to an amphibole schist. (For further description see Worley property.)

Microscopic characters.—The original minerals found in this rock (secs. H50, H51) consist of large platy crystals of enstatite, which enclose grains of olivine and magnetite. The enstatite is very faintly pleochroic and occurs in allotriomorphic form, enclosing magnetite which varies in size from small grains to fine dust-like specks. Olivine occurs usually in clusters of grains, entirely enclosed within the large enstatite crystals. Needles of colorless, monoclinic amphibole are seen penetrating the enstatite; a transition zone always separates these minerals, thus suggesting the secondary character of the amphibole. A small amount of fibrous material is present, which may be anthophyllite. Chlorite is present as the alteration product of both the enstatite and the secondary hornblende; it is strongly pleochroic, is optically positive and has a small optical angle. A small amount of talc is present as the alteration product of the enstatite. Carbonate is present usually in association with the secondary amphibole.

OLIVINE WEBSTERITE

(Near Rabun Gap, Rabun County)

Megascopic characters.—This is a fine-grained, dark-colored rock, the individual minerals of which can not be recognized in the hand specimen. It has a decidedly oily appearance and is thoroughly massive in structure. Black shiny plates of what appear to be hornblende and occasional spots of pyrite are the only features which attract the eye.

Microscopic characters.—Under the microscope the rock (sec. H1) is seen to be formed of phenocrysts of olivine in a ground-mass of augite, bronzite, green spinel, and pyrite and alteration products, consisting of hornblende, biotite, chloritic material, serpentine and magnetite.

The olivine, occurring in equigranular or elongated masses, has been extensively cracked and the cracks, which roughly parallel the cleavage, have been filled with serpentine and fine grains of magnetite. Not only has the olivine altered to form serpentine and magnetite, but it has given rise to the unusual products, hornblende and biotite. Hornblende is observed entirely surrounding olivine and projecting into it in such a way that the alteration of the one to the other is unmistakable. The same relationship is found to exist between the olivine and biotite. At a number of places the biotite was seen entirely enclosed in an olivine crystal as narrow shreds along the cracks or as larger foliae extending from one crack to another.

Augite and bronzite occur as small grains, which often form aggregates of considerable size. Augite appears to predominate over bronzite; both have been extensively altered to hornblende and biotite. The hornblende is strongly pleochroic; $\mathfrak{b}$ and $\mathfrak{c}$ = dark bronzy yellow, and $\mathfrak{a}$ = very pale yellow.

The hornblende forms at places large poikilitic crystals enclosing numerous irregular-shaped crystals of olivine, bronzite and augite. The general appearance of the rock gives the impression that the hornblende began to form along the contacts between the various minerals, and gradually absorbed the original minerals until only remnants of them are left, separated from each other by bands of hornblende. Even in the case of the augite the alteration has been limited to its outer edges. If this alteration did take place it is difficult to explain the presence of the large hornblende individuals.

Olivine Websterite (Rossweinose), Near Rabun Gap, Rabun County

CHEMICAL ANALYSIS		NORMATIVE MINERALS	
SiO_2	45.71	Orthoclase	7.23
Al_2O_3	5.03	Albite	2.10
Fe_2O_3	1.28	Anorthite	8.90
FeO	8.92	Diopside	36.69
MgO	22.90	Enstatite	1.56
CaO	11.48	Olivine	37.39
Na_2O	.27	Magnetite	1.86
K_2O	1.20	Ilmenite	.46
H_2O-	.11	Apatite	.67
H_2O+	1.59	Pyrite	.85
TiO_2	.23	Water, etc.	1.70
P_2O_5	.27		99.41
S	.46		
MnO	.10		
	99.55		

ALTERED HYPERSTHENITE[1]

(One and One-half Miles North of West Point)

Megascopic characters.—This is a medium grained rock of a decidedly greenish color. With the unaided eye it can be seen to be composed of two minerals; a bright green one which gives that tone to the rock; and a brownish to black mineral. The rock has an incipient schistosity. It gives place with further alteration to an amphibolite composed of long, bright-green hornblende needles in parallel arrangement.

Microscopic characters.—In thin section (No. H90) this rock is seen to be composed of large pyroxene individuals penetrated with numerous needles of amphibole.

The pyroxene is only moderately pleochroic with $\mathfrak{c}$ almost colorless to slightly greenish, $\mathfrak{a}$ reddish and $\mathfrak{b}$ the same as $\mathfrak{a}$, but fainter. The optical angle is so large that it is difficult to determine which direction is the acute bisectrix, although it appears to be $\mathfrak{a}$; and thus the mineral is negative and is hypersthene, although it is quite

[1] For a petrographical description of other and similar rocks from this locality, see Bull. Geol. Survey of Ala., No. 5, 1896, pp. 160-165.

likely that the less ferruginous orthorhombic pyroxenes may also be present in some of the specimens. The pyroxene contains inclusions of magnetite which vary from megascopic grains to fine dust-like particles unevenly distributed in it. The degree to which the hypersthene has altered to amphibole is quite variable in the different specimens, but is well advanced in them all.

The amphibole is developed in the enstatite in the form of long needles and as irregluar-shaped individuals scattered through it; it is monoclinic and exhibits a pale green pleochroism. (See analysis of amphibole from this same locality under actinolite.) Numerous basal sections are present showing the well developed amphibole cleavage. It is usually quite massive, in sharp contrast with the uralitic hornblende, and but for its relationship with the pyroxene it would seem to be an original mineral. To a small degree it has been altered, to strongly pleochroic chlorite. The alteration of the pyroxene to the amphibole is by no means limited to its edges, but on the contrary it has progressed within it, especially along cleavages. The two minerals are clearly distinguished in oridnary light by their difference in pleochroism and index of refraction.

Olivine is found in some samples of these rocks in irregular shaped grains, often showing a slight alteration to greenish-yellow serpentine.

METAPYROXENITE

(McPherson Property, near Villa Rica)

Megascopic characters.—This is a greenish-grey schistose rock in which chlorite appears to be the most abundant mineral. It is dotted here and there with yellowish masses of carbonate, which effervesce only slightly in cold, dilute, hydrochloric acid. Upon close examination the outlines of original, platy crystals of pyroxene are recognizable. Needles of amphibole can also be seen.

Microscopic characters.—Judging from the distribution and nature of the alteration of the remnants of enstatite crystals, this rock (sec. H47) was originally a pyroxenite and probably an enstatitite. It is now composed of more than fifty per cent. of alteration products, chiefly chlorite, carbonate and amphibole.

The enstatite is in every instance fringed with narrow shreds of talc which are arranged with their long direction at right angles to the surface of the enstatite. This relationship suggests strongly that the latest alteration of the enstatite has been to talc. The presence of chlorite in the enstatite, both as aggergates and as separate foliae along the cleavage lines, show that the alteration of the enstatite has also lead to the formation of chlorite, even where they are now separated by a band of talc. Amphiboles of both the orthorhombic and monoclinic varieties are present in the enstatite as well as in the confused mass of chlorite and carbonate which fill the interspaces between the enstatite individuals. The orthorhombic amphibole, anthophyllite, predominates over the monoclinic variety and usually possesses a finely fibrous form. The chlorite is moderately pleochroic and consists of foliae oriented in all directions, but with a slight tendency toward parallelism. Large masses of carbonate occur, often enclosing foliae of chlorite; their association with the enstatite and amphibole suggests that they were derived from the alteration of both of them. The formation of the chlorite and carbonate has lead to the development of a considerable amount of magnetite, which is scattered through the decomposed portion of the rock.

ALTERATIONS

In connection with the discussion of the various alterations of the basic igneous rocks, no attempt will be made to discuss every type observed; on the contrary, only the most common ones, which, in general, have lead to the formation of masses of considerable size and which are more or less closely connected with the development of talc, soapstone and asbestos, will be considered here. Thus limited, the alterations may be discussed under the following heads:

1. Amphibolitization.
2. Chloritization.
3. Steatitization.
4. Serpentinization.

The necessity of discussing these four modes of alterations, as applicable to the different types of rocks here under discussion makes it necessary to be exceedingly general in the description, and also to omit the unusual, and therefore the most interesting ones observed. Besides the description of the modes of alteration, a few general remarks will be included relative to the conditions under which they take place. It will be understood that all these different modes of alteration may have affected the same rock mass, and that these processes have not in general continued to their ultimate conclusion, but have been stopped by changed physical conditions, or they may be still in progress.

AMPHIBOLITIZATION

In general, amphibolitization is a deep-seated process which takes places especially under conditions of differential pressure. Contrary to the prevailing conditions in this zone, the alteration of both the orthorhombic and monoclinic pyroxenes takes place with decrease in specific gravity and consequently an increase in volume; but in the case of olivine the reverse is true. The change from pyroxene to fibrous hornblende, uralite, takes place in the belt of cementation; and it appears that it is in this belt that enstatite rocks are altered to mass-fiber asbestos.

GABBROS AND DIORITES

As stated at another place in this report, augite, an essential constituent of normal gabbro, has been observed in a number of instances altering to hornblende. This very common alteration, which has been fully described by Williams[1] in the case of rocks practically identical with those found in Georgia, need not be commented upon here. (See photomicrograph plate I, fig. 1.)

The alteration of the basic plagioclase in both gabbro and diorite (hornblende gabbro) to hornblende is a process which is common, but less often commented upon. By the introduction of magnesium

[1] Williams, G. H., The Gabbros and Associated Hornblende Rocks: Bull. U. S. Geol. Survey, No. 28, 1896.

and iron plagioclase may lead to the formation of various ferromagnesian silicates, but most commonly to hornblende, together with a variable amount of zoisite, epidote, chlorite and smaller quantities of other minerals. The hornblende is developed in greatest abundance and belongs probably to the mineral species, actinolite. This alteration is well illustrated in the case of the material from the Elberton-Union Point-Monticello area.

The two alterations described above lead to the formation of massive or schistose rocks composed largely of hornblende. The further alteration of these hornblendic rocks will be described later under the head of "chloritization."

PERIDOTITES AND PYROXENITES

As elsewhere stated, olivine and enstatite[1] are the essential constituents of the peridotites and pyroxenites, and the most common type contains a mixture of both. For this reason the alteration of the peridotites and pyroxenites will be described together.

ALTERATION OF OLIVINE TO AMPHIBOLE

The alteration of olivine to amphibole is one of the most common observed, as common if not more so on a large scale than its alteration to serpentine. This alteration, as observed in thin section, is not controlled in the slightest degree by the physical properties of the olivine; and thus the needles of amphibole pierce the olivine grains without regard to their boundaries, cleavages or cracks. In this respect this mode of alteration stands in the sharp contrast to that of serpentinization. The needles are oriented in all directions and are usually straight; although occasionally they may be gently curved. They extend continuously from one olivine grain to another, so that a single needle may pierce consecutively as many as six or even eight differently oriented olivine individuals. The development of the amphibole needles in both size and number gradually leads to the diminution in the amount of olivine until the rock is converted

[1] What is said here of enstatite applies equally to all members of the enstatite-hypersthene series.

from a dunite, perhaps, into amphibolite, in which olivine may be absent. This alteration is shown in its various stages in photomicrographs. (Plate I, figures 1, 2, 3.)

The amphibole thus formed is colorless and may be orthorhombic, as is usually the case; or it may be monoclinic. The orthorhombic variety is anthophyllite; the monoclinic variety is, doubtless, cummingtonite, although it can not be distinguished optically from tremolite or actinolite.[1]

The alteration of olivine to anthophyllite or cummingtonite involves the elimination of a part of the magnesia and iron or an addition of silica. If it is assumed that silica is added and that the ratio of magnesium to iron in the olivine is 3 to 1, the following equation expresses the chemical change involved:

$$Mg_3Fe(SiO_4)_2 + 2SiO_2 = Mg_3Fe(SiO_3)_4.$$

Or if the elimination of iron and magnesia be assumed, the equation may be written:

$$(Mg,\ Fe)2SiO_4 - (Mg,\ Fe)O = (Mg,\ Fe)SiO_3.$$

The alteration of olivine to tremolite is not so simple; it involves the addition of both silica and lime. The chemical change may be written thus:

$$3Mg_2SiO_4 + 2CaCO_3 + 5SiO_2 = 2Mg_3Ca(SiO_3)_4 + 2CO_2.$$

As previously stated, these alterations take place under deep-seated conditions and are accompanied by a decrease in volume. Solutions are necessary since a loss of iron and magnesia or an increase of silica is essential. That shearing movements have no place in the development of the change is demonstrated by the fact that the needles are arranged in all directions in respect to each other; and further, that no differential movement has taken place is demonstrated by the fact that the long amphibole needles are, as a rule, not disturbed. This is of interest not only in connection with the development of the amphibole itself, but also in connection with the development of its fibrous form.

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[1] See Pratt and Lewis, Corundum Deposits of North Carolina: North Carolina Geol. Survey, Vol. 1, p. 125.

FIG. 1.

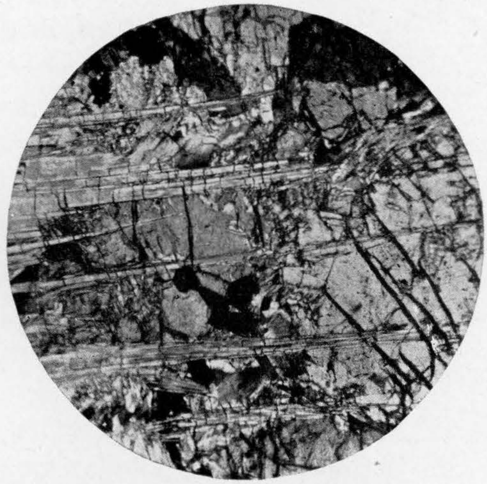

FIG. 2.

FIG. 1.—Gabbro-diorite (sec. 79), showing alteration of augite to hornblende. Central core of augite with rectangular cleavage, surrounded by hornblende with its characteristic, prismatic cleavage. Magnified 38 diameters.

FIG. 2.—Dunite (sec. 63), showing alteration of olivine to anthophyllite; long slender needles of anthophyllite with cross cleavages penetrate olivine grains. Magnified 38 diameters.

FIG. 3.

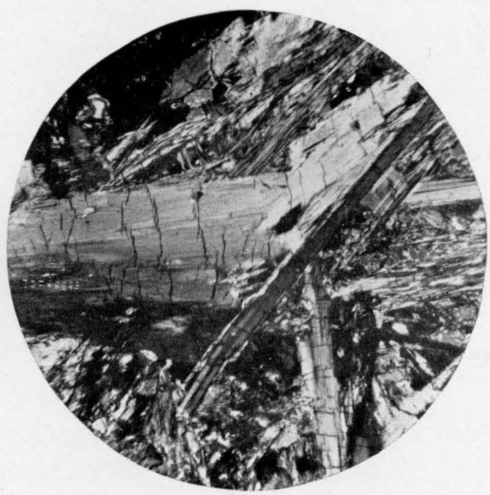

FIG. 4.

FIG. 3.—Same as Figure 2; anthophyllite is partly altered to talc at lower part of section. Magnified 38 diameters.

FIG. 4.—Amphibolite (sec. 46), showing last stage of alteration of olivine to anthophyllite; small remnants of olivine grains here and there between the fibrous amphibole needles; a small amount of talc and chlorite is present. Magnified 38 diameters.

The amphibole developed under the conditions described above is not always fibrous, or at least its fibrous quality is not evident. But in many instances where the fibrous nature is not apparent, it will become so on exposure to weathering. In fact, the incipient, fibrous condition, the extensive development of the prismatic cleavage, appears to originate with the mineral in the absence of stress or strain,[1] the crushing and granulation of the rock having preceded the development of the amphibole.

ALTERATION OF ENSTATITE TO AMPHIBOLE

The alteration of enstatite to the equivalent amphibole, anthophyllite, is a physical one and need not be accompanied by any chemical change, a process known as paramorphism. The conditions under which this alteration takes place would seem to be somewhat different from those of the alteration of olivine to anthophyllite, since this change takes place with increase in volume and would be thus opposed by the pressure found at great depths; but the alteration is concomitant with that of olivine, as the amphibole may extend from the olivine into the enstatite.

The alteration of enstatite to anthophyllite may progress in such a way that the secondary anthophyllite may take the form of the original enstatite. Such an alteration is illustrated by photomicrograph (plate II, figures 1, 2). Or the anthophyllite may penetrate the enstatite in all directions in the form of lath-shaped prisms. The result is the same, the formation of a more or less fibrous amphibolite, the extent of the development of which may be observed in thin section between crossed nicols, by the increase in the birefringence of the altered part. This alteration, together wtih or without a similar alteration of the olivine if present, is believed to have resulted in the formation of the mass-fiber asbestos deposits of Georgia. The origin of the mass-fiber is believed to be due largely to the alteration of enstatite, because of the general similarity of the mass fiber to the enstatite rock, the amphibole having assumed the form of the

[1] See section on origin of asbestos, pp. 102-107.

enstatite; and because of the relationship of the mass fiber to the unaltered portion of the rock mass, which is usually found to be largely olivine. It has not been definitely proved that enstatite may not assume a fibrous form and thus constitute mass-fiber deposits, but it seems unlikely.

CHLORITIZATION

The formation of chlorite, in general, involves hydration, carbonation and oxidation, changes characteristics of the zone of katamorphism. The formation of talc and serpentine takes place under similar conditions; but it would seem, since the chlorite in many cases appears to have preceded the formation of the other minerals mentioned, that it forms at somewhat greater depths. In the formation of chlorite from augite or hornblende, little has to be added with the exception of water; on the other hand in the formation of chlorite from olivine and orthorhombic pyroxenes a considerable addition of alumina, as well as water, must be made.

HORNBLENDIC ROCKS

In a previous section it was explained how rocks composed largely of hornblende may be formed from gabbros and diorites.

When these hornblendic rocks are subjected to the processes usual to the zone of katamorphism, one of the commonest changes of the hornblende is to chlorite. Such an alteration requires the addition of only water and the separation of lime, iron and silica. The alteration is to chlorite rather than talc, because of the presence of alumina and absence of the required amount of magnesia. Not only does the hornblende alter to chlorite, but basic plagioclase, if present, may also give rise to chlorite, as has been observed at a number of different localities. (See photomicrographs, plate II, figs. 3, 4.)

The above alterations give rise to bodies of impure, chloritic soapstone, which is composed of varying amounts of the following minerals: chlorite, talc, hornblende, quartz, magnetite and carbonates. The soapstone may retain the massive structure of the original rock, or it may assume a schistose structure. An alteration of this kind

FIG. 1.

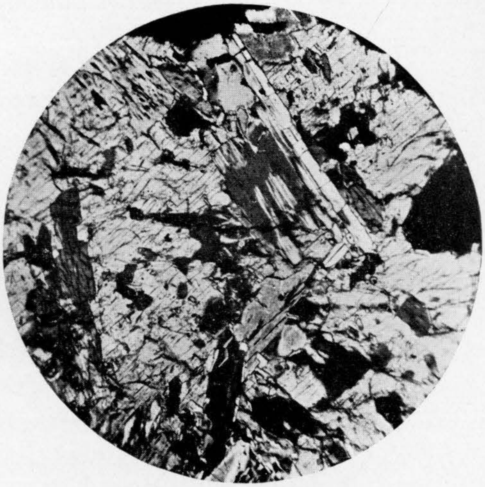

FIG. 2.

FIG. 1.—Enstatitite (sec. 56), showing alteration to amphibole; a single, prismatic section of enstatite and its alteration product, amphibole, occupies the entire section; below to the left, fibrous amphibole needles are parallel to cleavage of enstatite, above they are transverse to it. Magnified 38 diameters.

FIG. 2.—Enstatite (sec. 51) altering to amphibole; a single crystal of enstatite includes numerous irregular-shaped crystals of amphibole. Magnified 38 diameters.

FIG. 3.

FIG. 4.

FIG. 3.—Hornblende gabbro (sec. 79), showing plagioclase altering to foliae and shreds of chlorite; the latter is developed not only around the edge of the former, but also within it. Magnified 38 diameters.

FIG. 4.—Gabbro-diorite (sec. 92), showing at the upper left hand side plagioclase altering to a confused aggregate of chlorite foliae, and also the amphibole altering to talc, the light colored, speckled band extending across the middle of the figures. Magnified 38 diameters.

with the retention of something of the massive structure is well illustrated at the locality on the John McElhenny property, 7 miles south of Monticello.

PERIDOTITES AND PYROXENITES

ALTERATION OF OLIVINE TO CHLORITE

The alteration of olivine to chlorite would seem, from a chemical standpoint, to be a rather unusual one, since it requires a considerable addition of alumina; it has been described, however, as taking place in the peridotites of North Carolina[1] under the same conditions as in Georgia. The chemical change may be represented by the following reaction, in which it is assumed that clinochlore is formed:

$$3(Mg, Fe)_2SiO_4 + Al_2O_3 + 4H_2O - (Mg, Fe)O = H_8(Mg, Fe)_5Al_2Si_3O_{18}.$$

Chlorite develops as shreds or foliae most abundantly around the edge of the olivine grains, and to a more limited extent along the fractures within the grains. It is often strongly pleochroic, but varies considerably, even within a single individual. Not only does the olivine alter directly to chlorite, but it commonly gives rise to it secondarily through the intermediate product, amphibole. While the direct alteration is not so common as that of amphibole to chlorite, it does take place without the formation of appreciable serpentine. (See photomicrographs, plate III, fig. 1.) Thus rocks composed of olivine and hornblende, of either a primary or secondary nature, may alter to masses of chloritic schist of considerable size. But owing to the greater amount of iron usually present in the olivine, the rock thus formed generally contains a considerable quantity of magnetite along with the unaltered or partly altered minerals.

ALTERATION OF ENSTATITE TO CHLORITE

The alteration of enstatite to chlorite is quite as common as that of olivine to chlorite. The chemical change is very similar, and may be represented as follows:

$$5(Mg, Fe)SiO_3 + Al_2O_3 + 4H_2O - 2SiO_2 = H_8(Mg, Fe)_5Al_2Si_3O_{18}.$$

[1] Pratt and Lewis, op. cit., pp. 123-124.

It will be seen from this reaction that no iron or magnesia is eliminated, but silica instead; and thus the reaction takes place without the formation of magnetite. The formation of chlorite from enstatite is usually around the edges of the mineral and along cleavage cracks as illustrated in photomicrograph plate III, fig. 2.. At only a single locality has it been observed that masses of chloritic rocks of considerable size have been derived from enstatite, although the alteration has been frequently observed.

STEATITIZATION

Talc is a secondary mineral and is derived chiefly from amphiboles, especially the non-aluminous ones, orthorhombic pyroxenes and to a lesser extent from olivine, etc. Of all the modes of formation, that from the amphiboles seems to be by far the most common. Thus in the formation of talc or steatite from dolomitic limestones, the latter is largely converted into amphibole, usually tremolite, and then into talc.[1] Similarly, in the alteration of igneous rocks, such as peridotites and pyroxenites, talc is commonly formed through an intermediate product, amphibole. The alteration of olivine to talc is less common, but worthy of consideration in this connection.

The formation of talc which takes place, generally, in the presence of water, carbon dioxide and oxygen, is active near the surface of the earth, in the belt of weathering.

HORNBLENDIC ROCKS

In the same way that chloritic soapstone is derived from gabbros and diorites, soapstone composed largely of talc may also be formed. While the aluminous hornblendes usually give rise to chlorite, under certain conditions the alumina appears to be carried away in solution and talc is formed instead of chlorite. Furthermore, in the case of the alteration of peridotites and pyroxenites which are low in alumina and rich in magnesia and iron, to amphibole, the non-aluminous or aluminum-poor varieties are generally formed; and

[1] See Smyth, C. H., School of Mines Quarterly, Vol. 17, 1896, p. 333. Pratt J. H., North Carolina Geol. Survey, Econ. Paper No. 3, 1900.

FIG. 1.

FIG. 2.

FIG. 1.—Peridotite (sec. 40), showing the alteration of olivine to chlorite; an olivine grain near the center of the figure is surrounded by a band of chlorite foliae. Magnified 38 diameters.

FIG. 2.—Enstatitite (sec. 64), showing alteration of enstatite to chlorite; lower right-hand half of figures composed of olivine; the other half is composed largely of enstatite altering to talc the light colored, speckled area and chlorite. A remnant of enstatite is enclosed by a large foliae of chlorite which, in turn, is bordered on one side by talc and the other by olivine. Magnified 38 diameters.

FIG. 3.

FIG. 4.

FIG. 3.—Amphibolite, mass-fiber asbestos (sec. 67), showing alteration of fibrous anthophyllite to talc, the speckled areas. Magnified 38 diameters.

FIG. 4.—Dunite (sec. 17), showing alteration of olivine to talc, which occurs as broad, light-colored foliae, showing at places a well-developed cleavage. Magnified 38 diameters.

in the alteration of these, talc and a very subordinate amount of chlorite usually develops.

Talc begins to develop from amphibole in scales along the cleavage planes; these scales increase in size and number until talc entirely replaces the amphibole and becomes pseudomorphous after it. In other instances talc develops as irregularly arranged shreds and confused aggregates which later appear to reform into large foliae. (See photomicrographs, plate II, fig. 4; plate III, fig. 3.)

When derived from igneous rocks talc, as in the case of chlorite, is generally associated with impurities and unaltered material, of which the following are characteristic: amphibole, carbonate, magnetite, pyrite, etc. Talcose masses thus formed are generally termed soapstone.

PERIDOTITES AND PYROXENITES

ALTERATION OF OLIVINE TO TALC

Chemically the alteration of olivine to talc involves an addition of water and a loss of a large amount of iron and magnesia, as represented by the following equation:

$$4(Mg, Fe)_2SiO_4 + H_2O - 5(Mg, Fe)O = H_2Mg_3(SiO_3)_4.$$

The iron and magnesia thus eliminated are either deposited, as magnetite and magnesite; or, as is more often the case, they are removed in solution. Iron is more commonly deposited than the magnesia.

As previously stated, the peridotites and pyroxenites have been extensively crushed, and the constituent minerals fractured. Along the periphery of the olivine grains, as well as along fractures, talc is developed, the fractures allowing the penetration of solutions which make the alteration possible. The formation of serpentine may not accompany that of talc, which suggests that the conditions under which the two minerals are formed are somewhat different. The talc thus developed may form foliae of considerable size or it may take the form of confused aggregates of microscopic scales. (See photomicrograph, plate III, fig. 4.)

ALTERATION OF ENSTATITE TO TALC

The formation of talc from enstatite is a natural one and of very common occurrence; chemically it consists in the substitution of hydrogen for a part of the magnesium or iron. The change may be represented in its simplest form by the following equation:

$$4MgSiO_3 + CO_2 + H_2O = H_2Mg_3(SiO_3)_4 + MgCO_3.$$

In enstatite, as in amphibole, talc may devolop as scales along the cleavage cracks and gradually replace it, forming a pseudomorph. More often, however, talc is formed as irregularly distributed and oriented scales in the enstatite, which develops in size until the original mineral is replaced. (See photomicrographs, plate IV, figs. 1, 2.)

It is quite common to observe talc being derived from enstatite indirectly, through an intermediate product, which appears to be bastite. The bastitic material forms along the cleavages of the enstatite and separates the talc scales which are developed in it from the enstatite. And after the enstatite has entirely altered to this intermediate product, the talc seems to continue to be formed.

Rocks composed entirely of enstatite, enstatitites, may alter to masses composed largely of talc, often with the development along certain planes of large, foliated masses of pure talc. In case olivine is present, as is generally the case, a less pure talcose rock, or soapstone, usually results. This is due to the fact that the olivine alters to talc less readily than the enstatite, and is likely to remain as yellowish grains in the talcose matrix; or it may alter to form serpentine and magnetite. In the former case peridosteatite[1] is formed; while in the latter a talcose serpentine rock is found, the pattern of the two minerals outlining roughly that produced by the original olivine and enstatite.

SERPENTINIZATION

PERIDOTITES AND PYROXENITES

The alteration of both peridotites and pyroxenites, but particularly the former, to serpentine is of very common occurrence, and

[1] Pratt and Lewis, op. cit., p. 123.

FIG. 1.

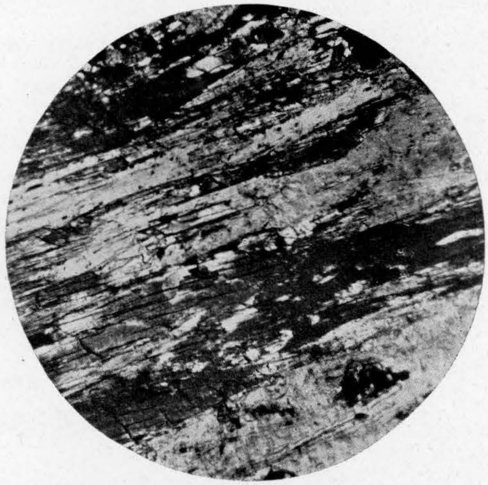

FIG. 2.

FIG. 1.—Enstatitite (sec. 64), showing alteration of enstatite to talc. The talc appears as light-colored bands along the cleavage of the enstatite. A magnetite crystal occurs in one of the talc foliae. Magnified 38 diameters.

FIG. 2.—Same as Figure 1, but with the alteration of enstatite to talc in a later stage of development. The light-colored areas are talc. Magnified 38 diameters.

FIG. 3.

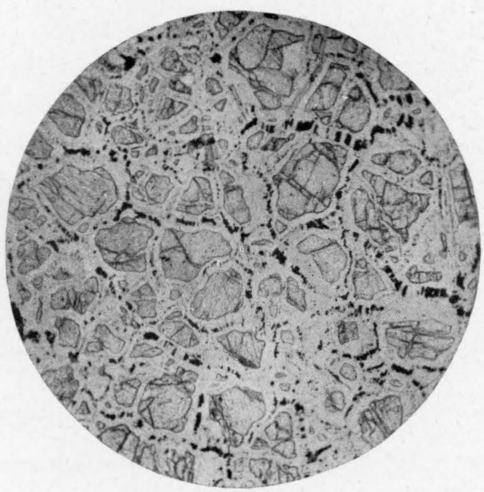

FIG. 4.

FIG. 3.—Dunite (sec. 19), showing alteration of olivine to veins of fibrous serpentine with the separation of magnetite, which occurs as an almost continuous dark line in the center of the serpentine veins. Magnified 38 diameters.

FIG. 4.—Same as Figure 3, but showing a later stage of the alteration of olivine to serpentine. The magnetite here occurs as separate masses. Magnified 38 diameters.

need be described here only briefly. When a rock has been completely altered to serpentine it is often difficult to determine its original character; however, it often happens that the serpentine retains the structure of the original mineral to such a degree as to permit its determination more or less accurately.

ALTERATION OF OLIVINE TO SERPENTINE

The alteration of olivine to serpentine involves essentially the hydration of the olivine. If the olivine is rich in iron, the latter separates as magnetite; and if the olivine contains little or no iron, magnesia separates in the form of magnesite. Typical reactions may be written as follows:

$$3Mg_3Fe(SiO_4)_2 + 6H_2O + O = 3H_4Mg_3Si_2O_9 + Fe_2O_3.$$
$$2Mg2SiO_4 + 2H_2O + CO_2 = H_4Mg_3Si_2O_9 + MgCO_3.$$

The formation of serpentine always begins along the periphery of the olivine grains and along cleavage cracks. In the case of the Georgia material, which is almost universally rich in iron, magnetite separates out either as small granules, which may form a continuous chain marking the line along which the alteration began, or as segregated grains of considerable size. (Photomicrographs, plate IV, figs. 1, 2.)

This alteration may be seen in all stages of progress and under varying conditions, depending upon the composition of the olivine. The serpentine thus developed may possess a fibrous form with the fibers either parallel or perpendicular to the enclosing walls.

ALTERATION OF ENSTATITE TO SERPENTINE

Enstatite may alter to serpentine in much the same way as olivine, but usually to a much less extent. The alteration may be represented by the following equation:

$$3MgSiO_3 + 2H_2O = H_4Mg_3Si_2O_9 + SiO_2.$$

As observed in the rocks of this State, the silica appears to be removed by solution. Usually, however, under the conditions that give rise to serpentine from olivine, enstatite alters dominantly to talc, either directly or indirectly. Thus, in the alteration of rocks composed of both enstatite and olivine it is very common to find both talc and serpentine, as previously described. Serpentine, however, is commonly seen filling cracks in the enstatite in much the same way as in olivine.

ORIGIN AND RELATIONS

In the foregoing pages a brief description has been given of the occurrence, distribution and general characters of the different types of basic, magnesian rocks. It remains to discuss the relationships of these rocks to one another, both from the point of view of field relations and from the standpoint of chemical and mineralogical composition. An attempt will be made to show that all these rocks are genetically related, that they represent differentiates from a common magma, that they are approximately of the same age, and that some of the most apparent differences are due to differences in degree or kind of metamorphism.

That all these rocks are of igneous origin seems so obvious, in the light of recent contribution to knowledge on this subject, that this fact will be considered as already demonstrated.

FIELD RELATIONSHIP

RELATIONSHIP OF THE GABBROS AND DIORITES TO THE HORNBLENDE SCHISTS AND HORNBLENDE GNEISSES

The apparent differences in structure and composition of the hornblende schists and gneisses and the gabbros and diorites are believed to be due largely to differences in metamorphism, and it is thought that the latter have, in general, given rise to the former.

While rocks with a gneissic or schistose form are more common than those with massive form, both types are found together, occupying the same relation to the enclosing rocks, possessing the same dike-like form, and sometimes showing a gradation in structure from the one to the other. These facts prove at least that a part of the gneisses and schists are derived from gabbros and diorites, those in which the above relationships are found to exist. But it is the exceptional case that a gradation from the massive to the schistose form may be observed, owing to the existence of more complete metamorphism, which has destroyed this relationship; however, the close similarity of the entire series of hornblende gneisses and hornblende schists suggests that they all have had a similar origin, and that a theory which explains the origin of a part is applicable to the entire series.

The more massive rocks tend to occupy broader and less elongated areas than those of schistose structure, a fact which, in part, accounts for the preservation of the massive character. However, it often happens that the massive rocks are found in narrow dikes, a condition which appears to be best explained by considering them of somewhat more recent origin. Schistose varieties are always found with the massive ones; the reverse is, however, not the case.

Briefly, because of their close association geographically, the similarity in their mode of occurrence and alteration, and the gradation which exists at some places, the massive and schistose rocks are believed to have had a common origin, and to be of approximately the same age, although some of the more massive gabbros, though belonging to the same period of eruption, are somewhat later in origin.

RELATIONSHIP OF THE PERIDOTITES AND PYROXENITES TO THE HORNBLENDE SCHISTS, HORNBLENDE GNEISSES, ETC.

The relationships of the peridotites and pyroxenites to the associated basic rocks are so nearly identical that they may be considered as a unit. These rocks, which occur usually as comparatively small, lenticular dikes, are invariably associated with the hornblende schists and gneisses; and if not in direct contact with them, they are in close proximity. Generally, they are enclosed in, and lie parallel to, the schistosity of the hornblendic rocks; although they are occasionally found cutting the schistosity at a moderate angle. The peridotites and pyroxenites have suffered the same deformative movements, such as folding and faulting, that have affected the associated hornblende rocks, and have been metamorphosed mineralogically, and at places structurally, to probably as great if not a greater degree; for this reason it seems necessary to consider them all as belonging to the same period of eruption and approximately of the same age. The fact that the peridotites and pyroxenites are found at places cutting the schistosity of the hornblendic rocks proves that they were somewhat later in formation, but their close association with the latter suggests a common origin. These facts are best explained by considering the more basic dikes as representing the last phase of eruptive activity which was begun by the intrusion of the material now represented by the hornblende schists and hornblende gneisses.

Associated with the peridotites and pyroxenites, especially in Towns and adjoining counties, are found gabbroic dikes which bear identically the same relation to the hornblendic rocks as the former, and must be regarded as of similar origin and of the same age. In the southeastern part of the Piedmont Plateau, gabbros and diorites are found more abundantly, while peridotites and pyroxenites, so far as they can be recognized, are almost entirely absent.[1] Here, however, it is believed that the nassive gabbros and diorites bear the same relation to the hornblende schists and hornblende gneisses that they do further to the northwest, while the less massive and more altered ones were contemporaneous in formation with them and have given rise to the hornblendic rocks.

CHEMICAL AND MINERALOGICAL RELATIONSHIP

RELATIONSHIP OF THE GABBROS AND DIORITES TO THE HORNBLENDE SCHISTS AND HORNBLENDE GNEISSES

There are few rocks found in Georgia which are properly termed diorites, because of the basisity of the plagioclase, which is commonly found to be labradorite. This fact is evident both from a study of the rocks themselves and from the chemical analyses, particularly if the latter are calculated into normative minerals. The feldspars

[1] Twelve miles east of Elberton a single peridotite dike has been found, the only one in that part of the State.

have been found to range from labradorite to anorthite with little or no orthoclase present. Thus the rock termed diorite may be, as a rule, more properly called a hornblende gabbro.

A comparison of all the analyses of gabbros, diorites, hornblende schists and hornblende gneisses quoted will reveal two significant facts: the small percentage of silica; and the close similarity in the composition of the rocks of massive and schistose structures. The percentage of silica is found to vary from 41.40 to 49.00, values which are low even for gabbros and far too low for diorites. A comparison of the analyses of the gabbro from the Ogeechee Brick Company's plant at Union Point (page 32) with the analysis of the hornblende gneiss from the Meckline property near Toccoa (page 20) will reveal striking resemblances, although the rocks are very different in appearance. Although the number of analyses is small, their significance is increased by the fact that the samples were chosen from the freshest material available to represent the greatest differences found in the rocks of this type.

Mineralogically, these rocks are characterized by the presence of basic plagioclase, ranging from labradorite to anorthite, as mentioned above, by the total absence or small percentage present of orthoclase and quartz, and by the presence of hornblende. These facts taken together with the close resemblance in chemical composition of the various types of rocks lead to the belief that the hornblende schists and particularly the hornblende gneisses have been derived from gabbroic rocks.

RELATIONSHIP OF THE PERIDOTITES AND PYROXENITES TO THE GABBROS, DIORITES, ETC.

As is necessarily the case, the peridotites and pyroxenites differ widely in chemical composition from the gabbros, and it is thus difficult to point out any chemical relationships which would indicate their common origin; however, the presence of intermediate rocks, such as olivine gabbro and troctolite, which are clearly transitional types, indicates this relationship. The passage from gabbro or troctolite to pyroxenite or peridotite takes place with an increase in magnesia, lime, alumina and, in general, silica. While the gradation in composition is significant, the proof of the close relationship of these rocks is based on their field association.

AGE OF INTRUSION

Although the relative age of the various rocks of the Crystalline Area of Georgia can be worked out with some difficulty, their absolute age can be arrived at only tentatively on theoretical grounds. The basic, magnesian rocks have been assigned to various ages ranging from Archaean to Carboniferous by different geologists working in different parts of the great belt. It is not possible to go into the reasons for these differences in opinion; suffice it to say that in Georgia the relationships of these rocks to those with which they are associated, and their present condition, suggest pre-Cambrian age.

That this series is more recent than the Carolina gneiss is obvious because they are intruded into it. Its pre-Cambrian age is tentatively held because of the following facts: While the rocks of this series are found closely associated geographically with the Ocoee group of Cambrian age, at no place do they cut those rocks; on the other hand, they are cut by all the granites, with the exception of the oldest granite gneisses, which probably range in age from Carboniferous to pre-Cambrian; and finally their extreme metamorphism, practically as great as that of the Carolina series, suggests an extreme age.

PART II. ASBESTOS DEPOSITS OF GEORGIA

INTRODUCTION

SIGNIFICANCE OF THE TERM—ASBESTOS[1]

"Asbestos" is a Greek word which signifies inextinguishable, inconsumable, unquenchable. The French refer to it as a "mineral filamenteux et incombustible," while the Germans use the very expressive term "Steinflachs" (stone flax). The Italians employ the term "amiantho," from the Greek "amiantos," which signifies undefiled, pure, incorruptible; and the French-Canadians call it "pierre á cotton" (cotton stone), on account of its similarity in appearance to cotton.

While asbestos was known as far back, at least, as the time of the Roman Empire, the term has been loosely employed and applied to any mineral substance which had a fibrous structure and more or less fire- and acid-proof properties. Only in more recent years has it become recognized that the term, asbestos, was used for a number of different mineral species, which are more or less distinct, both physically and chemically, but possess in common the properties mentioned above.

HISTORY OF ASBESTOS[2]

Asbestos has been known and used to a limited extent for probably 2,000 years. Many references are made to it in the writings of the Greeks, and much wonder expressed at its fire-resisting property. The Greeks gave the name, asbestos, to the fibrous mineral because

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[1] Circle, Fritz, Crysotile Asbestos: Canadian Dept. of Mines, Mines Branch, 2d Edition, 1910, p. 18. (foot note).

[2] Moore, N. F., Ancient Mineralogy, 1859, pp. 151-153.

of its use for lamp wicks in many of the ancient temples. Strabo[1] and Plutarch[2] refer to such lamps as "perpetual" and "inextinguishable," because they could be kept burning with the addition of oil without replacing the wicks. Thus the mineral asbestos was given the significance of the lamp. Pliny[3] refers to *linum vinum,* asbestos linen, as being made into napkins, which, he says, he has seen at an entertainment blazing with fire, and in this way whatever soiled them was burned off and they were rendered brighter than they could have been by water. Pliny also refers to asbestos as the "funeral dress of kings;" but he says it is a rare and costly cloth, the material being difficult to weave because of the shortness of the fiber.

During the Middle Ages, asbestos was used little or not at all; but about the middle of the eighteenth century the asbestos deposits of the Ural Mountains were opened up and a small factory established for the manufacture of asbestos goods. Owing to the limited demand for the goods, the industry disappeared and interest lapsed until about fifty years ago. In 1859 Moore[4] records the manufacture of asbestos into paper, gloves, purses, ribbons, girdles, etc. At that time asbestos had been discovered in Cyprus, Siberia, the Ural Mountains, and the Italian Alps. As early as 1862 asbestos was discovered in the region of the Des Plantes River, and in 1877 in the famous Thetford and Coleraine regions of Quebec. As late as 1878 the total production of asbestos in Canada was only 50 tons. The rapidity with which the industry has been built up in that country may be realized to some extent if the production for that year be compared with that for 1912, when 131,260 tons, valued at $2,979,384, were produced.

The association of corundum and asbestos with the basic dike rocks, peridotite and pyroxenite in particular, has played a significant part in the discovery of asbestos in Georgia. About 20 years

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[1] Strabbo, p. 396.
[2] Plutarch, De Def. Orac., Vol. 11, p. 410.
[3] Pliny. N. H. XIX, p. 1.
[4] Op. cit.

ago the search for corundum was at its maximum. Much prospecting was done in what was termed the corundum belt, the belt of peridotites and pyroxenites, which extends from Canada through the Piedmont Plateau region to Alabama. Since the most important deposits of both these minerals are confined to this belt, the search for corundum naturally lead to the discovery of asbestos, and as a matter of fact, practically all the important asbestos deposits known at present in Georgia were discovered and prospected in a small way about that time.

The small demand for this low grade material and the low price it brought on the market caused all early attempts to be failures, with a single exception—that of the Sall Mountain Company. This company began operations in White County in 1894, and has continued until the present time. For many years it was the largest producer in the United States, and has lost that place only since the discovery of asbestos in Vermont, where the southern continuation of the Canadian deposits is found. Georgia now ranks second among the States in the production of asbestos. The Sall Mountain mines have the distinction of being the oldest producing ones in the United States at the present time.

ASBESTIFORM MINERALS

CHEMICAL AND MINERALOGICAL CHARACTERISTICS

As geenrally employed today, the term asbestos is used to include a group of minerals of fibrous, crystalline structure, which, combined with other qualities, such as resistance to heat and acids, differentiates them megascopically from all other minerals. Better usage demands that the term be restricted to fibrous minerals of the amphibole group, while chrysotile be applied to the fibrous variety of serpentine.

An outline of the asbestiform minerals, which shows their mineralogical and chemical relationships and differences, is as follows:

Outline of Asbestiform Minerals

- Asbestiform minerals.
    - Amphibole group.
        - Orthorhombic division.
            - Anthophyllite, (Mg, Fe) SiO_3.
        - Monoclinic Division.
            - Tremolite, $CaMg_3$ $(SiO)_4$
            - Actinolite, Ca $(Mg, Fe)_3$ $(SiO_3)_4$.
                - Mountain Leather, Wood, and Cork.
            - Crocidolite, $NaFe_2$ $(SiO_3)_3$.
    - Serpentine, H_4 $(Mg, Fe)_3$ Si_2 O_9.
            - Chrysotile.
            - Picrolite.

As first constructed, the pyroxene group was made a third major division in order that enstatite and uralitic augite might be included. Occasionally in literature a fibrous enstatite is mentioned, but in the study of the basic rocks of Georgia, which contain many enstatite rocks, no example of the fibrous form of this mineral has been observed, and for that reason it was omitted. Much material is present in this State which appears to be a fibrous enstatite, but when examined microscopically it is found to be an amphibole and hence anthophyllite. The alteration of enstatite to bastite is common, and while the latter has a somewhat fibrous structure it is more closely related to serpentine than to the original enstatite, and also it can scarcely be classed as an asbestiform mineral. Uralitic augite has some claim for a place here, but, owing to its not being found in Georgia, its rarity and consequently the lack of knowledge as to its physical properties, it also was omitted. Furthermore, by omitting the pyroxene group, it is hoped that the alteration of pyroxene to serpentine and amphibole with or without the development of a fibrous structure, will be emphasized, as that alteration seems to be the rule in the Georgia deposits.

AMPHIBOLE GROUP

It will be observed that all the asbestiform minerals are metasilicates; that they all contain iron, and with the exception of crocidolite, they all contain magnesium; that anthophyllite is distinguished from tremolite and actinolite by the absence of calcium, and crocidolite from all the other asbestiform amphiboles by a notable percentage of sodium; and that of the asbestiform amphiboles, tremolite and actinolite are most closely related chemically.

The fibrous form of anthophyllite, tremolite, and actinolite[1] may be considered an exaggerated development of the prismatic cleavage, since the orientation of the fibers is always that of the cleavage flakes with the elongated direction representing crystallographically the vertical or c axis. This is always the case, since neither of the lateral axes, a or b, nor any intermediate direction ever represents the direction of elongation.

ORTHORHOMBIC DIVISION

ANTHOPHYLLITE

Anthophyllite is a metasilicate of magnesium and iron with the theoretical composition: silica, 55.6; ferrous oxide, 16.6; and magnesia, 27.8. It is distinguished chemically from tremolite and actinolite, which it resembles very closely megascopically, by the absence of calcium, and microscopically it is distinguished by the fact that it shows parallel extinction.

The following are typical analyses of the fibrous anthophyllite from Georgia, and also two analyses[2] of crystals from near Bakerville, Mitchell County, North Carolina, the only locality in the United States where good crystals are found:

Analyses of Anthophyllite

	1	2	3	4	5	6
SiO_2	56.40	57.98	55.80	53.71	51.29	58.10
Al_2O_3	1.15	.63	3.74	1.89	2.81	.94
Fe_2O_3			1.12		4.88	
FeO	11.40	10.39	5.62	7.14	2.45	9.69
MgO	28.68	28.69	29.83	29.62	29.61	30.60
CaO	.50	.20	none	trace	trace	.04
H_2O-		.12				
H_2O+	1.63	1.67	2.16		7.06	
TiO_2			trace		.10	trace
MnO		.31	.80	.64	.52	.10
Undetermined	.24	.01	.93	7.00	1.28	.53
	100.00	100.00	100.00	100.00	100.00	100.00

[1] Crocidolite may be included here, but it has not been studied, so no positive statements can be made in regard to it.

[2] Pratt, J. H., and Lewis, J. V., Corundum and the Peridotites of North Carolina: N. C. Geol. Survey, Vol. 1, 1905, p. 290.

1. Analysis by Dr. Charles Baskerville.
2. Analysis by Prof. S. L. Penfield.
3. Analysis by Dr. Edgar Everhart, Fibrous anthophyllite from E. P. West estate, 1 mi. S. of Aerial, Habersham Co., Ga.
4. Analysis by Dr. Edgar Everhart, Sall Mountain Asbestos Co., Sall Mountain, White Co., Ga.
5. Analysis by Dr. Edgar Everhart. National Asbestos Co., Hollywood, Habersham Co., Ga.
6. Analysis by Dr. Edgar Everhart. John Martin Property, near Soque, Habersham Co., Ga.

In Georgia anthophyllite occurs very extensively, associated with peridotites and pyroxenites, where it owes its origin to the alteration of olivine and enstatite. It is known only in that connection, and consequently only as a secondary mineral. The alteration to anthophyllite may be so complete that in the case of either an olivine or enstatite rock, the whole mass may be converted into anthophyllite, usually with a well developed fibrous structure, thus forming what is termed mass-fiber asbestos. Mass fiber is always, so far as is known, anthophyllite. (See plate V, fig. 2.) All secondary anthophyllite is somewhat fibrous, although this quality is developed to a varying degree.

Cummingtonite, or amphibole-anthophyllite, is similar in its mode of occurrence to anthophyllite, and is frequently found with it, although it is very difficult to distinguish in thin section from tremolite and actinolite, it having the chemical composition of the former and the optical properties of the latter.

MONOCLINIC DIVISION

TREMOLITE

Tremolite is the calcium-magnesium variety of amphibole, possessing the theoretical composition: silica, 57.7; magnesia, 28.9; and lime, 13.4, with ferrous iron replacing magnesia up to 3 per cent.

Optically, tremolite and cummingtonite are so nearly identical that they can not be distinguished; chemically they are decidedly different, the former containing calcium and little or no iron, while the latter contains much iron and no calcium. Since the separation necessitates a chemical analysis, which has not always been made, it will be understood that when the term tremolite, or colorless amphibole, is used, either mineral may be meant. But, since tremolite is much more common, it is usually present instead of cummingtonite.

Tremolite occurs frequently, associated with anthophyllite in altered peridotites and pyroxenites, sending long, slender needles through the olivine in all directions, thus showing its secondary character. It occurs also in altered gabbros, diorites, etc. It is often fibrous, and can be easily distinguished from anthophyllite by its inclined extinction.

ACTINOLITE

Actinolite is similar in composition and occurrence to tremoilte, but it contains more iron and usually shows some pleochroism in thin sections as well as a more pronounced body color. The separation of tremolite and actinolite is not always easy, and often the distinction has not been made, and the mineral is called a colorless or slightly colored, monoclinic amphibole.

The following analyses represent samples of long needles of actinolite, which are derived from the alteration of olivine and enstatite rocks:

Analyses of Actinolite

	1	2
SiO_2	55.80	54.36
Al_2O_3	4.52	4.65
Fe_2O_3	2.25	2.46
FeO	2.02	2.54
MgO	23.46	21.10
CaO	10.04	12.70
H_2O	.31	.60
TiO_2	none	.20
MnO	.80	.24
Undetermined	.80	1.15
	100.00	100.00

1. McPherson property, Villa Rica, Carroll Co., Ga.
2. Higgenbothem property, 1½ mi. N. of West Point, Troup Co., Ga.

True asbestos, from a mineralogical standpoint, is the fibrous form of tremolite and actinolite. There is no known locality in

Georgia where commercial deposits of asbestos of this variety are found, although it is of widesprĕad occurrence in the form of slip-fiber veins in many magnesian rocks. Tremolite and actinolite play a conspicuous rôle in the development of the talc and soapstone deposits of Georgia rather than with the asbestos deposits. (See slip-fiber asbestos plate V, fig. 3.)

Mountain wood is a compact, fibrous, grey to brown mineral often resembling dry wood; and, in fact, it may be mistaken for it, except where handled or closely examined. The fibers are often long and of variable texture.

Mountain leather and *mountain cork* are closely related forms, the only difference being the thickness of the material. They are formed of interlaced fibers of white to gray to yellowish color. Mountain leather is found in the form of thin sheets, which resemble organic rather than inorganic material.

All three of the above forms may be considered hydrated forms of the monoclinic amphiboles which contain little or no alumina, and are for that reason classed with tremolite and actinolite. They are found associated with limestone along fracture planes. Mountain leather is quite common at some of the marble quarries of Georgia in the form of thin, tough sheets.

Analyses of Mountain Leather and Mountain Cork

	1	2
SiO_2	46.42	57.20
Al_2O_3	2.32	
Fe_2O_3	.14	
FeO	.50	4.37
MgO	20.20	22.85
CaO	7.22	13.39
Na_2O	.69	
K_2O	.12	
H_2O-	.18	
H_2O+	22.00	2.43
MnO	trace	
	99.79	100.24

1. Mountain leather from Kennesaw Marble quarry, near Tate, Pickens Co., Ga.
2. Mountain cork, given in Dana's System of Mineralogy, 6th edition, p. 395.

CROCIDOLITE

Crocidolite, or blue asbestos, as it is sometimes known, is a metasilicate of sodium and iron with the theoretical composition: silica, 49.6; ferric oxide, 22.0; ferrous oxide, 19.8; soda, 8.6.

This rather rare mineral is found in large quantities only in West Griqualand, South Africa. It is a beautiful, highly fibrous mineral with a very silky luster, and of dull-lavender color. It is popularly known in its semi-precious form as tigers eye, when largely altered by the oxidation of iron and the infiltration of silica. Were it not for its poor heat-resisting power, this mineral would compete on the market with the highest grade of serpentine asbestos.

In South Africa crocidolite occurs in cross-fiber veins, which range from 2 inches to more than 4 or 5 inches in width. The fibers run from wall to wall without jointings, and are fine, elastic and so distinct that they can be easily separated by rubbing between the fingers. The enclosing rock is a dark-brown shale.

SERPENTINE

Serpentine is a hydrous, magnesian silicate which is found only as a secondary mineral. It may be formed from any silicate which is rich in magnesia, such as olivine, pyroxene, amphibole, garnet, etc. It may be formed from dolomite or other sedimentary rocks rich in magnesia. In Georgia, however, it occurs most abundantly as an alteration product of a member of the peridotite family, and chiefly from the mineral, olivine.

It is usually found in massive form, but in some places it is granular, and exceptionally it is delicately fibrous. Its color varies from light green to dark green to almost black, and its luster is commonly wax-like.

True asbestos can be distinguished from serpentine asbestos by testing them for water, the latter being a hydrous mineral, which gives off a considerable amount when heated.

The principal varieties of fibrous serpentine are chrysotile and picrolite.

CHRYSOTILE

Chrysotile (amianthus) is the variety of serpentine which has fine, silky, flexible fibers of light green to olive green to brownish color. It occurs in Georgia in very narrow veins in the massive serpentine. At no place are the veins found more than one-eighth of an inch wide, and usually in very limited numbers. None of the occurrences approach commercial proportions. (See plate V, fig. 1.)

Chrysotile constitutes the great bulk of the asbestos of commerce. It is mined in Canada and Vermont, while it occurs also in Wyoming and in the Grand Canyons of the Colorado, and sparingly in other places.

It is strange, but nevertheless a fact, that the same types of rocks which yield the large serpentine masses in Canada and the northern part of the United States and constitute the important chrysotile deposits known at the present time, alter in the southern part of the United States to amphibolite and thus form the commercial deposits of amphibole asbestos.

PICROLITE

Picrolite is similar to chrysotile, but the fibers are coarser and more brittle. It occurs along planes of movement in the serpentine and has no economic significance, although it finds its way into the mill with chrysotile at some of the Canadian mines.

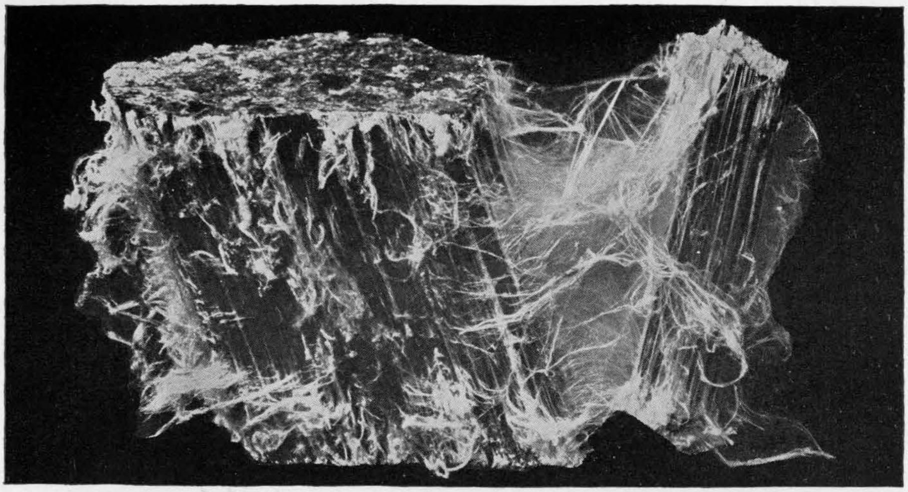


FIG. 1.—Chrysotile Asbestos from Canada.

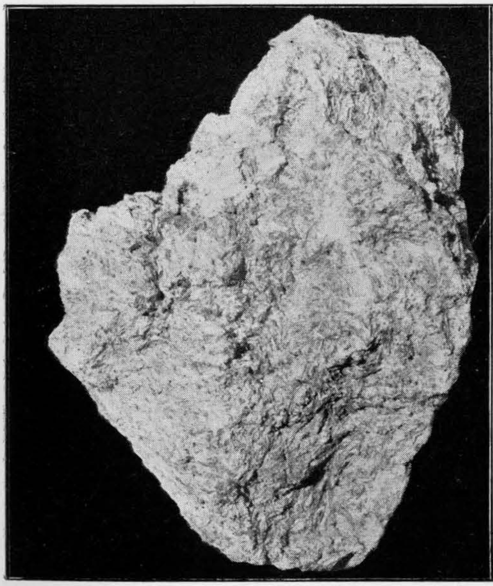


FIG. 2.—Mass-Fiber Asbestos, Sall Mountain, White Co. Ga.

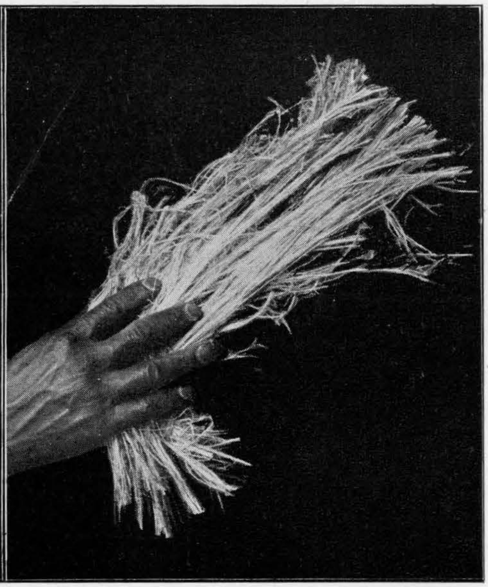


FIG. 3.—Slip-Fiber Asbestos, Luthersville, Meriwether Co. Ga.

Analyses of Asbestiform Minerals

No	Name	Location	SiO_2	Al_2O_3	Fe_2O_3	FeO	MgO	CaO	Na_2O	Authority
1	Anthophyllite	Sall Mountain, Georgia	57.12	.75	-----	6.36	29.44	-----	(a)	R. L. Packard
2	do	Nacoochee, Georgia	57.73	.72	-----	8.61	28.77	.08	.57	do
3	do	Berrong Prop. Nacoochee, Ga	52.25	5.07	-----	6.61	28.10	.88	.24	Edgar Everhart
4	do	Georgia	57.13	5.92	-----	6.38	27.01	trace	(a)	do
5	do	Miller Prop., Burton, Ga	59.14	.13	10.20	-----	28.47	trace	(a)	do
6	do	Pine Mtn., Rabun Co., Ga	54.32	1.04	5.52	4.54	29.60	trace	(a)	do
7	do	Rabun Co., Ga	56.52	3.57	-----	10.08	27.13	trace	(a)	Geo. P. Merrill
8	do	Camp Prop., Moreland, Ga	59.36	2.11	-----	8.13	32.00	.05	(a)	Edgar Everhart
9	Tremolite	Ronoke, Va	55.81	1.66	-----	6.81	21.09	12.74	(a)	R. L. Packard
10	Actinolite	Cohutta Talc Co., Chatsworth Ga	56.68	1.10	7.73	-----	21.00	10.97	(a)	Edgar Everhart
11	Mountain Leather	Kennesaw Qy., Tate, Ga	46.42	2.32	.14	.50	20.20	7.22	.69	do
12	Mountain Cork	Zitterthal	57.20	-----	-----	4.37	22.85	13.39	-----	Scheerer(?)
13	Crocidolite	South Africa (?)	51.22	(a)	34.08		2.48	.03	7.07	DeLarrarent
14	do	Cumberland, R. I.	51.03	(a)	17.88	21.19	.09	(a)	6.41	Joseph P. Iddings
15	Chrysotile	Black Lake, Standard Qys., Canada	40.42	.82	2.60		41.85	(a)	(a)	Milton Hersey
16	do	Thetford, Canada	39.05	3.67	2.41		40.07	(a)	(a)	J. T. Donald
17	do	Chrysotile, Vt	38.19	3.79	3.30	1.65	40.91	(a)	(a)	C. H. Richardson
18	do	Grand View ,Grand Canyon, Arizona	43.68	.34	.51	-----	40.64	.09	.14	R. C. Wells
19	Picrolite	East Broughton, Canada	37.88	1.10	2.70	.36	43.29	.82	(a)	Milton Hersey

Analyses of Asbestiform Minerals—(Continued)

No	Name	Location	K_2O	H_2O 100°C	Ign.	TiO_2	P_2O_5	S	MnO	Total	Authority
1	Anthophyllite	Sall Mountain, Georgia	(a)	(a)	5.47	(a)	(a)	(a)	-------	99.14	R. L. Packard
2	do	Nacoochee, Georgia	.14	(a)	2.52	(a)	(a)	(a)	-------	99.14	do
3	do	Berrong Prop. Nacoochee, Ga	.76	.17	5.42	.40	.04	.06	tr.	100.00	Edgar Everhart
4	do	Georgia	(a)	(a)	3.05	(a)	(a)	(a)	(a)	99.49	do
5	do	Miller Prop., Burton, Ga	(a)	(a)	(a)	(a)	(a)	(a)	.52	98.46	do
6	do	Pine Mtn., Rabun Co., Ga	(a)	(a)	1.13	.05	(a)	(a)	1.20	97.40	do
7	do	Rabun Co., Ga	(a)	(a)	2.96	(a)	(a)	(a)	-------	100.26	Geo. P. Merrill
8	do	Camp Prop., Moreland, Ga	(a)	(a)	(a)	tr.	(a)	(a)	.14	101.79	Edgar Everhart
9	Tremolite	Ronoke, Va	(a)	-------	1.81	(a)	(a)	(a)	(a)	99.92	R. L. Packard
10	Actinolite	Cohutta Talc Co., Chatsworth Ga	(a)	(a)	2.00	(a)	(a)	(a)	.18	99.66	Edgar Everhart
11	Mountain Leather	Kennesaw Qy., Tate, Ga	.12	.18	22.00	(a)	(a)	(a)	tr.	99.79	do
12	Mountain Cork	Zitterthal	-------	(a)	2.43	(a)	(a)	(a)	-------	100.24	Scheerer(?)
13	Crocidolite	South Africa (?)	(a)	(a)	4.50	(a)	(a)	(a)	.10	99.48	DeLarrarent
14	do	Cumberland, R. I	(a)	-------	3.64	(a)	(a)	(a)	(a)	100.24	Joseph P. Iddings
15	Chrysotile	Black Lake, Standard Qys., Canada	(a)	(a)	14.37	(a)	(a)	(a)	(a)	100.06	Milton Hersey
16	do	Thetford, Canada	(a)	(a)	14.48	(a)	(a)	(a)	(a)	99.68	J. T. Donald
17	do	Chrysotile, Vt	(a)	(a)	13.43	(a)	(a)	(a)	(a)	101.27	C. H. Richardson
18	do	Grand View ,Grand Canyon, Arizona	.11	1.18	13.12	(a)	(a)	(a)	.17	99.98	R. C. Wells
19	Picrolite	East Broughton, Canada	(a)	(a)	14.52	(a)	(a)	(a)	(a)	100.67	Milton Hersey

(a) Not Determined.

PHYSICAL PROPERTIES

The physical properties upon which the value of asbestos depends are as follows: fineness, length and flexibility of fiber, tensile strength, fire- and acid-resisting properties, and conductivity. The relative value of these different factors depends necessarily upon the use to which the material is put. Thus, when the asbestos is to be used in the preparation of cement for boiler coverings and similar purposes, fineness, length and flexibility of fiber and tensile strength are not as important as conductivity and heat-resisting properties. Or, if it is to be used as a filtering material, the acid-resisting property is more important than any other; and in the weaving of cloth length and flexibility of fiber, and tensile strength are absolutely essential to a high degree. For these reasons it is of value to compare the various types of asbestos in regard to their physical properties.

LENGTH OF FIBER

The absolute length of fiber is very difficult to determine in the case of all types of asbestos. A mass of fiber may appear to be as much as 12 or 14 or even 18 inches in length, in the case of slip fiber, but if the material is pulled apart and the bundles separated, the length is found to decrease with the size, the longer bundles being composed of a number of smaller, shorter ones. And even if the veins are only an inch or a fraction of an inch wide and the fibers appear to have a length equal to the width of the vein, close examination will often reveal planes of jointing in the fiber, which may or may not be made evident by a thin layer of foreign material. It is common in the amphibole asbestos to find the distance between two joints as much as 6 inches and the fibers appearing to extend the entire distance. The following results may be of interest in this connection:

A piece of Georgia slip-fiber amphibole asbestos 18 inches long was separated by hand and the diameter and length of the bundle were recorded. This subdivision was continued until the fibers were as fine as could be handled, with the result shown below:

Measurements of Georgia Slip-Fiber Asbestos

Length of fiber bundles	Diameter of fiber bundles
14 inches	0.359 millimeter
9½ "	0.111 "
7¾ "	0.059 "
5½ "	0.034 "
5 "	0.025 "
⅓ "	0.006 "

It must be understood that the smallest division of the fiber possible from a mechanical point of view, is made up of a number of still smaller fibers. Thus it is possible to speak of absolute length of fiber only in connection with the diameter of the fiber bundle, since the decrease in length of fiber with decrease in diameter is due not only to the mechanical difficulties of separation, but also to the fact that the smaller bundles of fibers are composed of still smaller bundles, a process which continues beyond the range of the microscope.

Other pieces of slip-fiber asbestos which showed no sign of jointing throughout their length measured 26½ and 31 inches. It is believed that these exceptionally long bunches contain interlaced bundles which are much shorter than the total length measured. Amphibole asbestos, notwithstanding the length of the fibers, does not rank with chrysotile for many reasons, principally because of its poorer flexibility and tensile strength.

In the case of mass-fiber asbestos, such as that milled at Sall Mountain, the fibers in the individual bundles have lengths varying from a small fraction to an inch, and averaging about one-half of an inch; but in fiberizing the material, owing to its lack of flexibility, the fibers are broken so many times that they are exceptionally one-fourth of an inch long, while the bulk is one-tenth of an inch and less.

According to Cirkel,[1] chrysotile in veins three-fourths of an inch and more in width yields spinning fiber of excellent quality, while the bulk of the material mined contains veins from one-fourth to one-half of an inch in width. Jointings in the veins of chrysotile are quite as common as in those of the amphibole type.

FINENESS OF FIBER

Both amphibole and serpentine asbestos when fiberized by rubbing between the fingers and examined under the microscope is seen to be made up of very fine fibers of .002 mm. in diameter and less; but if one of these fibers is examined closely it will be seen to be made up of still smaller fibers. Thus it seems that subdivision will continue indefinitely. Merrill[2] has measured anthophyllite fibers down to .002 mm. in diameter; while Cirkel[3] has published the interesting data quoted below:

Measurements of Asbestos Fibers

	Smallest diameter millimeters	Number of fibers per lineal inch.
Canada:		
Thetford	0.0010	25,000
Black Lake	0.0010	25,000
Broughton	0.0015	16,650
Templeton	0.0015	16,650
St. Adrien	0.0020	12,500
Carded asbestos	0.0010	25,000
United States:		
Grand Canyon, Arizona	0.00075	33,325
Casper Mountain, Wyoming	0.00075	33,325
Russia:		
Ural Mountains	0.00075	33,325
Siberia:		
Yenisei River	0.0010	25,000
Africa:		
West Griqualand	0.0090	27,775
Transvaal (Carolina District)	0.0015	16,650
Western Australia:		
Pilbarra District	0.0015	16,650

[1] Op. cit., p. 50.

[2] Merrill, Geo. P., Proceedings U. S. Nat. Mus., Vol. 18, 1895, pp. 282-283.

[3] Op. cit., p. 85.

After a comprehensive study of the physical properties of asbestos and various organic fibers, Cirkel[1] draws the following conclusions:

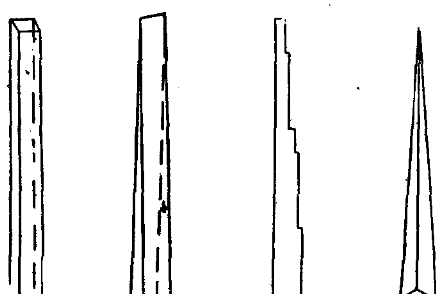
1. "The structure of asbestos fiber outwardly is almost identical with organic fiber, namely, that each apparently single fiber is composed of numerous, exceedingly fine filaments.

2. "The difficulty of spinning asbestos fiber lies in the fact that, unlike silk, cotton, or wool, no imbrications or teeth-like obstructions are in evidence on the surface of any asbestos fiber whatever.

3. "The variations in outward structure of the fibers examined are not strong enough to form a basis of reliable differentiation. One fact, however, seems to stand out, and that is, the glassy or metallic, rod-like appearance of many asbestos fibers under high microscopic power, with the exception of those from Thetford-Black Lake, Canada, and Russia."

The cross section of the fibers of both serpentine and amphibole asbestos are very much alike; the fibers are prismatic with approximately square cross section (Fig. 1). Some are seen to taper down to wedge-shape forms (Fig. 2); others are notched near the ends (Fig. 3), while rarely they are seen to taper to a triangular point (Fig. 4)[1].

Cut Showing Shapes of Asbestos Fibers (Enlarged).



1 2 3 4

[1] Op. cit., p. 87.

[1] See Merrill, Geo. P., op. cit., p. 283.

From a practical standpoint the ultimate fineness of fiber is not as significant as the fineness that can be obtained by various types of fiberizers. From this point of view, serpentine asbestos is superior to all types of the amphibole variety, with the possible exception of crocidolite, because the latter not only does not fiberize so readily, but also because the fibers are more or less brittle and break easily.

FLEXIBILITY OF FIBER

Chrysotile and crocidolite are far more flexible than any other types of asbestos. Although there is some difference in the quality of chrysotile in respect to this property, there is doubtless more in the case of most varieties of amphibole asbestos. As a rule, anthophyllite appears to be somewhat more flexible than fibrous tremolite or actinolite.

TENSILE STRENGTH

The actual test of the tensile strength of asbestos fibers is seldom attempted, and the experiments that have been made proved unsatisfactory on account of the nature of the fiber bundles.[1] Each fiber, no matter how delicate, is made up of a bundle of finer threads, which, on account of their smooth surfaces, slip on each other instead of breaking.

Haussman[2] found that a cylinder of crocidolite four hundredths of an inch in diameter supported 91 Hanoverian pounds[3] without breaking; whereas one made of asbestos (the exact type was not mentioned) seven-hundredths of an inch in diameter broke with 6 ounces. It is very likely that crocidolite has the greatest tensile strength of any asbestos known. Chrysotile, however, has sufficient strength for weaving into cloth and for similar uses.

HEAT- AND ACID-RESISTING PROPERTIES

The chief commercial use of asbestos is based on its highly refractory nature—its resistence to heat. Speaking of chrysotile,

[1] Cirkel, Fritz, op. cit., p. 85.
[2] Houssman, Handbuch, 1847, p. 734.
[3] The Hanoverian pound=489.57 grammes, the U. S. pound=453.59 grammes.

Cirkel[4] states that "Temperatures of 2,000° to 3,000° F. are easily withstood, while with some varieties a temperature of 5,000° F. has apparently produced no visible effect." The relative heat-resisting properties of the various types of asbestos seem not to have been determined; however, with the exception of crocidolite, the amphibole types are believed to be quite the equal of the serpentine variety, if not superior. When heated in the flame of a Bunsen burner to red heat chrysotile gives off a large amount of water, becomes yellowed, and its fiber loses entirely its elasticity; when rubbed between the fingers it has a brittle, harsh feel, caused by the fibers breaking up into a powder. Anthophyllite under the same conditions becomes yellow, but gives off very little water; its fibers remain soft and retain their flexibility unimpaired. Owing to the inability of crocidolite to withstand high temperatures, it does not command the price that chrysotile does; it would, otherwise, being quite its equal in every other respect.

In regard to resistence to acids, the amphibole asbestos (tremolite or anthophyllite) is to be preferred to any other type. F. Schrader[1] has concluded that asbestos, in order to be of most service in the chemical industry, should be the amphibole variety, in which the proportions of bases to silica is 1:1. In the case of chrysotile, in which the proportion of the bases to silica is 3:2, it is attacked by very weak acids, which have the power of dissolving the bases and leaving the silica without destroying the fibrous structure.

INSULATING PROPERTY

Asbestos is of great value in the arts as insulating material for both heat and electricity. As an electrical insulator it is somewhat excelled by magnesia products, as has been shown by a series of experiments made by George F. Sever,[1] in which magnesia boards were compared with those made of asbestos. At the same time Sever showed that the reverse was true in regard to heat insulation. The

[4] Op. cit.
[1] Schrader, F., Chemiker Zeitung, 1897, p. 285.
[1] Min. Res. U. S., 1904, pp. 1125-1130.

experiment consisted in pasting a thin sheet of tissue paper on one side of each type of board tested, and bringing the opposite side to within one-half inch of the center of the upright carbons of an arc lamp, and observing the time required for the tissue paper to become charred. This test showed the asbestos board to be a very much better non-conductor of heat than the magnesia board. Furthermore, the asbestos board has been shown to possess far superior mechanical qualities, and hence it is used extensively in electrical insulation.

Chrysotile from the Grand Canyon of Arizona is particularly suitable for use as a high-grade electrical insulator because of its freedom from iron, both in the composition of the material and as an accessory in the form of pyrite and magnetite.

Asbestos has been popularly considered a non-conductor of heat, a view which is erroneous according to Donald,[1] who considers, and very rightly too, that the non-conducting character is due to the porous nature of the prepared material rather than the physical properties of the mineral itself. According to Clark Maxwell and Winkelmann the conductivity of perfectly still air is the ideal toward which the conductivity of porous, insulating material can only approach.[2] Frederick Bacon[3] has summarized his conclusions in this connection as follows:

"Results for asbestos lead one to the conclusion that its value as a heat insulator is due rather to its fire-proof qualities than to its low conductivity, which, indeed, appears to be no lower than the conductivity of wood."

Data giving the relative values of the different types of asbestos as insulating material is not to be found in literature. However, the following illustrates and shows roughly the insulating value of crocidolite:

---

[1] Donald, J. T., The Mineral Industry, Vol. II, 1893, p. 4.
[2] Cirkel, Fritz, op. cit., p. 300.
[3] Cirkel, Fritz, op. cit., p. 301.

Tests of Insulating Value of Crocidolite

Description	1	2	3
Pounds water condensed per hour	12,225	3,152	3,484
Pounds water condensed per sq. ft. per hour	1,698	437	484

Column No. 1 shows results with bare pipe; No. 2, with pipe covered with crocidolite mattress, having a one-inch asbestos cord over it; and No. 3, with pipe covered with 1½-inch crocidolite cord, having small asbestos strings between. In the above experiment the average steam pressure was 95 pounds; the average engine room temperature 57° F.; and the surface of each pipe 7.2 square feet.[1]

The value of asbestos for steam pipe and boiler coverings is clearly recognized, and various types are being made and extensively used at the present time. The value of the different types of asbestos for such purposes is probably very nearly the same, since it has been shown that the non-conductivity is conditional on the porosity of the covering. The following table shows the result of tests made by C. L. Norton of the Massachusetts Institute of Technology on the various types of pipe coverings produced by the H. W. Johns-Manville Company:

Steam Pipe Cover Tests

Heat transmitted per square foot per minute B. T. U.

Name.	Thick.	B. T. U. per sq.ft. per 1° dif in temp.	0 lbs. Pres.	25 lbs. Pres.	50 lbs. Pres.	100 lbs. Pres.	150 lbs. Pres.	200 lbs. Pres.	250 lbs. Pres.	500° F.	600° F.
Asbesto-Sponge	1″	.00754	1.04	1.46	1.70	2.01	2.23	2.38	2.53	3.22	3.98
Asbesto-Sponge	2″	.0059	0.83	1.15	1.33	1.57	1.74	1.86	1.97	2.52	3.12
Asbesto-Sponge	3″	.0054	0.76	1.05	1.21	1.42	1.59	1.71	1.81	2.31	2.85
Magnesia J-M	1″	.0083	1.16	1.61	1.86	2.21	2.45	2.60	2.77	3.54	4.36
Magnesia J-M	1½″	.0075	1.05	1.46	1.69	1.99	2.21	2.37	2.50	3.20	3.96
Magnesia J-M	2″	.0063	0.88	1.23	1.42	1.67	1.86	1.99	2.11	2.69	3.33
Asbestocel	1″	.0094	1.29	1.83	2.12	2.51	2.78	2.97	3.14	3.92	4.96
Fire Felt	1″	.00975	1.36	1.90	2.19	2.59	2.88	3.09	3.36	4.16	5.15
Air Cell	1″	.0133	1.86	2.60	2.99	3.51	3.92	4.21	4.45	5.68	7.04
Vitribestos	1″	.0168	2.35	3.28	3.78	4.46	4.96	5.30	5.62	7.19	8.88
Moulded	1″	.0116	1.62	2.26	2.61	3.08	3.42	3.64	3.88	4.97	6.13
Indent	1″	.0114	1.60	2.22	2.57	3.02	3.37	3.60	3.82	4.88	6.02
F-F A.S.1″	2″	.0080	1.13	1.57	1.81	2.14	2.38	2.54	2.69	3.45	4.25
F-F 1″ & A.S.2″	3″	.0062	0.87	1.22	1.41	1.66	1.88	1.98	2.08	2.67	3.30
F-F 1″ & Mag1″	2″	.0079	1.11	1.55	1.77	2.11	2.34	2.51	2.66	3.40	4.20
Bare pipe	0	.05	6.	9.6	14.6	19.5	21.4	23.0	----	34.0	52.0

[1] Cirkel, Fritz, op. cit., p. 240.

This table gives the actual heat transmission through the various pipe covers when used upon pipes at temperature between 212° F. and 600° F.

Assuming that coal with a calorific value of 13,500 B. T. U. per pound costs $4.00 per short ton, that the boiler efficiency is 67 per cent., the cost of keeping steam pipes hot 365 days of 24 hours each where interest is reckoned at 6 per cent. and depreciation at 10 per cent. may be shown in the following table:

Steam Pipe Cover Test

Yearly cost of 100 sq. ft. of Covered Pipe.

Name	Thick.	Pipe at 25 lbs. gauge	Pipe at 100 lbs. gauge	Pipe at 200 lbs. gauge	Pipe at 600° F.	Original price only applied.
Asbesto-Sponge	1"	$ 19.40	$ 25.40	$ 29.50	$ 46.90	$ 21.50
Asbesto-Sponge	2"	18.30	23.10	26.30	40.20	36.50
Asbesto-Sponge	3"	16.70	23.30	26.60	39.10	48.00
Magnesia	1"	20.22	26.80	31.06	50.31	17.00
Magnesia	1½"	19.60	25.50	29.70	47.20	22.50
Magnesia	2"	18.40	23.30	26.80	41.60	30.50
Asbestocel	1"	22.70	30.20	35.30	57.20	16.00
Fire Felt	1"	24.30	31.90	36.30	60.00	21.20
Air Cell	1"	30.80	40.80	48.60	79.80	14.20
Vitribestos	1"	40.00	52.90	62.10	101.40	24.00
Moulded	1"	26.90	35.90	42.20	69.70	13.00
Indent	1"	27.00	35.80	41.40	68.00	16.00
F-F 1" & A. S. 1"	2"	23.20	29.50	33.90	52.60	36.50
F-F 1" & A. S. 2"	3"	21.10	26.00	29.40	44.00	48.00
F-F 1" & Mag. 1"	2"	22.80	29.00	33.40	33.40	52.00
Bare Pipe	0	110.00	225.00	236.00	600.00	----------

SUMMARY OF PHYSICAL PROPERTIES

In regard to fineness, length and flexibility of fiber, and tensile strength, crocidolite and chrysotile are far superior to all other types of asbestos. In acid-resisting property, amphibole asbestos (including anthophyllite, tremolite and actinolite) is superior; while in fire-resisting properties chrysotile and amphibole asbestos are probably of equal value and far superor to crocidolite. Chrysotile combines the greatest number of properties to the highest degree, and is thus by far the most important for most types of work; nevertheless, in a few cases amphibole is to be preferred, and in a number of cases can be used with equal advantage.

TYPES OF ASBESTOS

Three types of asbestos are recognized, depending upon the arrangement of the fiber in respect to the wall rock, and in respect to each other. They are termed cross fiber, slip fiber, and mass fiber. Both cross- and slip-fiber asbestos occur in veins, with the fibers arranged parellel to each other. In case the fibers are approximately perpendicular to the enclosing walls it is called cross fiber, and when they are parallel to the walls, it is designated slip fiber. There are all gradations from one type to the other, thus showing that movement of one wall in respect to the other may convert one type into the other. On the other hand, it must not be concluded that slip fiber is always formed from cross fiber, for in many instances there is evidence that such was not the case. Disturbed cross-fiber veins testify to the occurrence of movements since the period of their formation. Slip fiber is found in the slipping plane, and the direction of the fibers records the direction of the motion.

Mass fiber is sharply contrasted with cross and slip fiber in that it does not occur in veins, but forms the body of the rock. The fibers are arranged in bundles of varying size and oriented in all directions in respect to each other, and are often distinctly radial in arrangement. This is the most important type of amphibole asbestos, commercially, because the whole mass of the rock can be utilized, often by removing little or no waste material, as at the Sall Mountain mines.

Crysotile occurs as both types of vein fiber, but never as mass fiber. Its characteristic form is as cross-fiber veins. Fibrous tremolite and actinolite occur only in slip-fiber veins.[1] Anthophyllite occurs in all three ways, but its characteristic occurrence is as mass fiber. Crocidolite is known only in cross-fiber veins.

The fact that anthophyllite occurs in mass- and cross-fiber form,

[1] In the case of all the material from Georgia this is true, although Merrill (Merrill, Geo. P., Proceedings U. S. Nat. Mus., 1895, pp. 286-287) mentions a single case where tremolite is found in veins with the fiber transverse to the enclosing walls. The occurrence is described by Heddle and LaCroix, (Trans. Royal Soc. of Edinburgh, XXVIII, pp. 502, 531, 1877-78,)

and tremolite and actinolite do not, seems to suggest strongly that the fibrous form of the latter is attained only under conditions of stress and strain.

MODES OF OCCURRENCE

By "mode of occurrence" is meant both the relation of the asbestos to the enclosing rock, with which it is genetically associated and the origin and relations of the latter.

Diller[2] has recognized four modes of occurrence of asbestos in the United States, which are as follows:

"The first mode is as cross-fiber veins of chrysotile in serpentine derived from peridotite, a deep-seated igneous rock, as near Lowell, Vt., and Casper, Wyo. So far as known it is much the most important mode of occurrence and is well illustrated at the Thetford mines, in Canada.

"A second mode is as cross-fiber veins of chrysotile with serpentine in limestone. Its most important illustration is in the Grand Canyon of the Colorado River in Arizona.

"The third mode of occurrence is a mass-fiber amphibole (anthophyllite), composing stocks and dikes of fibrous amphibolite, and is well illustrated in the deposits worked for many years at Sall Mountain, Ga. Asbestos of this mode has recently been opened and has attained some importance at Kamia, Idaho.

"The fourth mode is as slip-fiber veins in rocks which for the most part are cortlandite and pyroxenite, but which locally pass into peridotite, as at Bedford and Rockymount, Va."

All the economic deposits known at the present time can be very easily placed in this classification; but other deposits, though of no commercial value, are not included. For this reason an attempt has been made at a classification which will express the genetic relationships of the various types of asbestos, and at the same time will include all the deposits. Basing such a classification on the

[2] Diller, J. S., Bull. U. S. Geol. Survey 470, pp. 506-507.

same grounds as that outlined by Diller, it has been elaborated to the following form:

Classification of Asbestos Deposits

From rocks of sedimentary origin.
- Limestones and dolomites.
  - With the aid of igneous rocks.
    - Chrysotile in serpentine derived from limestone through the aid of diabasic intrusions—Grand Canyon (Diller, second mode).
  - Without the aid of igneous rocks.
    - Asbestos in slip-fiber veins—Mountain leather in Georgia marbles.
- Shales, etc.
  - Cross-fiber veins.
    - Crocidolite in South Africa.

From rocks of igneous origin.
- Peridotites.
  - Through the process of serpentinization.
    - Chrysotile in cross- and slip-fiber veins (Diller, first mode).
  - Through the process of amphibolitization.
    - Mass- and cross-fiber anthophyllite (Diller, third mode).
    - Slip-fiber anthophyllite, tremolite and actinolite.
- Pyroxenites and allied rocks.
  - Through the process of serpentinization.
    - Chrysotile in cross- and slip-fiber veins.
  - Through the process of amphibolitization.
    - Mass- and cross-fiber anthophyllite (Diller, third mode).
    - Slip-fiber veins, tremolite, actinolite and anthophyllite (Diller, fourth mode).

It will be seen that the crocidolite deposits of South Africa have a natural place in this scheme, as well as the interesting, though unimportant, deposits of mountain leather, which are so commonly found in association with marble deposits, as at the Kennesaw marble quarries in Pickens County, Georgia. Illustrative localities are cited under each type, and, wherever possible, deposits are chosen which are described in this volume.

ORIGIN OF ASBESTOS

Notwithstanding the unique character of asbestos, which has attracted the attention of the observant eye for hundreds of years, little has been written as to its origin until comparatively recent time. The commercial development of the chrysotile deposits of Canada in the last few decades has greatly stimulated scientific thought in regard to those most valuable and interesting deposits, with the result that, while there is still much uncertainty in regard to the details, and even the important features of their origin, a great deal has been learned. Even less has been written in regard to the development of amphibole asbestos, especially the mass-fiber type. Merrill[1] has stated that the fibrous form of amphibole asbestos in slip-fiber veins may be due to stress; and Diller[2] has suggested that mass-fiber anthophyllite has probably been derived from intrusions of pyroxenite, although he does not give his reasons for this belief.

In discussing the origin of chrysotile asbestos a brief summary will be given of the theories as accepted today, which seem to most nearly approximate the true conditions. The amphibole types will be treated at greater length, especially in regard to the deposits as they have been studied in Georgia.

CHRYSOTILE ASBESTOS

Chrysotile asbestos occurs as cross- and slip-fiber veins in serpentine, and hence the discussion of its origin may be limited to the following subjects: the origin of the serpentine masses; the origin of the cracks in which the chrysotile is formed; and finally the method of formation of the chrysotile in the veins.

ORIGIN OF SERPENTINE MASSES

In regard to the origin of the serpentine masses, the problem can usually be quite readily solved in the individual case; the Canadian serpentine areas are generally conceded to have been derived

[1] Merrill, Geo. P., Proc. U. S. Nat. Mus., Vol. 18, pp. 286-290.
[2] Diller, J. S., Min. Res. U. S., 1907, pt. II, p. 718.

from original intrusions of olivine rocks, peridotite and probably dunite; on the other hand the serpentine of the Grand Canyon, in which are found the veins of chrysotile, is clearly derived from the associated limestone. With this one exception all the serpentine areas of North America are derived from basic, magesian rocks of igneous origin, which are in the main altered peridotites, but to a smaller extent altered pyroxenites, etc.

DEVELOPMENT OF THE FISSURES

The origin of fissures in the serpentine in which are formed the chrysotile veins is still an unsolved question, although many suggestions have been made. It has been suggested that the cracks or fissures were formed during the original solidification of the rock from a molten mass; since the rate of cooling in the contact zone was much faster than in the interior of the mass there would be a tendency to relieve the tension by the formation of cracks. That cracks were formed in this way, which later aided the process of serpentinization of the mass is probably true; but it has been shown that the development of the chrysotile has been, in general, later than the formation of the massive serpentine and the readjustments following its formation, and that the veins of chrysotile are not limited to the contact zone, but are in some cases much more extensively developed well within the serpentine mass than near the contact. That the cracks could not be formed during the process of serpentinization seems to be certain, since that process necessitated a material increase in the volume of the rock mass which was opposed by the country rock. According to Fritz Cirkel,[1] it seems likely that readjustment of the rock mass took place after this process was completed, which lead to the formation of joints and slickensides, as seen in the Canadian quarries today; but that the formation of the chrysotile was later than this readjustment is demonstrated by the fact that asbestos veins are seen cutting through the joints and slickensides. He concludes, following the suggestion made by

[1] Op. cit., p. 91.

Merrill,[1] that the cracks in the serpentine are the result of shrinkage, due in part, probably, to the loss of silica and also as incidental to the change from a highly hydrated colloidal substance into a less hydrated and more solid form. The intrusion of granite, which is usually found near rich chutes of chrysotile, has also had a part in the formation of the cracks and fissures; that the formation of the chrysotile was relatively late, is proved by the fact that the greater part of the veins show no effect of movement in the rock mass, since the fibers have remained perpendicular to the enclosing walls.

FORMATION OF CHRYSOTILE IN VEINS

R. W. Ells,[2] in describing the formation of chrysotile, states that "The vein asbestos appears more naturally to have been produced by a process of segregation of serpentinous matter from the sides of the fissure, very much as ordinary quartz in many mineral veins is known to have been produced, the segregated or infiltered matter gradually filling the original fissure and meeting near the center." Holding a different view, Dresser[3] states that "while the veins run in all directions through the rock, the larger veins are usually those along joint planes. Of these, the horizontal series, which are sometimes over two inches wide and extend for 100 to 200 feet, could never have been open fissure, nor is it conceivable that small areas of rich ground * * * could ever have had as many open fissures as they now have filled veins. It, therefore, seems most probable that a process of replacement of the wall rock has gone on contemporaneously with the deposition of asbestos." Cirkel[4] believes that the serpentinous matter was derived from the walls of the fissure and deposited under conditions of intense heat, extreme pressure and slow cooling, conditions which lead to the development of fine, delicate crystals which incrust the walls, and through mutual interference grow toward the center of the veins.

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[1] Merrill, Geo. P., On the Origin of Veins of Asbestiform Serpentine: Bull. Geol. Soc. of Amer., Vol. 16, pp. 131-136.

[2] Ellis, R. W., Canadian Geol. Survey. Bull. on Asbestos, 1903.

[3] Dresser, John A., Canadian Min. Inst., Vol. XII, 1909, pp. 170-171.

[4] Cirkel, Fritz, op. cit., pp. 92-93.

It would seem that a gaping fissure is not needed for the development of a vein of chrysotile, but only a crack, which may be practically closed, along with readjustment could take place with the aid of solution; and thus the vein is formed of the wall rock and the impurities are either segregated or removed through solution.

Cirkel[1] summarizes his ideas in regard to the Canadian deposits in the following way:

"1. Intrusion of olivine (dunite) through the earth crust from below.

2. Gradual alteration of the rock to serpentine through hydration, and perhaps loss of silica, increase in volume.

3. Slow readjustment of the rock masses, resulting in the formation of joints and slickensides.

4. Subsequent formation of fissures as receptacles for asbestos fiber, through shrinkage of the rock, and also through the injection of granite dikes.

5. Infiltration of serpentinous solution from the sides of the wall through process of segregation, and subsequent crystallization of chrysotile.

6. Second slow readjustment of the magmatic rock-mass, and formation of slip fiber."

All the above processes are supposed to have affected the Broughton region, while only the first five affected the Thetford and Black Lake regions.

AMPHIBOLE ASBESTOS

The discussion of the origin of amphibole asbestos[2] is naturally divided into two parts: the origin of the amphibole, and the development of the fibrous or asbestos form. It is believed that the fibrous mineral is never the result of original crystallization from a molten magma, but is secondary; and that the fibrous form may or may not be developed at the time of the formation of the secondary mineral.

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[1] Op. Cit., p. 101.

[2] Crocidolite will not be considered with the other types of amphibole asbestos.

ORIGIN OF THE AMPHIBOLE[1]

It may be stated that anthophyllite is usually developed from orthorhombic pyroxene or olivine, although more rarely tremolite and actinolite are formed. Tremolite and anthophyllite are not always secondary to a pyroxene, as they may be developed in magnesian limestones as a product of dynamic metamorphism, and in veins in various basic igneous rocks. In pursuing this subject, attention is directed in particular to the origin of mass-fiber asbestos deposits, which, so far as known, are always composed of anthophyllite.

The alteration of a pyroxene to an analogous amphibole is not an uncommon alteration; on the contrary, it is the rule, whenever the physical conditions change so as to make the pyroxene unstable and the amphibole stable. Just what changes are required to produce this alteration can be pointed out only in a general way. Pyroxenes are dominantly pyrogenetic minerals and form directly from molten magmas, although some also occur as metamorphic minerals. On the other hand, tremolite, actinolite and anthophyllite are known chiefly as secondary minerals, due to metamorphic processes. It would thus seem that pyroxenes are most stable under static conditions at high temperature; while tremolite, actinolite and anthophyllite are stable under conditions of differential pressure and at somewhat lower temperature. Whatever the cause, it has been observed that where deep-seated rocks, which originally contained pyroxene or olivine, after suffering the effects of dynamic metamorphism through long periods of earth movements are brought to the surface by erosion, they may be found either partly or entirely altered to amphiboles.

Whenever rock showing original mineral or minerals is found in association with the mass-fiber deposits of Georgia, it has been found universally to contain olivine, in some cases enough to clearly ally it with the peridotite group, if not indeed with the dunites. Furthermore, as shown in photo-micrographs (Plate I, figures 2, 3, 4), olivine has been seen in all stages of alteration to anthophyllite, from where the amphibole forms only a few slender needles running

[1] See "amphibolization."

through the groundmass of olivine, to where it constitutes practically the entire rock with only small remnants of the original olivine grains left. It would thus appear that a peridotite or even a dunite may alter to mass-fiber asbestos. That this alteration does take place to a limited extent is certain, but whether deposits of commercial proportions are formed in this way can not be conclusively stated. Although this alteration has been observed, and mass-fiber deposits are seen in association with rocks which are undoubtedly altered dunite, the fact that one part of an intrusion has altered completely and an adjacent part only slightly, suggests that this difference is due to a difference in the original mineral content of the rock or in the proportions of the different minerals present. From a study of the field relations at certain places, such seems to be the case; especially since enstatite, often in very subordinate quantities, is found associated with the olivine rocks at most of the localities studied.

Furthermore, enstatite has been observed altering freely to anthophyllite; in fact, masses of original enstatite have unquestionably given rise of mass-fiber anthophyllite. This alteration is best shown at the Pig Pen Mountain deposit in Rabun County, and 7 miles east of Canton on the W. T. Worley place. The conclusion is inevitable that enstatite and olivine-enstatite rocks give rise to mass-fiber anthophyllite; and, while it seems probably that dunites may also, it can not be stated conclusively that such is the case.

The origin of the amphibole in the case of cross- and slip-fiber veins may be the same, in the main, as in the case of chrysotile. At least there is no evidence that the amphibole, either tremolite, actinolite, or anthophyllite, was derived directly from some other mineral as in the mass-fiber deposits; on the contrary the collection of the material in veins shows the more active agency of solutions, although the material was doubtless collectetd from the adjoining rock walls. Slip-fiber asbestos is unquestionably formed in previously existing fissures; and in the case of cross-fiber, while the proof is not so easily obtained, the same condition doubtless existed. The veins are in every way similar to those of chrysotile, the fibers being perpendicular to the enclosing walls, and sometimes continuing from the one to the other, but more commonly jointed one or more times.

DEVELOPMENT OF THE FIBROUS FORM

Merrill[1] is inclined to believe that the fibrous form of amphibole asbestos is due, in some cases if not all, to a process of shearing. This is a natural conclusion at which to arrive from a study of veins of slip fiber where evidence of motion is unmistakable; but in the case of cross-fiber veins and even more so with mass-fiber deposits such an explanation does not seem to suit the facts. In both of the last two types mentioned there may be no evidence whatever of motion. As Merrill[2] has pointed out, shearing may be effective in the case of fiber arrangement at any angle to the enclosing walls short of right angles; but where the fibers are at right angles to the enclosing walls, shearing can not be invoked as the cause of fibrous structure.

With mass-fiber deposits, although there is usually a contact layer of schistose soapstone separating it from the country rocks, there is no record of shearing forces; furthermore, it would be impossible for a shearing force, though present, to cause the anthophyllite to assume a fibrous form when that mineral is arranged in all directions to the direction of force, from parallelism to right angles. Shearing in different directions and at different times may be invoked to account for the phenomenon; but in the case of the cross-fiber veins this assumption can be disproved, since shearing in any direction would have disturbed them.

Heddle[3] and Merrill[4] have described the spontaneous fibration which amphibole undergoes when exposed to weathering agencies. This has been observed in a great many places in Georgia; at some the process is so striking that one is led to ask whether weathering

[1] Merrill, Geo. P., Proc. U. S. Nat. Mus., 1895, pp. 286-290.
[2] Op. cit., p. 289.
[3] Trans. Royal Soc. of Edinburgh, Vol. XXVIII, p. 502, 1877-78.
[4] Op. cit., p. 288.

alone may not be sufficient to cause the fibrous form. While this is not believed to be the case, weathering without doubt does accentuate the condition and may make possible the production of a better grade of fiber. The weathered mass-fiber asbestos yields a better grade of fiber when milled, because it requires less beating to separate the fibers and consequently they are less broken up in the process.

What, then, causes the fibrous form in the case of mass- and cross-fiber anthophyllite? This question has never been satisfactorily answered, but the author, as the result of both megascopic and microscopic study of much of the material from Georgia, suggests the following as a partial explanation:

Since the fibrous form of amphibole may be satisfactorily explained as the result of the abnormal development of the prismatic cleavage, that this cleavage was developed at the time of the formation of the mineral, and that the cleavage was made more pronounced through the agency of weathering. In other words, that the formation of abnormal cleavage is a crystallization phenomenon, for which no explanation is offered, while its commercial opening up is due, in part at least, to weathering agencies.

These considerations bring up the subject of the depth of the deposits of amphibole asbestos. It has appeared almost universally that the asbestos rock would give place to less fibrous material at depths and finally to material that was not fibrous. This condition, if it is true, could readily be accounted for by the theory just advanced, that weathering is an essential part of the process of developing amphibole asbestos.

The above suggestion is made for mass- and cross-fiber anthophyllite in particular; while in the case of slip-fiber veins shearing may be the active agency, as previously suggested.

MINING AND MILLING ASBESTOS

In describing the processes of mining and milling asbestos, a somewhat detailed description of the methods employed at the two active plants in Georgia will be given, followed by a general statement of the processes employed in the serpentine area of Canada as described by Fritz Cirkel.[1] A comparison of the two processes will clearly reveal the simplicity of the one used in Georgia in winning and preparing the amphibole asbestos for market. This process is inherently more simple, because, in the first place, with mass fiber there is little foreign matter associated with it which has to be separated, and thus the process resolves itself into simply disintegrating or fiberizing the asbestos rock; and in the second place, where grading is done it is accomplished by sorting the material before it is sent to the mill.

METHODS EMPLOYED IN GEORGIA

MINING

The winning of the crude asbestos in Georgia has been entirely from open cuts or quarries. Although the deposits of commercial asbestos are usually small, there are almost invariably rough, brownish boulders which outcrop on the surface. These outcrops call the attention of the prospector to the deposit, although they may not give him any accurate knowledge of its extent. The distribution of fragments on the surface, which may be the only indication of the presence of asbestos, will give him a fair idea of the size of the area underlain. The size of the asbestos deposit can ordinarily be roughly determined by digging a few moderately shallow pits, as the asbestos is usually covered by a very thin covering of soil.

In the areas where quarrying has been done, removing the soil was a very small item. When the work is once started, the asbestos body is usually followed to a place near a contact with the country rock, for there the material is almost invariably soft and a bench for blasting can be easily made if that is necessary. Most of the bodies examined are not only softened by the action of surface waters around their edges, but also along jointings or other fissures in the body itself. This weathering process may have progressed, espe-

[1] Op. cit., pp. 103-157.

cially in the smaller bodies, until the entire mass can be dug readily with a pick; in others, however, masses of the fresh, hard rock are encountered, which have to be broken up by explosives. Where this is necessary the drilling is done by hand, and dynamite is used to charge the hole. The mass-fiber asbestos rock is not hard, but exceedingly tough, so that drilling is difficult and blasting ineffective, except when a good bench is present. The outline of the pit or quarry is naturally irregular, although roughly elliptical, since it is determined by the shape of the asbestos body.

MILLING

The rock, which has been either dug up or blasted and broken with a sledge, is loaded on small hand cars or wheelbarrows, and hauled to the drying sheds, where it is allowed to dry naturally or artificially over a floor of steam pipes. (See plate XIV, figure B.)

When the asbestos rock is sufficiently dry, it is passed through an American jaw crusher, as at Sall Mountain, or through a Sturtevant rotary crusher, as at the Asbestos Mining and Manufacturing Company's plant. In the former case, the rock from the jaw crusher is passed through a rotary crusher before going through the Raymond pulverizer. The pulverizer consists of a metal case containing a revolving shaft to which are attached eight arms; to the end of each arm is attached a chilled steel beater arranged so that its face is at an angle of 45 degrees to the direction of motion, and alternating in direction so that one slopes to the right and the next to the left. This machine is run at a high rate of speed, and as the rock is fiberized it is carried upward by a suction fan, which is so regulated that the coarse material is returned to the fiberizer, the dust is allowed to settle in a dust room, and the fiber is conveyed to a bin which feeds into the packer below.

At the plant of the Asbestos Mining and Manufacturing Company, the material from the rotary crusher is passed directly through a Stedman disintegrator, consisting of a metal case in which are arranged four rings of metal bars which alternate in direction. When the asbestos rock of from one-fourth to one-half inch mesh is fed into this machine, which is run also at a high rate of speed, it is fiberized in very much the same way as in the Raymond pulverizer, and separated by air currents in the same way.

The process may be represented graphically by figure 2, page 111, which illustrates the process employed at the Sall Mountain Company's plant.

The asbestos thus milled is sacked in 100 or 200 pound sacks and is then ready for the market.

METHODS EMPLOYED IN CANADA

MINING

In the Canadian chrysotile area a large part of the mining of the crude asbestos is from quarries, although some of the companies are finding it more economical to do regular underground mining. The quarries are located on those portions of the serpentine mass which contain a high enough percentage of fiber to make it profitable to work; these areas may be termed pay chutes. The quarries are commonly rectangular in outline, and the rock is worked by a series of benches, or terraces.

After the blasting, the rock containing fiber is separated from the fiberless material, and the latter, which constitutes from 30 to 60 per cent. of the total rock mined, is sent to the dump. This separation is accomplished by hand sorting and breaking the large pieces with heavy sledges and steel wedges into such sizes that they can be further broken with small hammers. All the rock which contains long fiber is sent to the sheds, where it is hand cobbed, a process of separating the fiber from the enclosing barren rock. The resulting material is separated into three grades, depending on the length of the fiber, known as No. 1 crude, No. 2 crude and No. 3 crude; this is sacked in 100-pound bags for the market. The waste from the cobbing sheds, together with the short fiber from the mines, is sent to the mill for mechanical treatment. Only a small amount of material, that of the highest grade, is treated by hand; the bulk of the material goes through the mill, the various processes of which are represented by fig. 1, page 111.

MILLING[1]

A typical mill consists first of a crusher of the jaw-breaker type through which the asbestos rock is sent; from this it is passed through two dryers; the rock is then passed through a second jaw-breaker, then through a rotary crusher and next into a fiberizer; from the fiberizer the fines are passed over a screen where a fan takes up the liberated fiber; the residue from the screen is passed over another screen, a similar separation effected, and the sand from this screen carried off to the dump; all the fiber thus collected is passed through a grading screen which makes two grades, some of the sand is lost and the fiber is carried by suction to collectors and rescreened to form the finished product.

Thus, it is seen that the process of mechanical treatment consists of two parts; first in crushing and disintegrating the rock so as to liberate the fiber; and second in freeing the fiber thus separated from sand, and grading it.

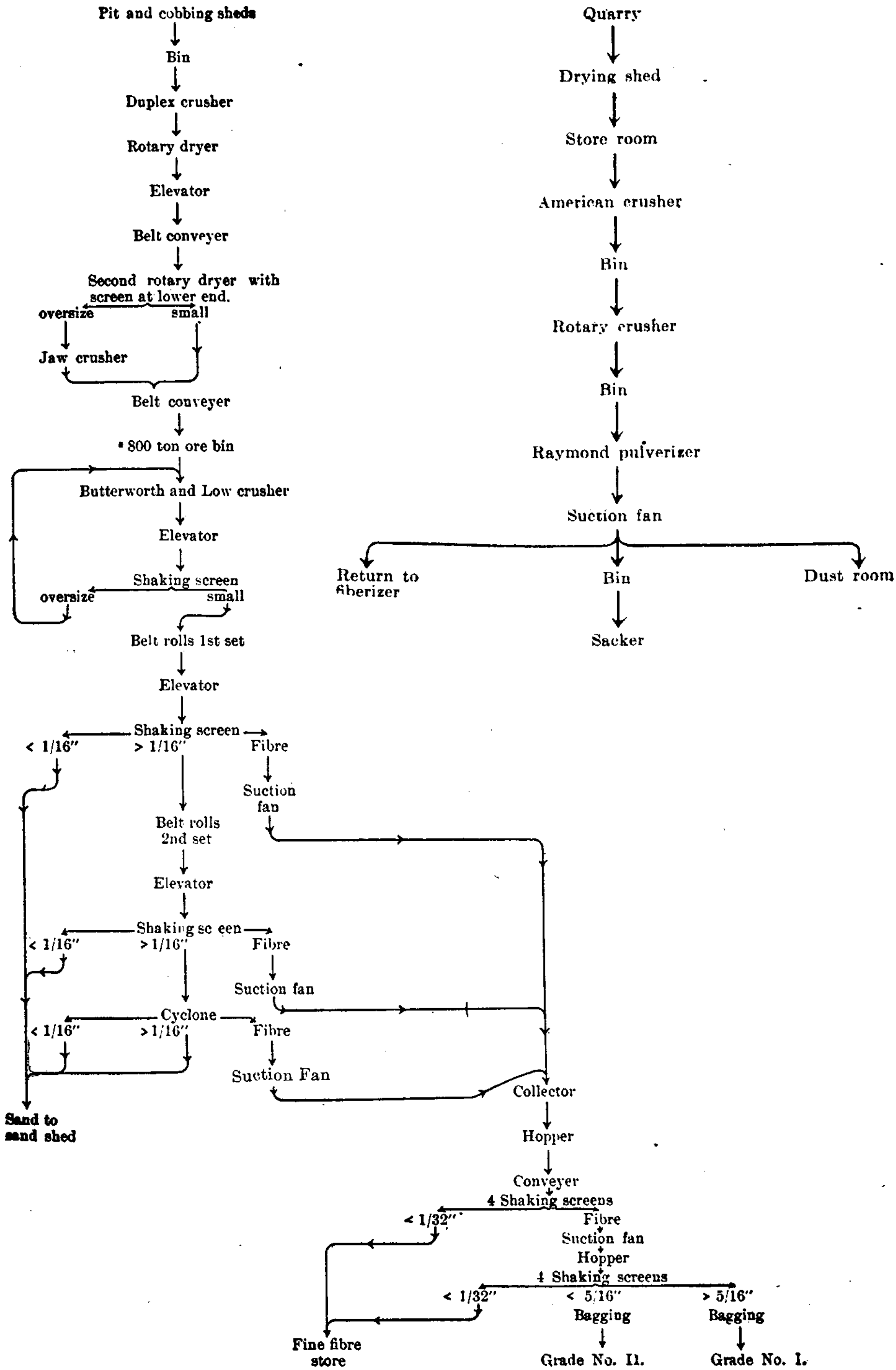
PRODUCTION AND USES OF ASBESTOS

PRODUCTION OF ASBESTOS

The production of asbestos in the United States has always been small; and although there are a number of localities where large quantities of the material are available, the industry here is overshadowed by the production in Canada. But, notwithstanding the almost inexhaustible quantities in Canada, it is practically certain that in the future the importance of the industry in this country will grow to substantial proportions. While Canada holds the first place in the production of asbestos, the United States holds the first place in its manufacture, having imported in 1912 more than 81 per cent. of

[1] For a detailed description of the different types of machinery used and their selection and arrangement to form the different milling processes, see Fritz Cirkel, op. cit., pp. 120-157.

FIGURE 1. FIGURE 2.



the total exports of Canada, and more than 67 per cent. of her total production.

According to Diller,[1] "The nearness and reliability of the Canadian supply, largely owned in the United States, evidently constitutes the basis of the American supremacy in the development of asbestos manufacture." The total value of the imports to this country in 1912 was something less than a million and a half dollars.

Imports of Asbestos into the United States, Calendar Year 1912 in Short Tons.

	Unmanufactured		Manufactured
	Quantity	Value	Value
Austria-Hungary	------------	$ ----------	$ 72,772
Belgium	6	146	22,957
Canada	71,426	1,441,475	348
England	3	510	173,095
France	------------	------------	1,366
Germany	29	4,684	84,742
Italy	6	918	7,661
Neatherlands	------------	------------	119
Russia in Europe	53	8,279	------------
Scotland	------------	------------	699
Total	71,523	1,456,012	363,759

In 1912 there were only three States, Georgia, Vermont and Wyoming, producing asbestos; of these Vermont ranked first, both in quantity and value of the output.

The following table shows the quantity and value of the annual output since 1880:

[1] Diller, J. S., Min. Res. U. S., 1912, Advance Chapter on Asbestos, p. 3.

Annual Production of Asbestos in the United States, 1880-1912

Year	Production			Year	Production		
	Quantity (Short tons)	Value	Average price per ton		Quantity (Short tons)	Value	Average price per ton
1880	150	$4,312	$28.75	1897	580	$6,450	$11.12
1881	200	7,000	35,00	1898	605	10,300	17.02
1882	1,200	36,000	36,00	1899	681	11,740	17.24
1883	1,000	30,000	30.00	1900	1,054	16,310	15.47
1884	1,000	30,000	30.00	1901	747	13,498	18.07
1885	300	9,000	30.00	1902	1,005	16,200	16.12
1886	200	6,000	30.00	1903	887	16,760	18.90
1887	150	4,500	30.00	1904	1,480	25,740	17.39
1888	100	3,000	30.00	1905	3,109	42,975	13.82
1889	30	1,800	60.00	1906	1,695	28,565	16.85
1890	71	4,560	64.23	1907	653	11,899	8.22
1891	66	3,960	60.00	1908	936	19,624	20.97
1892	104	6,416	61.69	1909	3,085	62,603	20.29
1893	50	2,500	50.00	1910	3,693	68,357	18.51
1894	325	4,463	13.73	1911	7,604	119.935	15.77
1895	795	13,525	17.01	1912	4,403	87,959	19.98
1896	504	6,100	12.10				

From 1894 until 1908 Georgia contributed a large part of the total production of the United States. Until this latter date the amphibole asbestos had been the principal type mined in the United States; but since that time the chrysotile deposits of Vermont, Wyoming and Arizona have come into prominence, particularly those of Vermont. While it is certain that the chrysotile deposits of this country will always be of greater importance than those of the amphibole type, yet it is believed that there is a future for the latter. Georgia is the only State in the Union where the amphibole asbestos has been mined successfully, and it is the only one in which that type is being produced at the present time. Deposits, however, in every respect similar to those at Sall Mountain, Georgia, have been prospected quite extensively near Kamiah, Idaho; all attempts to mine it, however, have proved failures. Similar deposits are known in North Carolina, but there they have attracted little attention.

From the following table[1] the supremacy of Canada in the pro-

[1] Diller, J. S., op. cit., p. 4.

duction of the world's supply of asbestos is clearly shown, with Russia second and the United States third.

World's Production of Asbestos, 1900-1911, in Short Tons

Country	1900	1901	1902	1903	1904	1905
United States	1,054	747	1,005	887	1,480	3,109
Africa:						
Cape Colony	174	99	45	305	411	501
Natal	------	------	------	------	------	1
Rhodesia	------	------	------	------	------	------
Transvaal	------	------	------	------	------	------
Australia	101	52	------	------	------	------
Canada:						
Asbestos	21,621	32,892	30,219	31,129	35,635	50,669
Asbestic	7,520	7,325	10,197	10,548	13,011	17,594
Cyprus	------	------	------	------	------	------
India	------	------	------	------	------	------
Russia	4,238	4,927	4,968	5,803	8,269	8,009

Country	1906	1907	1908	1909	1910	1911
United States	1,695	653	936	3,085	3,693	7,604
Africa:						
Cape Colony	522	604	1,267	1,674	1,403	(a)
Natal	------	------	------	------	3	(a)
Rhodesia	------	------	55	272	332	(a)
Transvaal	------	------	------	------	77	(a)
Australia	------	------	45	3	------	(a)
Canada:						
Asbestos	60,761	62,130	66,548	63,349	77,508	100,893
Asbestic	21,425	28,296	24,225	23,951	24,707	26,021
Cyprus	21	99	521	172	487	(a)
India	------	------	------	------	3	(a)
Russia	10,142	11,497	13,129	14,654	12,193	17,071

(a) Statistics not available.

USES OF ASBESTOS

In the following pages no attempt will be made to catalogue all the uses to which asbestos has been put; but, by calling attention to a number of diversified uses, it is hoped that a fair idea will be gained as to the importance of the industry. Those uses to which the amphibole asbestos may be put will be especially emphasized.

As was mentioned previously, the utilization of asbestos is not new, but dates back at least 2,000 years. Mention was made of the Greeks and their use of the mineral as lamp wicks and cloths for wrapping the dead. Charlemagne, in the eighth century, is reported to have used asbestos table cloths. The difficulty in weaving the fiber, first mentioned by Pliny, doubtless caused the industry to languish for so many years; in fact, until the demand for fire-proofing and insulating materials became evident. The construction cities has led to a greater fire risk, and consequently to a demand cities has lead to a greater fire risk, and consequently to a demand for something to offset it. Practically all large buildings of modern construction contain asbestos in one form or another as a fire-proofing material. The actual extent to which this may be used will be described later. And, further, the increase in the use of machinery for all purposes, from automobiles to steam drills used in quarries has been enormous; and along with it has come the demand for heat-insulating materials. These two properties, incombustibility and poor conductivity, together with its fibrous nature, are the foundations of the commercial application of asbestos.

Cirkel[1] estimates that 65 per cent. of the mill stock was used in 1910 in the manufacture of mill boards, paper coverings, and allied articles; while he predicts that in the near future 75 per cent. of the world's supply will be manufactured into asbestos slates and shingles, an industry which was begun in 1906.

It may be advantageous to describe the uses of asbestos on the basis of the grade of the fiber, thus making two divisions of the subject.

USES OF HIGH-GRADE FIBER

Under the head of high-grade fiber will be included that material which is put on the market under the trade name "crude," together with the highest grade from the mill, material which sells for as much as $300 and more per ton. The uses of the high-grade fiber are the oldest, dating back to the time of the Roman Empire,

[1] Op. cit., p. 246.

but at the present time it is a question whether they are the most important.

This grade of fiber may be used for spinning and weaving, much the same as organic fiber. Much difficulty was experienced at first in spinning the fibers because of the smoothness of their surfaces, a condition which caused the fibers to slip on one another. However, this difficulty is so far overcome that a thread can be spun which will run 32,000 feet to the pound. This thread may then be converted into rope or cloth for various purposes where fireproof material is desired. (See plate VI, figure 1.)

In the preparation of asbestos rope, asbestos fiber alone may be used, or, in case greater strength is desired, a steel core of wire may be inserted. The all-fiber rope is generally considered strong enough for fireman's use. A one-half inch rope will support 200 pounds with ease, while one of the same diameter with a wire core will sustain almost 2,000 pounds.

The increased demand for asbestos in fabrics, for automobile tires, and more especially as friction facing for automobile brakes, has been most remarkable; and for both high and low pressure steam packing it is replacing rubber.

Asbestos cloth made in many weights and thicknesses is coming into use for many and varied purposes. It is especially desirable for safety drop curtains for theaters, and all public halls; while in some cases stage scenery is made of it. Asbestos may be woven into carpets and upholstery for chairs and other furniture, into curtains, shades, and tapestries to be used in theaters, hotels, and other public buildings. Mats and doilies of asbestos may be made in attractive designs, to protect the dining table from hot dishes and for handling hot vessels.

In the construction of firemen's suits, asbestos cloth finds an important use; it not only provides the fireman with fireproof clothing, but it also serves as a non-conductor, thus protecting him from the heat.

One of the newest uses for asbestos is in the making of asbestos

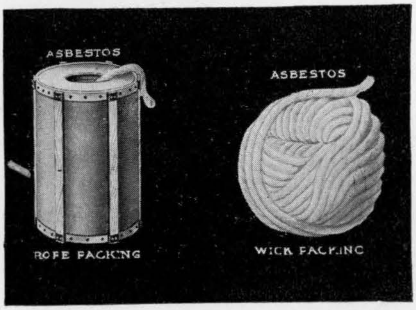


FIG. 1.—Asbestos Cord.

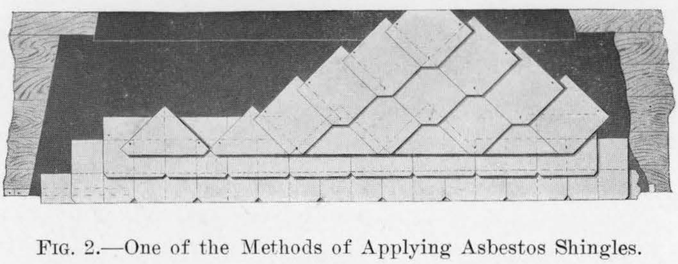


FIG. 2.—One of the Methods of Applying Asbestos Shingles.

FIG. 3.—A house Covered with Asbestos Shingles.

socks, which are recommended as practically indestructible, and at the same time soft and pliable. Asbestos leggins and shoe coverings are being manufactured for workers in molten metal.

USES OF LOWER GRADES OF FIBER

The uses of the lower grades of asbestos fiber, including asbestic (serpentine sand with more or less short fiber) may be classed under three heads, asbestos for building purposes; asbestos for insulating purposes; and miscellaneous uses. While the first two divisions are by no means mutually exclusive, they are justified if they simplify the discussion.

ASBESTOS FOR BUILDING PURPOSES

ASBESTOS SLATE OR SHINGLE

Cirkel[1] estimates that as early as 1910, 10,000 tons of asbestos was used in the slate industry. The original process was an invention of Ludwig Hatschek, of Bocklabrueck, Austria, and was patented in 1906. Since that time manufactories have been opened up in Hungary, France, Germany, Russia and the United States, in which the original process or other more recent ones have been employed. The slates are made principally of asbestos fiber, together with cement, and moulded into shape under enormous pressure. The Century shingles, manufactured by Keasbey Mattison Co., of Ambler, Pennsylvania, are stated to contain 15 per cent. of asbestos fiber and 85 per cent. or Portland or hydraulic cement, and to be submitted to a pressure of 700 tons to the square foot. The resulting slate is very hard and strong and is recommended because of its poor conductivity of heat, fire-proof and water-proof quality and durability. It is made in various shades and colors, which are particularly attractive for residences. The slates are quoted from $7.00 to $16.00 per square, depending on the size and color. The initial cost is rather high; but, considering that the maintenance expense is practically nil, the final cost is only moderate, if not low.

[1] Cirkel, op. cit., p. 266.

Asbestos slate is consirably lighter than natural slate or tile; its weight when laid is about the same or a little in excess of a roof of the same size covered with wooden shingles. Asbestos slate may be laid in the regular shingle fashion or diagonally, according to the French method of application; the average weight per square when laid in shingle fashion is 272 pounds, and when laid diagonally the average weight per square is 416 pounds. (See plate VI, figs. 2, 3.)

ASBESTOS-PROTECTED METAL

Plain steel sheathing has long been used as a building material in the construction of factories, warehouses, garages, etc.; while in more recent times the same sheathing with a coating of asbestos has come into use because of its resistance to rust, fire, acid fumes, and other corrosive agencies. It is made either in flat sheets or in corrugated form. In either case a central layer of sheet steel is used; this is immersed in a bath of cementing material and covered on both sides with asbestos felt, composed of 15 per cent. asbestos fiber and 85 per cent. Portland or hydraulic cement. The sheathing when made is subjected to enormous pressure, up to as much as 650 tons per square foot. The resulting product is used for roofiing, blast furnaces, garages, for train sheds, elevators, rolling mills, etc. It is strong, light, and easy to apply.

On account of its heat-insulating value it is particularly adapted to use in tropical or semi-tropical countries. The United States Government used this material in the construction of some of the buildings in the Panama Canal zone.

ASBESTOS PAPER

Asbestos paper is made in many thicknesses and is used in various ways in buildings. It may be used in sheet form on the side walls and floors to prevent loss of heat in winter and the penetration of heat in summer, as well as to prevent the penetration of sound. For this latter purpose it would be particularly desirable in apartment houses. It may be used to wrap all joists which come in contact with the chimneys, as well as to prevent electric wires from coming into contact with woodwork. The furnace, the furnace pipes and the hot-air flues may be separated from woodwork by asbestos paper; and in case the upper story is hot in summer, the temperature may be lowered by spreading a layer of paper under the shingles or slates. If so used, it would tend to make the house more comfortable both in winter and summer, and reduce the chance of fire and the cost of fire insurance.

In the construction of refrigerators on board ship, and cold storage buildings in cities, asbestos paper and mill boards may be used to advantage as non-conducting materials to line the double walls surrounding the cold chambers. (Plate VII, fig. 4; plate VIII, fig. 3.)

ASBESTOS WALL PLASTER

Asbestos wall plaster is being extensively used in fireproof buildings in many of the large cities of the world. In the preparation of the plaster, asbestic is largely used, a material which consists of serpentine grains and very short asbestos fiber. Plaster made of this material with more or less fiber can be applied in the ordinary way.

When rich in asbestos fiber, plaster acts as an absorbent and non-reflector of sound. Halls with objectionable acoustics may be improved by its use; the substitution of asbestos plaster for a hard wall finish will effectively prevent reverberation and echoes.

ASBESTOS LUMBER FOR MOULDINGS, PANELS, ETC.

Asbestos fiber has been manufactured into a great variety of materials for interior decoration, such as sheets, mouldings, and panels which can be sawed, planed and worked in every way like wood. There are a number of different products of this nature which go under different trade names.

Asbestos lumber is employed in the protection of electric short circuiting of electric cars, and for general fireproofing purposes.

In regards electrical resistance, magnesia boards are superior to those made of asbestos,[1] while in regards heat-insulating value

[1] See the insulating value of asbestos.

the reverse is true. Thus from the standpoint of fire risks asbestos boards possess more merit than magnesia boards. Tests have been made in regard to the mechanical strength of asbestos boards, showing them to be superior to those made of magnesia.

The asbestos boards made by Keasbey and Mattison Company, at Ambler, Pennsylvania, are stated to contain 25 per cent. asbestos and 75 per cent. Portland cement. These ingredients after being mixed together, are submitted in sheets to a pressure of 83 tons per square foot. The magnesia board is prepared by permeating the asbestos mill board with a solution of silicate of soda and bicarbonate of magnesia, the water being removed by subjecting the mill board to pressure.

Asbestos lumber, since it can be stained, polished and finished to almost as high a degree as wood, can be used to advantage as flooring, and for decorative purposes in public buildings, hotels and theaters.

FIRE-PROOFING INTERIOR WOODWORK

All the interior woodwork of a building may be fire-proofed according to the Pyrono process.[1] This is a modern invention, and the fire-proofed woodwork is just now being introduced. The Hurt Building, in Atlanta, Georgia, has all its doors and door frames of this kind. A door, for instance, is composed of five layers: a central core of wood followed on each side by a layer of asbestos sheathing about one-eighth inch in thickness, and finally a facing on either side of wood veneer. Plate VIII, figs. 1, 2.) A door made in this way is not distinguishable in appearance from an ordinary door, but it has the advantage of being fire-proof. A fire on either side of it will burn off the thin coating of veneer, thus reaching the layer of asbestos; this layer, though thin, is pressed so tightly upon the interior core of wood that all oxygen is excluded and the wood can not burn, although the core may char. Wood is a good non-conductor of heat, while charcoal is a better one, and since the pre-

[1] The Pyrono Process Company, The Ruggery, Columbus, Ohio, made by the Alfred Struck Co., Louisville, Ky. (Process patented.)

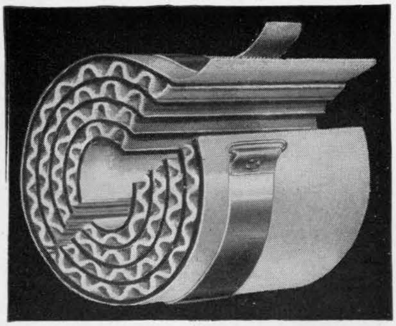


FIG. 1.—Asbestos Air Cell Pipe Covering.

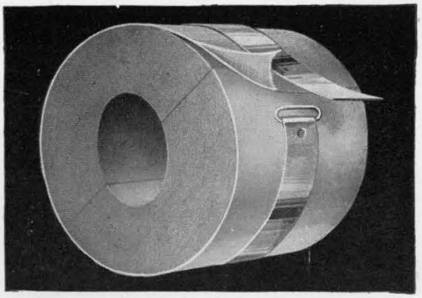


FIG. 2.—Asbestos Magnesia Sectional Pipe Covering.

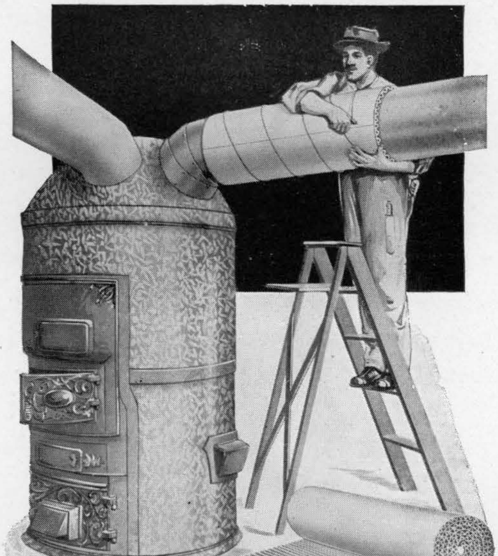


FIG. 3.—Asbestos Covering Applied to Furnace and Furnace Pipes.

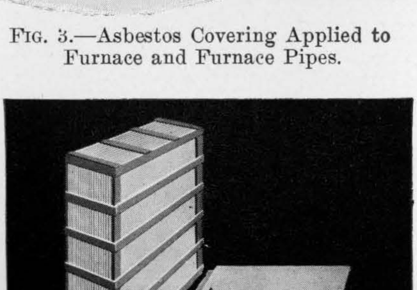


FIG. 4.—Asbestos Millboards.

vention of the passage of flames or high temperature is the essential thing, the charring may be considered an advantage so long as the door remains intact.

The asbestos sheathing used in the preparation of this type of fire-proof woodwork is made of long-fibered asbestos and weighs from 8 to 10 pounds per square. A door of this type with a central core of pine 1¾ inches thick was submitted by its manufacturer to a continuous temperature of 1,900° F. for nearly one and one-half hours without charring through the pine core.

The Pyrono door and other fire-proof woodwork is recommended for interior work in compartment buildings of fire-proof constructin and is guaranteed to withstand the combustion of all articles used in the furnishing and decoration of a single compartment, and thus prevent the spread of fire from one compartment to another.

ASBESTOS TILING FOR FLOORS

Asbestos, together with cement, has been made into floor tiling, for which it is recommended because of its impermeability, hardness equal to that of cement, elasticity as great as that of wood, lightness, durability and low conductivity of sound. Such floors show greater resistence to abrasion than marble or brick, and make less noise when walked upon.

ASBESTOS PAINTS

Paints are made containing asbestos fiber which are suitable for rough woodwork such as the interior of warehouses and factories. When thus applied it makes the surface coated much less susceptible to fire. Paint with a small amount of fiber is coming into use for the higher grades of work, since it has been found that when used in moderate quantities the asbestos lengthens its life and strengthens the paint.

FOR INSULATING PURPOSES

One of the largest and most important uses of asbestos is in the preparation of material for heat and electrical insulation. For those purposes it has been manufactured into many forms, among which the most important are cement, pipe coverings, and mill boards. The purpose of the heat-insulating material is threefold: saving in cost of fuel; increase in power and general efficiency; and reduced temperature and greater comfort in the surrounding atmosphere. For electrical insulation its purpose is not only that of a safety device, but is often a fundamental part of the construction.

ASBESTOS CEMENT

Asbestos fiber is mixed with plastic clays in certain proportions to make a cement which is extensively used as a covering for boilers and steam pipes to prevent heat radiation. The cement thus prepared is mixed with water to make a thick, plastic mass and is applied with a trowel. As a rule two or three coats are put on, one on top the other, as the lower one dries. Care has to be taken to prevent the cement from falling off before it dries; the lower coats are necessarily very rough, since the smoothing of them with a trowel causes the cement to drop off. But when the coats have been applied and a continuous shell is formed, it adheres quite firmly. In case greater strength is necessary, as in the case of moving machinery, the surface may be covered with canvas. Magnesia, and in some cases infusorial earth, is used with asbestos fiber in the preparation of an insulating cement. (See plate VIII, fig. 4.)

ASBESTOS COVERINGS

Asbestos, together with magnesia and other cementing materials, has been moulded or otherwise constructed into many types of insulating products, such as pipe coverings, sectional and removable boiler coverings, mill boards and asbestos wood. The production of these materials constitutes an important part of the business of the asbestos manufacturer. Numerous types of each product are made, each one to suit particular conditions. (Plate VII, figs. 1, 2, 3.)

The 85 per cent. magnesia pipe covering, which contains 15 per cent. of asbestos fiber, is the standard cover for pipes. Other types have been made containing asbestos up to more than 90 per cent. Two types are shown on Plate VII, figs. 1, 2. Since the insulating

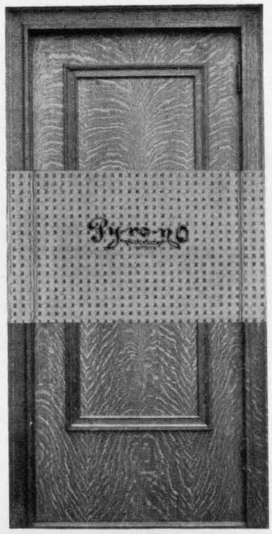


FIG. 1.—Pyrono Door.

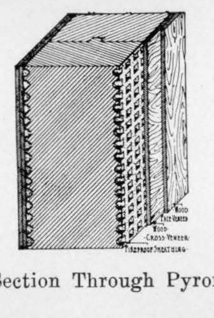


FIG. 2.—Section Through Pyrono Door.

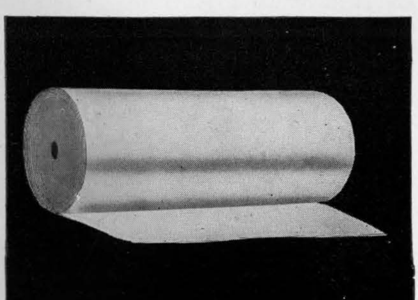


FIG. 3.—Asbestos Paper or Building Felt

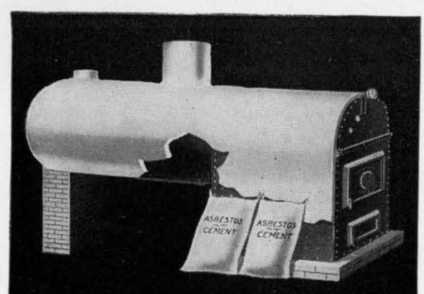


FIG. 4.—Asbestos Cement Applied to Steam Boiler.

value of asbestos is dependent upon the number of air spaces it contains, a number of different covers are made of layers of paper which is crinkled so as to produce artificially air cavities. Asbestos air cell paper is made for wrapping hot-air pipes, furnaces, etc.

All steam locomotives have to be covered in order to prevent loss of heat, particularly so as their motion creates a movement in the surrounding air which cools them off much more rapidly than if they were stationary. For this purpose numerous types of coverings have been made; asbestos mattresses, consisting of an outer cover of asbestos cloth and filled with fiber, may be used. These are particularly desirable, since they can be readily removed for repairs, and replaced without injury. Magnesia lagging, containing 85 per cent. magnesia and 15 per cent. long fiber asbestos, is generally used on the locomotives in this country.

Mill boards are somewhat similar in their construction to asbestos paper, but are thicker, and consequently firmer. They find a great variety of uses as insulators, such as in cylinder covers, steam chest covers, fire-proof boxes, and in lining stoves and ranges. The manufacture of mill boards is similar to that of ordinary card board; it is made of asbestos fiber and a binder, with more or less china clay in some instances; by special treatment they can be rendered water proof, thus giving them a wide application.

Asbestos wood is analogous to mill boards and is used particularly in electrical insulation, such as cut-outs, switchboards, and other general uses. For insulation in electrical appliances the asbestos should be free from magnetite, an impurity much more common in the chrysotile asbestos than in the amphibole type.

MISCELLANEOUS USES

Under the heading "miscellaneous uses" belong a large number of products; but only a few of the most important will be mentioned here.

In recent years there has been a tendency to substitute asbestos fire-brick for the old type of fire-clay brick. This substitution is justified on the following grounds: it is more economical, more easily applied, does not burn out, and clinkers will not adhere to it. Fire brick made of asbestos are used for lining cooking stoves, doors of boilers and furnaces, etc.

The amphibole asbestos, on account of its resistance to heat and acids, is used extensively in the chemical laboratory as a filtering medium. For this purpose the fibers have to be especially free from all impurities and finely fiberized. The chrysotile variety, being more easily affected by acids and heat, is not as suitable as the amphibole variety.

On the other hand, for making twine, where length and flexibility of fiber are required, chrysotile is very valuable. The twine thus made may be used where organic fiber would be destroyed by fire. To prevent spreading of a crack in the neck of a flask or retort, asbestos yarn or twine soaked in a solution of sodium silicate and then treated with a solution of calcium chloride may be effectively used to bind the cracked part. Asbestos wool mixed with a solution of sodium silicate makes a fire-proof cement of great strength for mending cracks in stoneware.

Asbestos has been successfully used in Germany in collecting lead fumes. The specially prepared asbestos thread is strung on frames through which the dust is filtered; and the dust thus collected on the screens is mechanically shaken off into bins.

Although to the knowledge of the writer no asbestos furniture has ever been put on the market, yet it does seem that there is an opportunity for its use. Steel office furniture has taken, or is taking, the place of wooden furniture. Will asbestos finally replace iron for this purpose? It seems quite reasonable to expect it, as the asbestos furniture would be as strong, would not warp and would be fire-proof. In addition it could be finished in almost any way so as to be attractive in appearance.

Asbestos is used in making asbestos stove mats, asbestos lined cooking utensils, asbestos flat iron holders, and numerous small articles in every day use.

FUTURE OF THE ASBESTOS INDUSTRY IN GEORGIA

Of the different types of asbestos, mass-fiber anthophyllite holds one advantage over all others; it yields a higher percentage of fiber for a given amount of rock handled. This feature is most strikingly brought out by a comparison with the chrysotile deposits of Canada. It is estimated that the average recovery in Canada for 1912 was 6.45 per cent. of the total rock mined,[1] while in Georgia the recovery exceeds 95 per cent.; on the other hand the average price per ton in 1912 for the chrysotile produced in Canada was $27.78, while in Georgia it was quoted at $12.00. Assuming an average value of $9.00 per ton,[2] the following will express the relationship:

	Canada	Georgia
Recovery	6.45 per cent.	95 per cent.
Value	$27.29	$9.00

Canadian extraction 1/17 of that in Georgia.
Average value 1/3 that in Georgia.

These figures apply to the Georgia deposits of mass-fiber anthophyllite. The slip fiber deposits, while more numerous and often more attractive looking, can have no commercial value except under extraordinary circumstances at the present price of the material. This difference is due, obviously, not to the difference in the quality of the material, but to the additional expense required to mine a deposit less than a foot wide on an average as opposed to quarrying in an open cut.

In regard to the possible uses of amphibole asbestos, the following is quoted from Joseph Hyde Pratt:[3] "Where asbestos is used

[1] Summary Report, Mines Branch, Department of Mines of Canada, 1912, p. 156, Ottawa, 1913.

[2] The exact figures can not be disclosed here, as the information is confidential, but according to the best information of the writer the price was never as low as the figure mentioned here.

[3] Min. Res. U. S., 1901, p. 892.

as an ingredient in fire-proof paint, for wall plaster, as boiler coverings, as packing in the manufacture of fire-proof safes, and for nearly all purposes in which non-conductivity of heat and not length of fiber is the important factor, the amphibole variety can be used." The uses for the low grades of asbestos are increasing materially every year, and in most cases, as suggested above, the amphibole asbestos can be used with as good results as the chrysotile. The amphibole asbestos has been used in the manufacture of retort and furnace cement, boiler lagging, steam-pipe covering, and asbestos cement for boiler and pipe coverings. In answer to a letter in regard to the uses of the material from Sall Mountain, Mr. Charles W. Kane, sales manager for the Sall Mountain Company, states that in some cases their customers prefer not to say what uses they make of it; he then enumerates the following uses: by the General Electric Company in the United States and Europe for insulating purposes, for composition plastic flooring, for rubber substitutes, and asbestos cement. Other than the uses mentioned above, the following may be suggested for the Georgia product: furnace linings, fire-bricks, steam pipe coverings, asbestos shingles, and asbestos cement floor tiling. These, it will be understood, are the uses in which the bulk of the low grade asbestos of the world is consumed.

Both of the plants in Georgia are making or planning to make asbestos cement. Georgia asbestos with or without a small quantity of the longer fiber asbestos should supply the market for asbestos cement in this part of the country. Plastic clay of the highest grade, which is customarily used as the binding material, can be bought in Georgia at a minimum price, scarcely more than is required for loading it on board the cars. If the manufacture of other products could be established here to supply local demand, the normal output of Georgia could be readily consumed. The asbestos industry is still in its infancy, but as surely as it continues to grow, all deposits, as easily accessible as are some of the mass-fiber deposits in this section of the country, will become of value. The quantity within this State is not large enough ever to make it a factor in the markets of the world, but it is sufficient for the establishment of an industry of substantial proportions.

ASBESTOS DEPOSITS OF NORTH AMERICA

In general, the asbestos deposits of the United States are limited to its extreme eastern and its western parts, with a barren area represented by the Mississippi Valley.

In the East the asbestos deposits are associated with the area of pre-Cambrian rocks, composed of gneisses and schists, which extends from east-central Alabama northeast along the Piedmont Plateau to the Gaspé Peninsula in Quebec, a distance of more than 1,600 miles. More specifically, the asbestos deposits are associated with a belt of altered peridotites and pyroxenites, which extends the entire length of this belt and outcrops usually as small isolated masses along its western edge. These rocks are found in all the states of the Atlantic seaboard from Alabama to Canada. In the northern part of the belt, the alteration, especially of the peridotites, has been to serpentine, with a greater or less development of veins of chrysotile; while in the southern part the alteration of both peridotites and pyroxenites has been to amphibolite and thence to soapstone, with a much smaller development of serpentine. Thus it may be stated that the same general type of rock which alters to form the chrysotile deposits in Canada, may in the southern part of the United States form the deposits of amphibole asbestos.

In the East, chrysotile has been mined in Canada and Vermont; while amphibole asbestos has been mined to a limited extent in Maryland, Virginia, and Georgia. Deposits of both types of unknown value are also to be found in North Carolina.

In the western part of the United States asbestos has been found at a number of widely separated localities; chrysotile is found in Wyoming, Arizona and California, and true, or amphibole, asbestos is found in Idaho and Texas. Of these the deposits in Wyoming and Arizona have attracted the most attention.

The Texas deposits are located near Llano and represent the

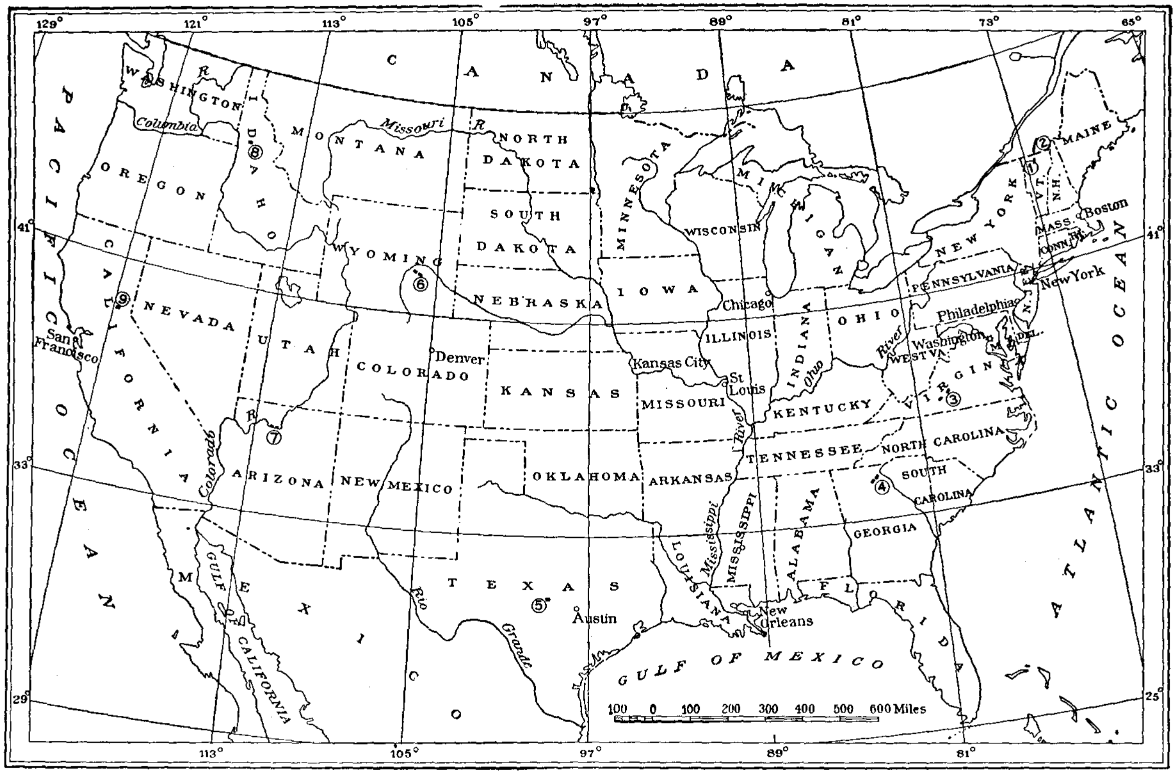


FIG. 3.—Map of the United States, showing the distribution of asbestos deposits. (From U. S. Geological Survey.)

Locations	Nature of the Material
1. Vermont, Chrysotile	Chrysotile
2. Quebec, Thetford, Black Lake and Danville	Do
3. Virginia, near Bedford and Rockymount	Amphibole (slip-fiber)
4. Georgia, Sall Mountain and Hollywood.	Do (mass-fiber)

Locations	Nature of the Material
5. Texas, Llano	Do (slip-fiber)
6. Wyoming, near Casper	Chrysotile (cross- and slip-fiber)
7. Arizona, Grand Canyon	Chrysotile (cross-fiber)
8. Idaho, Kamiah	Amphibole (mass-fiber)
9. California, Towle	Do (slip-fiber)

slip-fiber type of amphibole asbestos. The other deposits, whose approximate locations are shown on the accompanying map (fig. 3, page 128), are described in brief in the following pages in this report.

ASBESTOS DEPOSITS OF CANADA[1]

HISTORY OF THE ASBESTOS INDUSTRY

Asbestos was discovered in Canada as early as 1862 in the region of the Des Plantes River, but not until 1877 in the famous Thetford and Coleraine regions. Mining began in 1878, and increased steadily until about 1890, when the prices which had prevailed began to diminish and continued to do so until only the mills producing under the most favorable circumstances could operate. This period of depression was indeed the herald of a new era of prosperity, in that it lead to a more economic method of production—the installation of machinery for milling and fiberizing to take the place of hand labor. The development of the asbestos industry since that time has been rapid, the increase in production from 1895 to 1911 being from 8,756 tons to 100,893 tons, or from a value of $368,175 to $2,922,062. This increase is due not only to the installation of machinery, but to the ever-increasing demand for the material, brought about by its extensive and varied uses.

ASBESTOS DEPOSITS

The only type of asbestos mined in Canada is the chrysotile asbestos, which is fibrous serpentine. The serpentines of Canada are derived (1) from limestones and (2) from peridotite intrusions. To the latter class belong the important commercial deposits of the Broughton, Thetford, and Blake Lake areas.

CHRYSOTILE DERIVED FROM LIMESTONE

The deposits of asbestos derived from limestone occur in the Grenville series, which extends from Ottawa eastward for several hundred miles. The serpentine is closely associated with the bands of limestone which traverse the gneiss, running in a northeast-south-

[1] Circle, Fritz, Chrysotile Asbestos, Its Occurrence, Exploitation, Milling and Uses: Mines Branch, Canada Dept. of Mines, 1910.

west direction. The occurrence of asbestiform serpentine, however, is restricted to the country north of Ottawa.

The stratum of limestone, with which the serpentine is associated, is about 700 feet wide and is bordered on both sides by orthoclase gneiss. The limestone contains as accessory minerals mica, pyrites, small veins of graphite, pockets of hematite, and grains of serpentine disseminated through the whole rock. The asbestos-bearing serpentine frequently assumes the form of concretionary masses, sometimes resembling rounded boulders; as disconnected masses or pockets, from 12 inches up to 3 feet in diameter; as irregular masses of limited extent; and as deposits of circular or elliptical sections, having a diameter from 3 to 50 feet, and serpentine walls varying from 6 inches up to 3 feet thick. The surface outcrops of the deposits are usually elliptical, with the line of separation between the serpentine and the associated limestone sharp and well defined.

The distribution of these deposits of serpentine in the inclosing limestone is very irregular, being scattered throughout its entire thickness. The veins of chrysotile generally follow the contours of the deposits, and vary in width from a small fraction of an inch to half an inch. The crysotile is light yellow or light green, of a very fine silky fiber, and contains a smaller percentage of iron than the Canadian asbestos of the other type.

On account of the shortness of the fiber and the irregular distribution of the serpentine in the limestone, this type of deposits has not been developed to the extent that asbestos derived from peridotite has, although profitable mining has been carried on at some places, at Denholm, for instance.

CHRYSOTILE DERIVED FROM PERIDOTITES

The second type of serpentine, that derived from peridotites, constitutes a great belt which extends from southern Vermont through Quebec to the Gaspé Peninsula. This belt is divided into three parts:

1. Danville-Eastman-Vermont belt.
2. Broughton-Thetford-Black Lake belt.
3. Gaspé Peninsula area.

DANVILLE-EASTMAN-VERMONT BELT

The first belt, which may be termed the Southwestern, extends from near Danville southeast a distance of 62 miles, where it crosses the international boundary into Vermont near a small town named Mansonville. This belt is characterized by a chain of hills formed of serpentine, which is closely allied to a contiguous band of diorite and dioritic rocks. The serpentine outcrops, while they appear to be separated from each other, occupy a well-defined line and may be more connected than surface indications show, since exposures are poor, due to the thick covering of soil and heavy forest growth.

The rocks of this belt are intrusives in metamorphosed sedimentary rocks—slates, sandstones, quartzites, quartz schist, and conglomerates—which are considered by the Canadian Survey to be of Cambrian age. Most of these rocks, especially in the northern part, are flanked by ridges of crystalline schist and gneissic rocks. In the southern part the dioritic and related rocks flank the sedimentary belt on the east, and in many places serpentine merges gradually into these dioritic masses.

Crysotile asbestos has been discovered in six different places over this district.

BROUGHTON-THETFORD-BLACK LAKE BELT

The Broughton-Thetford-Black Lake belt, named from the three largest mining centers, is the most important from a commercial standpoint and is, doubtless, the largest area of serpentine along the eastern coast of North America. It constitutes the great productive belt of asbestos and chrome iron ore of Canada; and with the exception of the Danville quarries (of the former belt) it produces all her commercial asbestos.

The total length of this belt is 23 miles, with a width varying from 100 feet in the extreme eastern part to 6,000 feet in the Black Lake region; its greatest width, however, is in the township of Coleraine, where it reaches 3½ miles. The productive serpentine of this belt is confined to the southeastern part of a series considered Cambrian in age. This series consists of quartzites, chloritic schists, slates, and mica schists. The serpentines are not confined to any single horizon, but are invariably associated with quartzitic rocks or with greenish schists, or dark slates; and at many points throughout the area with dioritic masses, sometimes of large extent. The serpentine at places forms mountainous masses from 700 to 1,000 feet above the surrounding country, and gives a rugged aspect to it through its sharp outlines and weathered surfaces.

The rocks of this belt represent altered dunite, peridotite, and pyroxenite. The first is essentially an olivine rock, the second is essentially olivine with more or less pyroxene, and the third consists essentially of pyroxene. These three types may occur separately or as parts of the same mass, showing gradations from the one to the other. The first essential requisite in the formation of asbestos fiber is the complete alteration of the original rock to serpentine, and since this has not been accomplished over the entire area, barren stretches are thus accounted for.

The asbestos occurs in bands of varying width, cutting the serpentine, with the fibers parallel and perpendicular to the enclosing walls. These veins follow as a general rule, straight lines, and cut the serpentine in all directions without any apparent regularity, except in a few cases where they are parallel to each other and dip more or less in the same plane. The veins cross each other at random, split to form smaller veins, or coalesce to form a larger one.

The width of the veins varies from microscopic threads up to several inches, but the bulk of the material quarried varies from one-fourth to one-half inch. The fiber often appears to be longer than this, but on close examination it is seen to be divided by a thin seam of serpentine with more or less magnetite and chrome iron ore. Veins which are three-fourths of an inch or more usually yield material of excellent quality for spinning and command the highest price.

Slip fiber is the term applied to the occurrence of asbestos in which the fibers are arranged parallel to the enclosing walls. Asbestos of this type often appears to possess a fiber of superior length, but upon careful inspection it is found to be of the same length and grade as the cross fiber. The occurrence of slip fiber is limited to a belt about 14 miles long extending from near Broughton to near Thetford.

GASPE PENINSULA AREA

On the Gaspé Peninsula the development of serpentine has been on a large scale, especially on Mount Albert and Smith Mountain in the Shickshock Mountain range. Here it is found interstratified with slates and sandstones and sometimes with diorites. In the western part of the area there is little promise of commercial asbestos, but in the eastern part, at Mount Serpentine, on the Dartmouth River, asbestos has been discovered in bands of serpentine associated with hornblende rock. Chrysotile also has been found on Asbestos Island and on the north shore of McKenzie Bay.

ASBESTOS DEPOSITS OF VERMONT

INTRODUCTION

Asbestos[1] in Vermont was discovered as early as 1824, and in 1861 Prof. Edward Hitchcock made frequent mention of its occurrence in his report. However, it was not until 1899 that a Canadian lumberman rediscovered the deposits and recognized their commercial importance. He opened a prospect where the Lowell Lumber & Asbestos Company is now mining and milling asbestos.

GEOLOGIC OCCURRENCE

The asbestos of Vermont is of the crysotile variety and is associated with a band of serpentine rocks which extends somewhat intermittently from the Gaspé Peninsula through the famous Thetford and Black Lake regions of Quebec, across the international boundary into Vermont, and through the latter in a north-south direction.

Commercial asbestos, so far as has been discovered, is limited

[1] Kemp, J. F., Min. Res. U. S., 1900, pp. 862-866.
Richardson, C. H., Seventh Rept. State Geologist of Vt., 1909-10, pp. 315-330

in this State to its northern part, and more particularly to Orleans and Lamoille counties. According to Prof. Hitchcock, the serpentines are confined to a broad band of talcose schist, which has a width of 15 miles in the northern part of the State and a minimum width of 2½ miles in the southern part. This is bounded on the west by a series of hornblende, sericite and mica schists of pre-Cambrian age, and on the east by sedimentary rocks consisting of schists, slates, sandstones, and quartzites, probably of Cambrian age.

ORIGIN

The serpentines of this belt are derived from the alteration of ultra-basic rocks, largely peridotites, pyroxenites, and gabbros. The original rocks have been altered to serpentine and amphibolite with more or less talc. In the northern part of the State the latter is in very subordinate amount, but to the south it is present in larger quantities. This fact is doubtless due to the change in the type of rock found in passing from the northern part of the State southward, the olivine-rich peridotite giving way to pyroxenite. While the former tends to alter to serpentine, the latter is more likely to change to a talcose rock.

Although chrysotile is the material sought after in this region, fibrous amphibole also occurs, the former usually as cross fiber and the latter as slip fiber. The best development of asbestos of both types is in the immediate vicinity of faults, or near the upper and lower contacts of the serpentine and amphibolite.

DESCRIPTION OF INDIVIDUAL DEPOSITS

There are four localities which are worthy of mention from an economic point of view. They are all situated near Lowell, and are within an area of less than 10 miles square.

The first is situated 2 miles northwest of Lowell. The serpentine rocks here can be traced a distance of 25 miles with a width of one-half mile or more. Prospecting has been carried on with the result that good asbestos in the form of cross-fiber veins up to 1½ inches in width has been found on the northeast and eastern side of the intrusion. The mass is not equally serpentinized; on the western side of the area the rock is largely unaltered olivine. According to Richardson,[1] the showing of asbestos is sufficient to warrant construction of a mill to produce a car-load of asbestos per day.

The second area, located on the northeast side of Round Mountain, is several miles long and one mile wide. In the north and northeast part of the area, slip fiber and cross fiber are present in considerable quantities. Erosion has removed the sedimentary rocks on the east, and thus leaves the serpentine bare for hundreds of feet, making the thoroughly serpentinized rock easily available.

The third of the areas, situated on the southwest side of Belvidere Mountain, was leased by the New England Asbestos Mining & Milling Company, and was deeply prospected and at one time worked, but owing to mismanagement, has been closed for many years. The asbestos near the surface is largely slip fiber, while at a depth of 40 feet much cross fiber is reported. Richardson[2] states that "by conservative management, this property may yet become a producer of considerable asbestos."

The fourth, and most important, field for the production of asbestos is located at Chrysotile, on the northeast side of Belvidere Mountain. It is owned by the Lowell Lumber and Asbestos Company. On this property the serpentine forms a precipitous cliff and the excavations are made on the face of this escarpment. Both cross fiber and slip fiber of a good grade are to be found. An enormous supply of asbestos-bearing serpentine rock is available, which will yield 10 to 15 per cent. of marketable asbestos material. A large, thoroughly modern mill is in operation here, and produces a large part of the total production of the United States.

ASBESTOS DEPOSITS OF VIRGINIA[3]

For some years prior to 1907, Virginia produced a small amount

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[1] Richardson, C. H., op. cit., p. 322.
[2] Op. cit.
[3] Diller, J. S., Bull. U. S. Geol. Survev, No. 470, Pt. I, pp. 520-521. Min. Res. U. S., 1907, Pt.II , pp. 718-719.

of asbestos of the amphibole type; but since that date there has been little or no work done on the deposits.

Asbestos deposits are found in Franklin and Bedford counties.

The Bedford asbestos mines are located 12 miles south of Bedford City, where they cover two small areas of 2 and 5 acres each. The prevailing rock of the region is composed of hornblende and olivine, but locally pyroxene and olivine, or wholly olivine. The rock varies from a cortlandite to a peridotite, and finally to a pyroxenite. All types contain acicular crystals and fibrous bundles of anthophyllite, and rarely cross-fiber veins of that mineral. Slip fiber has been developed along shearing planes, striking northwest and southeast and dipping southwest. An 18-inch vein has been followed along the strike for 30 feet, and on the dip for 50 feet. The veins vary much in thickness and are unreliable as a basis for mining operations. A small body of mass-fiber anthophyllite similar to that at Sall Mountain, Georgia, is found in this region in a dike 5 feet wide.

Asbestos is found in Franklin County near Rocky Mount, where a small amount of mining has been done. The asbestos occurs as a slip-fiber vein in an amphibolite, which is composed largely of tremolite. The amphibolite occurs in mica schist. A shaft has been sunk on this vein to a depth of nearly 40 feet, and some 40 tons of asbestos have been mined. The region does not present a very favorable showing of asbestos from a commercial standpoint.

ASBESTOS DEPOSITS IN WYOMING

LOCATION

Asbestos deposits[1] have been found in Wyoming in the Casper, Haystack and Clear Creek ranges, Natrona and Converse counties; in the Big Horn Mountains, Sheridan County; in the Seminole Mountains and the Encampment District, Carbon County; and in the Wind River Range, Fremont County. Of all these localities, the

[1] See H. C. Beeler: Colorado School of Mines Magazine, Vol. 1, No. 10, pp. 5-9; No. 11, pp. 5-9, July and Aug., 1911. Eng. & Min. Jour., Vol. 90, p. 955, Nov. 12, 1910.

F. H. Barrow: Eng. & Min. Jour., Vol. 90, p. 559, Sept. 17, 1910.

deposits in the Casper region are the most important and have attracted most attention.

There are two separate asbestos-bearing areas in the front range of the Rocky Mountains near Casper, Wyoming—one on the Casper Mountain, 8 miles south, and the other on Smith Creek about 20 miles southeast of Casper. The Casper Mountain area embraces approximately 4½ square miles and the Smith Creek area nearly 7 square miles.

STRUCTURE AND ROCKS OF THE REGION

Both the Casper Mountain and Smith Creek areas are anticlinal, and are formed of central cores of igneous rocks, surrounded by Paleozoic and Mesozoic sediments, which dip in all directions from the central masses, and separate them by a broad syncline. The rocks of the asbestos-bearing regions are hornblende schist, diorite granite and serpentine. The granite is generally considered the oldest rock of the region, and it is cut by diorite and serpentine dikes. The serpentine dikes strike northwest and southeast, and if continued from one area in the direction of the other, they would meet under the syncline of sedimentary rocks, which may be the true condition. The serpentine is bluish in color, and is much crushed and sheared. The mass is so thoroughly serpentinized that traces of its original character are only seen in thin sections, which clearly show that it was derived from an olivine-rich rock, probably dunite.

ASBESTOS DEPOSITS

The asbestos of the Casper Mountain region is almost entirely chrysotile; it occurs both as cross and slip fiber. The color varies from almost colorless to pale green to yellowish bronze. While the veins of cross-fiber are found from a small fraction to an inch in width, the average range is from one-eighth to one-fourth of an inch. The veins are usually parallel, but often cross each other, thus suggesting that the formation of the asbestos belongs to more than one period. Belts of asbestos-rich serpentine from 4 to 10 feet wide occur at intervals separated by barren or "lean" areas.

The asbestos contains less chromite and magnetite than the Vermont and Canadian material; so little, in fact, that Beeler[1] states that he has not encountered any in his investigations.

The slip fiber occurs in considerable quantities in the sheared portions of the serpentine. As a rule it is of as good a quality as the cross fiber, and is in part due, no doubt, to the crushing and shearing of what was originally cross-fiber.

The asbestos is generally best developed near the contact of the serpentine and the granite with which it is associated.

AVAILABLE SUPPLY

In regard to the supply of asbestos rock available, Beeler says[2] "Consider if you will three proven deposits varying from a mile to at least a mile and a half in length showing fiber zones from 100 feet up to several hundred feet in width and exposed by the natural canyon condition to a depth of 400 to 800 feet, now apply to these the most conservative figures available for the fiber content of the exploited deposits and the resulting tonnage will startle even those who are accustomed to large tonnage figures. Inexhaustible seems to be the real word to apply to these deposits and the quality of the fiber produced is an acknowledged fact."

While Beeler's report is optimistic to a high degree, there appears no reason to take the opposite view. Considering the facts of the location, the large amount of mill rock which will yield 5 to 10 per cent. of fiber, the transportation facilities and the distance from the markets, it seems possible that Wyoming will become a prominent asbestos-producing state.

ASBESTOS DEPOSITS OF IDAHO[3]

Asbestos has been found in Idaho, 14 miles southeast of Kamiah, in the form of mass-fiber amphibole, illustrating the third mode of occurrence of that mineral, according to Diller. The occurrence here is similar in every way to that at Sall Mountain, Georgia.

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[1] Beeler, H. C., op. cit., Vol. I, No. 11, p. 9.

[2] Op. cit.

[3] Diller, J. S., Contributions to Economic Geology: Bull. U. S. Geological Survey, No. 470, pp. 519-520.

At this locality, asbestos appears in the form of dikes or lenticular bodies intruded in mica schist. There are about a half dozen outcrops of this kind over an area of several square miles. The largest of these bodies is about 200 feet long, 40 feet wide, and extends 35 feet above the ground. From deep prospecting it appears that these bodies pinch out rapidly downward, so that they can hardly be expected to have a vertical extension as great as their greatest lateral dimension. There is a large amount of the material available.

No production from this locality was reported in 1912.

ASBESTOS DEPOSITS OF CALIFORNIA

Asbestos has been found in varying quantities in 13 counties in California. Most of the material is of the chrysotile variety found in serpentine. The origin of the serpentine, in the majority of instances, at least, is due to the alteration of basic rocks.

Prospecting and a small amount of mining was done in Placer County, the location of some of the most promising deposits in the State, prior to 1905; during that year 10 tons were shipped to San Francisco. There was no production from this locality in 1912, but prospecting was continued.

While asbestos is widely distributed over the State, for the most part, it occurs in small quantities.

ASBESTOS DEPOSITS OF THE GRAND CANYON, ARIZONA

INTRODUCTION

The asbestos deposits[1] of the Grand Canyon of Arizona occur in serpentine derived from rocks of sedimentary origin. This locality will always be of scientific interest, whether it yields large quantities of commercial material or not, because it has thrown considerable light on the mode of formation of asbestos.

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[1] Diller, J. S., Contributions to Economic Geology, Bull. U. S. Geol. Survey, No. 470, 1910, p. 516-519.
——— Min. Res. U. S., 1911, p. 997.
Pratt, J. H., Min. Res. U. S., 1904, pp. 1137-1140.
Noble, L. F., Amer. Jour. Sci., 4th ser., Vol. 29, 1910, p. 520.

LOCATION

The asbestos deposits are located in Coconino County, Arizona, about 70 miles northwest of Flagstaff, the county seat. Grand Canyon is the nearest point on the railroad at a distance of about 20 miles from the farthest locality. There are three known localities in a distance of 60 miles, two of which have been described; but of the third, little is known on account of its inaccessibility. The deposits are located in the Grand Canyon at a depth of 4,000 feet or more from its rim, and 1,000 feet or more above the river.

GEOLOGICAL OCCURRENCE

The rocks in which the asbestos occurs consist of the Algonkian series of sedimentary rocks, lying unconformably upon Archaean granites and gneisses. Above the Algonkian series and lying unconformably upon it are sedimentary rocks of Cambrian age.

The structure of the Algonkian rocks is monoclinal with a dip of from 10° to 20° to the northeast. They are cut here and there by normal faults of small displacement. This series, while deep-seated and of great age, has been effected to a remarkably small degree by earth movements which tend to fracture and metamorphose the rocks. In this respect this mode of occurrence of asbestos stands in sharp contrast to that of peridotites.

The following section,[1] made by L. F. Noble, shows the relationship of the asbestos to the enclosing rock as it is exposed in Asbestos Canyon, one of the important localities in the region:

Section of Asbestos-Bearing Rocks in Asbestos Canyon

	Feet
8. Diabase.	
7. Layer of green serpentine	2
6. Pure white crystalline limestone	1½
5. White crystalline limestone with bands and nodules of serpentine	2
4. Serpentinous, nodular and banded layers carrying veins of asbestos	1
3. Banded crystalline limestone with bands and nodules of serpentine	10
2. Nodular, cherty limestone	4
1. Soft blue slate	5

As may be seen from the above section, the asbestos is associated with serpentine derived from the alteration of limestone due, no

[1] Op. cit.

doubt, to the influence of the neighboring diabase. The serpentine layer which carries the asbestos is usually from 12 to 14 inches in thickness, and is parallel to the bedding of the limestone. It is exposed for a distance of three-fourths of a mile. The asbestos occurs in parallel cross-fiber veins which are remarkable for their continuity, often extending 150 feet. While as an average the 12-inch layer would yield about 15 per cent. of asbestos, locally it will yield as much as 40 per cent. of high grade material.

The second locality, near Grand View, is 30 miles east of the locality described above. The asbestos zone is only a foot or so wide and can be traced for a distance of about 2 miles. Extensive prospecting has been done here, and a test of the material was made with the result that it was pronounced to be of the highest grade.

CHARACTER AND ORIGIN OF THE ASBESTOS

The asbestos is of the chrysotile variety, possessing a golden-yellow color grading into pale green. The veins have few partings, and little if any magnetite. It is finely fibrous, silky, and of great tensile strength.

It occurs in serpentine which is derived from magnesian limestone through the action of intruded diabase, with which it is associated. The important role which the diabase has played is demonstrated by the fact that serpentine and asbestos are developed in the limestone only where the latter is in contact with diabase. Serpentine and asbestos are never developed in the diabase itself, neither are they ever developd in shale where the latter cuts it. Thus, it is evident that the limestone is as essential to the development of serpentine and asbestos as the diabase, and vice versa.

OUTLOOK

Although the lineal extent of the deposit is a mile or more at each of the localities described, its thickness is only one foot, or at most two feet. The proportion of high-grade crude to mill stock is larger than at any known asbestos deposit. The freedom of the fiber from magnetite gives this material an additional value for certain purposes. Thus, it may well be concluded that the wide lateral distribution of the deposits, the ratio of high-grade crude to mill stock, and the freedom from magnetite, together with the superior quality of the fiber, will probably some day overcome the difficulties of accessibility, transportation, and thinness of the workable asbestos body.

DETAILhD DESCRIPTION OF THE GEORGIA DEPOSITS

The asbestos deposits of Georgia are associated with the crystalline schists of pre-Cambrian age which occupy both the Piedmont Plateau and a part of the Appalachian Mountain provinces. While asbestos has been found associated with basic igneous rocks over almost the entire area of crystalline schists, the distribution of deposits likely to be of commercial value is much more limited and is, in general, confined to a belt extending from Rabun and Towns counties southwest into Alabama in the neighborhood of West Point. And even in this belt, the most important deposits are found in its northern part, and more specifically in Rabun, White and Habersham counties.

Besides the localities described in the following section of this report, asbestos has been noted from a number of others and described under the soapstone deposits, the most important of which are as follows: S. M. Harris property, Pauling County; and Rodgers and McLendon, J. W. Stallings and W. A. Freeman properties in Carroll County.

RABUN COUNTY

GENERAL FEATURES

The Carolina gneiss, consisting largely of granite gneiss, injection gneiss and mica schists, together with the Roan gneiss, is the predominant rock in Rabun County. At the head of the valley of the Litttle Tennessee River there is a considerable area of granite. There are two prominent belts and a number of isolated areas of basic rocks in this county. The western belt crosses the Georgia-North Carolina State line a few miles north of Dillards; it is prominent in the upper part of Betty Creek, and with a break in the valley of Persimmon Creek it reappears near Burton and continues southwest to form the prominent belt which crosses the northwestern part of Habersham County and runs into the central part of White County, past Nacoochee to near Cleveland. The second belt of basic dike rocks is found in the extreme eastern part of the county near Pine Mountain. This belt comes into Georgia from Jackson and the eastern part of Macon counties, North Carolina, and is most prominent in Georgia in the northeastern part of Rabun County. From there it appears at intervals in a southwest direction east of Tallulah Falls, near Hollywood, Demorest, and, finally, near Gainesville. A few localities are found between these major belts.

There are a number of localities in Rabun County where mass-fiber asbestos is found in large quantities; but the ruggedness of the country and the poor transportation facilities make these deposits quite inaccessible under the present market conditions. However, these deposits are likely to have in the future a commercial value which will make them accessible.

DESCRIPTION OF PROPERTIES

LAUREL CREEK MINE[1]

The Laurel Creek mine, once one of the most important corundum mines in the United States, was first worked for corundum in the early seventies, but was later abandoned. About 1880 it was worked for asbestos. In mining the latter mineral hard, heavy rocks were encountered, which were afterwards found to be corundum, a discovery which made a poor asbestos mine become an exceedingly rich corundum mine. Since 1880 no asbestos has been mined here.

The mine is situated in the southern portion of lot 72, 3rd district, one mile northeast of Pine Mountain, and from 16 to 18 miles from Clayton and Walhalla, the nearest railroad stations. The intrusion is located on the northern bank of Laurel Creek, from which the mine takes its name.

The country rock is a granite gneiss with a prominent band of

[1] King, Francis P., Corundum Deposits of Georgia; Bull. Ga. Geol. Survey No. 2, 1894, pp. 77-83.

hornblende gneiss on the eastern side. The intrusion, which is 1,700 feet long and 750 feet wide, is a peridotite, and in large measure a dunite, partly serpentinized. (See Plate IX, figure A.) Along the western contact, however, there is a prominent body of anthophyllite occupying an elongated band between the peridotite and the country rock. Immediately next to the country rock there is a layer of talc schist, followed by a zone of somewhat altered mass-fiber asbestos and finally the hard, poorly-fibrous anthophyllite rock. Near the eastern contact there is developed some soapstone, but in rather small quantities.

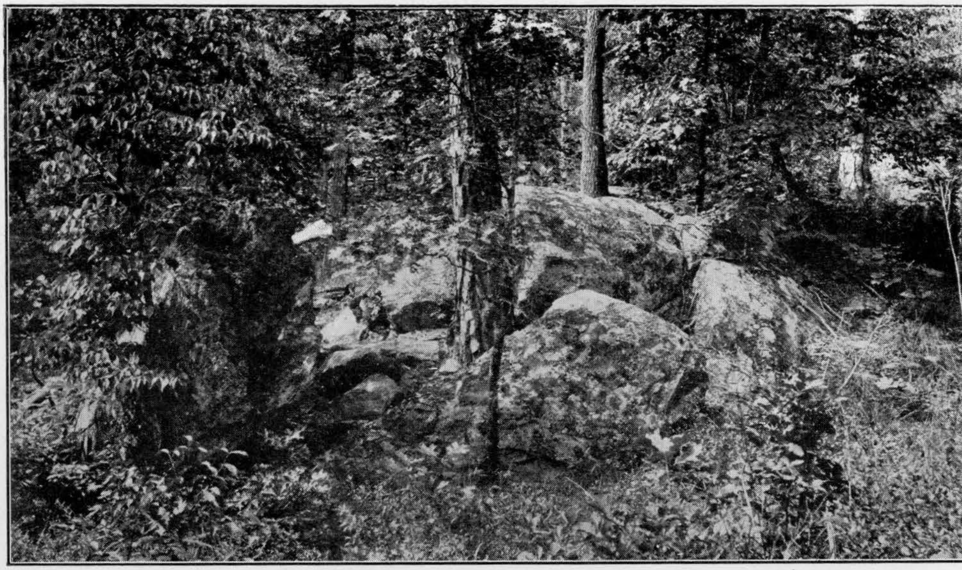
This locality does not offer a favorable prospect for commercial asbestos or soapstone.

HICKS ASBESTOS MINE

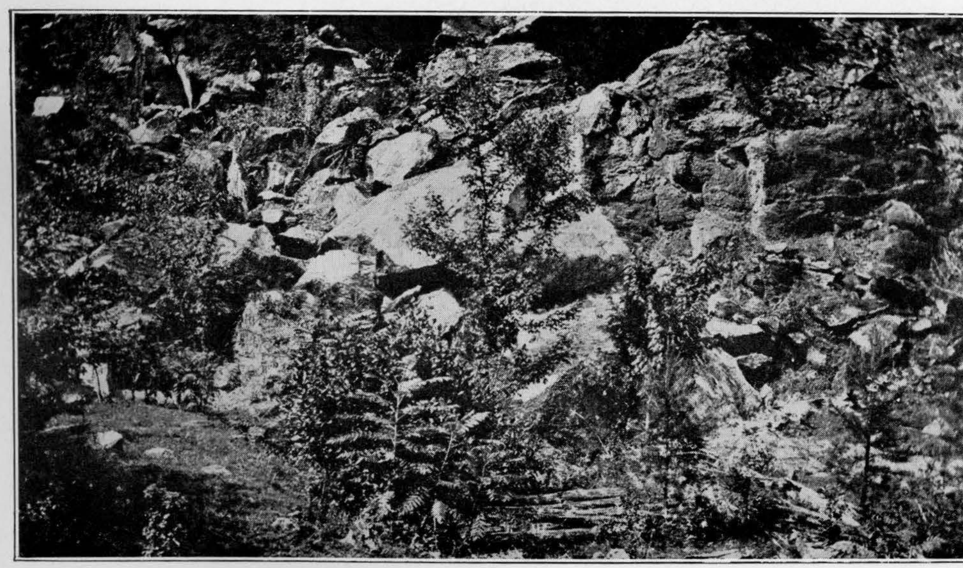
Northeast of Laurel Creek mine, on lot 81, 3rd district, there has been some prospecting for asbestos on the property of Joe Hicks. Considerable long-fiber asbestos is reported to have been shipped from here about 1885; but since that time the property has been abondoned.

The intrusion of this property is 150 feet wide and at least 300 feet long, forming the crest of a small divide between two branches. It strikes N. 30° E. and dips to the east. A tunnel was started in the bank of the eastern branch and run 30 feet, but the intrusion was not encountered. Further up the slope a long cut and numerous pits were made. The openings as well as natural outcrops show numerous veins of both cross and slip fiber as well as bodies of mass fiber associated with hard peridotite or serpentine rocks. The original rock varied from a dunite, grading, with an increase of enstatite, toward a pyroxenite.

There is at this locality a large amount of asbestos of both long- and short-fiber types, but the transportation facilities make it inaccessible at the present time. It does seem quite likely, however, that with depth the asbestos rock will give place to hard, partly-altered, rock.



A. PERIDOTITE BOULDERS ON THE WYKLE PROPERTY, NEAR SOQUE, HABERSHAM COUNTY.



B. OUTCROP OF PERIDOTITE AT THE LAUREL CREEK CORUNDUM MINE, NEAR PINE MOUNTAIN, RABUN COUNTY.

PIG PEN MOUNTAIN LOCALITY

On a spur of Pig Pen Mountain one mile southeast of Pine Mountain and about the same distance south of the Laurel Creek mine, there is a small intrusion which is now represented largely by mass-fiber asbestos. It is 50 feet wide and at least 200 feet long and is located on lot 54 (?), 3rd district.

The greater part of the body is a badly weathered mass fiber, some of which is soft, but a part is hard enough to form a large outcrop projecting above the surface. Only a small area, about 15 by 18 feet, is composed of partly-altered rock, which represents a pyroxenite, enstatitite, in the process of alteration to an amphibolite (?). This rock, when studied in thin section, shows enstatite and a small amount of olivine. Judging from the present exposure there is a large quantity of mass fiber of a good grade available at this locality.

THE NICHOLSON ESTATE

On lots 27 and 28, 3rd district, the Nicholson estate, asbestos was mined at about the same time as on the Hicks property.

According to King[1]: "The outcroppings are in the form of large bowlders of a talcose anthophyllite, similar to that found at Laurel Creek mine; but outcroppings of a like character may be found at intervening points, from Laurel Creek, alongside the same gneissic hornblende dike."

This property was not visited by the writer.

ANDREW GENNETT PROPERTY

Four miles east of Clayton on the Clayton-Pine Mountain road there is a small dike of mass-fiber asbestos and soapstone. The exposure is to be found only a few feet from the north side of the road.

Some prospecting has been done here, exposing a dike 30 feet long and from 7 to 8 feet wide at its middle point, and thinning out rapidly toward each end. The intrusion dips at a moderate angle

[1] King, Francis P., op. cit.

to the north. There is a small amount of mass-fiber asbestos present at this locality.

A somewhat similar outcrop is reported to occur in the creek bottom, across the ridge to the south.

H. V. M. MILLER PROPERTY

The H. V. M. Miller property is located on lot 7, 1st district, 3 miles northwest of Burton on a small branch of Dicks Creek.

According to King:[1] "The peridotite formation is about 550 yards long and 200 yards wide. It is made up, as far as can be determined, by outcroppings, entirely of chrysolite changing into chromiferous chrysolite to the northeast. It differs, therefore, from other peridotite formations of Rabun County in the absence of anthophyllite. The country rock is a gneiss, while hornblende gneiss lies close by on the northwest side."

Prospecting for asbestos, which was done here about 1890, was confined to the southwestern part of the intrusion. A number of open cuts were made in hard olivine rocks, at some places largely serpentinized, showing veins of both slip- and mass-fiber asbestos. Some beautiful specimens of foliated talc are found along with the asbestos. So far as the exposure show, only a small part of the intrusion has been altered to talc and asbestos, and they are confined to planes of movement in the rock mass. There is no mass fiber present.

Notwithstanding the good quality of the long-fibered asbestos found at this locality, it is very doubtful whether it can ever be worked profitably on account of the relatively small amount of that mineral present as compared to the mass of the unaltered and partly altered rock.

TEN MILES NORTHEAST OF CLAYTON

A small prospect pit was made some years ago in search for asbestos near the head of Mill Creek, 10 miles northeast of Clayton and 5 miles east of Dillards.

[1] King, Francis P., op. cit., p. 86.

A small opening 6 feet square exposes a peridotite (harzburgite) with veins of both cross- and slip-fiber asbestos. A small cut in the bank nearby shows some decomposed peridotite, with a small amount of asbestos. This locality is not at all promising, and considering its location, it will doubtless never have any commercial value.

L. D. GARLAND PROPERTY

Four miles west of Dillards, on the property of L. D. Garland, lot 157, 2nd district, there is a prominent outcrop of talcose, asbestos rock which is locally known as "Soapstone Mountain." The intrusion is in a cleared field on a small ridge at the foot of the mountain. Its width is probably not more than 30 feet, while its length is at least 200 feet. Several rather large outcrops are found in this area.

The rock is a mass-fiber asbestos largely altered to talc, and has been locally used for building chimneys, etc. The asbestos is of a low grade, but prospecting might develop some fresher and more fibrous material.

MRS. MARGARET BEAVETT PROPERTY

On the property of Mrs. Margaret Beavett, 2 miles northwest of Dillards, on the north side of Betty Creek, lot 177, 2nd district, there is a small intrusion of basic rock containing some asbestos and soapstone. The intrusion is 15 feet wide, and is associated with hornblende gneiss, which forms the immediate country rock. The entire body has been thoroughly decomposed, so that little fresh material is in sight. It strikes N. 50° E., and dips 80° S. E. Between the hornblende gneiss, which is exposed on either side of the intrusion, from 6 to 10 inches of chlorite forms a layer around the central asbestos mass. Some corundum has been found at this locality, but the intrusion is so small that it can have little or no commercial significance.

A. A. DARNELL PROPERTY

An intrusion of dunite 100 feet wide and at least 200 yards long is found on the property of A. A. Darnell, lot 156, 2nd district, 5 miles west of Dillards. It is near the headwaters of Betty Creek and located on a steep ridge some hundreds of feet above the valley below. It is reached only by a mountain trail.

Little asbestos and soapstone have been developed here, and no prospecting has been done. The country rock is a quartz-biotite gneiss, in which the dunite strikes N. 30° E., and dips 30° N. W. When studied in thin section the rock is seen to contain about 90 per cent. olivine, magnetite and chromite, and about 10 per cent. alteration products, of which the following are present: anthophyllite, tremolite, or cummingtonite, magnesite, chlorite and talc. Alteration has evidently not progressed far enough to develop a commercial deposit of asbestos or soapstone, but the initial stages of that alteration are clearly shown.

R. H. LAMB PROPERTY

During the year 1893 some prospecting was done on the property of R. H. Lamb, lot 188, 2nd district, 4 miles northwest of Dillards, with the result that a small amount of corundum was found but a larger amount of asbestos and soapstone. King[1] described the intrusion of basic, magnesian rocks as running for 2,000 feet, 45° west of south, and having a maximum width of 450 feet. The exposures in the region are not good, and from the limited amount of work done here, it appears that there are a number of small intrusions rather than one very large one. Over the divide from Lamb's home toward Betty Creek there is a dike about 35 feet wide and traceable for several hundred yards. The rock is a peridotite, probably a dunite, which has been somewhat serpentinized; in it has developed a small amount of asbestos and soapstone along the contact with the country rock and in fissures in the rock itself.[2] It strikes in the direction of the main intrusion on Lamb's Creek, which is several hundred yards east of Lamb's house. Here asbestos and soapstone are found on two separate ridges. Some mass fiber, having very coarsely crystalline structure, is found altering to talc; some

[1] King, Francis P., op. cit., pp. 84-85.
[2] This dike may be on lot 177 and may not be on R. H. Lamb's property.

masses of light green, somewhat fibrous soapstone, are also to be found here. The quantity of these minerals present can not be determined from the present exposures, but it is a promising place for prospecting.

West of this region a dike of dunite is reported, while to the east still another is said to be exposed near the creek.

TWO AND ONE-HALF MILES NORTH OF DILLARDS

On the east side of the Tallulah Falls Railway, 2½ miles north of Dillards and one mile north of the Georgia-North Carolina line there is a conspicuous outcrop of an amphibolite. The dike is 30 feet wide, and is traceable for only a short distance. In addition to the amphibolite, some partly altered peridotite (?) is to be seen. Cutting the mass are veins of asbestos and talc. Chlorite is found along the contact and in alteration planes in the main body.

There is some mass fiber here, but it appears with depth to give place gradually to the hard unaltered or partly altered rock. On account of its location on the railroad, the locality is worthy of investigation.

TOWNS COUNTY

GENERAL FEATURES

The Roan gneiss series, with its extensive development and its variable character, is one of the dominant rock types in Towns County. It is represented by hornblende gneiss, diorite, gabbro, peridotite and pyroxenite. From Hiawassee east to the county line, hornblende gneiss is prominently developed; it is present in the form of narrow bands, which, on account of their superior resistance to weathering agencies, stand out more prominently than the associated Carolina gneiss, and form most of the rock exposures as well as the greater part of the surface float. North and west of Hiawassee there are a number of areas of more basic rocks of the Roan series in the form of lense-shaped masses, with which are associated corundum, asbestos and soapstone in small quantities.

The Carolina gneiss, although as a rule less prominently exposed than the Roan gneiss, underlies the greater part of the county. East of Hiawassee it is seen at places, represented by a garnetiferous mica schist; while west of Hiawassee it is represented largely by a gneiss and is relatively more abundant than to the east. North of Hiawassee on Bell Mountain a heavy bed of quartzite is exposed some hundreds of feet in thickness. It dips almost vertically and forms a precipitous slope on the northeast side of the mountain.

Although the basic rocks are extensively developed in Towns County, few if any deposits of asbestos or soapstone which offer any commercial value are known.

DESCRIPTION OF PROPERTIES

BELL CREEK MINE

The Bell Creek corundum mine, belonging to the estate of Wm. R. McConnell, is located on lot 6, 18th district, 4 miles northeast of Hiawassee. The intrusion is located in the flat creek bottoms, where the natural exposures are poor.

The intrusion is associated with granite and hornblende gneisses, and appears to be several hundred feet long and a hundred or more wide. The central area is composed of an altered peridotite, probably a dunite, with a band of chlorite and soapstone forming the contact zone. Some long-fibered asbestos is found here, but in small quantities and with no commercial promise.

A thin section of some of the freshest material from this locality showed the following minerals, arranged in the order of their importance: olivine, serpentine, amphibole (including both orthorhombic and monoclinic varieties), and magnetite. The rock has been much sheared by pressure, with the result that it has developed a gneissic structure.

THOMAS EDWARDS PROPERTY

On the adjoining lot to the north from the Hog Creek mine, a small prospect pit was sunk in search of asbestos about 14 years ago. The pit is on the property of Thomas Edwards, and is located in a level field where natural exposures are absent. On the dump from the old shaft, which is said to have been sunk about 10 feet, is considerable long-fiber asbestos. Judging from the surface float, the area is probably small, and unworthy of further investigation.

J. N. GIBSON ESTATE

On lot 42, 18th district, the J. N. Gibson estate some prospecting has been done for corundum, and a small amount of asbestos and soapstone has been discovered. There are two separate areas of basic rocks on the lot, one in the southwestern and the other in the northwestern corner. In the southwestern corner the exposures are poor and there is little to be seen on the surface, although the discovery of corundum on the surface led to some prospecting. In the northwestern corner, however, on the eastern slope of a small hill of magnesian rocks, there is quite a large pit, which was made in search for corundum. The associated rock is a corsely crystalline phase of the hornblende gneiss, with a small dike of what was originally probably a peridotite. While there is no asbestos at this locality, on the western slope of the hill some cross- and slip-fiber asbestos was seen with soapstone in a ditch 5 feet wide and 20 feet long. The prospect for commercial asbestos on this property is very poor.

There are other areas of basic rocks in the neighborhood, with which chloritic soapstone and some asbestos is associated, but they are unworthy of further mention.

HAMILTON MINE

The Hamilton mine is located on lot 60, 17th district, 3 miles northeast of Young Harris; it was worked for corundum many years ago. So far as was noticed, there is no peridotite at this locality. The country rock is a hornblende gneiss, which varies locally to a gabbro, and probably a troctolite. Chlorite-actinolite schist is present, but little if any soapstone or asbestos.

HOG CREEK CORUNDUM MINE

The Hog Creek corundum mine, belonging to the estate of Wm. R. McConnell, is located on lot 92, 17th district, 2 miles west of

Hiawassee. The conditions here are very similar to those on the J. N. Gibson estate north of Hiawassee. Hornblende gneiss and olivine gabbro form the country rock in which a small intrusion of dunite a few feet wide and a hundred or so feet long is found, striking northeast and dipping southeast. Chlorite schist is found along the contact with the country rock, and it is in this that the corundum has been found. Zoisite, associated with long needles of actinolite, is characteristic of this locality. Small fragments of pink and blue corundum are to be found on the dumps of the old workings. No asbestos was found here, although King[1] reports the occurrence of anthophyllite as surface boulders.

Southwest of this locality, and on the strike of the formation, there is a larger intrusion of dunite, in which pits have been sunk in search of chromite. The country rock here is the same as at the former locality, but with somewhat more variation. Olivine gabbro grading to a troctolite is present. The dunite dike is probably a hundred yards wide and several hundred yards long. Five trenches and pits have been made here by W. M. Scott in search for chromite. The chromite occurs abundantly as grains scattered through the dunite, and as small magmatic segregations of almost the pure mineral. Genthite is found in the cracks of the dunite at the north end of the intrusion, where it forms pale green crusts which become almost white upon exposure. Fragments of quartz incrustations are to be seen here on the surface. Massive black hornblende, zoisite and corundum are also present.

A small area of dunite to the northeast may or may not be separated from the main mass. The presence of small fragments of corundum lying loose over the field led to the search for that mineral at this place, but without success.

There is no prospect for commercial soapstone or asbestos on this property.

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[1] King, Francis P., op. cit., p. 89.

OTHER DEPOSITS IN TOWNS COUNTY

A number of small dikes of altered basic rocks are found on the road from Hiawassee to Young Harris. Some gabbro, olivine gabbro and troctolite were observed as well as an impure chloritic soapstone. These areas are associated with hornblende gneiss, of which they are doubtless basic differentiates. Nothing was observed which gave any promise of commercial value.

HABERSHAM COUNTY

GENERAL FEATURES

The Carolina gneiss underlies the greater part of Habersham County, where it is represented in its typical phase by biotite gneiss, and locally by mica schist. In the southeastern part of the county there is a large amount of rock which is undoubtedly of sedimentary origin, some of which is certainly later in formation than the Carolina gneiss. Two miles east of Hollywood and 4 miles southeast of Turnerville, there is a belt 3 miles wide in which limestones are found in association with slates and mica schists. This belt, which contains an exposure of about 60 feet of limestone one-half mile south of Camp Yonah, may be the equivalent of the Brevard schist of the Pisgah Folio of North Carolina.

South of Tallulah Falls the quartzite, graywacke and mica schist which form the falls extend for an unknown distance into Habersham County. Granites are present here mainly in small masses, and particularly as stringers in the Carolina gneiss, forming injection gneiss. The Roan series, including hornblende gneiss and basic dike rocks, is most extensively developed in the northwestern part of the county near Soque, but other areas of more or less importance are found at widely distributed points.

The peridotites and pyroxenites, with which the asbestos deposits are associated, are found in two belts: a western, which extends from near Burton southwest to near Cleveland, and an eastern, which is much less important and which extends from north of Hollywood southwest past Demorest. With the first named belt are associated some of the most important asbestos deposits of the State, such as on the Berrong, Martin and Wykle properties.

DESCRIPTION OF PROPERTIES

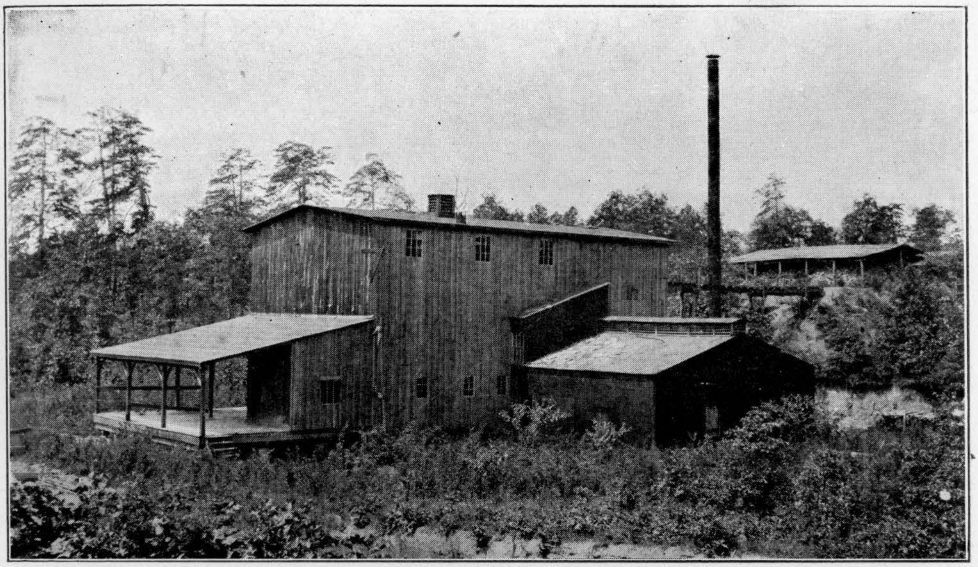
ASBESTOS MINING AND MANUFACTURING CO.

Location.—The property formerly owned by the National Asbestos Company has recently been purchased by the Asbestos Mining and Manufacturing Company, with headquarters at Hollywood, Georgia. The property is located one-half mile south of Hollywood and 5 miles north of Clarkesville on the Tallulah Falls Railway. The company owns about 19 acres of land lying immediately west of the railroad, which the asbestos body parallels at a distance of less than 100 yards.

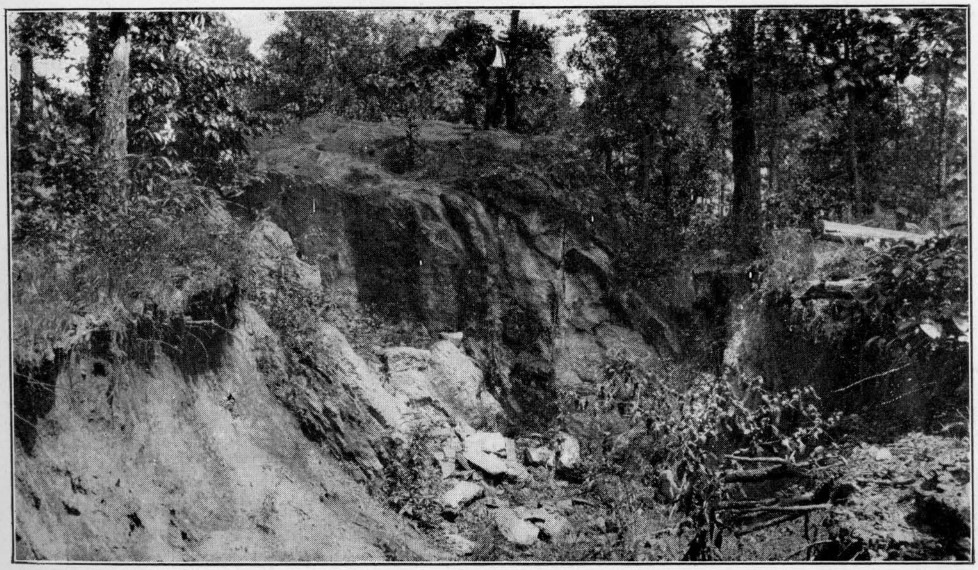
A small amount of asbestos was produced here in 1907, but from that time the property has lain idle until the latter part of 1913, when it came into the possession of the present company. During December of 1913, four car loads of asbestos were sold from here. It is the intention of this company to sell a part, probably the larger part, in the fiberized form and to manufacture a part into cement and later into pipe coverings, etc.

Description.—Judging from surface exposures, there is a single intrusion of asbestos rock on this property. It is approximately 180 yards long and from 20 feet at the north end to 85 feet wide near the south end. The strike of the intrusion is N. 20° E., with the central part bowed toward the east, so that its course is not a straight line, but a curved one. The country rock is a much altered biotite (?) gneiss cut by granite dikes and stringers. The intrusion has been opened up at its ends, while its middle part is represented by surface fragments and rough, brownish outcrops.

At the south end an open cut has been made into the asbestos rock a distance of 60 feet. Near the entrance a decomposed asbestos rock is encountered. It is so soft that it can be easily dug with a pick, but on examination it is seen to contain a fairly good grade of fiber. After passing through some 20 feet or more of this material, a hard, greyish rock with poorly developed fibrous form is found. At



A. MILL OF THE ASBESTOS MINING & MANUFACTURING COMPANY, HOLLYWOOD, HABERSHAM COUNTY.



B. OPENING OF THE PROPERTY OF THE ASBESTOS MINING & MANUFACTURING COMPANY, HABERSHAM COUNTY.

a depth of 15 feet the latter gives place to a hard green rock with practically no fiber, as encountered in the bottom of the cut. Near the back end the soft, yellow asbestos is again met with. The western contact is not reached by the cut.

The north end of the dike, so far as can be determined from surface indications, is marked by a rounded exposure projecting a few feet above the ground. A short cut has been made into its south side, which shows the mass to be composed of a hard, poorly fibrous rock, similar to that exposed near the middle of the cut at the south end. Some good mass fiber and some veins are exposed here, but they constitute a small fraction of the exposure. A smaller quantity of the yellow asbestos is found here. (Plate X, fig. B.)

A general survey of the area develops the facts that the major part of the intrusion in sight is composed of a hard asbestos rock which yields a light grey, short fiber, after being milled; that there is a large amount of soft asbestos rock which will yield as good a grade of fiber as any of the material present, but with yellow color; and that on being followed down, the center of the intrusion is likely to be formed of hard, partly altered peridotite. Weathering has affected the body irregularly, so that, while the major portion of the yellowed material is near the contact, it is also present wherever surface waters have had access, as along cracks and fissures. There is, relatively, a small amount of vein fiber developed, and what is present has been indurated by silicification. Bodies of mass fiber are developed in the intrusion, which may represent original differences in the mineral composition of the mass, or lines along which the alteration could take place most easily. Some clearly defined veins from one to two inches wide were observed near the south end of the intrusion, composed of bundles of fibers, arranged, not at right angles to the walls, nor parallel to each other, but resembling a narrow strip from a body of mass fiber.

A microscopic examination of a piece of the less altered rock showed the following minerals: olivine, anthophyllite, actinolite, magnesite, talc, chlorite, serpentine, magnetite and chromite. A part of the mass at least was a peridotite, although a study of the material gives the impression that possibly a large percentage of pyroxene was originally present, but is now entirely altered. This theory would account for the variations in the amount of alteration, by the variation in the amount of the more easily altered pyroxene present.

Three grades of material can be conveniently marketed, depending on the character of the rock furnished to the mill: a fair grade of grey, short fiber asbestos; a large quantity of grey material with a very small amount of fiber; and finally an equally large quantity of moderately good fiber which has been stained yellow by surface weathering. At present some of the output is being sold as cement for boiler coverings, pipe coverings, etc. For this purpose the asbestos is mixed with clay from Dry Branch, Ga., in certain proportions, the clay acting as the binder or cementing material.

Milling.—A well located and conveniently constructed mill was built here some years ago. (See plate X, figure A.) The asbestos is located on a slope above the railroad, so that the rock from the mine can be hauled on a level to the top floor of the mill and fed to the crusher without any elevation. After passing through the mill the finished product comes out on the lower floor which is on the level of the railroad. The mill has a capacity of 12 tons per day, but with a small expense this could be doubled by putting in an additional fiberizer or disintegrator. Enough power is generated to run the mill with the addition, and the preliminary crusher has a capacity more than large enough to supply two fiberizers.[1] A spur track, which was built here some years ago, has been removed, so that the finished product has to be hauled to Hollywood, a distance of about one-half mile, until the business justifies its replacement.

The conditions of mining, milling and transportation are such that the asbestos can be put on the market at a very low price. The future of the industry depends only upon securing a market for the material.

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[1] For a description of the mill see the general heading "Mining and Milling."

J. J. HOLCOMB PROPERTY

On the property of J. J .Holcomb, 3 miles east of Nacoochee and 1½ miles south of Aerial, there are 3 outcrops of talcose-asbestos rocks. The deposits are south and southwest of Holcomb's house and near the Chattahoochee River.

The largest and most promising exposure is on the bank of the river and shows an area, 8 by 10 feet, of mass-fiber asbestos in a very pronounced radiating form. No prospecting has been done here to reveal the actual extent of the deposit. A few hundred yards northeast of this outcrop there is a small prospect pit in the creek bottom showing 10 feet of asbestos rock of a fair grade. The extent of the deposit can not be determined. A short distance further on there is still another small opening which reveals a soapstone body only a few feet in thickness and of a very poor quality.

Of the deposits described, the first is by far the most promising, both in regard to quality and accessibility.

E. P. WEST ESTATE

On the estate of E. P. West, lot 118, 11th district, one mile south of Aerial, some prospecting has been done for asbestos. The prospects are located in a flat, pine woods where natural exposures are practically absent. A number of open cuts and shafts have been made here, showing that the asbestos is distributed over a considerable area. The thickness of the intrusion is at least 30 feet, and while the exposures are not continuous, it may have a length of as much as 100 yards.

Although the greater part of the asbestos deposit is badly weathered, there is a small amount of hard, partly altered rock, which, when studied in thin section, is seen to contain enstatite altering to anthophyllite, with magnetite as an accessory mineral, thus suggesting that the rock was originally a pyroxenite.

On account of the badly disintegrated condition of the greater part of the mass, the poorly fibrous nature of the fresh material and the heavy covering of soil, the property does not present a very attractive outlook.

A. E. BERRONG PROPERTY

The property of A. E. Berrong is located 4½ miles northeast of Sautee on Sautee Creek. The main outcrop, and the only one prospected, is on the north side of the creek; on the south side there is a large amount of float on the surface, and one small outcrop well up on the slope of the hill.

On the north side of the creek there is a dike of altered rock at least 30 feet wide and 50 to 75 feet long. It is striking north and south and dipping at a moderate angle to the west. A large part of the body at the southern end is a massive serpentine rock, while along the eastern edge of the intrusion there is a considerable quantity of high grade mass fiber. Several cuts and shafts have been made into the dike, but no material has been marketed from here. In the cut on the eastern side a fresh, coarsely crystalline, mass-fiber asbestos is exposed; while in the pits slightly further west considerable mass fiber has been encountered, some of which has been much affected by surface weathering. Prospecting here has not been sufficient to disclose the lateral extent of the deposit.

On the south side of the creek, there is a body of high-grade mass fiber 6 feet in diameter projecting above the ground; while on the opposite side of the small ridge to the south another outcrop of similar material is reported to have been found. Judging from the surface float, the asbestos rock may be present here in quite large quantities.

Two twin sections of the freshest rock exposed on this property showed olivine in such quantities as to prove that the original mass was partly, at least, a peridotite, and probably a dunite. But since the samples examined were from the area where serpentine has been found to the exclusion of anthophyllite, and since the areas of mass fiber are so different from the former, it seems possible that the latter was originally different, and may have represented a pyroxenic phase, possibly a pyroxenite.

There is considerable mass fiber of good quality in sight on this property, but its approximate quantity must remain in doubt until further development is undertaken.

G. L. LYONS PROPERTY

Prospecting for corundum was done many years ago on the property of G. L. Lyons, 5 miles north of Sautee, and one-half mile north of A. E. Berrong's property and the same distance south of the south end of the John Martin property. The dike of basic rock crosses the creek a short distance west of Lyons' house, while the prospect pits are to be found near the crest of the ridge on the south side.

Two small cuts were dug here in search of corundum. In the southeast one is exposed 15 feet of decomposed material, which is largely soapstone, of both chloritic and talcose nature. Associated with it are some slip-fiber veins of asbestos, but not in quantities which would seem to justify further working. In the other is exposed hard serpentine rock. The intrusion is at least from 15 to 20 feet in thickness, and probably extends more or less continuously for 100 yards.

There is a moderately large amount of talcose soapstone which is poorly fibrous, but the commercial outlook is not bright.

JOHN MARTIN PROPERTY

Location.—One of the most extensive asbestos properties in Habersham County is that owned by John Martin of Atlanta. While prospecting has been done on the place from time to time, no asbestos has ever been marketed.

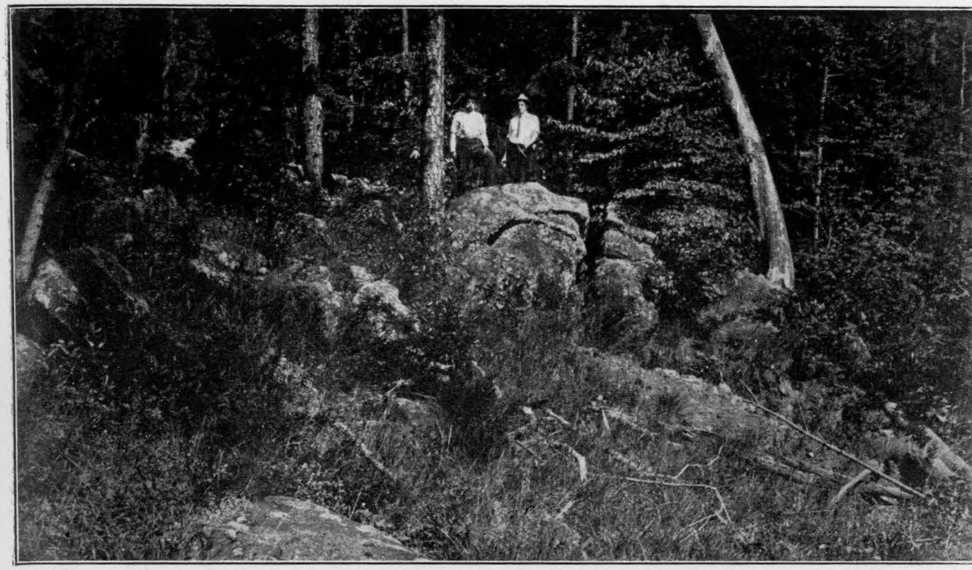
The property is located in the northern part of the county and near the White-Habersham County line, 11 miles on an air-line northwest of Clarkesville and 1 to 1½ miles west of Soque. It is from 8 to 9 miles by road from Nacoochee, the nearest railroad station. Asbestos has been found more or less extensively on lots 64, 65 and 66, 6th district, largely on what is known as Mack and Wolfpit mountains. The deposits occupy small isolated areas scattered over a distance, in a north-south direction, of 1½ miles. The country is hilly or semi-mountainous, but most of the deposits can be made accessible by building a few roads from one-half to one and one-half miles in length.

For convenience of description, the property is divided into a "north end" and a "south end." This is a natural division, since there is an intervening area which contains few if any asbestos deposits. The localities on the north end will be described in reference to Mack and Wolfpit mountains.

Description.—On lot 64, on the south end of the property, there is a large deposit of mass fiber, occupying the crest of a small spur and covering an area 150 feet long and 50 feet wide. (See plate XI, figure A.) Eight pits and cuts have been made over this area, exposing, in most cases, a talcose, anthophyllite rock, which has been weathered to a variable degree. The actual thickness of this dike can not be determined with accuracy, but it is at least 30 feet and appears to dip to the west. Associated with the deposit is a biotite granite usually possessing a gneissic structure. This granite is so commonly seen that, in the absence of other rock exposures it gives the appearance of being the country rock, when in reality it is relatively much younger than the basic dike with which the asbestos is associated.

This locality offers the largest and most easily accessible deposit of asbestos on this property. The tonnage in sight here is certainly very large.[1] On and near the surface the asbestos rock, while in large measure stained yellow, is much fresher than that below. A great quantity of soft, yellow asbestos rock that can be dug readily with a pick, is to be seen in the bottoms of the pits. Some of the mass fiber has largely altered to talc, with partial or total loss of its fibrous structure. Talcose and chloritic schist is found along the contacts and in layers between the larger masses of anthophyllite rock. Some of the mass fiber is very coarsely crystalline and contains bundles of fibers as much as 2½ inches in length; other bodies of mass fiber are less coarsely crystalline and the fibers have a distinctly

[1] Mr. S. B. Logan, Supt. of the Sall Mountain Company's mine and mill, has estimated that there is 50,000 tons of asbestos rock in sight on the whole property.



A. NATURAL OUTCROP OF ASBESTOS ROCK ON THE SOUTH END OF THE JOHN MARTIN PROPERTY, NEAR SOQUE, HABERSHAM COUNTY.

B. OPENING ON THE NORTH END OF THE JOHN MARTIN PROPERTY, HABERSHAM COUNTY, SHOWING THE ALTERED PERIDOTITE ROCKS.

radiating form. Considerable slip fiber and some cross fiber is present. Vein-like masses of coarsely crystalline chlorite of dark green color are present, as well as foliae of chlorite scattered through portions of the anthophyllite rock. Some moderately fresh enstatite-olivine rock occurs nearby, and doubtless represents the original source from which the alteration products described above were derived.

A small exposure of only partly altered rock is found in the southwest bank of a branch a short distance to the south; and on the crest of the main ridge to the north a small dike of talc schist is found. For a mile north of this locality there are a few scattered outcrops of altered peridotites, but without much commercial promise; and then follow the deposits on the north end of the Martin property.

On the north end of this property there are a dozen or more intrusions of variable size, containing a variable mineral content. These deposits are, to some extent, arranged in groups and will be described by their local names.

On the south slope of Mack Mountain, considerable prospecting was done for corundum. A tunnel was dug here for a distance of 100 feet or more, and thus it happened that this locality came to be called Tunnel Pit. An open cut was first made on the crest of the ridge exposing a basic dike rock partly altered to soapstone and asbestos. (See plate XI, fig. B.) The latter occurs in cross-fiber veins as much as two feet thick, as well as in slip-fiber veins. Talc and soapstone are present, but only in limited quantities, surrounding the areas of less altered material. On the dump from this cut small hexagonal crystals of corundum are common. In an attempt to strike the same body at a lower level, a tunnel was driven from the western slope of the hill, but from all appearances, the basic rock was not reached. In the entrance to the tunnel a badly weathered granite gneiss is seen dipping to the west. Further on the schistosity dips at a lesser angle and finally becomes horizontal.

The roof of the tunnel has fallen in, so it is impossible to reach the back end.

Immediately north of this locality, and on the crest of the ridge which leads east to Mack Mountain, is what is known as Chestnut Pit. There are a number of small openings at this locality in what appear to be different intrusions. One of them is on the northern slope of the ridge. The dominant type of material found here is soapstone, together with lesser quantities of mass fiber, and slip fiber. The soapstone, which varies in color from greyish white through yellow to brown, is composed chiefly of talc and anthophyllite with smaller amounts of chlorite, magnetite and limonite. Veins of long-fibered asbestos cut the soapstone and partly altered peridotite, but the quantity of this material is not large, although the veins vary from a fraction of an inch up to two feet in width. The principal intrusion has a width of 75 feet, a considerable part of which is soapstone, although it is somewhat fibrous in structure. Some talcose mass-fiber asbestos is present, but in subordinate quantities.

On the eastern slope of Wolfpit Mountain to the west, there are a number of small intrusions which are represented by a schistose soapstone, and in part by foliated talc. While these intrusions are only a few feet wide there are six of them, and they contain quite a large amount of soapstone, none of which is massive enough to saw into pencils.

North of Wolfpit Mountain there are still other intrusions. A small prospect here is known as Hump Pit, because of the projection above the ground of a considerable body of talcose-anthophyllite rock. This is surrounded by a softer material of about the same mineral composition. The dike here appears to be only about 20 feet wide, and dips almost vertical. Its lateral extent is unknown. Across a small ravine there are several small intrusions of soapstone, and some almost pure laminated talc, but little or no asbestos.

North of this last locality is what is known as Still Pit (named from an abandoned wild-cat still found near by). Here is found one of the largest and least altered intrusions on the property. It is located near the northwest corner of the property and occupies an area of perhaps 150 by 25 feet. A trench has been cut across the dike revealing a vein of long-fibered asbestos about 2 feet wide. Pure foliated talc occurs along with the asbestos. They are associated with a small amount of impure soapstone and a large quantity of brownish, partly-altered peridotite, which forms the mass of the intrusion. No mass fiber has been found here. The locality, owing to its position at the head of a small gorge, has been for a long time exposed to active erosion and consequently all the softer material has been removed. While the long-fibered asbestos makes a prominent showing, its commercial aspect is not promising because of the large amount of hard rock that would have to be removed in order to win it.

There is a very large amount of both asbestos and soapstone present on the property. Asbestos is found in largest quantity and under most accessible conditions on the south end of the property, while soapstone is relatively more important at the north end. Some foliated talc is present, but there is none sufficiently massive and pure enough to be used as a high grade talc for pencils, gas tips, etc.; a large quantity of soapstone is present, however, which could be used for foundry facings, etc.

WYKLE PROPERTY

The property now owned by D. L. Pitner, F. G. Jones, N. F. Haygood, and Robert C. Canady, formerly known as the Wykle property, is located in the northern part of Habersham County near the White-Habersham County line on lot 61, 6th district. It adjoins the John Martin place on the west and is 1½ miles a little north of west of Soque and 11½ miles on an air line northwest of Clarksville on the Tallulah Falls Railway. It is 7 miles by air line (at least 8 miles by the shortest road that can be built) from Nacoochee, the nearest point on the Gainesville and Northwestern Railway. The prospects are located on the western and southwestern slopes of Wolfpit Mountain, at an elevation of 400-600 feet above the valley of Chickamauga Creek to the west, while the valley at this point is only 150 feet higher than the railroad station at Nacoochee. The property occupies an area of 245 acres.

The asbestos and associated soapstone deposits are located in a northeast-southwest belt which crosses the ridge extending west from Wolfpit Mountain. A few outcrops are to be found on the north slope and on the crest of the ridge, but they are relatively more conspicuous on the south slope to a branch and on the bluff on its south side. Near the crest of the ridge and on its north slope, the deposits consist largely of talc and soapstone with subordinate amounts of cross-and slip-fiber asbestos; while on the south side there is a large amount of hard, partly altered rock, some bodies of mass fiber, which varies from soft fibrous to hard, poorly fibrous material. (See plate X, figure A.) Some foliated talc and vein asbestos are found here. Conspicuous outcrops of peridotite and pyroxenite are present. On the south side of the branch, there are some prospect pits with considerable cross- and slip-fiber asbestos, soapstone and some pure foliated talc.

West of this main belt described above, and near the White County line, there are a large number of intrusions of both peridotite and pyroxenite, but principally the former. These rocks are weathered to a variable degree, in some places giving rise to a hard, blue asbestos rock. Some dunite is present, showing fine needles of anthophyllite penetrating the olivine grains. The greater part of the material is too hard and too poorly fibrous to be of value as a source of asbestos.

Asbestos is found at a goodly number of places on this property. although they are quite variable in their nature: some bodies contain good mass fiber, some soapstone, and others hard, partly altered rock. The relative quantities of these various materials can not be determined from the present exposures. It would seem, from a study of the area, that the softer asbestos rock would rather rapidly give place to hard rock upon being followed downward. The factors which tend to detract from the value of the property are the following: the small proportion of mass fiber to the partly altered rock, the distance from the railroad, and the necessity of grading roads to make the deposits accessible. However, further prospecting may show that the numerous bodies of mass fiber are more extensive than is indicated at present, so that the asbestos together with the soapstone, which can be ground for foundry facings, etc., may more than overcome the difficulties enumerated above. The property is worthy of attention, and the present surface indications justify further prospecting.

OTHER PROPERTIES IN HABERSHAM COUNTY

On the property of W. V. Morrison, one mile east of Soque and 10 miles northwest of Clarkesville, there is a small dike of soapstone exposed in the field opposite his house.

Another dike from 30 to 40 feet wide is found on the property of Ellis Lovell, 2 miles northeast of Soque. The dike is one-fourth mile southwest of Lovell's house and on the north side of a small branch. An open cut 20 feet long exposes a hard serpentine rock with some cross- and slip-fiber asbestos. Some soapstone fragments were seen on the surface, but the locality gives little commercial promise for either asbestos or soapstone.

On the property of F. M. Wood, lot 30, 11th district, 2½ miles northeast of Soque, there is a dike of altered basic rock 40 feet wide, on the east bank of a creek near his house. The main body is a hard serpentine, but it contains a small amount of cross- and slip-fiber asbestos. Some years ago prospecting for corundum was carried on here.

A short distance north of Wood's property there is an outcrop of soapstone on the north side of the public road. It is on lot 17, 13th district, near the dividing line between the properties of L. B. York and T. P. Wilson.

Other outcrops are reported further northeast.

WHITE COUNTY

GENERAL FEATURES

Carolina gneiss is the dominant type of rock found in White County. It is represented in the eastern part by a very old gneiss, probably a metamorphosed granite, which has been intimately intruded, often forming injection gneiss, by a later granite. In some places this granite forms large bodies, such as may be seen occupying a long lense-shaped belt extending from west of Soque south to Cleveland, forming in part Lynch, Sall and Yonah mountains. Encircling this granite belt, the hornblende gneiss of the Roan series is exposed in a series of bands of varying widths. Associated with these hornblende rocks, sometimes in contact with them, but often not, are found small irregular dikes of peridotite or pyroxenite, with which the asbestos deposits are associated. These are most prominent in the northeastern part of the county.

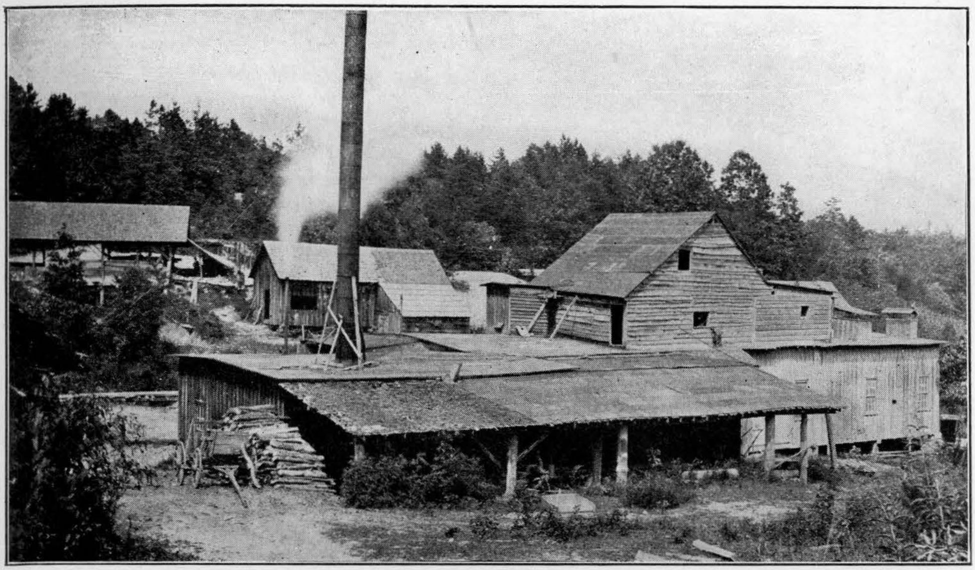
Extending from about 2 miles west of Nacoochee to the foot of the Blue Ridge Mountains, there is a belt of rocks, quartz schist, greywacke and gneiss, which gives some evidence of sedimentary origin.

DESCRIPTION OF PROPERTIES

CALHOUN MINING COMPANY'S PROPERTY

A small amount of prospecting for asbestos has been done on the Calhoun Mining Company's property, 4 miles southwest of Sautee on a southwestern spur of Sall Mountain. The deposit is similar in its mode of occurrence to that at the Sall Mountain mine, 1½ miles to the northeast. The asbestos rock is associated with a biotite-granite gneiss, and has a northeast-southwest strike. The length of the intrusion is difficult of accurate determination, as the exposures are poor; but it appears to be 125 feet long and probably 15 feet wide.

Along the contact of the intrusive body and the country rock, laminated soapstone is developed, while the central mass is composed of anthophyllite, together with talc, chlorite and some of the less altered rock. Some cross-fiber veins cut this central mass, and have



A. PLANT OF THE SALL MOUNTAIN COMPANY ON SALL MOUNTAIN, WHITE COUNTY.

B. NEAR VIEW OF SALL MOUNTAIN, WHITE COUNTY.

a width of from one-half to three or four inches. At one place the asbestos rock has been cut by a coarse-grained pegmatite, which is separated from the asbestos by a continuous layer of chlorite, a condition which is not known to exist at any other place. This occurrence shows that the pegmatite was later in origin than the associated rock and that its presence influenced the nature of the alteration of the asbestos rock in its immediate vicinity.

There is undoubtedly a fair quantity of fiber at this place; just how much will have to be determined by subsequent prospecting; but its location on a steep slope 200 feet above the road makes it quite inaccessible, considering the present price of the material.

SALL MOUNTAIN COMPANY

Location.—The Sall Mountain Company owns two separate properties in White County; one is located on the northeastern slope of Sall Mountain, 12 miles northwest of Clarkesville; and the other 2½ miles north of Cleveland. These two properties are nearly five miles apart on an air line. Most of the mining that has been done during the past 20 years has been on Sall Mountain, and the fiberized material hauled by wagon to Clarkesville. During 1912 the Gainesville and Northwestern Railroad was constructed, making these deposits more accessible. The Sall Mountain deposit is within 3 miles of Nacoochee and the deposit north of Cleveland, is within one-half mile of Asbestos, stations on the newly-constructed railroad. During the latter part of 1913 the mill for fiberizing the asbestos rock was moved from Sall Mountain to Gainesville, and the crude rock shipped there to be milled. (See plate XII, figure A.)

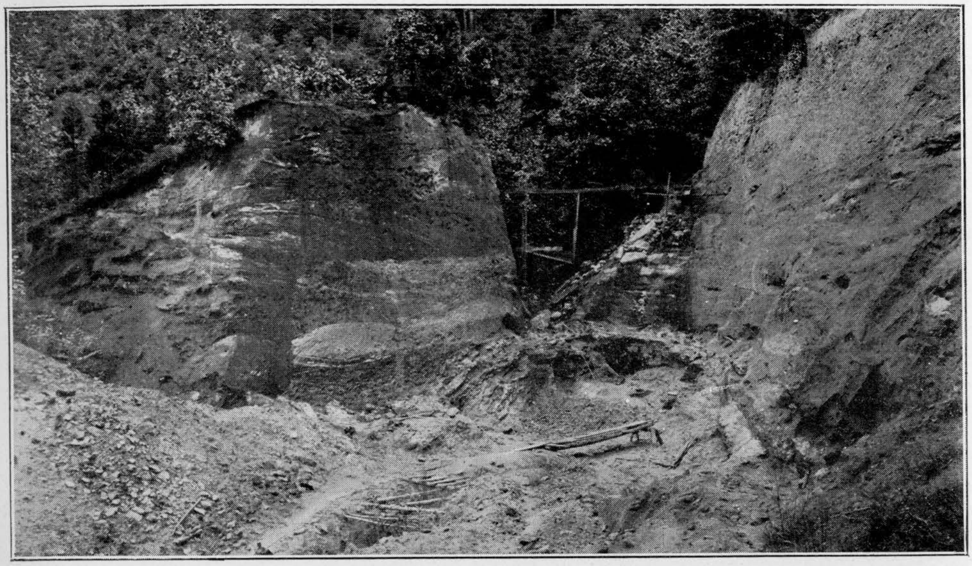
Description.—The deposits on Sall Mountain are located on an easily accessible northeastern spur of the mountain. (See plate XII, figure B.) The country rock is a biotite-granite gneiss, which varies widely in texture and in the proportions of the component minerals. This gneiss is cut by a more recent granite and by pegmatite dikes.

Within an area of about 80 acres, six separate masses of asbestos have been discovered. Three of the largest deposits were close together and in a line running N. 80° E. Four of these deposits were quite small; one of them contained no more than 100 tons of asbestos rock. All of them were roughly elliptical in outline, and had no downward connection with the parent mass, with the possible exception of the largest. The largest mass was 100 feet long, 50 feet wide and has been worked to a depth of about 50 feet. (See plate XIII., figures A, B.) The asbestos has been worked out with the exception of the southwestern end, where a good body of fresh rock 20 feet wide and possibly 15 feet thick is seen to plunge downward under the overlying gneiss. The asbestos rock in this deposit was irregularly weathered; a large outcrop of the brownish rock projected above the ground and called attention to the deposit. As this was worked out, disintegrated rock, colored yellow to red by oxidation of the iron content and so soft that it could be dug with a pick, was encountered. Irregular shaped masses of the fresh grey rock were found in this weathered portion, and finally the fresh material in the southwestern corner.

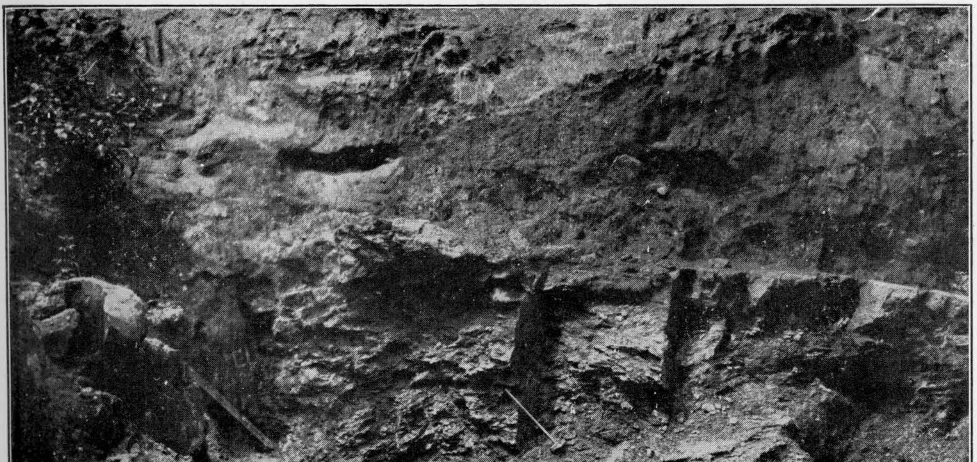
The next deposit in point of view of size was found along the strike of the first deposit and less than 100 yards distant. Here a lense-shaped body, 100 feet long by 30 feet wide and 15 to 20 feet deep, of soft, yellow ore has been mined. All the other bodies were smaller, but similar in occurrence, and weathered to a greater degree.

All the asbestos found at this locality is mass-fiber anthophyllite, a type which has been mined at only one other place in North America, namely, at Kamiah, Idaho. The rock may be very properly called an amphibolite, and is made up of bundles of fibers, ranging in length from 1½ inches down to one-fourth of an inch and less, arranged in all directions in respect to each other, but usually in a more or less distinctly radiating form. The rock is massive in structure and contains no veins of cross or slip fiber. Near the contact with the wall rock there is usually a layer of very schistose talc. When fresh the rock is greyish-white, but is frequently yellowed by the oxidation of the pyrite and magnetite, as mentioned above.

In thin section the asbestos rock is seen to contain, in the order



A. VIEW OF THE SALL MOUNTAIN COMPANY'S MINE ON SALL MOUNTAIN, WHITE COUNTY, SHOWING OVAL SHAPED ASBESTOS BODY OVERLAIN BY DECOMPOSED GNEISS.



B. SAME AS ABOVE, NEARER VIEW, SHOWING THE JOINTED STRUCTURE AND SHARP LINE OF CONTACT.

of their importance, the following minerals: anthophyllite, talc, dolomite, chlorite, serpentine, magnetite and pyrite. When fiberized this material, owing to the lack of flexibility of the fibers, gives a pulp containing fibers one-fourth inch and less in length. The asbestos rock yields more than 95 per cent. of fiber.[1]

All the known asbestos deposits at this locality have been worked out, with the exception of the southwestern corner of the largest mass, mentioned above.

The deposits, located 2½ miles north of Cleveland, near Asbestos station, as stated before, are in every way similar in their occurrence to those on Sall Mountain, with the exception that all the asbestos masses have been much weathered by exposure to surface action, and there has been developed relatively a much larger percntage of talc, both as a contact layer and also as scales scattered through the mass. The deposits are located in almost level, cultivated fields, where disintegration has effected both asbestos and country rock. (See plate XIV, figure A.) Fragments of asbestos are scattered over the surface of about ten acres. It is impossible to determine by surface examination the extent of the various bodies or their relationships without extensive prospecting or by removing the rock itself. As shown at present there are at least four elliptical bodies of asbestos lying in a N. 45° E. line, and extending over a distance of one-fourth of a mile. The largest body, at the north end, has a length of 200 feet and a maximum width of 50 feet. Some hundreds of tons of soft, yellow, talcose asbestos have been taken from this body. At the south end of the property there is another intrusion 50 feet long and 20 feet wide, which dips to the west at an angle of 57°. The bottom of this deposit has not been reached, although a large quantity of material has been taken out. Between these two localities there are a number of smaller bodies of asbestos which have not been sufficiently prospected to determine their extent.

All the deposits at this locality lie near the western contact of the area of granite gneiss with the schists and hornblende gneiss.

[1] Mr. Logan, the superintendent of the mill, states that in milling 9 tons of rock, after moving to Gainesville, there was not more than 50 pounds of waste material.

The asbestos from this locality, while somewhat weathered and stained by surface waters, yields a fair grade of fiber when milled, much better in proportion than the higher grade rock, because it requires less beating to fiberize it and consequently the fibers are not so much broken up.

Mining and Milling.—For description of process of mining and milling see the general head "Mining and Milling."

LUMPKIN COUNTY

DESCRIPTION OF DEPOSITS

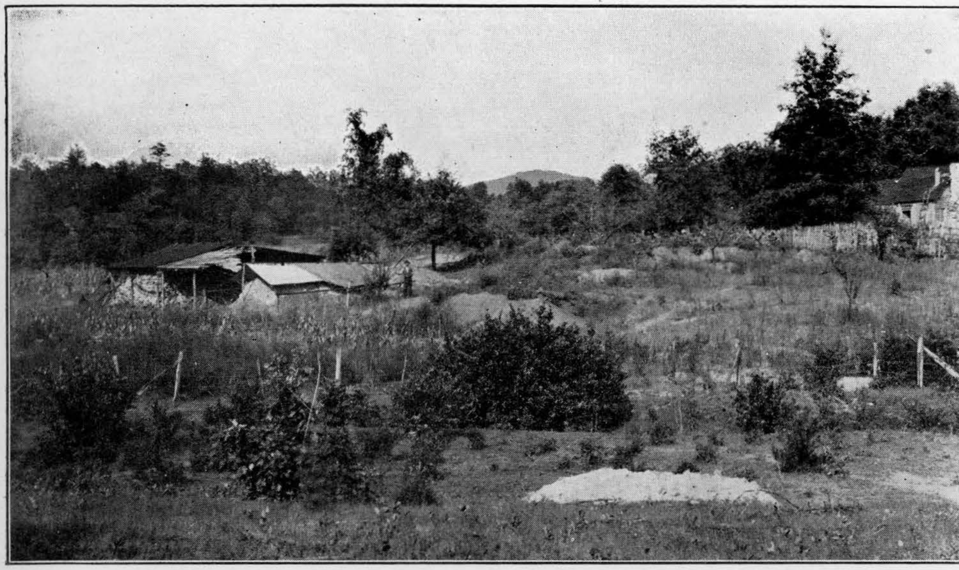
ONE MILE NORTHEAST OF NEW BRIDGE

Several small prospect pits have been dug one mile northeast of New Bridge, near the house of John Sullens, in search of asbestos. Two small openings, a hundred yards or more apart, show a small amount of slip-fiber asbestos and foliated talc. At the southern opening there is from 3 to 4 feet of talcose rock exposed. There are no indications that these openings are on a continuous body, although the strike of the one, N. 32° E. dip N. W., is in the direction of the other. It seems more likely that there are two small areas, too small to be of any commercial value. The asbestos is largely altered to talc, and the latter has been much decomposed by weathering agencies.

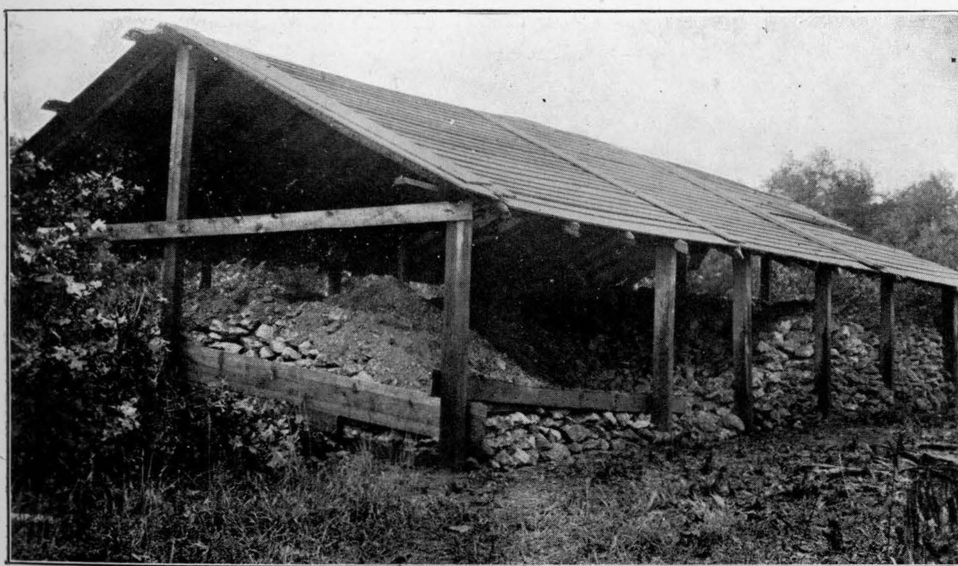
HALL COUNTY

GENERAL FEATURES

The general geological features of Hall County are similar in many ways to those of Gwinnett, the adjoining county on the southwest. The narrow sedimentary belt passes west of Gainesville, where it is composed of a rather prominent quartzite. It parallels the Southern Railway and lies for the most part on the northwestern side of it. On either side of this belt is found the Carolina gneiss, with only small, narrow strips of Roan gneiss, the latter being found almost exclusively on the southeastern side. No large granite areas were observed in this county, but numerous smaller granitic intrusions are found in the Carolina series.



A. THE SALL MOUNTAIN ASBESTOS COMPANY'S PROPERTY, NEAR ASBESTOS STATION, WHITE COUNTY, SHOWING ASBESTOS DRYING SHEDS.



B. NEAR VIEW OF ONE OF THE DRYING SHEDS OF THE SALL MOUNTAIN COMPANY, WHITE COUNTY.

Asbestos and soapstone are known in only one locality, and even there the commercial prospect is not promising.

DESCRIPTION OF PROPERTY

ONE MILE WEST OF GAINESVILLE

A small amount of prospecting for asbestos has been done one mile west of Gainesville on Soapstone Hill. This deposit was discovered many years ago in the search for corundum.[1] The intrusion can be traced several hundred yards in a north-south direction and has a maximum width of about 300 feet. The succession as exposed in the road from the lower to the upper contact is roughly as follows:

Section of Roadside One Mile West of Gainesville

	Feet
Peridotite (?), much altered and decomposed	10
Clay, residual	16
Soapstone, decomposed, and clay	23
Chloritic soapstone	5
Soapstone, cross-fiber asbestos, chlorite schist, etc	34
Clay with some soapstone and corundum	30
Soapstone	12
Clay, residual	12
Clay and chloritic schist	44
Soapstone, decomposed	12
Clay and soapstone, some asbestos veins	100

Asbestos occurs only in slip- and cross-fiber veins up to 5 inches in width, and is much weathered and, in part, converted into talc. Soapstone is relatively much more abundant than asbestos, and is, in large measure, of the chloritic type. Owing to the depth to which it is disintegrated by surface weathering, little or no good material is in sight. Large specimens of corundum, showing alteration to margarite, are present.

One of the problems in connection with the alteration of the original rock and its subsequent weathering, is to account for the alternating bands of soapstone, chloritic schist and clay.

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[1] King, Francis P., Corundum Deposits of Georgia: Bull. Geol. Survey of Ga. No. 2, 1894, pp. 98-100.

CHEROKEE COUNTY

DESCRIPTION OF PROPERTY

W. T. WORLEY PROPERTY

The property of W. T. Worley, formerly owned by S. J. Blackwell, is located 7 miles east of Canton on lot 71, 4th district, and 2nd section. It is situated on a small ridge one-fourth of a mile off the public road.

The asbestos is associated with an intrusion of pyroxenite, probably enstatitite, which has a northeast-southwest trend and is at least a quarter of a mile long and 200 yards wide. Other outcrops of the same material are said to occur along the strike in both directions, but they were not visited. The pyroxenite is present as a local, basic segregation, as is demonstrated by its relationship to the enclosing hornblende gneiss.

On account of its size, when taken together with the hornblende gneiss, of which it is properly a part, the intrusion has not suffered as much metamorphism as have most other areas. There are no large quantities of talc or soapstone present; on the contrary, they are conspicuously absent. A large part of the mass has remained a pyroxenite with little alteration. Some local segregations of magnetite and corundum in pieces 3 to 4 inches in diameter have been found. At some places the pyroxenite is altered largely to amphibole; and along lines where movement has taken place slip-fiber asbestos is to be found. Hyalitic fragments, so characteristic of rocks of other more altered areas, have been found here to a slight extent.

This property was quite extensively prospected some years ago: a tunnel 80 feet long was driven in on the eastern side of the intrusion, in an attempt to follow a vein of slip-fiber asbestos; a shaft 30 feet deep was sunk nearby, but with no success; besides these, a few other small pits have been dug at various places over the intrusion.

The asbestos, although it occurs both as slip and cross fiber along fault planes, and also to a small extent as mass fiber, is developed to but a comparatively small extent.

JACKSON COUNTY

GENERAL FEATURES

Unlike the counties which surround it, Jackson County contains only small areas of granite, with the Carolina and Roan gneisses forming the prevailing types of rock. The Carolina is represented largely by biotite gneiss and mica schist. Some phases of the gneiss suggest strongly a metamorphosed granite. Cutting the Carolina in long narrow bands, scarcely more than 100 yards in width, is found the Roan gneiss, which locally exhibits a more basic phase, approaching a peridotite in composition. Associated with these more basic areas are found small quantities of asbestos and soapstone. Granites are found in the county in numerous small dikes, representing a number of different periods of intrusion; they are relatively more important in the eastern part of the county than in the western. Diabase dikes have been observed at a number of localities, for example, 2½ miles north of Center on the western side of the Southern Railway.

The asbestos and soapstone deposits, so far as known, are found only in a limited area near Nicholson and Center, where they give little promise of commercial importance, and near Statham.

DESCRIPTION OF PROPERTIES

L. M. ARNOLD PROPERTY

A sample of asbestos has been received from L. M. Arnold, who reports that a deposit is located on his property, 1¼ miles east of Statham. A small area, about 40 feet square, of rough bowlders of asbestos is found in a cultivated field; but, judging from the distribution of surface fragments, the area underlain is somewhat larger than that. The sample received is of cross fiber, but judging from the description of Mr. Arnold, mass fiber is also present.

An attempt is being made to sell the crude material to one of the asbestos mills in the State.

M. L. CARTER PROPERTY

A small pit has been sunk in search of asbestos on what was formerly known as the Jesse Strickland place, but which is now owned by M. L. Carter, 1½ miles northeast of Nicholson. Asbestos is found over a very small area, not more than 40 feet long and 12 feet wide. In the pit, which is located in a cotton field, some cross-fiber veins of asbestos were encountered. The fiber is short and of poor quality, and presents little or no promise of commercial value.

L. G. HARDMAN PROPERTIES

One and one-fourth miles north of Center a small dike, about 40 feet wide and 200-300 feet long, is exposed in a cut on the Southern Railway. The soapstone, which strikes north and south, is enclosed in the Carolina schist, and has been cut by a pegmatite dike of more recent origin. The soapstone is of the talcose variety, and represents as promising an exposure as any found in the county. The material is yellowed near the surface, but is steel-grey when fresh. Some less altered rock was observed near the south end of the dike, which seemed to represent an altered peridotite.

On the "Estes Place," now owned by Dr. L. G. Hardman, 2½ miles north of Center and one-half mile west of the Southern Railway, there is a large knoll of about 20 acres covered with fragments of a hard, poorly-fibrous amphibolite. The main rock mass, which projects above the surface at numerous places on the crest of the knoll, is a hard, lichen-covered rock which offers no prospect for commercial asbestos or soapstone. The intrusive body, whose dimensions are probably about 250 by 150 feet, is cutting a mica gneiss which is, in turn, cut by hornblende gneiss and pegmatite dikes.

Some coarsely crystalline anthophyllite rock was observed, the individual crystals of which measured as much as 2 inches in length. There are gradations from this massive rock to a somewhat fibrous material, and finally to a talcose rock or impure soapstone. None of the rock is fibrous enough to be of value as asbestos. The soapstone seems to be confined to the contact zone with the enclosing rocks, as only fragments were seen on the surface and the contact is at all places hidden. The surface exposures offer little promise of commercial asbestos, and the only prospect for soapstone is to be found along the contact of the intrusive body with the country rock.

Near the junction of Oconee River and Cabin Creek, there is a small soapstone dike on the property of Dr. L. G. Hardman. There are no natural outcrops and none of the unaltered or partly altered rock is present. The surface, for the extent of an acre or more, is strewn with soapstone fragments and some cross-fiber asbestos. Some fibrous talc, pseudomorph after amphibole, was observed. Weathering has affected the region to a considerable depth.

A small area of similar material is found on the Hardman property 3½ miles southwest of Nicholson near the junction of Oconee River and Curry Creek. At this locality several large soapstone bowlders are seen on the edge of the river marsh. The exposures are poor, and it can not be determined whether they are in place or not. The rock appears to have been anthophyllite, but now is largely altered to talc. A basin-shaped hole in one of these rocks suggests its use by Indians as a place for grinding corn.

J. P. JOHNSON PROPERTY

On lot 253, Newton District, these is an area of from 15 to 20 acres strewn with fragments of soapstone. This property is controlled by J. P. Johnson, of Center.

The intrusion represents a dike not more than 250 yards long by 75 to 100 yards wide. Some of the party altered rock from this locality showed in thin section probably 10 per cent. of olivine partly serpentinized, with a colorless amphibole (tremolite or actinolite) predominating, and small quantities of talc, chlorite, carbonate, and magnetite. It probably represents an altered peridotite.

Fragments of impure soapstone are present, but there are no natural exposures of the material in place. This locality gives no promise of commercial asbestos, and little or no promise of soapstone.

WALTON COUNTY

GENERAL FEATURES

So far as is known at the present time, the only area of basic rocks in Walton County is located east of Monroe, near Compton. Granite gneisses of the Carolina series, with areas of granite, particularly in the western part, underlie the greater part of the county.

DESCRIPTION OF PROPERTIES

PERRY BREEDLOVE PROPERTY

On the property owned by Perry Breedlove, lot 160, 3rd district, 4½ miles east of Monroe, corundum was found prior to 1894.

The rocks of the neighborhood are deeply weathered, but appear to consist of biotite gneiss cut by aplitic granite and pegmatites The area covered by the basic rocks can only be approximately determined by a study of the distribution of float on the surface; while the original nature of the rock must remain in doubt on account of its altered condition. Small bodies of almost pure talc and others of chlorite were observed. Asbestos, now largely altered to talc, is found scattered over the surface and at places can be seen forming veins from 2 to 3 inches in width.

While it cannot be determined with certainty, there appear to be a number of separate masses instead of one continuous body of basic rocks. Judging from the poor exposures, the surface float and the general conditions surrounding the deposit, it is doubtful whether the soapstone or asbestos will ever have any commercial value.

OTHER PROPERTIES IN WALTON COUNTY

Soapstone and corundum are reported on the property of Judge A. C. Stone, 1¼ miles northeast of Monroe. A dark-green chloritic soapstone, probably derived from a hornblende gneiss, has been found on the property of J. A. Parker, 1¼ miles west of Compton.

MORGAN COUNTY

GENERAL FEATURES

The location of Morgan County, between Jasper and Greene counties, which are described briefly in this report, makes it unnecessary to repeat the description here, as the conditions in the three counties are similar.

DESCRIPTION OF PROPERTIES

G. W. MURELLE PROPERTY

Fragments of asbestos have been found scattered over a cultivated field on the property of G. W. Murelle, 4 miles east of Newborn and 1½ miles east of Broughton. Owing to the complete distintegration of the rocks of the region, and the heavy covering of soil, little can be seen of the extent or of the nature of the enclosing rock; the country rock, however, appears to be hornblende gneiss.

Judging from surface fragments there are three, small, basic areas, neither of which covers more than an acre. Asbestos of a coarse, brittle nature is found in cross-fiber veins. Fragments of corundum are abundant at one place, in pieces from 3 to 6 inches in diameter; their central part is massive, but their outside is covered with ill-defined crystals. Some soapstone fragments, apparently derived from hornblende, are also found. All three areas are roughly outlined by the distribution of the quartz encrustations which cover the surface.

While asbestos at this place is very limited in quantity, the locality is worthy of mention because of the occurrence of corundum.

FULTON, DEKALB AND CLAYTON COUNTIES

GENERAL FEATURES

Associated with the Carolina gneiss, there is a belt of basic rocks, the Roan gneiss, which extends from the eastern part of Campbell and the northern part of Fayette through the central part of Clayton County in a northeasterly direction to near Conley, where it crosses the line into DeKalb County. Its northern continuation is entirely cut out or much deflected by the large batholitic masses of granite near Stone Mountain and Lithonia. At Conley and south for some miles, there is a variation in the typical development of the Roan series, and along with the hornblende gneiss there is a more massive phase which is represented by pyroxenite and gabbro. At places the pyroxenite, which is now largely altered to hornblende, was originally an enstatitite, and the hornblende, in turn, is partly altered to chlorite. Thus the dominant alteration product is a chloritic soapstone, although some asbestos is developed, as, for instance, near Lakewood.

Other bands of hornblende gneiss cross Fulton, DeKalb and Clayton counties, but there is little or no prospect of commercial asbestos or soapstone associated with them.

DESCRIPTION OF DEPOSITS

ASBESTOS NEAR LAKEWOOD

A small area of what was originally a pyroxenite (?) is located on the southeastern bank of the lake at Lakewood and about 300 yards south of the bath house.

The pyroxenite is limited to a rather small area, and is associated with hornblende gneiss. A part of the body of the rock is poorly fibrous and represents the alteration of the original mineral, probably enstatite. Veins of asbestos of varying widths and differently spaced, cut the rock. At places, the rock is minutely veined.

COBB COUNTY

GENERAL FEATURES

Only one asbestos deposit in Cobb County is known at the present time, although it is likely that others similar to the one here described occur. Owing to the poor outlook from a commercial standpoint, little prospecting has been done in the county.

DESCRIPTION OF DEPOSITS

J. H. CANTRELL'S PROPERTY

A single small, basic intrusion has been found on the property of J. H. Cantrell, 1½ miles south of Smyrna and 1¼ miles west of Gilmore, a station on the Atlanta-Marietta electric car line. The deposit is located about one-four mile south of Mr. Cantrell's home.

The intrusion is enclosed in a gneissose granite and strikes to the northeast and dips at a high angle to the southeast. It is 100 feet long and from 15 to 20 feet wide. At the surface a greyish, talcose, chloritic rock outcrops, enclosing veins of cross- and slip-fiber asbestos. At lower levels this soft material gives place to the hard, unaltered rock composed essentially of olivine and enstatite, which may properly be termed a harzburgite, although it possesses a somewhat gneissic structure.

Asbestos occurs here in two forms, and probably represents the fibrous forms of two minerals; there are veins of hard, poorly fibrous actinolite of greenish color, and other veins of larger dimensions containing cross-fiber asbestos with a pearly lustre and fine, delicate fibers. The latter form shows parallel extinction, and is doubtless anthophyllite.

A shaft has been sunk to the depth of 30 feet, penetrating the outer layer of soft soapstone and reaching the central core of hard rock. On account of the scarcity of the asbestos, and its generally brittle and poorly fibrous nature, the property has little commercial prospect.

PAULDING COUNTY

GENERAL FEATURES

The greater part of Paulding County is occupied by a large mass of granite gneiss which is considered the oldest rock in the region and a part of the basal complex on which the Ocoee series of sedimentary rocks rests. This gneiss is cut by a series of basic rocks, original diorites and gabbros, in the main, but now more or less metamorphosed into hornblende gneisses. Associated with these later hornblendic rocks are smaller, more basic areas, which represent local segregations, or possibly the last and most basic phase of this intrusive period. Later than these occur granites which have aided in the metamorphism of the older rocks, and represent not less than two or three periods of intrusion.

Associated with these basic intrusive rocks, is to be found much impure chloritic soapstone and some asbestos, neither of which give much promise of commercial value, except at a few localities.

Numerous other intrusions or "bust-ups," as they are termed locally, similar to the one described near Walton's store, in Douglas County, are to be found along the strike to the northeast into Cobb County.

DESCRIPTION OF PROPERTIES

DEAN AND HUNT PROPERTIES

Soapstone and asbestos occur on the properties of Dr. R. J. Dean and W. H. Hunt, one mile west of Hiram on the south side of the Southern Railway, on lots 763 and 750, 2nd district, 3rd section.

A narrow dike, forming the backbone of a low ridge, and not more than 50 feet in width, can be traced in a northeast-southwest direction for the distance of three-fourths of a mile. The dike is associated with hornblende gneiss. As no fresh material is available, it is difficult to determine the original character of the rock. However, some of the freshest specimens, when studied in thin section, reveal remnants of olivine crystals to such an extent that it is safe to conclude that the rock was originally a member of the peridotite family.

The most important alteration products, noted in the order of their abundance, are as follows: Anthophyllite, actinolite (?), chlorite, and talc. The anthophyllite is poorly fibrous, very brittle and does not occur in large masses in pure form. Associated with the anthophyllite is one of the hornblendes, probably actinolite, which is usually massive and not fibrous. Chlorite predominates over talc.

Some fibrous masses of amphibole are present here, which resemble the material from the S. M. Harris property (see description of soapstone deposits), but they have a greenish color and are less fibrous.

Very impure soapstone occurs here, composed largely of chlorite and amphibole needles. There is little or no possibility of commercial soapstone or asbestos on this property.

JESSE COLE PROPERTY

Some years ago a small amount of prospecting for asbestos was done on the property of Jesse Cole, near Bud, on Lot 1012, 19th district, and 3rd section.

Fragments of asbestos are found over an area about 200 square feet, three-eights of a mile west of Cole's house. Several pits have been dug within this area, exposing veins of cross-fiber asbestos in a much decomposed rock. The asbestos shows inclined extinction and is doubtless actinolite. The veins show clearly that movements have taken place since their formation. The country rock is hornblende gneiss, which contains, at places where it has been extensively altered, a large amount of epidote, both as scattered grains and in larger crystalline masses.

CAMPBELL COUNTY

GENERAL FEATURES

The rocks of Campbell County consist largely of Carolina and Roan gneisses with later granitic intrusions. The Carolina is represented largely by granite gneiss, although the mica schist phase is also present to a limited extent. The Roan gneiss is present in its typical development, and shows relatively few ultra-basic areas.

DESCRIPTION OF DEPOSITS

T. D. LONGINO PROPERTY

Asbestos has been found on the property of Dr. T. D. Lingino on lot 130, Red Oak district, 1½ miles southwest of Red Oak, and 6 miles northeast of Fairburn. The deposit is on a branch of Camp Creek about one mile west of the Atlanta and West Point Railroad. The country rock at this locality is hornblende gneiss, in which there are limited areas of peridotite. Asbestos occurs both in the peridotite as mass fiber, and in the hornblende rock as veins of slip fiber. Little prospecting has been done, and the exposures are poor, consequently the relationship of the different rocks and their alteration products is difficult to determine. Mass-fiber asbestos shows on the surface at several closely associated places in the form of large bowlders. The material is hard and poorly fibrous. The alteration of the asbestos to talc has taken place to quite a degree, and more recently, apparently, the whole mass has been extensively silicified. Olivine rock is seen in the first stages of alteration to anthophyllite.

The vein asbestos is much more widespread than the mass fiber, and is found both in the peridotite and in the hornblende rocks for a distance of one-half mile in a northeast-southwest direction. The veins at places are closely spaced and occupy a comparatively large percentage of the rock mass; at others, large veins appear along what seem to be planes of movement. This type of material is woody in structure, and has been extensively silicified.

It is unlikely that this material will improve in quality with depth. The southwestern continuation of this body is found on the property of W. H. Cook.

COWETA COUNTY

GENERAL FEATURES

Practically the entire area of Coweta County is underlain by granites and granite gneisses, which are cut at intervals by more basic rocks, hornblende gneisses, etc. The conditions are practically identical with those of the northern part of Meriwether County.

DESCRIPTION OF DEPOSITS

J. A. R. CAMP PROPERTY

A prospect conspicuous for the occurrence of long-fiber asbestos, is found on the property of J. A. R. Camp, on lot 211, 2nd district, 2 miles southeast of Moreland.

The country rock is gray, biotite granite and hornblende gneiss. A pit only a few feet deep has exposed a vein of cross-fiber asbestos

18 inches wide. Upon examination the fibers are seen not to extend the entire width of the vein, but to be divided into three unequal lengths, the longest of which is from 6 to 7 inches. The wall rock is a soapstone, the original character of which can not be determined.

While it is impossible to make a definite statement, the area occupied by the asbestos-bearing rock is probably very limited, judging from the distribution of surface fragments.

TROUP COUNTY

GENERAL FEATURES

The Carolina gneiss, represented by the granite gneiss phase, occupies the greater part of Troup County. Associated with this series is one prominent area of Roan gneiss, which extends from West Point northeast, past LaGrange, and gradually becomes less prominent farther on. The typical phase of this series, hornblende gneiss, is developed along this belt, but of more importance in this connection is the more basic phase represented here by gabbro and pyroxenite. East of West Point the latter is best developed, while west of LaGrange the former phase is most prominent. The hornblende gneiss is found with smaller basic segregations in other parts of the country, especially in its eastern part. Cutting the two above mentioned series are masses of granite and trap dikes.

Associated with the ultra-basic phase of the main belt are small quantities of asbestos and soapstone, the best development of which is northeast of West Point.

DESCRIPTION OF PROPERTIES

MRS. W. M. HIGGINBOTHEM PROPERTY

Asbestos-bearing rocks have been found on lots 275, 285, 286 and 315, 5th district, from one to one and one-half miles northeast of West Point. The greater part of the deposit is on the property of Mrs. W. M. Higginbothem, although its eastern continuation extends on to the properties of T. J. Mallory and W. D. Grant.

The asbestos-bearing rock extends from the Atlanta and West Point Railroad southwest to the Chattahoochee River, a distance of three-fourths of a mile. The width of the intrusive body varies from 150 yards to 300 yards. The dominant type of rock over this area is a pyroxenite, composed almost entirely of orthorhombic pyroxenes. It is associated with hornblende gneiss. The pyroxenite of this area is much decomposed and at places entirely so. The only original mineral in the rock is a member of the enstatite-hypersthene series, the mineral present varying from place to place. The alteration is taking place freely to form an amphibolite, and all gradations from pyroxenite to amphibolite are to be seen.

Asbestos occurs in narrow cross-fiber veins usually only an inch or so wide, which cut the rock at irregular intervals. The asbestos appears to have been formed in joints rather than in larger fissures. It is coarse fibered; at some places it has largely altered to talc, and at others more or less completely silicified. Some impure talc is found associated with these altered pyroxenites, but as a rule the alteration is to amphibolite and then to chlorite, yielding masses of very impure chloritic material. There is little commercial prospect for either asbestos or soapstone.

Masses of amphibole, varying from long, slender, light green needles to short, dark green prisms, have been found associated with the pyroxenite, showing alteration to talc. (See analysis, page 81.) A small amount of dark green serpentine is present.

Silicified asbestos and crusts of silica, both in amorphous and crypto-crystalline form, give evidence of a period of silicification later than that of the formation of the asbestos veins.

Corundum is reported to have been found on this property, but none was observed by the writer.

Some years ago prospecting was done on this and adjoining properties, but the results were not encouraging. The absence of mass fiber and the consequent limitation of asbestos to veins, the poor natural exposures, and the character and alteration of the original rock, do not make the prospect for commercial asbestos bright.

G. I. BRYAN PROPERTY

Considerable prospecting for asbestos has been done in the southeastern part of Troup County, 4½ miles west of Chipley, on the property of G. I. Bryan. The country is generally flat, and decomposition has led to the formation of a thick covering of soil which usually hides from view the underlying rocks.

The general country rock in this part of the county is a grey biotite granite gneiss. Over about 40 acres west of Bryan's house there are numerous intrusions of talcose-asbestos rock. While most of them are entirely altered to asbestos and talcose rocks, some of the material is fresh enough to show the following original minerals: olivine, enstatite, chromite, and probably picotite. Judging from the presence of these minerals and the alteration products, it seems that the original rock was a typical peridotite.

It is impossible to determine the number of different intrusions; the only information that can be obtained is from the study of numerous pits scattered over a cotton field. There are about 20 pits of varying size showing either asbestos or talcose material. A number of the larger pits have been sunk to the depth of 10 to 20 feet, but in no case do they expose hard rock. On account of the nearness of the upper limit of water level to the surface, the pits were not sunk deeper. The intrusive masses are represented on the surface by scattered fragments of asbestos, encrustations of quartz, and hyalitic material. Both the peridotite and the asbestos have been more or less silicified at places.

Asbestos occurs here mostly in the form of cross-fiber veins, but there is also a small amount of mass fiber present. The asbestos, so far as it is exposed, is enclosed between decomposed talcose material and is itself much yellowed by surface waters. As a rule the veins are rather wide and close together. At places they reach a thickness of one foot, and exceptionally more, but the fiber is coarse and woody.

The outlook for commercial asbestos in some of the pits is very good, especially at those where mass fiber is present. However, the decomposition of talc and soapstone from the surface of the ground to the upper limit of ground water, and the uncertainty of conditions below that, tend to detract from the outlook of the deposits.

MRS. LEILA BEASLEY PROPERTY

A small amount of prospecting has been done on the property of Mrs. Leila (?) Beasley, 4 miles northwest of Mountville, on lot 243, 7th district. From the very poor exposures, it seems that the immediate country rock is hornblende gneiss inclosing small areas of basic segregations and later intruded granite masses. The prospect pits were filled at the time of the writer's visit, consequently the only information available was that which could be derived from a study of the old dump. The asbestos occurs in cross-fiber veins and is coarse and woody in appearance. A small amount of soapstone was observed, but no rock which would throw light upon its original nature. The presence of an abundance of quartz encrustations on the surface, and some silicified asbestos, indicate that, subsequent to the formation of asbestos, extensive silicification had taken place.

There are three separate areas within the distance of a mile. At the middle one cross-fiber asbestos in a vein a foot wide was observed.

MERIWETHER COUNTY

GENERAL FEATURES

The Carolina gneiss, together with biotite gneiss, granite and numerous bands of hornblende gneiss, underlies the greater part of Meriwether County. Only in the southern part, near Warm Springs, are there any rocks of undoubtedly sedimentary origin; the same quartzite belt mentioned in the description of Harris County crosses the southeastern corner of this county. In the northern part near Rockymount, the gneisses give place to a belt of mica schist which extends to the northeast into Fayette County.

DESCRIPTION OF PROPERTIES

JOSEPH L. CHAMBLESS PROPERTY

The Joseph L. Chambless property is located 2½ miles south of Rockymount, and 8 miles southeast of Luthersville on the Greenville road.

The country rock here appears to be a mica schist cut by hornblende gneiss and diabase dikes. The nature of the rock which gave rise to the asbestos and talcose material is indeterminable, as alteration has progressed to too great a degree.

The area underlain by the asbestos-bearing rocks is 300 feet long and from 50 to 100 feet wide, judging from the distribution of float on the surface in a cultivated field. Veins of asbestos from a fraction of an inch up to 18 inches wide occur between walls of talcose rock. The asbestos, occurring in veins running in all directions, is poorly fibrous, coarse and brittle. A pit was sunk at the eastern end of the intrusion to a depth of 32 feet,exposing at the bottom asbestos which is somewhat harder than that at the surface. Some mass-fiber asbestos is present, in which the bundles of fibers are exceptionally large. This material was observed showing all stages of alteration to fibrous talc. Silicification here, as elsewhere, has at places hardened both the asbestos and the inclosing rock.

MRS. MILDRED CAMP PROPERTY

A small prospect pit was dug some years ago on the property of Mrs. Mildred Camp, 3 miles north of Luthersville, on the east side of the railroad. The prospect is located one-half mile northeast of Thomas Carmichael's house in the edge of a pine grove. The country is flat and the exposures are very poor.

The country rock is a granite or granite gneiss cut by numerous small pegmatite veins composed largely of quartz and muscovite. Judging from surface fragments, the area of the asbestos rock covers not more than one-half acre. A pit has been sunk to the depth of 10 feet, exposing a large amount of cross- and slip-fiber asbestos included in a talcose rock. The fiber is remarkably long, reaching a length of 18 inches, but of a rather coarse nature. For the amount of work that has been done the showing is very favorable.

HANCOCK COUNTY

GENERAL FEATURES

The rocks of Hancock County fall naturally into three divisions, each of which occupies a well defined position in the county. The southern portion consists of Coastal Plain sands and clays; the middle part is occupied by an extensive mass of porphyritic granite which extends from Milledgeville east into Columbia County; and finally the northern portion is underlain by granite and hornblende gneisses. The occurrence of basic rocks and their associated products, soapstone and asbestos, is limited to this northern part, and more specifically to the Roan gneiss. The Roan gneiss occupies a clearly defined belt extending from the northern part of Hancock and the southern part of Greene counties, east through Warren and McDuffie and into Columbia County, near Appling. This belt is probably continuous and, in general, parallel to the body of granite to the south. No work has been done on the belt of rocks in Warren and McDuffie counties; only a little has been done in Hancock; while somewhat more has been done in Columbia County.

DESCRIPTION OF DEPOSITS

MOSES W. HARRIS PROPERTY

A prominent outcrop of basic rock, with some associated asbestos, has been found on the property of Moses W. Harris, 8 miles northwest of Sparta.

A belt of asbestos-bearing rocks crosses the road a short distance south of Harris' house. This can be traced more or less continuously for one-half mile, and is said to appear at intervals along the strike in a southwestern direction for some miles. The country rock is so much decomposed that it is hard to determine its original nature, although it appears to have been a granite gneiss. The basic rock is so much altered from its original mineral composition that its nature is also in doubt. In thin section the following minerals, arranged in order of their abundance, were recognized: chlorite, amphibole, both anthophyllite and a member of the hornblende group, olivine, magnetite, talc and carbonates. The only original minerals are olivine and possibly some of the magnetite. The nature of the alteration products, which is chiefly chlorite, and a comparison of the rock with others whose origin is more clearly known, leads to the conclusion that the original rock was either a peridotite or an olivine gabbro, but more likely the latter.

Both cross- and slip-fiber asbestos occur here in limited quantities. It is evident that a part of the asbestos was formerly cross fiber and that movements in the rock mass have converted it into slip fiber. The veins vary from an inch up to 4 or 5 inches in width. A small amount of foliated talc was found, and some soapstone, but neither in large quantities. Fragments of quartz encrustations are abundant on the surface. The locality gives little promise of commercial asbestos.

PART III. TALC AND SOAPSTONE DEPOSITS OF GEORGIA

INTRODUCTION

Talc in one of its varieties has been used to some extent for many centuries: the Arabians, the Egyptians, and the Chinese, as well as the American Indians, have made use of it in one way or another because of its softness and consequent ease with which it can be worked into any desired form. The word "talc" is considered to have its origin from the Arabic word "talq," which, according to Aldrovandus (1648), was introduced into England through the Moors. Pliny refers to a rock which resembles fat as "steatitis," which was doubtless talc. Theophrastus refers to talc with its pearly luster as "magnetis," the source of the word magnesia. Agricola,[1] in 1546, gives as a synonym of magnetis, "talck;" and adds as other synonyms "Silberweiss," "Katzensilber" and "Glimmer." The latter name is at present applied by the Germans to mica. This confusion is, under certain circumstances, most natural, as their physical properties may be very similar.[2] Caesius[3] spells the word in Latin, "talchus," while the generally accepted way for his time was talcum.

Other names of more modern application will be added under the heading of varieties.

CHEMICAL AND PHYSICAL PROPERTIES

CHEMICAL PROPERTIES

Talc is an acid metasilicate of magnesium with the theoretical composition: silica, 63.5; magnesia, 31.7; and water, 4.8. As has been

[1] Interpretatio Rerum Metallicarum.

[2] The "sericite" deposits near Jasper, Pickens County, Georgia, were considered to be talc by some who have worked all their lives in the talc industry.

[3] De Mineralibus, 1636.

shown by Clarke and Schneider,[1] water is driven off from talc only at high temperatures. Their results may be tabulated as follows:

Temperature	105°	250°-300°	Red heat	White heat
Percentage of water lost	0.07	0.06	4.43	0.35

When decomposed by heat, talc gives up water and silica and forms enstatite. Under aqueous conditions it is one of the most stable of the mineral species, and thus appears to represent the end product of alteration in the belt of weathering.

Talc has many varieties based on the form and purity of the mineral; these will be enumerated later. The range in composition of specimens, both from this country and abroad, is represented by the following table of analyses:

Analyses of Talc

	1	2	3	4	5	6	7	8	9	10	11	12
SiO_2	62.42	59.34	61.73	53.79	53.46	60.15	63.07	61.35	60.26	57.08	61.85	60.60
Al_2O_3	1.43	1.09	2.25	5.33	3.41	.74	1.56	4.42	.31	{ 8.40	2.61	.30
Fe_2O_3	2.38	2.50	.36	6.38	7.56	.09	-----	-----			-----	-----
FeO	-----	.50	1.36	-----	-----	5.05	.67	1.68	.12	-----	.25	.60
MgO	30.24	30.12	31.68	28.44	28.14	28.71	28.76	26.03	33.04	27.16	34.52	35.30
CaO	trace	.04	trace	.10	.00	.04	.30	.82	.28	1.72	trace	.40
Na_2O	-----	.40	.18	-----	trace	.22	.79	.62	.24	-----	}	2.80
K_2O	-----	.32	.20	-----	trace	.32	trace	trace	-----	-----	} .17	-----
H_2O-	-----	.11	.41	-----	-----	-----	-----	-----	-----	-----	-----	-----
H_2O+	3.35	4.97	2.11	5.31	6.91	4.11	4.36	5.10	5.01	5.15	.60	*
TiO_2	-----	.10	.00	.14	.27	.02	-----	-----	-----	-----	-----	-----
P_2O_5	-----	-----	trace	-----	-----	.04	-----	-----	-----	-----	-----	-----
S	-----	-----	.02	-----	-----	.03	-----	-----	-----	-----	-----	-----
MnO	.31	trace	trace	-----	-----	.07	-----	-----	.96	-----	-----	-----
	100.13	99.49	100.30	99.49	99.75	99.59	99.51	100.02	100.22	99.51	100.00	100.00

1. Foliated talc, Miller property near Burton, Rabun Co., Ga. (contains fine grains of magnetite).
2. Foliated talc, Verd Antique Marble Quarry, Cherokee Co., Ga.
3. Massive, white talc, Cox property, Ball Ground, Cherokee Co., Ga.
4. Average of four analyses of talc from John Martin property, near Soque, Habersham Co., Ga.
5. Fibrous talc from John Martin property, near Soque, Habersham Co., Ga.
6. Average of three analyses of talc (pencil grade) from Georgia and Cohutta talc mines, Chatsworth, Murray Co., Ga.

[1] American Journal of Science, Vol. 40, 1890, p. 306.

* Not determined.

7. Talc, Kinsey Mine, North Carolina Geol. Survey, Econ. Paper No. 3, p. 14, Dr. Charles Bakerville, Analyst.
8. Talc, Hewitt Mine, idem.
9. Fibrous talc from New York, average of two analyses, 5th Ann. Rept., State Geologist of New York, Vol. 1, 1895, pp. 661-671.
10. Talc, Vermont, Report State Geologist, 1903, pp. 53-54.
11. Talc, Luzenach, France, Rept. U. S. Nat. Mus., 1899, p. 316.
12. Talc, Valley of Pignerolles, Italy, idem.

Analyses of Soapstones

	1	2	3
SiO_2	46.15	39.06	51.20
Al_2O_3	8.12	12.84	5.22
Fe_2O_3	2.04		
FeO	6.62	12.93	8.45
MgO	28.73	22.76	26.79
CaO	trace	5.98	1.17
Na_2O	.45		
K_2O	1.75		
H_2O-	.08		
H_2O+	5.20	6.56	6.90
TiO_2	.10		
P_2O_5	.24		
S	trace		
MnO	trace		.32
	99.48	100.13	100.05

1. Chloritic soapstone, Calhoun estate, 15 miles east of Elberton, Ga.
2. Soapstone, Albemarle Co., Va., Proc. U. S. Nat. Mus., 1895, p. 287 (foot note).
3. Soapstone, Grafton, Vermont, Ann. Rept. U. S. Nat. Mus., 1899, p. 316, Geo. P. Merrill authority.

PHYSICAL PROPERTIES

Talc occurs commonly as a foliated or micaceous mineral with a pearly luster and possessing such a degree of softness that it can be easily scratched with the finger nail. It has a greasy feel, and when pure varies in color from light green or light yellow to white or silvery white. The thin scales are translucent and often semi-transparent. Talc also occurs commonly in massive or crypto-crystalline form with a light grey, yellow or green color and greasy appearance when fresh, but dead white and lusterless after being exposed to the weather for a considerable time. Its light color, softness and greasy feel are characteristic properties by which it is commonly recognized; while the ease with which it may be worked, together with its resistance to heat and acids, is the basis of its commercial application.

VARIETIES OF TALC

Talc is the name of the mineral species which has the properties described above; but a number of varieties have been described based on its structure, origin or purity. Based on the structure there may be three divisions: foliated, massive and pseudomorphous.

Foliated:
- Talc, talcoid.

Massive:
- Steatite, soapstone.
- Potstone, hydrosteatite.
- Agalmatolite (in part), pagodite (in part).

Pseudomorphous:
- Agalite, beaconite, pyrallolite.
- Rensselaerite.

FOLIATED TALC

Talc in its more restricted meaning is applied to the foliated or laminated variety, as opposed to the massive form, which is termed steatite. This is the phanerocrystalline variety which often occurs in large sheets as much as three to four inches in diameter. Its color is characteristically light green and the thin foliae may be almost transparent.

Talcoid was K. F. Naumann's name for a white, lamellar mineral from near Pressnitz, Bohemia. It contains 68 per cent. of silica, a condition which may be explained by the presence of fine grains of quartz.

MASSIVE TALC

For the massive varieties of talc there are a number of names based on the purity and texture of the mineral.

Steatite is properly applied to the compact, crypto-crystalline type. It is the most valuable form of the mineral, as it can be sawed into pencils or worked into gas tips or ground to powder. When fresh and pure it varies in color from light green or cream colored to white or grey; but when ground it yields a white powder. It is commonly derived from the alteration of magnesian limestones.

Soapstone is properly applied to an impure form of steatite which contains varying amounts of chlorite, tremolite, pyroxene, magnetite, pyrite, quartz, and carbonates of calcium and magnesium. Its impurity is due to the fact that it is usually derived from the alteration of a basic, igneous rock, often pyroxenite. In common parlance this is the most widely used term, and is applied to any soft rock which can be cut readily. In Georgia it is used extensively to designate rocks in which chlorite predominates over talc; in this report such rocks will be designated chloritic soapstones. The latter are commonly derived from the hornblende gneisses and schists. The composition of soapstone necessarily has a wide range of variation.

The ease with which steatite or soapstone may be cut, together with its power of resisting heat, has lead to its use in making vessels for household purposes, whence it is called *potstone* or *lapadis ollaris* by older writers.

A variety of steatite which was found to contain 5.5 per cent. of water was called by Klaproth, *hydrosteatite.*

Agalmatolite is a term also introduced by Klaproth for a stone used by the Chinese for making images. The term itself is derived from a Greek word meaning image. Part of the agalmatolite of China is pinite, part pyrophyllite and part steatite.

Pagodite is also a name given to the figure stones of China, the name being suggested by the fact that miniature pagodas and other objects were made of it.

PSEUDOMORPHOUS TALC

Many pseudomorphous forms of talc have been described, and based on a few of these, a number of varieties have been described.

Agalite is a term applied to the fibrous talc or, more properly, steatite from New York, a material which is very largely used in the manufacture of paper. Its fibrous form is due to its formation from tremolite.

Beaconite is an asbestiform talc from Michigan, described by L. W. Hubbard.

The name *pyrallolite* was given by Nils G. Nordenskiold to a mineral from Finland which appears to be a pseudomorph after pyroxene.

A scaly, lamellar talcose substance, which passes into serpentine, from St. Lawrence County, New York, was named in 1837 by E. Emmons, *rensselaerite*.

The terms used in this report will be those which seem most suited to the purpose—those most easily applied and best understood. Talc will be used in a general way for both talc and steatite, but principally for the latter, as those are the deposits which are of most economic importance, and with which this report is chiefly concerned. Foliated talc, so far as known, occurs in such limited quantities that it is valuable only for museum specimens. Soapstone will be used in a general way for both the talcose and chloritic types; but when an individual deposit is described "soapstone" and "chloritic soapstone" will be used to designate the two types.[1]

ORIGIN

MODES OF FORMATION OF TALC AND SOAPSTONE

Talc is derived from rocks of both sedimentary and igneous origin; the most important deposits, however, come from sedimentary rocks, mainly magnesian limestones; soapstone, on the other hand, although derived from both types, comes largely from rocks of igneous origin.

[1] There is another mineral which, on account of its similarity to talc, both in appearances and uses, will be included here, namely, pyrophyllite. It will be understood that this is a distinct mineral species and is very different chemically from talc.

Pyrophyllite, as mentioned before, sometimes goes under the name agalmatolite and pagodite. It is a hydrous aluminum silicate with 66.7 per cent silica, 28.2 per cent alumina, and 5.0 per cent water. Structurally, it may be either radiated lamellar to somewhat fibrous, or massive to granular. At Graves Mountain, Georgia, it occurs in the radiated form, while in North Carolina it is found massive. The physical properties of pyrophyllite approach those of talc to such a degree that their uses are practically coextensive, the only difference being that pyrophyllite is often not massive enough to saw into pencils nor does it possess the quality which allows it to compete with talc for face powder and other high grade uses. The only occurrences of this mineral in Georgia are found in Lincoln County, near Lincolnton. (For descriptions, see Lincoln County.)

Thus the New York and North Carolina talc deposits are derived from limestones, while the soapstone deposits of Virginia and Vermont are of igneous origin. The talc deposits of Murray County, Georgia, which are of high grade, are an exception to this rule, if their derivation is from igneous rocks, as is supposed.

FROM SEDIMENTARY ROCKS

As stated above, the talc deposits of this country are derived largely from limestones, usually along the contact with siliceous rocks; the deposits in the Austrian Alps, however, Weinschenk[1] describes as being due to the replacement of schists composed of quartz, chlorite and graphite, along its contact with limestone. He invokes the aid of solutions from igneous intrusions to help in bringing about the transformation. No deposits of this latter type are found in the United States.

Talc has been described in pseudomorphous form after a large number of minerals, including amphiboles, pyroxenes, quartz, dolomite, etc. However, from a study of the deposits in Georgia and a review of the literature on the subject, it appears that the most important deposits are derived from amphiboles and pyroxenes, but principally the former.

The process of formation of talc from limestone is seen to be two-fold; the silication of the limestone to form tremolite, actinolite, enstatite, etc.; and the alteration of these silicates to talc.

THE SILICATION OF MAGNESIAN LIMESTONES

The alteration of a limestone to amphiboles and pyroxenes is a deep-seated reaction which takes place in the zone of anamorphism. The required magnesia and silica may both be present, as in the case of a siliceous dolomite, or they may be added through the agency of solutions. The reaction involved in the formation of tremolite and enstatite may be written as follows:

$$CaMg(CO_3)_2 + 2SiO_2 = CaMg(SiO_3)_2 + 2CO_2$$
$$CaMg(CO_3)_2 + SiO_2 = MgSiO_3 + CaCO_3 + CO_2$$

[1] Abhandl. Akad. J. Wiss., Vol. 21, pt. 2, p. 270, 1901.

These reactions take place with a decrease in volume, showing a readjustment brought about by the pressure of superincumbent rocks. Many other silicates may be formed by this process, depending largely on the purity of the original rock. Such alterations usually do not affect the entire mass of large bodies; but are more or less confined to the contacts, a condition which is explained by the fact that it is here that the limestone mass is most likely to be impure and it is here also that solutions can be most effective in supplying any additional material needed for the alteration. This is well illustrated in connection with the talc deposits of Fannin County, Georgia, and North Carolina, where the tremolite is almost exclusively developed near the contact between the marble and the overlying quartzite, and especially where the marbles and quartzites are interbedded.

The silication of the limestone in the case of the New Jersey deposits is described by Peck[1] as due to the influence of intrusive granite dikes, which aided in building up several silicates of calcium and magnesium, of which the most important were tremolite, pyroxene and phlogopite. In the case of the New York, North Carolina and Georgia deposits, the aid of igneous intrusions has not been present so far as known.

ALTERATION OF SILICATES TO TALC

The most common alteration of tremolite and enstatite is to talc. In association with practically every deposit in Georgia, whether in the limestone deposits of Fannin County, or in the altered, basic, igneous rocks of wide distribution over the State, or in the talc deposits of Murray County, talc has been found in pseudomorphous form after amphibole. This fact alone suggests the universal application of that alteration.

Such an alteration involves the processes of hydration and carbonation and is accompanied by a pronounced increase in volume;

[1] Peck, Frederick B., The Talc Deposits of Phillipsburg, N. J., and Easton, Pa.: N. J. Geol. Survey, Ann. Rept., 1904, 1905, pp. 161-185.

the change is thus characteristic of the belt of weathering. The chemical changes involved may be written as follows:

For tremolite: $CaMg_3(SiO_3)_4 + H_2O + CO_2 = H_2Mg_3Si_4O_{12} + CaCO_3$

For actinolite: $6CaMg_2FeSi_4O_{12} + 4H_2O + 6CO_2 + 3O =$
$4H_2Mg_3Si_4O_{12} + 6CaCO_3 + 3Fe_2O_3 + 8SiO_2$

For enstatite: $4MgSiO_3 + CO_2 + H_2O = H_2Mg_3Si_4O_{12} + MgCO_3$.

It will be seen that besides talc, more or less carbonates, iron oxide and quartz are formed, which may or may not be removed in solution In the case of a pure dolomite, tremolite would be formed instead of actinolite; and thus the only impurity left, after a complete alteration, would be calcite, which is usually present in small quantities only. It will be observed that in the case of an impure magnesian limestone, or in the case of an igneous rock, the initial alteration would be to more complex silicates than here represented, carrying more iron and alumina. So instead of tremolite, a mineral intermediate between actinolite and hornblende may be formed, the alteration of which, especially when not fully consummated, would lead to an impure talcose rock, or a soapstone.

As previously stated, the alteration of the limestone mass to amphibole and pyroxene may not be complete, so in the case of the amphibole and pyroxene, the same may be true. In reality, the fact that the alteration is often not completed gives the key to the solution of the problem of the origin of the talc. In New York, Smyth[1] describes the complete gradation from limestone to tremolitic limestone to tremolite schist and from the schist to the talc. The gradation from fibrous tremolite to fibrous talc is so perfect that there is no line of demarkation between them; as a matter of fact, Smyth states that much of what has been called fibrous talc is in realty fibrous tremolite.

FROM ROCKS OF IGNEOUS ORIGIN

In the preceding section, it has been explained how rocks of simple composition like magnesian limestones may give rise to de-

[1] Smyth, C. H. Jr., Rept. on the Talc Industry of St. Lawrence County, N. Y.: 15th Ann. Rept. State Geologist, Vol. 1.

posits of pure talc; and how the presence of impurities may lead to the formation of more complex silicates which alter to talc with the deposition of iron oxide and silica. Thus it is that igneous rocks which are usually complex in composition, give rise to soapstone rather than talc. Furthermore, in the section on the alteration of the basic, magnesian rocks, their various modes of alteration have been described. It remains only to recount those alterations which lead to the development of soapstone.

Igneous rocks may alter to talc directly, as in the case of olivine and enstatite rocks, or there may be an intermediate step—the development of amphibole. The latter type of alteration is by far the most common; thus the same general alterations which were described as applicable to the amphiboles derived from limestones are applicable here. A difference is shown in the case of an aluminous amphibole, hornblende, where the alteration is to chlorite rather than talc. This is true of the hornblende gneisses and hornblende schists in particular.

ORIGIN OF THE FANNIN-GILMER COUNTY DEPOSITS

All of the talc deposits of this State, which are derived from the alteration of limestone, are found, so far as is known, in Fannin and Gilmer counties, with the single exception of the isolated locality southwest of Ball Grond, Cherokee County. Thus these deposits constitute a unit so far as genesis is concerned, and present a sharp contrast in regard to their nature and association to the talc deposits of Murray County and the soapstone deposits of wide distribution over the State. These deposits, which represent the southern continuation of those found in North Carolina, are described briefly.

DISTRIBUTION OF TALC AND GENERAL GEOLOGY OF THE AREA

The talc deposits are limited to a narrow valley belt extending from near Culberson, North Carolina, southwest through Mineral Bluff and Blue Ridge to the Gilmer County line. The rocks of this region have been divided into the following formations, named in the order of their geological position:[1]

Lower Cambrian Series.......	Nottely quartzite Murphy marble Valleytown formation Brasstown formation Tusquitee quartzite Nantahala slate Great Smoky formation
Archaean....................	Carolina gneiss

The belt under discussion is immediately concerned with the rocks of Cambrian age, although the structural relations were largely influenced by the pressure transmitted by the extensive area of Carolina gneiss which lies to the east and parallels the valley belt at a distance of a mile or less. The valley belt, in which the talc deposits are found, has suffered extensive dynamic movements, which have resulted in the formation of three prominent and extensive overthrust faults. These faults are responsible for the absence of the Murphy marble, except for a few small narrow strips and lenticular masses. The talc is associated with the Murphy marble where it occurs along the fault line which separates the marble from the quartzite of the Valleytown formation. At a few places, the Dickey properties, 1½ miles north of and immediately south of Mineral Bluff, the talc appears to be in the quartzite as narrow beds between the more siliceous layers, and as scales surrounding the grains of quartz.

ORIGIN OF THE TALC

In general, the talc here was derived from the Murphy marble by the intermediate formation of amphibole as described in a preceding section, and as described by Pratt[2] in regard to the North Carolina deposits. There is one difference which makes itself known

[1] Ellijay folio (No. 187), Geol. Atlas U. S. Geol. Survey, 1913.
[2] Pratt, J. H., North Carolina Geol. Survey, Economic Paper, No. 3, 1900.

through a study of thin sections of some of the siliceous-talcose material.

Sections of some of the talcose quartzite found on the Dickey property south of Mineral Bluff show shreds and foliae of talc wrapped around the grains of quartz and often projecting inward to a certain extent. This occurrence of talc suggests that it was formed directly from the siliceous material through the agency of a probable dolomitic material which cemented the grains together. The anomalous position of the talc in the quartz grains may be explained by the crushing and recrystallization of the quartz, which is clearly shown, and which appears to be subsequent to the formation of the talc. However this may be, the talc here, as well as in other places, appears to be derived to some extent directly from the siliceous, magnesian material without the intermediate product, amphibole. This alteration is believed to apply to the disseminated scales, and not to commercial deposits.

ORIGIN OF THE MURRAY COUNTY DEPOSITS

GENERAL GEOLOGY OF THE DISTRICT

The talc deposits of Murray County lie immediately east of the Cartersville fault, a structural line which separates the metamorphic, more or less schistose, rocks on the east from the stratified, less altered, rocks on the west. The former, on account of their much altered character and faulted relation in respect to rocks of known age, have formerly been considered to be of pre-Cambrian age. Later work, especially along their northern and less altered continuation, has lead to the conclusion that a part, if not all, of the series known as the Ocoee series is in reality of Cambrian age and the equivalent of the clearly recognized Cambrian rocks to the west, although the greater metamorphism of the former precludes the possibility of exact correlation. The Ocoee series forms the prominent elevations known as Fort and Cohutta mountains, and contains the talc deposits. These rocks extend from the 800 to 900 foot levels to the tops of the mountains and eastward far beyond the limits of the region under discussion. (See map, page 247.)

The shales of the Connasauga formation on the other hand, begin at the base of the Ocoee series and underlie the eastern part of the valley region to the west.

The Ocoee series is quite variable in composition, and to the north, in the Cleveland quadrangle, it has been mapped as a number of different formations. The lowest beds exposed in the district are composed of a bluish-black, highly carbonaceous slate, carrying at places a large percentage of iron pyrites. This slate, on account of the ease with which it weathers, can be seen in fresh condition only where streams with a high gradient cut across it. Above this occur some hundreds of feet of slates and graywacke interbedded with coarser grained material until the heavy beds of quartzites and arkosic conglomerates are encountered. The latter form the cliffs high up on the slopes of Cohutta and Fort mountains.

Above the main beds of quartzite and graywacke there are found beds of chloritic (?) schist interbedded with beds of quartzite of variable thickness.

An analysis of a sample of this schist taken from a ledge above King Pit on the Georgia Talc Company's property, is as follows:

Analysis of Chloritic (?) Schist

SiO_2	45.53
Al_2O_3	21.58
Fe_2O_3	5.40
FeO	5.28
MgO	10.98
CaO	trace
Na_2O	.82
K_2O	2.02
H_2O-	.40
H_2O+	6.80
TiO_2	.80
P_2O_5	.07
S	.06
MnO	.08
	99.82

The stratigraphic section on the northeast side of Fort Mountain from the bed of Mill Creek to the highest point on the mountain is roughly as follows:

Section on East Side of Fort Mountain

	Thickness feet
Top of Fort Mountain.	
7. Schist or slate with some resistant layers; forms bench above cliffs	230
6. Quartzite, conglomerate and graywacke; forms cliffs	300
5. Graywacke	180
4. Slate (?); forms prominent bench	70
3. Graywacke	90
2. Talc prospects near Winklers house	50
1. Slate, quartz schist, etc., Mill Creek, largely concealed	260

STRUCTURE

As has been stated above, the Ocoee series has been faulted onto the Connasauga shales. The throw of the fault is not estimable, because of the impossibility of correct correlation of the various formations concerned, the lack of accurate knowledge as to the thickness of the formations, and other unknown factors. The concealment of some thousands of feet of strata is probably only a small part of the results accomplished by this fault, as it is evident that there has been a large amount of overlapping, which resulted in the bringing together of points on the surface which were miles distant.

Prior to the faulting just mentioned, both the Connasauga shales and the Ocoee series has been folded into a series of parallel anticlines and synclines of a northeast-southwest strike. The Ocoee series in the limited region under discussion dips to the southeast at angles ranging from a few degrees up to 45 degrees.

The talc deposits occur in the form of layers on sheets conforming to the structure of the associated rocks at all points where the contact has been observed. While it is impossible to trace a deposit from one exposure to another around the side of the mountain for more than one-half mile or so, yet the indications lead to the conclusion that they are much more extensive. While local rolls in the talc deposits are almost invariably present, no faulting has yet been observed in connection with them.

METAMORPHISM

In both the Connasauga formation and the Ocoee series, the more easily deformed beds have been so metamorphosed that traces of the original bedding has been, in a large measure, removed, accompanying the development of slaty cleavage. The limestones of the Connasauga formation have been little altered, while the shaly members, in places, have been converted into slates with good cleavage. The same is true of the Ocoee series, with the difference that the least altered beds are quartzites or graywackes and not limestones. Where originally shaly beds are found between heavy beds of quartzites, the former are the most altered rocks in the district, with the exception of the talc bodies, and have been changed into schists with well developed crystalline structure. This is well illustrated near the head of Mill Creek in the exposure on the eastern side. Here, originally shaly beds included between resistant quartzite layers have been altered to chloritic (?) schists with no trace of bedding; while the sandstones, though indurated and, in part, recrystallized, are not much deformed, nor have they lost all trace of bedding.

The material which now constitutes the talc deposits and associated rock has suffered, without doubt, the most extensive metamorphism of any in the region, with the result that its original mineral and structural characteristics have been obliterated beyond recognition. This fact, together with the work of solutions carrying in and depositing certain ingredients and leaching out and removing others, leaves the problem of the original nature of the deposits very difficult to solve. While an igneous origin is postulated for the talc-bearing rocks, no evidence of contact metamorphism has been observed.

NATURE OF THE DEPOSITS

RELATION OF TALC-BEARING ROCKS TO COUNTRY ROCKS

The talc deposits, limited to a relatively small area east of Chatsworth, are confined to the Ocoee series, and occur at varying horizons through a stratigraphic distance of not more than 1,000 feet.

The talc-bearing formations occur as sheets or beds which may be traced continuously for one-half to three-fourths of a mile at what appears to be the same horizon; and, while not showing continuously on the surface, these formations may occur at the same horizon for a distance of four or five miles or even farther. The strike and dip of the deposits are those of the country rocks; the dip is to the southeast at an angle of 45° and less.

The thickness of the talc-bearing rocks are not determinable with accuracy because of the poor natural exposures and the fact that the artificial openings do not expose at the same locality the hanging and foot walls. However, the maximum thickness is at least 50 feet on the west side of Fort Mountain, while on the east of Mill Creek the thickness does not appear to be more than 20 or 30 feet.

In general, the contacts between the talc-bearing rocks and the country rock are sharp, as in the mines of the Georgia Talc Company; while at some places, at the Piedmont Talc Company's opening, for instance, the gradation to the country rock appears to be perfect. Although the conformity between the talc-bearing rocks and the country rock may be constant, at the Fort Mountain mines of the Cohutta Talc Company, the former has the appearance of cutting across the bedding of the latter, a fact that can not be definitely ascertained.

MINERALOGY

Associated with the talc-bearing rocks the following minerals have been recognized, arranged roughly in the order of their abundance: Serpentine, "blue john," talc, chloritic material, carbonates, pyrite, magnetite, actinolite and manganese oxide.

TALC

The talc as it occurs in this region varies from almost white to dark green in color: it is translucent in thin plates and crystalline to subcrystalline. In structure, it is schistose to laminated. Its composition, together with the impurities contained, is shown in the following analyses:

Analyses of Talc from Murray County

	1	2	3	4	5
SiO_2	63.50	59.80	60.00	60.66	59.62
Al_2O_3	-------	1.00	1.07	.14	2.18
Fe_2O_3	------	5.00	4.83	.26	.84
FeO	------			5.33	4.92
MgO	31.70	29.15	29.05	27.94	24.39
CaO	-------	-------	-------	.12	4.30
Na_2O	-------	-------	-------	.68	.25
K_2O	-------	-------	-------	.96	.60
H_2O-	-------	-------	-------	.11	.32
H_2O+	4.80	5.05	4.05	3.16	2.38
TiO_2	-------	-------	-------	.04	trace
P_2O_5	-------	-------	-------	.04	trace
S	-------	-------	-------	.03	.04
MnO	-------	-------	-------	.20	.14
	100.00	100.00	99.00	99.67	99.98

1. Theoretical talc.
2. Talc from Cohutta Talc Company's mine.
3. Talc from Georgia Talc Company's mine.
4. Talc from Georgia Talc Company's mine, Grey pit.
5. Impure talc, Fort Mountain Talc Company's property.

Among the impurities found in the talc of pencil grade, the following have been recognized in thin section: magnetite, pyrite, dolomite, chloritic material and serpentine. With the increase in the percentage of chloritic material, serpentine and carbonate, the talc grades into material called "blue john" by the miners. The distinction between the talc and the "blue john," which may be nearly identical in appearance, is based on the hardness, and the separation can be made by an experienced miner with a single blow of his pick in the poorly lighted mine.

From numerous places, such as from the properties of the Georgia Talc Company, specimens of talc have been found with amphibole (actinolite) needles running through them, which show all stages of transition from the one to the other.

SERPENTINE

Serpentine usually occurs mixed with other minerals, but when purest it has a wax-like appearance and varies from massive and granular to schistose in structure. The largest quantity is to be seen on the Latch property. It outcrops as large massive ledges intersected irregularly by joints. Fibrous serpentine, chrysotile, occurs in very fine veins on the Latch property, and at the Fort Mountain mines of the Cohutta Talc Company. The fibers are delicate and silky, and vary from pale green to golden brown in color.

The following are three analyses of serpentines from the W. Z. Latch property, Murray County, where they are associated with the talc deposits:

Analyses of Serpentines

	1	2	3
SiO_2	37.55	44.21	43.36
Al_2O_3	2.32	3.57	4.26
Fe_2O_3	4.80	4.63	8.00
FeO	5.98	4.17	5.04
MgO	33.67	32.11	26.43
CaO	2.46	.02	.10
Na_2O	.15	.10	.25
K_2O	.10	.14	.42
H_2O-	.22	1.17	.06
H_2O+	12.28	9.89	11.70
TiO_2	.10	trace	.08
P_2O_5	trace	trace	.05
S	.20	.05	.06
MnO	trace	.08	.06
	99.83	100.14	99.87

1. Hard, dark green serpentine.
2. Dark green serpentine with chrysotile veins.
3. Light green serpentine with poorly fibrous chrysotile in slip-fiber veins.

"BLUE JOHN"

"Blue john,"[1] as stated above, is a combination of minerals, and is therefore of quite variable composition, as is shown in the following analyses:

Analyses of "Blue John"

	1	2	3	4	5	6	7	8	9
SiO_2	63.50	44.10	32.64	31.76	32.00	47.68	32.67	44.86	45.52
Al_2O_3	------	------	17.64	27.64	15.68	9.43	.36	1.50	.34
Fe_2O_3	------	------	1.05	2.20	3.22	9.07	.08	4.92	.39
FeO	------	------	8.35	3.00	12.30	------	3.88	1.00	5.33
MgO	31.70	43.00	26.67	22.89	14.00	29.39	28.39	30.02	32.90
CaO	------	------	.24	trace	10.81	trace	9.68	4.76	.04
Na_2O	------	------	.50	.22	.24	------	.30	.18	.25
K_2O	------	------	2.14	.24	.47	------	.35	.31	2.01
H_2O-	------	------	.30	.67	.62	------	.40	1.00	.14
H_2O+	4.80	12.90	9.34	11.54	9.58	3.40	23.04	11.30	12.60
TiO_2	------	------	.36	trace	.80	.45	trace	trace	trace
P_2O_5	------	------	.81	.03	.04	------	.02	.04	.02
S	------	------	.04	trace	.02	------	.20	.14	.08
MnO	------	------	.04	.04	.10	------	.03	.10	trace
	100.00	100.00	100.12	100.23	99.88	99.42	99.40	100.13	99.62

1. Theoretical talc.
2. Theoretical serpentine.
3. "Blue john," fine grained, bluish-black in mass, but green, translucent on thin edges; practically identical in appearance with the talc, but harder; can be scratched with finger nail; W. Z. Latch's property, near Chatsworth.
4. Same as 3, but somewhat harder; can not be scratched with finger nail. Cohutta Talc Co., Fort Mountain.
5. Similar to 3 and 4, but harder, more granular in appearance and does not resemble talc so closely. Grey pit, Georgia Talc Co.
6. Typical "blue john," some talc and some hard, dark green material. Cohutta Talc Co., Cohutta Mountain.
7. Talc and dolomite, light grey color, crystals of dolomite and magnetite plainly visible. Piedmont Talc Co.
8. Hard, light green, somewhat granular rock; King pit, Georgia Talc Co.
9. Appearance same as 8; Georgia Talc Co.

[1] On account of the need of a term, "blue john" will be used in this report to apply to the rock discussed above.

As compared with talc and serpentine, it will be seen that samples 3, 4, 5, and 6 run far too high in alumina; 3, 5, and 6 too high in lime, and all too low in silica and magnesia. The numbers 3, 4, 5, and 6 are typical "blue johns," which can not be distinguished from talc by their appearance. The alumina may be accounted for, in part, by the presence of chlorite; and the hardness is to be explained by the presence of serpentine. The hardness of numbers 5, 7 and 8 is due partly to the presence of dolomite, a condition which is especially true of number 7, although the dolomite grains are visible only with close inspection.

CHLORITIC MATERIAL

Chloritic material is to be found in almost all of the thin sections of "blue johns" and serpentines which have been examined. Optically, it is not truly a member of the chlorite group, or at least is difficult to determine definitely as such, on account of the very faint pleochroism, and the smallness of the flakes. However, at the Cohutta Talc Company's mine on Fort Mountain a member of the chlorite group has been found in large enough plates to be analyzed with the following results:

Analysis of Chlorite, Cohutta Talc Co.'s Mine, Fort Mountain

SiO_2	38.52
Al_2O_3	9.28
Fe_2O_3	1.18
FeO	4.64
MgO	33.75
CaO	.04
Na_2O	.37
K_2O	.92
H_2O-	.06
H_2O+	10.12
TiO_2	.03
P_2O_5	.00
S	.02
MnO	trace
	98.93

The mineral has a purplish color and a pearly luster. The laminae are stiff and very brittle. It occurs in plates up to three-fourths of an inch in diameter. The analysis suggests that the mineral is really a member of the chlorite group, while its physical characters seem to ally it to chloritoid.

CARBONATES

Carbonates occur in the form of disseminated grains in the talcose rocks and also as pure white masses of coarsely crystalline material associated with light green, foliated talc. In the first mode of occurrence it may constitute as much as one-fourth of the rock mass; while in the second it is found only as scattered masses, up to six inches in diameter, and is particularly characteristic of the Grey, King and Hollow pits of the Georgia Talc Company. While no quantitative tests have been made, numerous qualitative tests have, with the result that there is found to be quite a variation in the composition of these carbonates, the range being from dolomite towards magnesite, rather than toward calcite.

PYRITE AND MAGNETITE

Pyrite and magnetite, the "steel points" of the miners, are present in practically all the talc of the district in variable amounts. They vary much in size, from fine specks up to megascopic crystals two millimeters in diameter. The largest are found only on the Piedmont Talc Company's property. In the weathered talc found near the surface these minerals are represented by ocherous spots.

ACTINOLITE

Actinolite has been found, both in its massive and its fibrous forms. As described above it has been noted at numerous localities showing all stages of alteration to talc. Its presence in the talc can not be said to be detrimental because of the infrequency of its occurrence, the fineness of its needles, and its usually much altered condition.

Fibrous actinolite has been found on the Cohutta Talc Company's property on lots 294, 295 and 297, and on the Latch property, lot 296. It occurs in the form of slip-fiber veins of varying widths, although they are usually very narrow. The fiber is long, coarse and shows an extinction angle of 15 degrees. An analysis of some of the fibrous material from the Cohutta Talc Company's mine on Cohutta Mountain is as follows:

Analysis of Fibrous Actinolite

SiO_2	56.68
Al_2O_3	1.10
Fe_2O_3	7.73
MgO	21.00
CaO	10.97
H_2O+	2.00
MnO	.18
	99.66

MANGANESE OXIDES

Manganese oxides occur both as psilomelane in the form of encrustations, as black earthy powder, and also forming at places slickensided surfaces, probably of comparatively recent origin.

RELATIONS OF THE TALC TO THE SERPENTINE AND "BLUE JOHN"

The workable bodies of talc occur in lense-shaped masses which have their long direction in the direction of dip, although they pinch out both vertically as well as laterally. (See figure 4.) These lenses, which are usually connected by layers of talc, which may not be more than an inch in thickness, vary in thickness from 4 to 8 feet, or even more, and usually give way to "blue john," from which it separates by a natural cleavage, usually a slickensided surface. These slickensided surfaces are not confined to the contacts between the talc and "blue john," but are found running through both, causing the material to break up into lense-shaped pieces of small size. These natural cleavage planes may be so extensively developed that the talc breaks up into such pieces that its value for making pencils is impaired. These surfaces are not only slick, but are commonly grooved.

The talc bodies, while not confined to any particular part of the talc-bearing formation, appear to be somewhat more extensively developed near the upper and lower contacts with the wall rock, which varies from a quartz schist to a graywacke, quartzite or arkose. The hanging wall is commonly a quartzite or arkose.

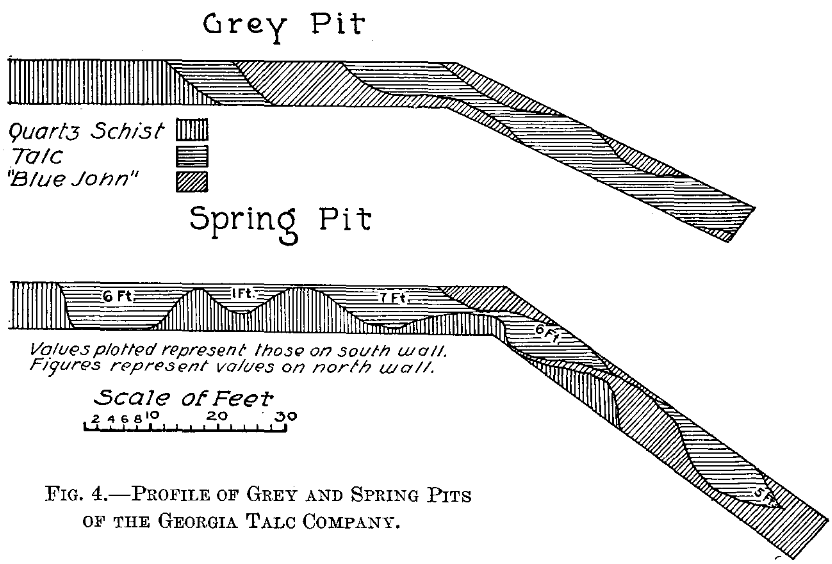

FIG. 4.—PROFILE OF GREY AND SPRING PITS OF THE GEORGIA TALC COMPANY.

The talc found near the surface is usually stained yellow by surface waters and rendered softer and more schistose, features which destroy its use for making pencils, although it can be used for making low-grade powder. With increase in depth the effects of weathering are less pronounced and the percentage of high-grade talc increases. Good "saw rock" is usually encountered at about ten feet from the surface. The greatest depth to which talc has been worked in this district is at the Grey pit of the Georgia Talc Company, where a tunnel has been driven back about 300 feet. At this depth there was no appreciable change in the quantity of talc present, but a marked change in the quality, due to the absence of the effects of surface weathering. There is no indication at that depth that hard, unaltered rock will be met with. However, a study of different localities in this district where erosion has been active to a variable degree, leads to the belief that the talcose rocks will give place to serpentine at depths of some hundreds of feet. The difference in the material exposed at the surface, due to the rapidity of erosion may be seen by comparing the soft material found on the Georgia Talc Company's property, where the gradient is moderate, with the hard serpentine rocks on the Latch lot, where the gradient is high. However, it is believed that the talc will, in general, continue to as great depths as it can be profitably mined.

GENESIS OF THE TALC

SOURCE OF ORIGINAL MATERIAL

The extreme metamorphism which the talc and its associated rocks have suffered has so obliterated the original character of these rocks that their origin is obscure; however, it is believed that these rocks are of igneous origin and represent dikes or sheets, a conclusion based on the following reasons:

While the talc-bearing rocks generally have the appearance of being conformable in strike and dip with the country rock, at some places, as at the Fort Mountain mine, this relation does not appear to hold, and the former have the appearance of a dike cutting across the bedding of the latter; moreover, this apparent conformity is what would naturally be expected, if the intrusions were later than the development of the schistosity in the country rock, because the intruded rocks would follow the line of least resistance, which is manifestly that of the cleavage of the rocks. Furthermore, the only place where the bedding can be determined with any degree of accuracy is in the heavy beds of quartzite or arkose, and in that association it would be quite natural for the intrusions to follow along beneath these beds rather than cut through them.

As has been stated, the contacts between the talc-bearing rocks and the country rocks are usually sharp, although at some places a gradation from the one to the other is found. In the mines of the Georgia Talc Company, high-grade talc is found immediately in contact with quartz schist, but more commonly separated by "blue john;" in all cases, however, in these mines the separation is sharp and distinct. On the property of the Cohutta Talc Company, on the southern slope of Cohutta Mountain, talc is found beneath a heavy bed of arkose and separated from it by irregular lense-shaped layers of chloritic, quartz schist, which alternates with and grades into the arkose. It is evident here that the chloritic quartz schist is derived from the arkose by the alteration of its feldspar content, a condition which may be due to contact metamorphism.

Broadly speaking, the talc-bearing rocks stand in sharp contrast with the country rocks, both in mineral composition and structure. In thin section the following minerals have been recognized: Serpentine, chlorite, material intermediate between serpentine and chlorite, talc, carbonates, pyrite, magnetite, apatite and zircon. As observed in the field, serpentine and talc of varying purity are present in largest amounts. The serpentine as seen on the Latch property and adjoining lots to the north and south, often occurs in massive form cut by jointing planes much the same as has been observed in the serpentinized peridotites farther east. Moreover, these serpentines have been sheared with the development of slip-fiber asbestos, as well as narrow veins of chrysotile. As seen in thin section poikilitic structure produced by the almost colorless chlorite enclosing irregular grains of serpentine is very common and at places extensively developed, a condition suggestive of igneous rather than sedimentary origin.

An average of eleven analyses of serpentine and "blue john" from the district, calculated so as to eliminate the loss on ignition, gives the following results:

Average of Eleven Analyses of "Blue John" and Serpentine

SiO_2	45.34
Al_2O_3	7.98
Fe_2O_3	3.19
FeO	6.03
MgO	29.48
CaO	5.53

Analyses of "Blue John" and Serpentine—(Continued)

Na_2O	.32
K_2O	.92
TiO_2	.14
P_2O_5	.13
S	.12
MnO	.05
	99.23

If this composite analysis be compared with that of the average peridotite it will be seen to be strikingly similar.

Not only are the talc-bearing rocks contrasted with the country rocks in composition and structure, but also to a greater extent in degree of metamorphism. No matter what the original character of these rocks may have been, they give evidence of far greater metamorphism than the slates, quartzites and arkoses which form the country rock and thus they appear to have represented originally an entirely different type of rock.

The general absence of limestones, a possible source of the talcose material, from this series of rocks and the fact that limestones would not be likely to occur in association with a series of quartzites and arkoses seem to eliminate the possibility of the talc deposits having that origin. Furthermore, limestones are known nowhere in this part of the country altering into masses of serpentine with the development of such minerals as chrysotile, amphibole asbestos and chlorite.

In brief, the postulation of an igneous origin in the form of dikes or sheets seems to satisfy the conditions better than any other theory, because it satisfies the conditions in regard to the relation of the talc-bearing rocks to the country rock, and offers an explanation for the sharp contacts between them, and the nature of the talc-bearing rocks, both as regards mineral composition, structure and the more altered character.

However, the absence of definite proof of the intrusive character of the talc-bearing rocks, both in regard to their relation to the enclosing rocks and their original mineral composition, prevents the evidence from being conclusive. The evidence in favor of sedimentary origin is largely negative and may be summarized as follows: The apparent conformity and gradation which exists between the country rocks and the talc-bearing rocks at some places, together with the sporatic occurrence of zircon and apatite in both types of rocks, the high percentage of carbonates of magnesium and lime in some of the samples which reaches as much as 80 or 90 per cent., the general absence of definitely recognizable igneous rocks in the district, and finally the theoretical possibility of an impure magnesian limestone giving rise to deposits of the nature found here. As a whole the theory of igneous origin is more tenable, although the conditions of sedimentary origin would more easily explain the conditions at certain localities.

NATURE AND ALTERATION OF THE ORIGINAL MATERIAL

Little definite information has been gained by a study of thin sections of the least altered of the talc-bearing rocks in regard to the original character of the material. The poikilitic structure seems to suggest that there were at least two minerals present. The presence of olivine grains in a pyroxene would account for the presence of chlorite enclosing serpentine by a very natural alteration, but there is absolutely no proof of their existence. The serpentine gives no evidence of being derived from olivine; on the contrary, it shows the structure of either hornblende or a carbonate, by the preservation of the original outline of the mineral and the cleavage cracks by the infiltration of magnetite. It has not been definitely proved, but this former mineral is believed to have been carbonate, although it is difficult to explain the preservation of its structure. However, if a carbonate was present where the serpentine is now it was doubtless a secondary mineral, as are the carbonates which the rock now contains.

Not knowing the original composition, it is, of course, impossible to point out the alterations which have led to the development of talc. The presence of actinolite showing alterations to talc at various localities is significant and suggests that the talc was formed through the intermediate mineral, amphibole.

ORIGIN OF SOAPSTONE DEPOSITS

In general, the hornblendic rocks, the gabbros, hornblende gneisses and hornblende schists, give rise to chloritic soapstones, which are of wide distribution in this State. The soapstone thus developed is commonly schistose and might be more properly called a chloritic schist; in some instances, when derived from massive rocks, the soapstone is more or less massive. In almost all cases the rock is sufficiently strong in all directions to be used locally for lining fireplaces, building chimneys, furnaces, etc.

While peridotites may alter directly to talc, this alteration is not so common as that of pyroxenites to talc. Enstatitites, in particular, alter readily to talcose rocks with magnetite as the most abundant impurity. Both the peridotites and pyroxenites alter to amphibolites, which in turn may alter to talcose rocks. This alteration appears to be the most common one which these rocks suffer. Along the contact of the pyroxenite and peridotite dikes with the enclosing gneisses and schists, there is usually developed a layer of talc schist which is quite pure, while the central portion of the mass may be more massive soapstone.

In brief, it may be stated that the peridotites and pyroxenites, the aluminum-poor rocks, alter to talc, while the gabbros, diorite and hornblende schists and gneisses, rocks richer in aluminum, alter dominantly to chlorite.

MINING AND MILLING

TALC

MINING

The mining of talc was carried on some years ago in Fannin and Gilmer counties; the work was done in open cuts and shafts, and the raw material shipped away to be prepared for the market. Mining in this district has not been as successfully or extensively carried on as it has in Murray County; and it is with the latter that the following pages are concerned, both in regard to mining and milling.

The early mining in Murray County was all of the "gopher" or "ground-hog" type; small pits and drifts were made into the natural outcrop, but these were continued only until the sides or roofs began to cave in, and then they were abandoned and work started at another place. As a consequence, pits have been dug at practically all known outcrops in the district. Owing to their shallow nature, only yellow talc of a low grade was obtained, material which was used largely for foundry facings. The result of this method of mining is reflected today in the fact that certain buyers demand yellow talc instead of the light green powder, produced from the fresh material which has not been affected by surface weathering; consequently impure red or yellow ocher is mixed with some of the talc to give it the desired color, when its presence is there purely as an adulterant. For this type of mining, the price of $1.00 per ton was paid.

Later, when all the easiest mined talc had been extracted, and when it was found that fresh green talc could be reached by deeper mining, the price paid the miner was increased until within the past few years he has received $2.00 per ton for the yellow talc and $3.00 per ton for green talc that could be sawed into pencils. This increased price induced the miners, who worked in pairs, to begin to timber the openings and work deeper, since the work was on a contract at so much per ton. But as the company did little in the way of supervision, the mining was unsystematic; narrow tunnels, merely wide enough to admit a small car, were driven in, and the talc which could be reached most easily was taken out. When difficulties presented themselves the miners abandoned the opening, and it was left for the timbers to decay and the roof to fall in. The small cars were pulled out from the tunnel over wooden tracks, by a whim located at the entrance, which was usually operated by hand. This was the method employed by the Cohutta Talc Company until within the last few years.

The Georgia Talc Company was the first to inaugurate more up-to-date methods and more systematic mining in the district. That company owns only one lot, and this had been extensively "ground hogged" before it came into its possession. Consequently deeper mining was necessary. The work at the present time is being done by day labor, the tunnels are well timbered and the work is more systematic and business-like. At one mine a gasoline engine has been installed to pump out the water, although all the cars are still being operated on wooden rails and pulled by whims, which are worked by hand or by horse-power.

The Cohutta Talc Company is now having its mining done by contract, but under intelligent supervision. A steam hoist is used in pulling the cars from the mine, and the pumping is done by steam-power.

Black powder is used instead of dynamite for blasting, so that as little as possible of the talc will be shattered and rendered unsuitable for sawing into pencils.

While there is still much room for improvement, the methods of today are far superior to those of ten or even five years ago.

MILLING

The crude talc is either sawed into pencils or ground into powder. All rock which will make pencils is sawed, because of the much higher price that is received for that product.

The sawing requires much hand labor. Large blocks, which are too bulky to be handled easily, are first sawed with a cross-cut saw. The sawing is usually done as follows: (1) Blocks lying on the cleavage face are sawed with the grain and at right angles to the cleavage; (2) the blocks are placed on the sawed face and cut with the cleavage; (3) the blocks with two flat faces are sawed across both cleavage and grain at intervals which represent the length of the pencils; (4) the blocks are sawed along the grain to make "stocks," the thickness of which represents the width of flat pencils and one of the sides of square ones; (5) finally, the "stocks" are sawed along the cleavage to make pencils.

A single saw is used for numbers 1 and 2; another is used for making stocks (No. 3); and two saws are employed to cut the stocks into pencils (No. 4). Thus, it requires four men to run the saws, not to mention an assistant to help handle the large blocks at their first and second sawings, and another to remove the pencils and scraps. The saws are set with moveable gauges so that pencils can be sawed to order. The commonest sizes are the following: ¼″ x ¼″, ½″ x 3/16″, ½″ x ½″, and 1¼″ x 3/16″ x 5″ long. These are the pencils used by metal workers. A tailor's pencil is made which has two beveled edges. The Cohutta Talc Company has formerly turned some pencils.

The pencils are packed in boxes, which hold one gross each. There are 24 gross in a standard case.

All the offal from the saws is ground along with other rock which is unsuitable for pencils, either because it is too hard, in too small pieces, stained yellow, or not compact enough. All this material goes first to a crusher, which reduces the size to from about an inch in diameter to powder; from the crusher the talc is conveyed to a pulverizer which may consist of a series of paddles, as is the case at the Cohutta mill, which beats the talc into dust; or it may be a rock emery mill, as at the Georgia mill, which grinds the talc to powder. In the first case, the powder is carried from the pulverizer by suction and is not screened; while in the second case the talc is passed through a 180 mesh silk cloth and the tailings reground. In all cases the talc is elevated and sacked from a packer in 200-pound sacks. (For a description of the three mills in this State see Georgia Talc Company, Cohutta Talc Company and Fort Mountain Talc Company.)

SOAPSTONE

QUARRYING

The soapstone deposits of Georgia have been worked for local consumption at numerous places over the Chrystalline Area of this State; but at all of them only comparatively insignificant openings have been made. Practically all these openings have been made into chloritic soapstone, which has a well developed cleavage and may thus be called a chloritic schist. Taking advantage of this natural cleavage, large slabs are quarried and later sawed into the desired shape with a cross-cut saw. Such are the methods employed in Georgia.

It seems advisable to include here a brief description of the methods employed at the larger soapstone quarries of this country. In general, a rectangular quarry is opened up in exactly the same way as a marble quarry. The surface of the quarry is leveled off, benches made, and the rock taken out in large rectangular blocks with the aid of channeling machines, gadders and wedges in the same way as in marble quarrying. These blocks are hoisted by cranes and placed on cars to be taken to the finishing sheds. There is much waste material, estimated from 80 to 90 per cent., due chiefly to the presence of fissures and veins, the weathering of pyrite and magnetite which discolor the rock, and in some cases to the hardness of the material.

FINISHING

The large blocks from the quarries are sawed by gang saws into slabs, as in the marble industry. The slabs are roughly marked off into various shapes according to the use to which the material is to be put, and then sawed on tables with circular saws. These smaller slabs are then smoothed on a revolving disc of cast iron with the aid of water and steel powder. These roughly shaped slabs are finally cut accurately to the correct shape, grooved on emery discs, bored and finished by hand to form the desired articles.

PRODUCTION AND USES

PRODUCTION

TALC

Unfortunately, the statistics of the early production of talc in Georgia are not available; and since, from 1909 until 1912, there were only two producers, the data collected by the U. S. Geological Survey is confidential. The result is that only a very fragmentary record can be given, which is as follows:

Production of Talc and Soapstone in Georgia[1]

Year	Tons	Value	Year	Tons	Value
1898	639	$ 4,054	1903	1,012	$ 9,042
1899	1,062	42,085	1907	739	11,473
1900	6,477	77,217	1908	455	7,261
1901	693	4,717			

Although the production for the last three years has not equaled the maximum production, it has far exceeded the figures given for 1908. Each year the workings are being pushed to greater depths, which results in the production of a larger percentage of "saw-rock," thus increasing the value of the product without increased production.

SOAPSTONE

The entire production of soapstone in Georgia has been for the purpose of satisfying the local demand for material for fire places, hearths, chimneys, etc. Since the man producing the material was generally the consumer also, no statistics are available. This industry was much more important years ago than today; the introduction of cement and the location of large granite and marble quarries within the State have largely put an end to it. Thus marble and granite tombstones have replaced the former soapstone ones because of their superior quality and only slightly greater cost; and cement and bricks are used in buildings where soapstone was formerly employed.

[1] The talc and soapstone produced in Georgia has come largely from the Chatsworth district, and in recent years entirely so.

USES

TALC

"The properties of talc which render it useful for many purposes are its foliated or fibrous structure, its softness, its whiteness or light color and luster, its medium weight, its sectile and flexible but not elastic quality, its greasy feel, its low conductivity but high absorption of heat and electricity."[1]

The highest grade of talc is termed "saw rock"; scraps from the saw tables, together with inferior grades of material, are ground.

The demand for talc sawed or turned into various objects is of relatively recent date. In the early mining of talc in Georgia and North Carolina, ground talc was more in demand, and blocks of talc of the highest grade were ground into powder. The reverse is true to-day; small pieces of talc are sawed into pencils even if their dimensions are such that but three or four can be made. This is due to the fact that the highest grade of powder brings on the market scarcely $20 per ton, whereas a ton of pencils brings up to $500 per ton. The principal uses of sawed talc are for crayons for metal workers, black-board crayons, slate pencils, gas and acetylene tips, and high-grade insulators. Of all these uses, the metal workers' crayons bring the highest price on the market.

Ground talc is used for a great variety of purposes. The highest grades are used extensively in making toilet articles, of which talcum powder is the most common. For this purpose the material has to be white, free from gritty particles and finely ground. It is also used as an ingredient in the lower grades of soap, as a lubricant when mixed with oil, in the manufacture of water-proof paint, in dressing skins and leather, in the ceramic arts, in the manufacture of rubber goods, etc. The lowest grades, especially those discolored by iron, are used for foundry facing in casting iron; the interior of the mould is sprinkled with talc, so that smooth castings may result.

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[1] Diller, J. S., The Production of Talc and Soapstone for 1912; Advance Chapter Min. Res. U. S., p. 12.

By far the most important use of talc is in the manufacture of paper, for which use fibrous talc is especially desirable. In order that paper made from cotton, linen and hemp rags and from wood, straw, etc., can be written or printed upon without the ink spreading, it is necessary to size it by applying starch, rosin or glue. Thin paper made of these ingredients alone is more or less transparent, and in order to make it opaque china clays have been extensively used; but more recently fibrous talc is supplanting the clay because it can be used in larger quantities and adds to the strength of the paper.

The talc mined in Georgia is sawed into crayons, particularly for the use of metal workers; and the offal from the saw tables, together with inferior talc, is ground and sold largely for foundry facing.

SOAPSTONE

Georgia soapstone has been used locally for a number of purposes, such as tombstones, fire places, chimneys, door steps, foundations, for walling cellars and wells, for lining furnaces, etc. Except in the lining of furnaces, such as are used in connection with cotton gins, the local demand is very small.

The qualities which render soapstone useful are its softness and consequent ease with which it can be worked, its stability as regards heat and acids, and its poor conductivity of heat and electricity. These properties have lead to its extensive use for slabs for table tops and acid tanks in chemical, biological, and other laboratories, as well as for switchboards, panels, and flooring in electric stations. It is also used extensively in the manufacture of laundry tubs, griddles, stove linings, foot warmers, fireless cookers, and many other articles.

DESCRIPTION OF TALC AND SOAPSTONE DEPOSITS

THE TALC DEPOSITS OF VERMONT[1]

The talc deposits of Vermont are found associated with crystalline schists occupying a belt running north and south across almost

[1] Pratt, Joseph Hyde, Min. Res. U. S., 1905.
Perkins, G. H., Report of Vt. State Geologist, 1907-8, 1909-10.

the entire State. Deposits have been developed in Windsor, Windham, Rutland, Washington, and Lamoille counties, with the greatest development in Windsor and Rutland counties. The deposits have been worked over a distance of 100 miles.

During 1912 there were four companies producing talc, and two producing soapstone. According to the statistics of that year, Vermont stood second in the production of talc, ranking next to New York. The greater part of the output is ground and used as a paper filler, for which use it brings about $6.00 per ton, whereas New York talc brings $10.00 per ton. The inferiority of the former is due to the lack of fibrous quality. A small amount of the hard talc, or soapstone, is cut into laundry tubs, etc.

The talc is found in a series of lenses of varying size and quality, and not in a continuous bed. It is closely associated with serpentine and actinolite schist, while the country rock varies from a gneiss to mica schist. In the northwestern part of Windham County, 8 miles southwest of Chester, a soapstone deposit has been located which shows an outcrop of talc or talcose rock 720 feet long, with an average width of 150 feet. On the west the talc is bounded by chloritic schist and on the east by serpentine, which is in contact with mica schist or gneiss.

The quarries are favorably located in regard to economic mining; they are situated on moderate slopes and aided both in mining and in transportation by gravity.

THE TALC DEPOSITS OF NEW YORK[1]

LOCATION AND GENERAL DESCRIPTION

Although New York has from the beginning been prominent in the production of talc, the area from which it is derived is relatively small, and the industry is limited to a narrow strip in St. Lawrence County only eight to ten miles long and a mile or less wide.

The region is composed largely of pre-Cambrian gneisses, with crystalline limestones forming irregular belts trending northeast and

[1] Smyth, C. H., Jr., Report on the Talc Industry of St. Lawrence Co., N. Y.; 15th Ann. Rept. State Geologist, Vol. 1, 1895, pp. 20 and 661-671.

southwest. Most of the limestone of this area is impure, and is wholly or in part replaced by silicates, of which tremolite and enstatite are dominant. The most important of these belts of altered limestones, and the one from which all the talc has been obtained, extends from near Talcville southwest to Silver Lake, a distance of about seven miles.

The limestone in the talc belt differs from the limestone farther north in that it is less crystalline and contains numerous thin layers of light colored, fine-grained material which stands out on a weathered surface. In this limestone, at a more or less definite horizon, are developed beds of tremolite and enstatite, which represent portions of the limestone formation containing a large amount of siliceous sediment. There is a gradation from tremolite limestone to a tremolite schist, depending on the composition of the original material. The talc is formed in the band of schist, and at one of the larger mines near Talcville, it is limited to the middle portion of that band. The layers of talc vary in thickness from a few feet to more than fifty, and are remarkably persistent laterally.

ORIGIN OF THE TALC

The relationship of the tremolite schist to the limestone, and the gradation of the one into the other, prove conclusively that the former was derived from a phase of the latter. The proof of the derivation of the talc from the tremolite beds is based on their constant association, the gradation from the one to the other, and the structure of the talc. The talc not only gives place to the tremolite schist above and below, but it often grades into irregular masses of it laterally. Furthermore, there is a constant gradation from fibrous tremolite, which shows an extinction angle of 16 to 18 degrees, to fibrous talc; and in reality much that has been called talc is fibrous tremolite. Finally, the fact that the talc here, as well as in so many other occurrences, is pseudomorphous after a fibrous mineral, leads to the conclusion that the beds of tremolite have given rise to the deposits of talc.

The presence of scales of talc in many places indicates that it is not entirely pseudomorphous, but that some of the talc has resulted directly from the independent growth of that mineral. From the relationship of the scaly to the fibrous talc, it is inferred that the fibrous structure of the deposit may be an indication of the lack of completeness in the process of alteration, which, if continued to the ultimate end, would convert all of the schist to scaly talc. Since the commercial value of the talc is dependent in a large measure on the fibrous structure, such a change would lead to the destruction of its most valuable property. On this subject, Smyth concludes that "While it is not impossible that such a complete alteration may have occurred in some portions of the deposit, it would, doubtless, be very irregularly distributed; and as it would be independent of the present topography, would be developed, at such depths as to prevent further working, only by a coincidence."

MANUFACTURE OF TALC PULP

The material from the mines has to be culled in order to separate the dark-colored material. That which has been selected is first passed through crushers and then through rolls, or buhrstones, where it is reduced to grains the size of a pea and smaller.

"From the rolls or buhrstones," according to Smyth,[1] "the talc goes either to Griffin mills or direct to the Alsing cylinders. These are drums of half-inch steel, 6 feet in diameter and 10 feet in length. They are supported by trunnions at the ends, and revolve about 25 times per minute. The cylinders have a lining of glazed brick, and in each one are placed some three and one-half tons of round flint pebbles about the size of an egg. A cylinder is charged with an amount of talc equal to one-fourth or one-third of the weight of the flint pebbles and, after the manhole is closed, is revolved until the talc is reduced to the requisite degree of fineness. This operation usually takes about two hours. When it is completed, the closing plate is removed and a grating substituted which will retain the

[1] Smyth, C. H., Jr., op. cit.

pebbles and permit the discharge of the talc. The cylinder is then revolved again until the talc is all removed, ready for packing and shipment."

It will be understood that this process differs radically from the grinding and bolting process to which ordinary ground talc has been subjected. This difference is made necessary because of the fibrous structure of the talc, which, when ground, forms a felt that can not be bolted; and, secondly, because it is advantageous to preserve the fibrous structure as far as possible, since that property is the foundation of its most extensive application.

USES

As has already been suggested, the properties of the New York talc which give it its commercial value are fibrous structure, pliability and softness. These characteristics make it valuable as a filler of medium grades of paper, for which the great bulk of the material is used. Formerly, clays were used extensively for this purpose; but as these did not strengthen the paper, and as only 30 to 40 per cent. was retained by the pulp, talc has been substituted because it not only increases the toughness of the paper, but because the pulp is able to retain from 70 to 90 per cent. of the fibrous material.

THE TALC DEPOSITS OF NEW JERSEY AND PENNSYLVANIA[1]

GENERAL DESCRIPTION OF THE TALC DEPOSITS NEAR PHILLIPSBURG, NEW JERSEY

The most important talc deposits of New Jersey and Pennsylvania are located along their boundary line, and extend from just north of Easton, Pennsylvania, across the Delaware River to a point about 2½ miles north of Phillipsburg, New Jersey. The rocks of the region are composed of pre-Cambrian gneisses, which extend across the northern part of New Jersey and through Pennsylvania, associated with dolomite of Cambrian age, the Kittatinny dolomite.

[1] Peck, Frederick B., Preliminary Notes on the Occurrence of Serpentine and Talc at Easton, Pa.; N. Y. Acad. Sci. Annals, Vol. 13, 1901, pp. 419-430; New Jersey Geol. Surv., Ann. Rept., 1904, pp. 161-185, 1905.

The pre-Cambrian rocks of the region, through extensive folding and faulting, are brought to occupy anticlinal ridges, which are more or less parallel, while the Cambrian dolomite forms the intervening valleys. The rocks of pre-Cambrian age are divided into two groups, as follows: (1) Massive granitoid gneisses, with indistinct banding or foliation, followed above by (2) a series of beds of widely varying character, all of which are distinctly banded or bedded, and which are, at least in part, of undoubted sedimentary origin. The second series is divided into: (2a) dark, basic, diorite gneisses; (2b) light colored feldspathic or sandy gneisses; (2c) beds of limestone and dolomite; (2d) talcose and chloritic beds, carrying lenses and beds of more or less pure hematite followed by other beds resembling (2a) and (2b) in character. The entire group from (2a) to (2d) is intruded by coarse pegmatite granite in the form of sheets or lenses lying parallel to the bedding.

NATURE AND ORIGIN

Along the horizon of the limestone and dolomite beds are found the important talc deposits of this region. Fourteen or more openings have been made within a distance of 3½ miles. "Wherever the pegmatite granites," accordng to Peck, "are found cutting the crystalline limestones and dolomite, or wherever they are found anywhere in the immediate neighborhood, the latter becomes utterly changed in character from their original condition. The contact effect of these granitic masses on the limestone-dolomite beds aided at least in building up in the latter one or more silicates of lime and magnesia, such as tremolite, pyroxene or phlogopite. Locally, these silicates have entirely replaced the original carbonates, but all intergradations can be found from nearly pure limestone or dolomite, containing but small amounts of the silicates, to rocks consisting wholly, it may be, of either pure white tremolite or white pyroxene, or an aggregation of phlogopite mica scales, or mixtures of these different mineral species.

"Then followed the subsequent alteration of these silicates of lime and magnesia to either serpentine or talc. In the alteration the tremendous forces which folded, squeezed, stretched, and faulted the rocks into their present condition, together with the hydrating and leaching power of ever-present water, were the principal factors.''

The material quarried in this locality falls into two classes, based on the uses to which it is put:

(1) Rock used in the manufacture of mineral pulp—ground rock.

(2. Rock quarried in blocks for decorative materials—slabs, columns, etc.

The rock quarried for use in the manufacture of mineral pulp is rather hard, compact, massive to very finely granular in texture, and very light green, or mottled green and white in color. It is composed largely of serpentine, which gives the rock its color, together with tremolite, more or less talc, and calcite. The talc and calcite are due to the alteration of the tremolite. The serpentine is derived from the alteration of phlogopite, which is formed along with the tremolite from the original dolomite.

An analysis of a representative sample of this rock used in the manufacture of the better grades of pulp is as follows:

Analysis of Mineral Pulp from New Jersey

Silica (SiO_2)	45.23
Alumina (Al_2O_3) Iron (Fe_2O_3)	2.68
Lime (CaO)	1.41
Magnesia (MgO)	38.34
Loss on ignition	12.30
	99.96

MANUFACTURE OF MINERAL PULP

The rock is quarried, broken with sledges into convenient sizes and then passed through rock crushers. The first crusher breaks the rock to the size of lump coal; the second reduces it to the size of pea coal. From the crusher it passes through French buhrstones, where it is ground to a fine powder. Finally, it is bolted much the same as flour, and sacked or barreled.

The rock which is quarried for decorative purposes is essentially a serpentine with calcite and dolomite either sprinkled through the serpentine or in the form of veins. It is massive and takes a good polish, and is used in making slabs and columns.

USES

The mineral pulp from this locality is largely used as a pigment in the preparation of mineral paint; as an adulterant in cheaper grades of soap; in the manufacture of rubber goods; and as a filler for paper where softness and flexibility are desired.

OTHER DEPOSITS

A deposit exactly similar to that near Easton and Phillipsburg is locatetd 2 miles north of Montville, in Morris County, New Jersey, but at the present time no talc or soapstone is being produced at this locality. The Lizzie Clay and Pulp Company, located 2 miles north of Phillipsburg, was the only producer in New Jersey during 1911.

The output of talc and soapstone of Pennsylvania is limited to the eastern border of the State. Besides the locality near Easton, talc is mined in Pennsylvania near Lafayette, on the Schuylkill, 6 miles northwest of Philadelphia. The talc here owes its origin to the alteration of peridotite or pyroxenite in the form of dikes. Soapstone has been much more extensively quarried in the past than it is at present. Prince's quarry, on the east bank of the Schuylkill, near Lafayette station, was opened more than one hundred years ago for quarrying door-sills. It is now closed and partly buried by a landslide. The Rose quarry on the west bank of the Schuylkill, in the same formation, has been reopened recently, and is furnishing material of good quality for stove and furnace linings, as a filler in the manufacture of paint and paper, and as a lubricant.

THE TALC AND SOAPSTONE DEPOSITS OF NORTH CAROLINA[1]

GENERAL DESCRIPTION

North Carolina stands first among the States in the production of high-grade talc for use in the manufacture of pencils, gas tips, etc. While this is true, more than one-half the production of the State is not really talc, but pyrophyllite, a mineral which closely resembles the former in physical properties, but differs radically in chemical composition.

The talc and soapstone deposits of North Carolina are derived (1) from material of sedimentary origin, and (2) from material of igneous origin.

The bulk of the material produced is of sedimentary origin. There are extensive deposits belonging to the second class which are either unworked because of their distance from transportation facilities, or worked only locally to produce stone for fire-places, chimneys, and similar purposes.

TALC AND PYROPHYLLITE OF SEDIMENTARY ORIGIN

TALC DEPOSITS

Both the talc and pyrophyllite deposits come under the head of sedimentary origin, and will be discussed separately.

The most valuable talc deposits of North Carolina are in Cherokee, Macon and Swain counties. They are associated with Cambrian marble along the Nantahala, Valley and Nottely Rivers. This rock, termed the Murphy (Cherokee) marble, is associated with quartzites and bordered by gneisses and crystalline schists. It extends a distance of about 40 miles in North Carolina and is continued south into Georgia for a much greater distance. The marble belt varies in width from one-eighth to one-half mile, and has a general trend of N. 35° E.

The region has suffered repeated dynamic movements which have

[1] Pratt, Joseph Hyde, Talc and pyrophyllite deposits in North Carolina: N. C. Geol. & Econ. Survey, Economic Paper No. 3, 1900.

Keith, Arthur, talc deposits of North Carolina: Bull. U. S. Geol. Survey No. 213, pp. 433-438.

caused the limestone to crystallize into a compact marble, and the sandstone to form quartzite. Along the contact of the marble and quartzite there is often an intergradation or interlamination of the two rocks. Along these contacts, and in the marble, are developed beds or irregular lenses composed of silicates, in large measure tremolite. The talc occurs in lense-shaped bodies enclosed in the marble, and varying in size from mere scales up to masses 50 feet thick and 200 feet long. The lenses follow closely the contact between the marble and the quartzite, but are sometimes, as at the Kinsey mine, wholly surrounded by the marble.

According to Pratt,[1] the formation of talc is due to the alteration of the tremolite deposits. He bases his conclusions on the following reasons: (1) The formation of talc from tremolite is of very common occurrence; (2) pseudomorphs of talc after tremolite are frequently encountered; (3) talc deposits have been found where the tremolite is not completely altered, but forms prismatic crystals running through the talc; (4) the talc when closely examined under the microscope shows a decidedly fibrous structure; (5) the presence of only a small amount of foliated talc; (6) tremolite is the only mineral associated with the talc deposits, except, of course, the calcite of the marble and the quartz of the quartzite; (7) except where tremolite has been observed in the talc, the latter is generally free from grit.

The talc is largely quarried from open pits, though some of the deposits, especially those on the hillsides, are worked by means of shafts and tunnels.

Where necessary, the material is sorted by hand, into three grades. The large pieces are cleaned by rubbing them with steel brushes, while the smaller ones are cleaned by an ordinary founder's scouring machine. The material is then dried by spreading it over a floor of steam heated pipes. When dried, it is ground in a buhrstone mill,

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[1] Pratt, Joseph Hyde, Talc & Pyrophyllite Deposits in North Carolina: Econ. Paper, N. C. Geol. & Econ. Survey No. 3.

and the foreign material is removed by sieving. It is then ground a second time, bolted, and sacked much the same as flour.

THE PYROPHYLLITE DEPOSITS

The occurrence of pyrophyllite deposits of commercial size are limited to a small area in Moore and Chatham counties; the principal mining has been done near Glendon along their border line. The deposits are associated with the slates of the region, but are not in direct contact with them. They are separated by bands of siliceous and ferruginous breccia which are probably 100 to 150 feet thick. The breccia contains some pyrophyllite, and grades into a bed of pyrophyllite schist. Between this schist and the massive beds of pure pyrophyllite, there are very often small seams of quartz and larger lenticular quartz masses several feet thick.

The strike of the formation is N. 55°-60° E., and the dip is 60°-70° N. W. The pyrophyllite rocks have a width of about 500 feet, one-fifth of which is workable and only one-fourth of that is commercial pyrophyllite. The material forms a continuous bed, a feature which distinguishes it markedly from the lense-shaped talc deposits of Swain and Cherokee counties. The impurities are largely quartz, chlorite, and hematite.

The milling process is in every way similar to that applied to the talc, and the finished product is almost identical in appearance to talc flour. Most of the material is best suited for grinding; some is massive enough to cut into pencils.

TALC AND SOAPSTONE OF IGNEOUS ORIGIN

Although the talc and soapstone of this class play a very unimportant part in the present production in North Carolina, the deposits are more widely distributed and of far greater extent than those of the preceding group. The soapstone and talc are derived from the metamorphism of basic intrusive rocks, which are rich in magnesium. They are associated with, and often form a part of masses composed of amphibolite, dunite and serpentine rocks. They occur in the form of lense-shaped bodies, usually 3 or 4 times as long as broad and seldom exceeding an acre in area. They are found in connection with hornblende gneiss and schist, the Roan gneiss, and owe their origin to the metamorphism of peridotites and pyroxenites, which may or may not be entirely replaced. The dunites are the prevalent type in the southwestern portion of the mountains of North Carolina, and the soapstone in the northeastern.

The talc is commonly associated with tremolite and actinolite, which are present in varying quantities, often to such an extent as to destroy the value of the deposit even as soapstone. Pure talc is commonly found in veins in dunites, while the soapstone deposits may either constitute the body of the rock, where the masses are small, or form an outer border around a less altered interior. There is a great variation in the mineral composition of the different masses, and even of the same mass. For this reason it is difficult to estimate the value of an individual deposit. It may be on this account that this type has received less attention than the former.

THE TALC DEPOSITS OF GEORGIA

The deposits of high-grade talc in Georgia are limited to two areas: those near Chatsworth, in Murray County, and those in Fannin, Gilmer and Cherokee counties. The former is by far the most important, and produces, at the present time, the entire output of this State.

FANNIN AND GILMER COUNTIES

LOCATION

The talc deposits of Fannin and Gilmer counties represent the southern continuation of those near Murphy, North Carolina; they are limited to a narrow valley belt extending from Culberson, North Carolina, southwest through Mineral Bluff and Blue Ridge into Gilmer County; and south of this no talc has been found except at a single locality southwest of Ball Ground, in Cherokee County. There are three general areas where more or less extensive prospecting has been done, namely, 3 miles northeast of Mineral Bluff, immediately west and southwest of Mineral Bluff, and 3½ miles southwest of Blue Ridge. All the deposits are located on or near the Louisville and Nashville Railroad.

GENERAL RELATIONS

The talc deposits are present either in the Murphy marble or in the Valleytown formation, and are closely associated with the faults which have disturbed the region. The ease with which the talc and the associated rock disintegrate causes the deposits to be located in the stream bottoms where little can be seen at the surface, and where prospecting is attended with difficulties because of the presence of water. (For description of the general geology of the district see origin of talc in Fannin County.)

Considerable talc was mined in this district some years ago; recently little work has been done except on the Wishon property south of Blue Ridge. There are a number of places here where it is quite probable that intelligent prospecting would lead to the discovery of talc deposits of value. However, as a whole this region is less promising than that in Murray County.

DESCRIPTION OF PROPERTIES

JAMES B. DICKEY PROPERTY

The talc on the James B. Dickey property is located 1½ miles northeast of Mineral Bluff. (Locality 4, Fig. 5, page 237.) The talc is found on the western slope of a narrow ridge one-third of a mile east of the Louisville and Nashville Railroad. This locality was worked 4 years ago, and a number of car loads of talc is said to have been shipped to D. M. Stewart, of Chattanooga, who used it for making crayons, gas tips, powder, etc.

The talc here is at approximately the same horizon as that south of Mineral Bluff. It occurs in the Valleytown formation associated with white quartzite, and is located only a short distance west of the fault line along which the Murphy marble occurs. At this locality quartzite forms the hanging and foot walls. Marble is said to have been encountered, but none was found by the writer.

The talc deposits at the surface varied from 4 to 6 feet in thickness; and within 25 to 30 feet along the dip decreased in thickness to one foot, and at places entirely pinched out. This deposit has

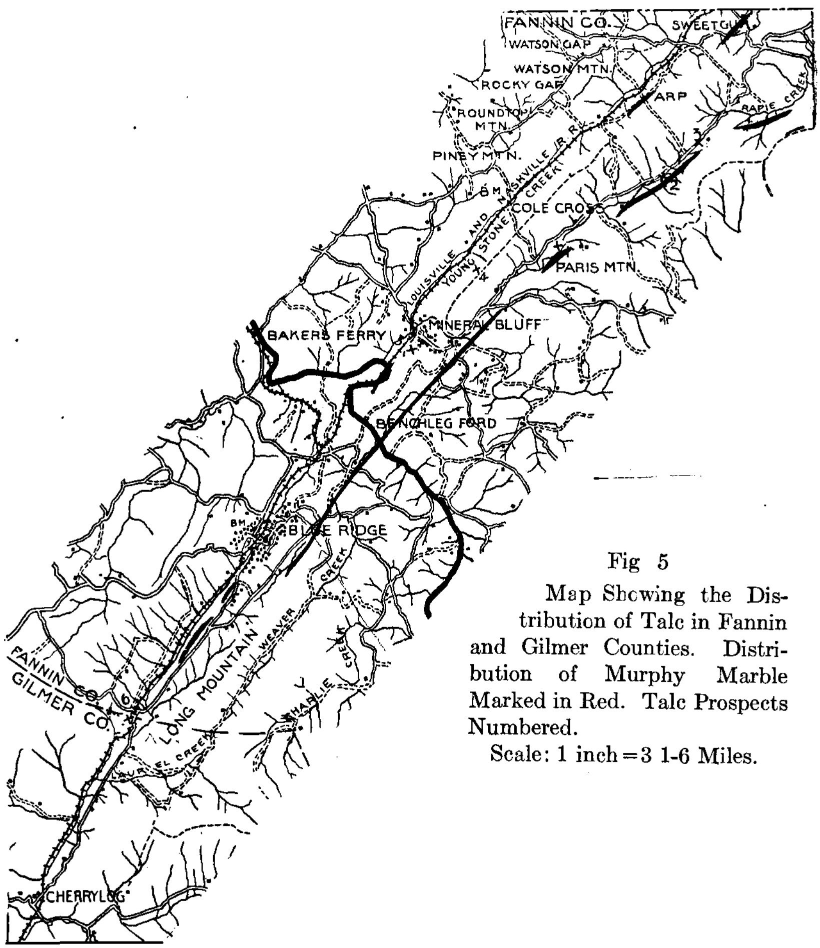

Fig 5

Map Showing the Distribution of Talc in Fannin and Gilmer Counties. Distribution of Murphy Marble Marked in Red. Talc Prospects Numbered.

Scale: 1 inch = 3 1-6 Miles.

been worked for a distance of 100 feet along the strike and to a maximum depth of 30 feet along the dip.

While it appears that the talc body opened up here was largely worked out, it is most likely that other deposits could be found along the strike. Little or no prospecting has been done to determine this, although the prominent quartzite beds with which the talc is associated could be easily traced, and the horizon of the talc determined approximately, with little difficulty.

W. T. S. AND G. M. DICKEY PROPERTY

Extending through the western part of the town and continuing southwest to beyond the Toccoa River (locality 5, fig. 5, page 237), there is a deposit of talc which appears to represent the southern continuation of that on James B. Dickey's place, 1½ miles farther north. The conditions at the two places are practically identical; the talc occurs in thin beds 2 to 4 feet thick, lying between beds of quartzite, and owing its origin to the alteration of originally dolomitic material. According to Laurence LaForge and W. C. Phalen,[1] these deposits lie near the top of the Valleytown formation. The deposits occur at several different horizons, but are not far apart stratigraphically. The strike is N. 45° E., with a variable dip to the east.

The talc occurs along the eastern side of the railroad and on the western slope of a small ridge, and extends from near Mineral Bluff station southwest across the Toccoa River, where it outcrops on a small knoll on the south side. To the north the talc and surrounding rocks are concealed in the low ground along Hemptown Creek.

There is a great difference in the talc at this locality; some of it is found mixed with grains of quartz and grading into quartzite; some contains chloritic material and pyrite; and finally some is pure and of a high grade. The talc is micaceous in structure and shows, besides the schistosity, a secondary wrinkling of the cleavage, thus affording evidence of two periods of deformation since its formation.

Mining of the surface talc was carried on here some years ago, although the property has been abandoned since then. Open cuts, made along the outcrop of the deposit, were followed down along the dip until water and other conditions interfered, and they were

[1] Op. cit.

then abandoned. It is said that the best talc was found where it left the hill to the north and appeared in the flat near the railroad.

CUTCANE CREEK DEPOSITS

Along the fault line which parallels Cutcane Creek, Murphy marble is found to be present in lense-shaped bodies.[1] From this marble talc has been formed at places, two of which have been prospected. Owing to the location of the deposits in the creek bottom, there are no natural exposures, and prospecting is much interfered with by water. Little can be seen at the present time, owing to the fact that the prospect pits have been filled.

The most important openings have been made on the properties of John Harper (location 1, fig. 5, page 237), and J. L. Grey (location 2, fig. 5, page 237), located 3½ and 5 miles northeast of Mineral Bluff. The talc is light grey in color, and, in most part, very hard and micaceous.

An opening has been made on the Grey property to the depth of 30 feet, in which 6 feet of the talc were found.

Map location 3 (fig. 5, page 237), one mile north of the opening described above, represents a small prospect which is now filled, in which a poor grade of talc is said to have been found.

Murphy marble is found at intervals from near the North Carolina line south for 13 miles, following along Cutcane Creek as far as Mineral Bluff, and continuing in a southwest direction to a point one mile east of Blue Ridge. Although there has been prospecting at the two places named along this line, it seems likely that further work might lead to the location of commercial deposits.

J. W. WISHON PROPERTY

Extensive prospecting has been done 3½ miles north of Blue Ridge along the Fannin-Gilmer county line (location 6, fig. 5, page 237), J. W. Wishon, who lives on the place, owns three-fourths of the mineral interest in this property. It is located about 100 yards west of

[1] Ellijay Folio (187), Geol. Atlas U. S., U. S. Geol. Survey, 1913.

the Louisville and Nashville Railroad, low down on the eastern slope of a small ridge.

This property was worked 6 years ago on the royalty basis of one dollar per ton for all talc loaded on cars. Several car loads of talc were shipped.

Owing to the inaccessibility of the deposit at the time of the writer's visit a part of the description given by L. C. Phalen,[1] who visited the property when it was being worked, will be quoted here:

"At this place the talc occurs as a vein or lense about 6 feet thick, striking 22° N. E. and having an irregular dip. The talc occurs in a slick brown clay called umber. The highest-grade talc occurs in small masses weighing 20 pounds or more, embedded in the clay. Stratified layers of the umber of varying colors are interlaminated with thin contorted layers of talc. A wall or band of sandstone of irregular strike divides the talc deposit. West of this sandstone lie small patches of white talc; east of it talc of various colors is found in paying quantities. At a point 100 feet south of the main talc pit the sandstone either dies out or plunges downward; at any rate, it was not found at that point, and the talc deposit there is 40 feet thick, apparently the thickness of the two bands east and west of the sandstone horse to the north. About 200 feet south of the main or northernmost pit, or 100 feet south of the 40-foot lense just described, the yellow or vari-colored phase of the talc disappears, but float of white talc is present at the surface. A pit beyond the point where the sandstone horse disappears is very probably west of the position of the sandstone. A tunnel dug 35 feet below the surface revealed no talc, not even the reddish, mottled, impure variety.

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

While it is not known whether the material from which the talc was derived belonged to the Murphy marble or the Valleytown formation, it is quite certain that the talc was derived from pure limestone or dolomite, and doubtless through the agency of underground waters, which gained access along the fault plane or planes.

From what has been done it seems quite probable that deeper working would reveal a deposit of the dimensions exposed at the surface, not yellowed and stained by surfical weathering. So far as is known, little or no work has been done to the north or south of these openings to determine the lateral extent of the deposits.

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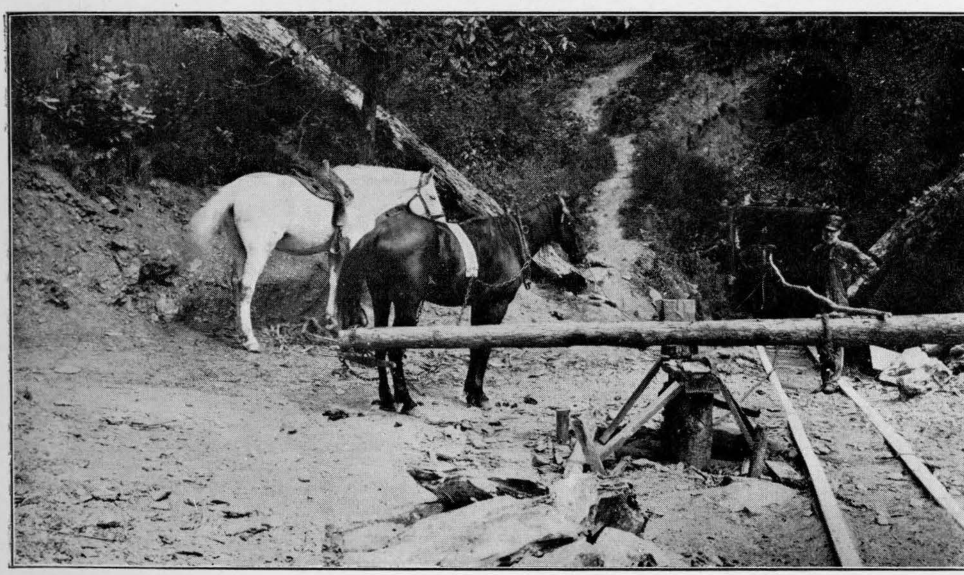
[1] Op. cit.

A. GEORGIA TALC COMPANY'S MILL, CHATSWORTH, MURRAY COUNTY.



B. SPRING PIT, GEORGIA TALC COMPANY'S PROPERTY, NEAR CHATSWORTH, MURRAY COUNTY.

CHEROKEE COUNTY

GENERAL RELATIONS

The rocks of Cherokee County may be divided into three large groups, based primarily on their age, but also representing in general three types of rocks.

The southeastern half of the county is composed of a series of crystalline schists and gneisses, of unknown age and partly of unknown origin—the Carolina gniess. Cutting this series in an intimate fashion and folded with it, is a series of hornblende gneisses—the Roan gneiss. Associated with the latter is a number of areas of more basic rocks with which are associated talc and soapstone. These two series of rocks constitute the first division mentioned above.

The northwestern half of the county contains two entirely different types of rocks; the oldest occupies the central part of the area and is composed of granite gneiss, which probably represents the most ancient rocks in the State, and the basement upon which the later ones were laid down, as well as the source of the earlier sediments. Surrounding this area is a series of schists, conglomerates, and graywacke which has been termed the Ocoee series, but which is the equivalent, in part at least, of the Great Smoky conglomerate to the north. Associated with this latter series of sedimentary rocks, which are of Cambrian age, are usually small isolated deposits of Murphy Marble, brought into their present position by the structural deformations which the region has suffered. Occurring in more or less close connection with this marble are the talc deposits of this county.

Although the geological conditions in Cherokee County are similar to those in Fannin County, and although the Murphy marble is present at no less than 10 different localities, very little talc has been discovered. Along fault planes in the marble, talc has been developed in variable amounts from fine scattered scales to slickensided surfaces a fraction of an inch thick. The only locality in the county where talc has been found more than an inch or so in thickness is on the Cox property west of Ball Ground.

The marbles in this county have never been worked commercially to any extent; but in Pickens, the adjoining county to the north, they have, without, however, exposing talc deposits which give any promise of commercial value.

DESCRIPTION OF DEPOSITS

MRS. EMMA A. COX PROPERTY

Mrs. Emma A. Cox owns the talc on lot 305, 4th district and 2nd section of Cherokee County This lot is located on Sharp Mountain Creek, 2½ miles west of Ball Ground, the nearest station on the Louisville and Nashville Railroad.

The talc outcrops on the west side of the creek for a distance of 1,400 feet, on a gently sloping ridge. And while the surface water drains off freely, the upper level of ground water comes close to the surface, thus interfering seriously with mining operations.

Since the discovery of talc on this lot many years ago by Mrs. Cox, numerous attempts have been made to develop the property, and much money has been spent here in prospecting, with little or no success. A small lense near the surface, probably 18 inches in thickness, seemed to give promise of an extensive deposit. This lense was worked out and all attempts to locate others of workable size have been failures, although a thin seam of talc is continuous over a considerable area.

Talc has been found to outcrop for a distance of 1,400 feet in the direction, N. 76° E., and to dip to the east at about the angle of 28°. The talc occurs in lense-shaped masses associated usually with a narrow bed of white quartzite, which, however, is absent at places. In the absence of the quartzite the talc is found in mica schist. When present, the quartzite commonly overlies the talc, but at one place it was seen to occur between two layers of talc. From the work that has been done the talc vein appears to run, with minor irregularities, in a uniform direction, and to dip with the schistosity of the rocks. At the dozen or more openings where the talc vein has been exposed, it is seen to vary in thickness from an inch or fraction of an inch up to a foot, but usually it is thin and less than 6 inches.

A number of large open cuts and drifts have been made, as well as one deep shaft and several smaller ones. The deepest shaft was sunk 126 feet through biotite gneiss without encountering anything but a talcose streak, although it must have cut through the horizon of the talc vein which outcrops somewhat farther west. No drifts were made from this shaft. A tunnel was driven on a level in the bottom of a small depression, following the talc vein along the strike for the distance of more than 400 feet. Within that distance no commercial talc was encountered, and the vein gave little promise of improving; consequently the work was abandoned.

The talc is pure white and contains little or no grit or other impurities. It is opaque and slightly schistose, but sufficiently massive for making pencils, etc.

The relationships here are very similar to those on the Wishon property south of Blue Ridge. From a study of the talc it is evident that it is derived from limestone. To the north and east there is a body of marble, doubtless Murphy marble, judging from its relationships, faulted into its present position. It is not unlikely that the talc is in some way connected with this marble by the faulting the region has undergone.

MURRAY COUNTY

HISTORY

The discovery and early history of the talc industry in Murray County are closely linked with the name of the late W. C. Tilton, who was interested in many things, including prospecting. About 1872, on one of his trips to Fort and Cohutta mountains, he discovered the presence of talc on lot 271, the lot now owned by the Georgia Talc Co. Failing in his efforts to buy the lot, although he is said to have offered $12,000 for it, he began mining talc on that lot in 1872 at the royalty of fifty cents per ton. Later, when the royalty was increased to $1.00 per ton, Capt. Tilton began prospecting elsewhere and discovered talc on the Fort Mountain lot, Number 297, which he bought and began developing. Later, he discovered talc on other lots; these he acquired until he owned at his death nine lots containing the bulk of the talc deposits of the district as far as their extent is known today.

The talc that was mined between 1872 and 1891 was hauled to Dalton, a distance of 16 miles, and shipped in the crude state to Cincinnati, Chicago, Hamilton, Ontario and elsewhere. The mining in those early days was what might be called "ground hogging," or "gophering;" it consisted in digging small pits and taking out whatever material could be reached without going far underground. The result was that only the surface material, stained yellow by weathering processes, was extracted. The yellow talc was used in those days for foundry facings, as it is today. The price of $1.00 per ton was paid for mining the talc and from $3.20 to $3.50 per ton was paid for hauling it to Dalton, the nearest railroad point at that time.

In 1891 Captain Tilton built a mill on his property near Spring Place, in which he ground the talc before marketing it. This mill was operated until 1897, the date of his death.

Since there were no direct heirs, a nephew of Captain Tilton's wife, M. H. Williams, by paying off the other heirs, came into possession of the talc interests. Mr. Williams continued to run the business until about 1903, when the Cohutta Talc Co. was incorporated. That company owns all the talc property formerly owned by Captain Tilton, except lots 279, 280 and 281, which at present belong to Mr. Williams and Mr. J. M. Sanders. In 1907, the new branch of the Louisville and Nashville Railroad having been previously completed, the mill was moved from the vicinity of Spring Place to Chatsworth, the station on the railroad nearest to the talc deposits. The mill has been operated with some intermission since that time.

Some of the stock in the Cohutta Talc Co., originally owned by New Yorkers, later came into the possession of the Farrars of Dalton, who own eighty per cent. of the stock at the present time.

The remaining twenty per cent. is owned by M. H. Williams and J. M. Sanders of Atlanta.

Lot 271 has the distinction of being the first lot on which talc was mined, and the most extensively developed lot at the present time. Mention has been made of Captain Tilton's attempt to buy this lot, which was owned at that time by S. T. Story, of New Orleans. Later the lot was sold, and passed through several hands until finally the Georgia Talc Co. was organized, with that lot as the source of the raw materials. The company was incorporated in 1905, in North Carolina, and since the middle of 1907 it has been active in the production of talc. For some years past it has been the largest producer of both ground talc and talc pencils in Georgia. These two companies, the Cohutta Talc Co. and the Georgia Talc Co., have been the chief producers of talc up to the present time, although talc has been mined in a small way on other lots, which will be described under the head of "Description of Properties."

LOCATION AND ACCESSIBILITY

The talc deposits of Murray County, so far as is known at the present time, are limited to the 26th district and 2nd section. They occupy an area of approximately 8 square miles, lying east of Chatsworth, the county seat (see figure 6, opposite page 247), on the slopes of Fort and Cohutta mountains. Chatsworth, the shipping point of the talc and the site of two talc mills, is located on the Louisville and Nashville Railway.

The talc deposits lie along the western extremity of the Appalachian Mountain province, where the rough mountainous region gives way to the gently sloping valleys and rolling hills of the Appalachian Valley province. Chatsworth is on the western edge of the valley region where the hills begin to rise to the east until they reach their culmination in Fort and Cohutta mountains at elevations of 2,835 and 2,716 feet, respectively, above sea level. The foot hills are rounded and accessible with comparative ease, while the sides of the mountains are particularly rough, owing to the massive cliffs of quartzite and the large talus slopes. The mountains rise at places as much as 1,400 feet in one-half mile. Although the country is rough, all the deposits, with a single exception, have been reached by a road or trail along which the talc could be hauled; the slope of the country is from the mines toward the railroad, a feature which aids in the hauling of the material.

DISTRIBUTION

The talc occurs most prominently on the western slope of Fort and Cohutta mountains, at an elevation of 1,000 to 2,000 feet above sea level; it is also found on the northern and eastern slopes of Fort Mountain, and still farther to the east on the eastern bank of Mill Creek. On the western slopes of Fort and Cohutta Mountains, the talc is found at three different levels at least. The lowest level is represented by the outcrops on the Georgia and Piedmont talc companies' properties. Two higher levels are represented by the deposits on the Cohutta Talc Company's property on the northern and southern slopes of Cohutta Mountain. These upper levels are probably from 300 to 400 feet apart, while the intervals between the lower of these and the lowest level is about the same. These deposits can not be traced from one place to another because of the steepness of the mountain slopes and the absence of exposures.

On the eastern side of Fort Mountain and the western side of Mill Creek, talc has been found abundantly as scattered boulders in clay; but the exact position at which it occurs has not been ascertained. On the eastern side of Mill Creek, however, there is a well defined level at which talc can be traced continuously for almost one-half mile. The correlation of this outcrop with that found on the northern slope of Fort Mountain seems likely; while the latter is tentatively correlated with that on lots 295, 296 and 319.

The outcrops on lots 292 and 294 are at about the same level and may, or may not, represent a continuous body; the occurrence is very similar. The talc on lots 306 and 271 is supposed to be continuous with that on lot 270, but even this is not certain. While a single talc

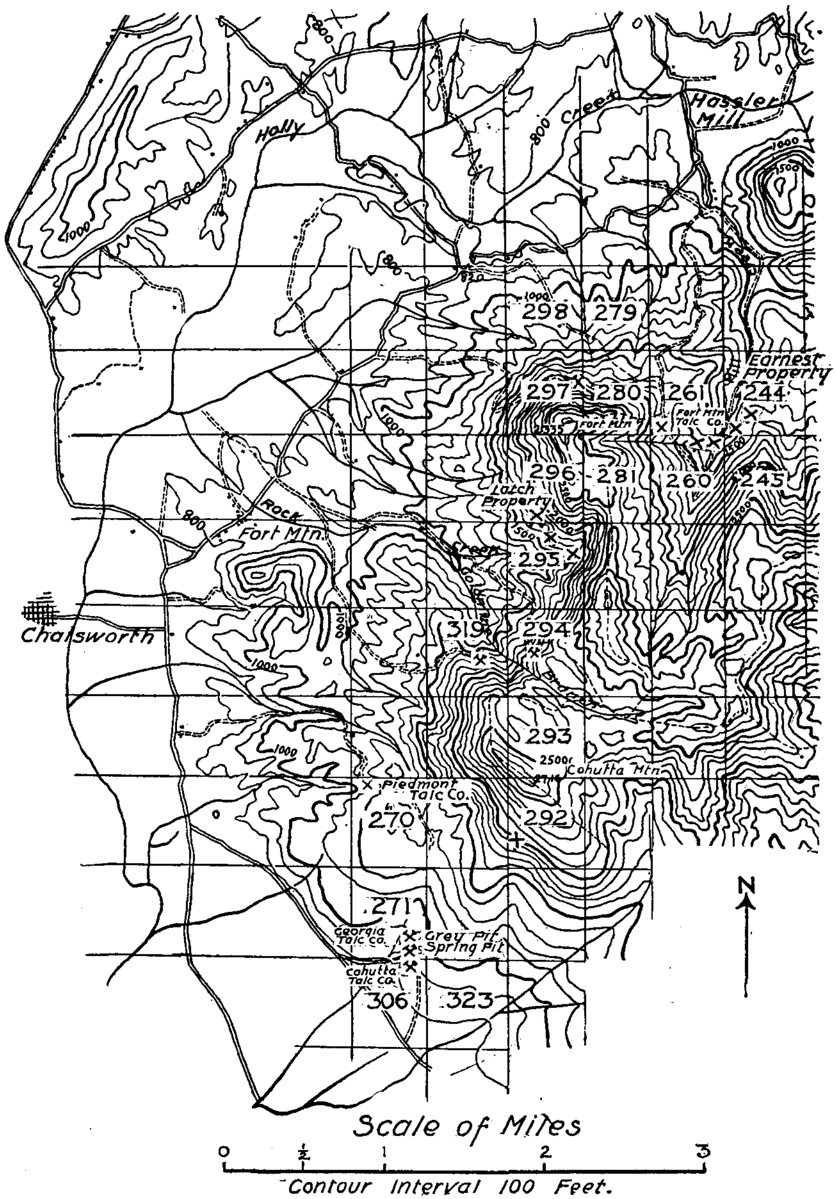


Fig. 6.—Map of a Part of Murray County Showing the Distribution of Talc (From the Cohutta Quadrangle).

mass has never been traced continuously for more than one-half to three-fourths of a mile, and while these broader correlations may be entirely erroneous, it does seem quite probable that the talc on lots 319, 295, 296, 297, 280, 261, 260 and 244 represents the outcrops of a single talc-bearing formation. This is inferred from the presence of the talc at all these localities below a heavy bed of quartzite or arkose, which seems to be continuous between these places. Sufficient work has not been done to warrant more than a tentative suggestion as to these correlations.

Talc has been mined most extensively on lots 271 and 297. The prospect for commercial talc deposits is quite promising over the entire area, and it seems that the district as a whole deserves more attention than it has received, considering that this is by far the most important talc-bearing district in the State.

DESCRIPTION OF DEPOSITS

FORT MOUNTAIN TALC COMPANY

Location.—The Fort Mountain Talc Co. owns the talc on three land lots, numbers 260, 261 and 245, in the 26th district and 2nd section of Murray County. They are located on the eastern slope of Fort Mountain, near the head of Mill Creek, a distance of 7 miles by road northeast of Chatsworth. On the east this property adjoins the lot owned by Warren Earnest, and on the west the property of Williams and Sanders. It extends from an elevation of about 1,800 feet on the eastern side of Fort Mountain down into Mill Creek, and at the south end, far up on the ridge on its eastern side.

William Lampkin, who first worked this property, about 1890, is reported to have mined about 200 tons. Later, a Dr. Irwin of New York got control of it and began mining for talc in the creek bank near Russell's house. He is said to have hauled from this locality from 50 to 75 tons of talc. Still later, J. P. Smithers, of Brooklyn, bought the property and did some prospecting on it. After Smithers' death, it came into the possession of its present owner—the Fort Mountain Talc Co. of New York.

Description.—Omitting local irregularities, the rocks of the region dip to the southeast at an angle varying from 20° to 30°. The highest exposures of talc are found at an elevation of 1,800 feet near the western limit of lot 261. From this point the outcrop, although not exposed on the surface, extends southeast to Mill Creek, where it turns to the northeast and runs off lot 245 onto the Earnest property. Thus, the talc-bearing formation is seen to dip out of the mountain on the west side of the creek and dip into it on the east side, the intervening area having been eroded to the north, although the continuity is maintained to the south.

The relationship of the talc to the surrounding rock is shown at no place on this property. However, judging from the large talc boulders which have been found in the clay near the creek, it is evident that a body of high-grade talc is present.

Extensive prospecting has been done in the creek bank near Russell's house. Here, the Fort Mountain Talc Co. has driven several tunnels in the creek bank into what appeared to be a promising deposit of talc. However, it was soon discovered that the talc and the slope of the hill were dipping at about the same angle, consequently the talc followed along the surface as it ascended the hill, and occurred only on the crest of a small spur. Prospecting has been continued up the mountain slope and a cross cut is being made to determine the point at which the talc formation leaves the mountain, as it must in consequence of the steeper slope at the higher level. The presence of the talc along the slope may be due, in part, to landslides, or, as is more likely, to a local roll in the formation.

Talc is also found at a lower level to the northeast of Joseph Winkler's house, where it appears to be in place. There the deposit is very thin, not more than 2½ feet, so far as exposed, and much decomposed and yellowed by surface waters.

Some recent prospecting on the east side of the creek is reported to have revealed a four-foot vein of fresh talc along the western line of lot 245 at an elevation of about 1,800 feet. This deposit resembles closely some of the material from the Cohutta Talc Company's mines on Cohutta Mountain in that it is white, or very nearly so, and contains no grit. Associated with this deposit of talc and near its upper limit, is a talcose rock carrying graphite which appears to occur in a well-defined layer. This material is about 400 feet above that on the Earnest property.

To sum up, talc occurs on this property at two levels about 400 feet apart. The lower horizon outcrops at about the 1,800-foot level on Fort Mountain near Winkler's house, and extends down the mountain to Mill Creek, where it turns to the northeast. The most favorable locality for prospecting is on the west side of the creek south of Winkler's house, and on the eastern side of the creek near Russell's house, where the deposit runs under the mountain. At the newly made openings at the upper level on the east side of the creek, the prospect seems good for commercial talc.

Milling.—A mill, which is thoroughly modern in all respects, has been constructed for both grinding and sawing talc. It is so constructed that the minimum amount of labor is required for its operation. The talc is hauled on a self-dumping car to the second floor of the mill. The talc to be ground is fed into a No. 1½ Sturtevant rotary crusher, the intake of which is at the level of the floor, so that no elevation of the material to feed the talc into it is required. From the crusher the talc is carried either to a storage bin or direct to a large Sturtevant emery grinder and finally to a New Age sieve bolter, clothed with 120-mesh brass wire screen. The fines from this machine are elevated to the sacker, while the tailings are carried to a second Sturtevant emery grinder and from there to the sacker. The grinding machinery is so arranged that only one handling, that of pushing the rock to be ground into the crusher, is required before the powder is sacked. The capacity of the mill is about 2 tons per hour. (See plate XVIII, fig. A.)

For sawing, there are the ordinary circular saws. A twelve-inch pipe line conveys the water from 5,000 feet up the creek to the mill with a fall of 540 feet. This static head gives a pressure of

220 pounds per square inch, and is capable of generating about 300 horse-power, when the flow of water in the creek is sufficient. It is estimated that 150 horse-power will be required to run the mill at full capacity. A $1\frac{1}{8}$-inch nozzle conveys the water to a Pelton wheel, which is connected directly with the mill.

THE WARREN EARNEST PROPERTY

Lot 244 of the 26th district, 2nd section, of Murray County, owned by Warren Earnest, is located on the east side of Fort Mountain, and on the east side of Mill Creek, about 7 miles by road from Chatsworth. It is situated on the north and northwest slopes of a steep ridge, at an altitude of from 1,000 to 2,000 feet above sea level. The talc-bearing formation follows around the slope of the mountain in a northeasterly direction, increasing in elevation above Mill Creek from 150 to 300 or 400 feet, due to the high gradient of the stream, which flows to the north, rather than to the strike and dip of the talc-bearing rocks.

The discovery of talc on this lot is of comparatively recent date. Warren Earnest, being aware of the presence of talc on the adjoining lot to the west, was led to search for and discover the talc on this lot. By digging numerous pits, and by prospecting with a post-hole digger, he has been able to trace the talc for a distance of one-half mile. The light covering of soil and the absence of talus make the prospecting relatively easy on this side of the valley. The talc occurs at a definite level, and extends continuously for at least one-half mile. The thickness of the talc-bearing rocks, which are enclosed between quartz schist or graywacke, is at least 20 feet.

Prospecting has shown that the talc occurs most extensively near the hanging and foot walls, and varies considerably in thickness, from five feet down to a few inches. The talc is here associated with, and gives way to "blue john," as it does on the west side of Fort Mountain. Six small prospect pits and one tunnel had been dug at the time of the writer's visit. The tunnel was being driven on a level into the hill, and had reached a distance of 40 feet, at which point from 4 to 4½ feet of yellow, weathered talc was exposed, which gave promise of changing to fresh green talc within a short distance.

The prospect for saw-rock, both at the short tunnel and elsewhere on the property, is very encouraging, although to reach it a distance of probably 50 to 75 feet of discolored material will have to be traversed. The conditions for mining are quite favorable.

THE W. Z. LATCH PROPERTY

Mr. W. Z. Latch owns lot 296, located on the west slope of Fort Mountain, about 4 miles northeast of Chatsworth. It is situated between lots 295 and 297, owned by the Cohutta Talc Co. The conditions are very similar on the three lots, especially on lots 295 and 296. The talc-bearing formation crosses this property in a northwest-southeast direction, running the entire length of the lot. Prospecting, however, is confined to its south central part. Talc was mined here about 1904 by W. Z. Latch and shipped to Chattanooga. In recent years no work has been done.

Talc occurs on this lot at about the same elevation, possibly slightly lower, as at the Fort Mountain mines. The thickness of the talc-bearing rocks appears to be about 100 feet, but only a very small amount of this is good talc. The greater part of the exposure is hard, somewhat massive serpentine rock, with talc developed most extensively at the upper and lower contacts with the country rock, although a lesser quantity is to be found in serpentine rocks along jointing planes or other openings, which have been favorable to the formation of talc. There are three small openings on this lot, one above the other. In the lower, cross-fiber crysotile has been observed in narrow veins.

THE SANDERS-WILLIAMS PROPERTY

Lots 279, 280 and 281 are owned by J. M. Sanders and M. H. Williams of Atlanta. These lots are located on the northeast and east slopes of Fort Mountain, adjoining the Fort Mountain Talc Co. on the east, and the Cohutta Talc Co. on the west. The western limit of the property is on the crest of the ridge, and extends down its eastern slope; consequently it is rather inaccessible.

A detailed description of the talc deposits on these lots is impossible because of their undeveloped state and the presence of masses of talus; but their location between two properties which are described elsewhere at some length leads naturally to the belief that talc occurs here. No exposures of talc have been visited on this property.

PIEDMONT TALC COMPANY

Location.—Lot 270, known as the Calhoun lot, is at present leased by the Piedmont Talc Company. In a small way, it was worked about twenty years ago by Samuel Fields, whose widow owns the property. The talc openings are located at the head of a small hollow in the northwestern corner of the lot, three miles southeast of Chatsworth, and about one-half mile northwest of the mines of the Georgia Talc Co.

The talcose rocks, exposed at several natural outcrops and in artificial openings for about 100 yards, are located nearer the contact of the Ocoee series with the Connasauga shales than any other deposit in the district. The total thickness of the talc-bearing rocks is at least 40 feet, although the upper limit is concealed.

Description.—While there is quite a marked variation in the quality of the talc at this place, it is generally characterized by its high content of pyrite and magnetite, and its schistose structure. There are no hard, partly altered rocks in this lot which throw light on the origin of the deposit. At the base there is a complete gradation from talc through chloritic schist to the unaltered country rock, a fact which suggests its origin from altered sedimentary deposits. A small percentage of the talc at this locality would be pure enough for making pencils if it were fresh, a larger quantity would be suitable for making a low-grade powder, and some is probably too impure for any use. There is no fresh green talc exposed; it is all stained by iron oxide. Pyrite and magnetite are present in the form of fine grains in some places, and as coarse grains in others, up to as much as one-tenth of an inch in diameter. In most of the talc at the outcrops, the iron oxide and sulphide have weathered completely and left yellow, ocherous spots.

Some years ago the Piedmont Talc Co. prospected this property quite extensively. One tunnel 30 feet long was driven in on a level and a shaft made from the back end of the tunnel to the surface. From this shaft up the slope for about 50 feet an open cut was made, exposing yellow talc and chloritic (?) schist. To the north of the short tunnel is another small prospect in a cream-colored, laminated talc; while about the same distance to the south is another small opening in which is exposed talc thoroughly impregnated with magnetite. (See plate XVII, fig. A.)

Although it is a question whether this property could be successfully worked for pencil talc on account of the relatively small amount of material suitable for that purpose, there is a large amount of material present which could be used for making powder for purposes for which a small amount of magnetite and pyrite would not be harmful.

THE COHUTTA TALC COMPANY

Location.—The Cohutta Talc Company owns lots 292, 294, 295, 297, 306 and 323 in the 26th district and 2nd section of Murray County. Of these, the first four mentioned are situated along the western side of Fort and Cohutta mountains, and are all accessible with difficulty, although talc has been mined and hauled from each one. Talc occurs on these lots, all of which are at about equal distances from Chatsworth, between the 1,700 and 2,000 foot levels. Lots 306 and 323 are situated in the foothills to the southwest of Cohutta Mountain, at a distance of 3½ miles from Chatsworth over a well-graded road.

Description.—Lots 292, 294, 295 and 297 are located in a north-south tier, arranged in the order given, from south to north., A brief description of each of these lots follows:

LOT 292, known as the Bramlet lot, is located on the southwestern slope of Cohutta Mountain. Talc has been worked at only one place, which is at an elevation of 2,000 feet above sea level, and 800 feet above the foothills below. A ridge road has been built on a fairly good grade to within 380 feet of the opening. From the opening of the mine to the end of this road, a gravity tram road has been built on a 36-per cent grade, with a total vertical fall of 210 feet.

A four-foot bed of talc is exposed here, lying immediately under a ledge of arkose, composed of 30 to 40 per cent. of feldspar evenly mixed with rounded quartz grains, and separated from it by a thin layer of chloritic schist, which is derived from the alteration of the former.

The dip of the quartzite and the talc body is to the southeast at about 40°. The talc is light green, foliated, and exceptionally free from iron. This opening was last worked about four years ago, and was abandoned on account of its inaccessibility and the consequent cost of hauling the talc to the mill, although the miners say that there was a good deposit in sight at the time work was discontinued. The condition of the opening makes it possible to study only the entrance. Other exposures are said to occur along the strike, but they were not visited by the writer.

LOT 294, known as the Hammock lot, is located on the northwestern slope of Cohutta Mountain, due east of Chatsworth. There are two localities[1] which have been worked, one on the east side and one on the west side of Goldmine Branch. The locality on the south side has been most extensively worked, and, according to Mr. R. E. Gordon, a former superintendent of the company, it is the best deposit on the property. The talc occurs at two levels. On the lower level, which has been worked recently, there are two large openings; and on the upper there are three.

The northern tunnel on the lower level has been driven east about 75 feet along the dip of the deposit at an angle of 25° near the entrance, but gradually becoming level. The talc body is about four feet thick from the entrance back 40 feet; there it thickens

[1] Location on the west side of the creek is shown to be out of lot 294, but, owing to the irregularity of the land survey, it is really in that lot.

in a short distance to 7 or 8 feet, and pinches out toward the end of the tunnel, giving place to "blue john." For the entire distance the talc is yellowed and much decomposed at places. This is rather deeper weathering than at most places, due probably to its location near the crest of a small ridge.

The second tunnel on the lower level was being worked during the summer of 1912, but is now abandoned. It cuts through 10 feet of decomposed graywacke, and then through weathered talc interbanded with "blue john" for 15 feet. The talc body is about 35 feet thick and shows the following section:

Section in Second Tunnel, Cohutta Talc Company

	Thickness feet
Graywacke.	
6. Talc, green, pencil grade	4
5. "Blue john"	4
4. Talc, yellow	2½
3. Talc, yellow, with large amount of pyrite and some hard layers of "blue john"	12
2. "Blue john"	3
1. Talc, yellow, much decomposed	10

At the upper level, several hundred feet above the lower, there are three openings from 25 to 50 feet above each other and extending around the side of the hill. The rocks at the entrances are massive, but irregularly jointed, the joints frequently showing slickensided surfaces.

The difference in elevation between these levels does not represent the actual interval by which they are separated, because there is a component of dip from the upper in the direction of the lower openings. The exposures are poor, and the relationship is difficult to determine.

On the east side of Goldmine Branch, talc was mined in a "ground-hog" fashion many years ago. There are three small openings 2,000 feet above sea level, which have been made immediately under a ledge of arkose. The talc appears to be not more than 4 to 5

A. COHUTTA TALC COMPANY'S MILL, CHATSWORTH, MURRAY COUNTY.

B. MINE OF THE COHUTTA TALC COMPANY ON FORT MOUNTAIN, MURRAY COUNTY.

feet thick, and to wedge out along the dip. The talc is quite pure and extensively laminated. The openings are very close together, and no effort was made to trace the deposit.

Lot 295 lies on the western slope of Fort Ridge at the head of Rock Creek. The prospects are at an elevation of from 1,630 to 1,700 feet above sea level, and are 150 to 250 feet lower than those on the end of Fort Mountain. Here the dominant type of rock is serpentine, which outcrops at numerous places. This is associated with graywacke above, which grades into quartzites and conglomerate forming the cliffs not far above. The hard, dark serpentine rocks show little or no schistosity, but are cut by jointings and irregular cracks into varying-sized blocks. Associated with the serpentine is both slip- and cross-fiber asbestos. The former is long and coarse and occurs in veins from 3 to 4 inches thick, and belongs to the mineral species actinolite (see analysis); the latter is chrysotile, and occurs in narrow veins, not more than one-fourth inch in thickness, but close together. (See plate XVII, fig. A.)

The talc is present not only at the contact with the wall rocks, but also as irregular masses along planes of alteration in the serpentine. Along the contact it is more laminated, softer, and more often stained yellow. When occurring as irregular masses in the serpentine, the talc is usually hard, in large part too hard for saw rock, more massive, and is fresher in appearance. These bodies are usually not more than 2 to 3 feet thick, at most, and pinch out or thicken in any direction.

It is impossible to determine the thickness of the talc-bearing horizon. The openings may all be on the same or they may represent two different levels. If the former supposition is true, the thickness is at least 70 feet, if the latter, each horizon may not be more than 20 feet thick.

There are three small openings, nothing more than pits, in the hard serpentine rock at the lower contact near the north end of the lot. It is here that asbestos is most extensively developed. The talc occurring in layers between the hard serpentine rock and the foot wall is not exposed, although these are the lowest openings present.

Seventy feet above the former and at the upper contact, there is a small tunnel about 15 feet long and an open cut exposing about 6 feet of much weathered talc. This is light green, where fresh, and extensively laminated. It is in contact with quartz schist above, and the base is not exposed.

On the south side of a small branch about 200 yards from the above locality, there are three large openings and numerous smaller ones. About 8 or 10 feet of talc and talcose rock is exposed at the lower level, and 75 feet higher up the slope 10 feet more. At the lower level a tunnel has been driven in about 60 feet, from which a large amount of good talc is reported to have been taken. At the opening is exposed some serpentine, a large amount of hard soapstone, and relatively little good talc. The upper opening shows the following succession, representing a total of 10 feet:

5. Graywacke.
4. Talc, laminated, stained yellow.
3. Talc, blue, too hard for saw rock
2. Talc, good saw rock.
1. Serpentine.

While there are from 15 to 20 tunnels and pits on this lot, all of which show talc and talcose rocks, the amount of saw rock is very limited, and its mining is attended with much uncertainty. The beds of commercial talc are thin and give place to hard soapstone or serpentine.

LOT 297 is situated on the northwestern end of Fort Mountain at an elevation of from 1,000 to 2,800 feet. Mining has been carried on here as extensively as on any lot of the Cohutta Talc Co.

The relationship of the talc-bearing rocks to the country rock is not very clear. Here, as much as at any other place in the district, the talc-bearing rocks give evidence of having had an igneous origin. So far as can be traced, talc is found for a distance of about one-fifth of a mile and appears to wedge out in both directions against the associated graywacke. It disappears to the south for a distance of three-fourths of a mile, until the Latch lot is reached; to the northeast it can not be found for the distance of about a mile, which may be due to the presence of a large amount of talus. The greatest thickness of the talc-bearing rocks is about 80 feet. There are nine principal openings which may be described, as follows:

The tunnel farthest to the northeast was driven on a slope of 45° for a distance of 15 feet along the hanging wall composed of quartzite. There is exposed five feet of talc and soapstone, the latter being somewhat fibrous, and containing some small veins of asbestos. This opening has been recently worked, but, like all the others on this lot, has been abandoned for the present.

Seventy-five yards southwest of the above, and on almost the same level there are three openings close together. The dumps show a bluish-black serpentine rock and some fragments of good talc. They have been abandoned so long that it was not advisable to attempt to go into them. The workable talc here is said to have been from 3 to 5 feet thick, and rarely as much as 6 feet.

The next tunnel to the southwest is the longest tunnel on the lot; it has been driven back more than 200 feet, in which distance the talcose body is said to have reached a thickness of 30 feet. A section in the tunnel is roughly as follows: (See plate XVI, fig. B.)

5. Quartz schist
4. Talc
3. Serpentine
2. Talc
1. Quartz schist

Thirty feet further to the southwest there is an old tunnel, whose entrance is 20 feet higher than the preceding. Here there is a large, natural outcrop of hard, serpentine rock at the entrance of two openings, located one above the other. These had been abandoned for such a long time that they could not be examined.

Twin tunnels, which were driven back 35 and 70 feet respectively, are found about 100 feet further southwest, showing approximately 10 feet of talc and soapstone at their entrances.

Still further on there is about 8 feet of talc and soapstone exposed in a tunnel which was opened up about 17 years ago and reopened a few years ago, but is now abandoned.

Finally a small opening showing yellow, schistose talc represents the farthest opening to the southwest. It is 220 yards southwest of the first opening described and about 50 feet higher up the slope.

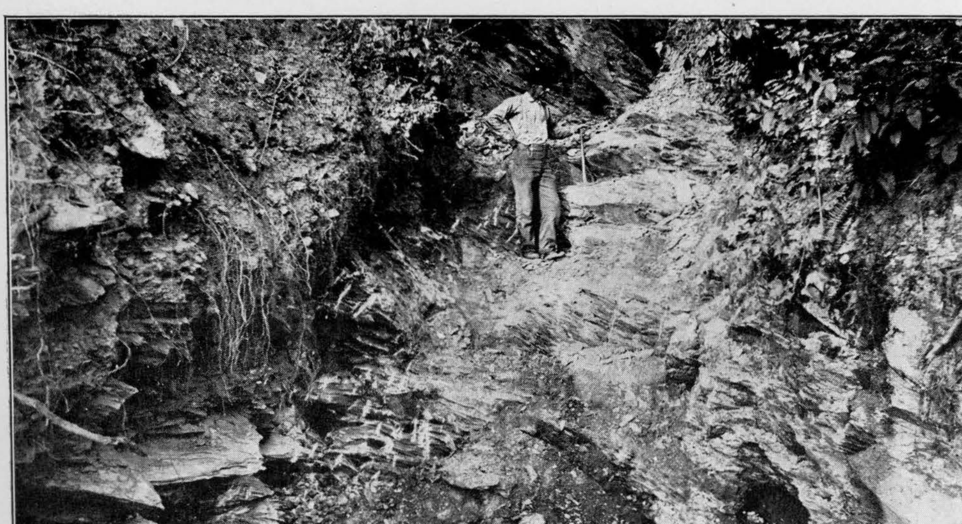
It has been observed at all these exposures that the talc and soapstone are more schistose and slickensided near the contact with the country rock, and that the central mass of serpentine rock shows little or no schistosity, but is cracked and jointed. In the longest tunnel, driven back about 200 feet, there is no evidence of the talc giving place to hard rock; the only difference is that the talc changes from a yellowish color to pale green, loses its opaqueness and becomes translucent. Talc was being mined at this locality during 1912, but has since been discontinued in favor of more accessible deposits.

Lots 306 and 323 are situated 4 miles southeast of Chatsworth at an average elevation of approximately 1,000 feet above sea level. These are the most accessible lots owned by the Cohutta Talc Co., lying, as they do, in the foothills to the southwest of Cohutta Mountain.

The talc-bearing rocks are known at only one level on these lots; they cross the northeast corner of lot 306 and enter 323 not far from the middle of its western side, and extend across the entire width of the lot. Mining was done on lot 323 by Capt. Tilton 20 years ago. Some 8 or 10 "ground-hog" holes were dug at that time. No mining has been done on it recently.

The only locality being worked at present by the Cohutta Talc Co. is near the north line of 306. There, a tunnel has been driven in an almost due easterly course for the distance of 165 feet. The hanging wall at this mine is graywacke; the foot wall is not exposed. The thickness of the talc-bearing formation is not known, but in the tunnel from 6 to 8 feet of it are exposed without showing either wall. There is no hard massive serpentine rock at this locality; all

A. OPENING ON THE COHUTTA TALC COMPANY'S PROPERTY ON FORT MOUNTAIN, 3 MILES NORTHEAST OF CHATSWORTH, MURRAY COUNTY.



B. OPENING ON THE PIEDMONT TALC COMPANY'S PROPERTY, NEAR CHATSWORTH, MURRAY COUNTY.

that is exposed is either talc or "blue john." Here the talc has been stained and rendered useless as saw-rock by the percolation of surface waters to a greater depth than at most other places in the district. At the back end of the tunnel, a distance of 165 feet from the entrance, considerable yellow talc is present, although the indications point to the fact that green talc will soon entirely replace it. The workable talc varies from one foot to 3 or 4 feet, but a great deal of otherwise good talc is found too hard to saw.

A steam hoist with a wire cable is used for pulling the cars from the tunnel, a great improvement over the whims used at all the other mines in the district. Notwithstanding the great depth to which the talc has been weathered, if this tunnel is pushed on deeper it gives promise of becoming quite an important producer.

Milling.—As was previously stated, the mill operated by this company was moved to Chatsworth from near Spring Place. It has been in operation since 1891, and differs considerably from the other mills in the district. (See plate XVI, fig. A.)

The talc is first fed into a rotary crusher which prepares the material for a No. 1 pulverizer made by Raymond Brothers of Chicago. The dust from the pulverizer is carried by suction to a dust trap above, where the greater part of the powdered talc is dropped; the finer particles are caried on into a large hopper-shaped box where they settle. The powder from the first dust trap is mixed with that from the hopper and is carried by an elevator to the sacker.

The arrangement of the machinery is very poor, in that no less than three separate handlings are necessary before the talc reaches the packer. The talc is thrown from the wagons on a platform, from which it has to be moved by hand to the rotary crusher, and elevated 4 feet to be fed into it. The rock from the crusher comes out on the floor and has to be shoveled by hand into the pulverizer.

There is one saw for facing and cutting blocks, another for sawing "stocks," and two others for sawing pencils. The size and shape of the pencils are changed to suit the order, although there is a series of regulation sizes which constitutes the bulk of the output.

When both mill and saws are running, a steam engine is employed; but for operating the saws alone, an eleven horse-power gasoline engine is used.

GEORGIA TALC COMPANY'S PROPERTY

Location.—The Georgia Talc Company owns one lot, Number 271, situated at the head of Duck Creek, on the western slope of a foot-ridge of Cohutta Mountain, 3½ miles southeast of Chatsworth. It is located south of the Piedmont Talc Company's property, and north of a lot owned by the Cohutta Talc Company. (See location on figure 6.) Its location is as favorable as any in the district, and much more so than the majority. The country slopes at a very moderate grade from the mines to the mill, a condition which makes it possible for two horses to haul from 1½ to 2 tons at a load.

Description.—The mines or pits, as they are termed locally, are situated in the eastern half of the lot, and extend from its southern limit northwest for slightly less than one-third of a mile. There are 5 tunnels of varying dimensions, and numerous small pits within this distance. From the opening furthest north, the talcose rocks can be seen at intervals in the direction of the exposure on the Piedmont Talc Company's property; while there are reasons for believing that the talc extends continuously from the one place to the other, it can not be stated positively that it does. The hanging and foot walls at all these openings are formed of graywacke, which is composed of fresh feldspar showing striations, bluish quartz and a dark-colored micaceous groundmass. The actual elevation of the talc-bearing rocks increases gradually to the north at the rate of 200 feet in one-third of a mile.

The five principal openings (see figure 7, page 263) are as follows:

SPRING PIT is located near the south end of the lot, 200 feet north of the Cohutta Talc Company's mine. The underground workings, as shown in the sketch referred to above, consist of a tunnel running a little northeast for 125 feet and then turning southeast for a distance of 150 feet. The main opening is run on a level, with the exception of the last 90 feet at the east end, which dips at about 40°. A side entrance leads off at (c) (see fig. 7), which opens out on the surface at (d), affording ventilation. At locality (a) there is 15 feet of somewhat decomposed talc with neither top nor bottom exposed; while at (b) the removal of the talc has led to the formation of a room 8 feet wide and 12 feet high, with neither foot nor hanging wall exposed. The talc in this room is bright green and translucent. (See plate XV, fig. B.)

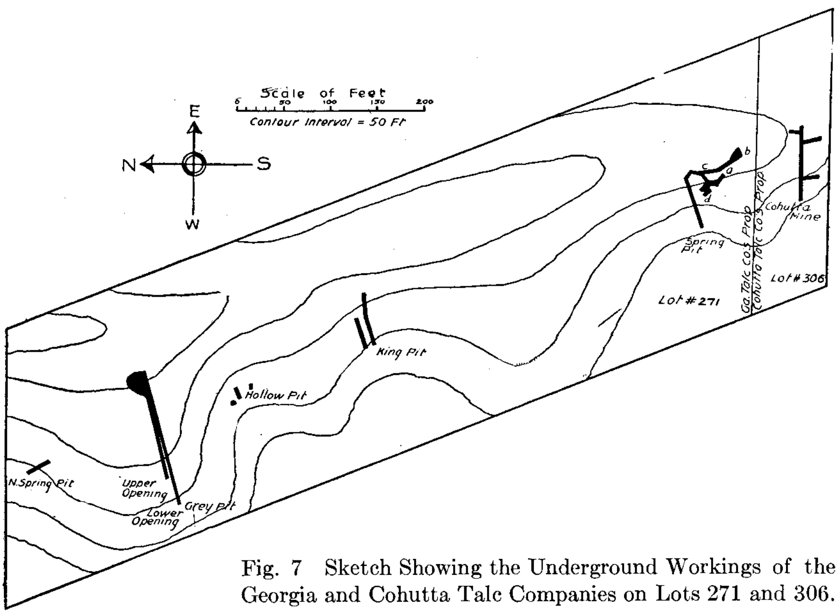


Fig. 7 Sketch Showing the Underground Workings of the Georgia and Cohutta Talc Companies on Lots 271 and 306.

The contact of the talc body with the graywacke is shown in the tunnel to be sharp and distinct, with no transition zone. There is no hard, massive serpentine rock at this locality; only talc and "blue john" are present. There is a large amount of talcose rock, which looks like saw-rock, but is found to be too hard to saw, although it can be ground. Weathering agencies have attacked the talc to a greater depth here than at most places. Back 50 or 75 feet from the entrance, streaks of yellow talc are found alternating with fresh material.

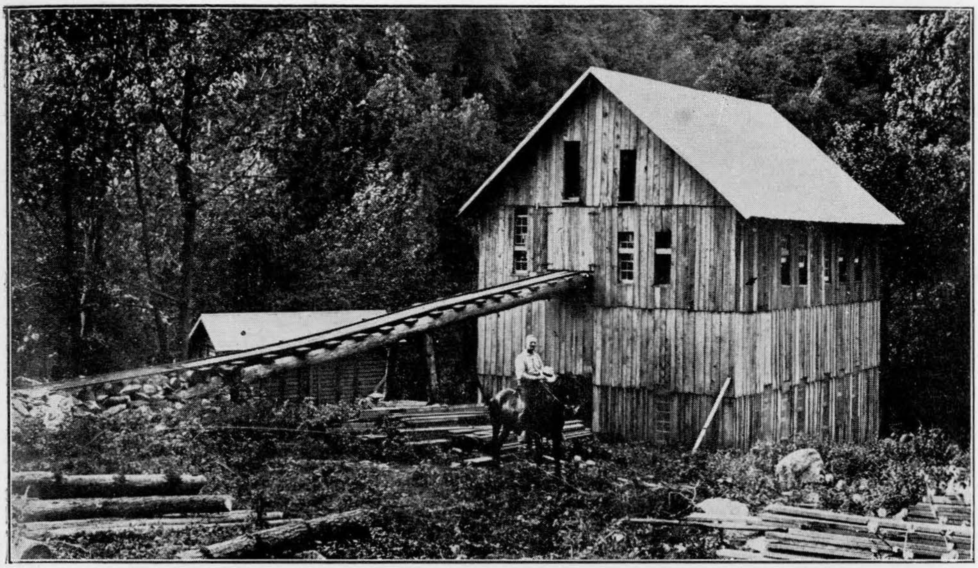
The Spring pit is at present one of the active mines in the region.

The King Pit has been abandoned for some time, but is being reopened. This mine is characterized by the amount of hard serpentine rock which is associated with the talc. There are also present masses of dolomite of irregular shape and varying size, with more or less light-green, foliated talc, which approaches chemically pure talc. The opening consists of a single tunnel, with no side entries, running practically straight for about 115 feet. The talc body is variable in thickness, but so far as could be seen is not more than 2 to 3 feet, and is enclosed in hard, light- to dark-green rock. It has yielded a good quantity of excellent saw-rock. There is another short tunnel parallel to the one just described and not more than 15 feet north of it. The thickness of the talc-bearing rocks at this locality is at least 30 feet.

The Hollow Pit, located 300 feet north of the King Pit, has been worked to but a limited extent. At the time of the writer's visit all the openings were filled with water, so little could be seen. There are three main openings and some smaller ones. At the northern one there is a considerable quantity of pencil talc exposed at the entrance, lying immediately on graywacke with a sharp line of contact between them. Above these lower openings occurs a peculiar rock, about 70 feet thick, with large phenocrysts of feldspar, followed above by some prospect pits which are now largely filled. Above the level of these upper pits is a natural exposure of chloritic (?) schist enclosing angular fragments of quartzite, varying in size from small pebbles to fragments six inches in diameter, composed of quartz, feldspar, and ocherous spots; alternating with the chloritic (?) schist, which contains quartz and feldspar grains, is a talcose schist.

The strike and dip of the lower level of talc-bearing rocks is N. 14° W. 40° E.

The Gray Pit has the distinction of having produced the largest amount of high-grade pencil talc, and of being the most extensively



A. MILL OF THE FORT MOUNTAIN TALC COMPANY, NEAR CHATSWORTH, MURRAY COUNTY.

B. MINE OF THE GEORGIA TALC COMPANY, MURRAY COUNTY; LOWER OPENING TO THE GRAY PIT.

developed mine in the district. It is locatetd near the central part of the lot and on the western slope of a hill which rises 200 feet above it. (See plate XVIII, fig. B.)

There are two large openings, one of which follows down on the dip of the talc rocks, and the other, starting in 70 feet lower down the slope, runs on a level for 216 feet to where it intersects the talc. This gives an outlet for the water and talc, and relieves the necessity of pulling them up a winding slope of 25° to 30°.

The total length of the lower tunnel is more than 300 feet. At a distance of 250 feet from the opening, the roof dropped out of the lower tunnel, making an entrance into the upper level. The roof in the upper tunnel has been falling occasionally for the past few years, with the result that the distance from the floor of the lower to the roof of the upper is about 45 feet, most of which was occupied by good saw-rock. The last 50 feet of this tunnel forms a room 50 feet square, with the wall varying from 6 to 12 feet in height. (See figure 4, page 212, for section made along the southern wall.)

At this mine the best grade of talc is light green and translucent, with a schistose structure, but is sufficiently massive for making pencils. This grades off into a darker rock which is unsuitable for sawing. Some talc was observed with actinolite needles running through it, showing all stages of alteration to talc. Masses of coarsely crystalline dolomite and fine, light green foliated talc of irregular shape and varying size are present.

Besides the two openings mentioned above, there are 8 or 10 lesser ones, mostly small pits, in the same level, some of which, however, are higher up the slope, and apparently separated from the lower openings by beds of graywacke.

North Spring Pit is the most northerly opening being worked at the present time. It is located in a small hollow about 300 feet north of the Grey pit. It is located immediately below a heavy bed of graywacke with large feldspar grains, a rock noted at the Hollow pit. There is a single short tunnel running S. 30° E. for a distance of 54 feet. Most of the talc encountered has been yellowed, although some saw-rock has been taken out.

The talc is pulled from the mines in cars operated on wooden rails by a whim at the entrance, which is worked either by hand or horse-power. The talc is hauled by contract from the mines to the mill.

Milling.—The mill operated by this company is located in Chatsworth on the Louisville and Nashville Railway. A spur track leads to the entrance of the storage house. Connected with this is the mill proper. The talc from the mines is thrown on a platform, which is on the level of the first floor of the mill; from this platform it is taken to the saw-room or to the crusher, depending on its grade. The rock to be ground is first passed through a Sturtevant Rotary Fine Crusher, Number 469, of the upright, open-door type. From this crusher it is carried by means of a cup elevator to the second floor into a bin, from which it passes through a Sturtevant "Vertical Rock Emery Mill, No. 728." Here the talc is pulverized and made ready for the screening process, which consists of a "scalper," a six-sided, revolving screen 7 feet long and 3 feet in diameter, in which the coarse particles are separated and returned to the pulverizer; the fines from the scalper are divided and conveyed to two bolts, each of which is six-sided, 14 feet long, 9 feet in circumference, and covered with a 180-mesh silk cloth. The powder which passes through these bolts is carried to the sacker and packed in 200-pound bags.

The saw room contains the usual equipment for making pencils. The mill is run by steam power, the equipment consisting of a 40-horse-power steam engine and a 60 horse-power boiler. A 15 horse-power kerosene engine is being installed to run the saws when the mill is not in operation. According to Mr. Glenn, the superintendent, it requires 14 men to run the mill and saws at full capacity, producing 4 tons of ground talc and from 100 to 125 gross of crayons per day, when working the best grade of saw rock. The output of the mines, together with trade conditions, keeps the mill running far below its maximum capacity the greater part of the time. (See plate XV, **fig. A.**)

Outlook.—A reference to figure 7, page 263, will clearly show the relation between the area from which the talc has been worked out, and the probable area underlain by talc. The outcrop follows roughly a contour connecting the various openings. From this line the talc dips under the hill to the east to an unknown depth. Considering the amount of work that has been done, it is certainly safe to figure that the deposits extend 500 feet, and it is very probable that they extend much farther from the outcrop, without any decrease in quantity. Thus, taking the average of the thickness of the talc deposits at the five different localities to represent the average conditions, compare the area of the belt one-third of a mile long and 500 feet wide with the areas of the underground workings, and a fair idea can be gained of the ratio of the amount of talc yet untouched to that which has been mined.

There are some other factors to be taken into consideration in this connection; with the increase in depth, the cost of mining will increase, this being due to the greater distance for hauling, pumping water, etc.; but to offset this, the amount of saw rock, as compared to the grinding rock, will increase with greater depth and will doubtless more than repay the added expenses of mining; especially so if more modern methods are employed, such as a steam hoist, steel rails, and, possibly, undercutting machines to replace the whim, wooden rails and, in part, hand labor.

OTHER TALC DEPOSITS IN MURRAY COUNTY

Besides the properties previously described, talc has been reported on the following lots in the 26th district, second section of Murray County: Lot 298, adjoining the Cohutta Talc Company's lot on the north end of Fort Mountain, and lot 293, known as the Fields lot.

SOAPSTONE DEPOSITS OF GEORGIA

The chloritic variety of soapstone has a greater distribution in this State than the talcose variety, a result due to the wider distribution of the hornblendic rocks from which it is formed; and, while it has not been examined in every county in the Crystalline Area of the

State, it would be quite safe to say that its occurrence is distributed to that extent. The largest areas examined are located east of Elberton in Elbert County, near Toccoa in Stephens County, and near Dahlonega in Lumpkin County. In the latter area, the soapstone is purer and of better quality than at the other two localities; however, taking everything into consideration, it seems doubtful whether either of these localities will ever be of value except to satisfy local demand.

Talcose, or true soapstone, is found most abundantly in the belt of peridotites and pyroxenites which crosses the State from Towns and Union to Harris County. Although chiefly derived from the more basic dike rocks, talcose soapstone is also derived from hornblendic rocks, and is found at numerous points outside of this belt, as in Columbia County. The soapstone contains as impurities the following minerals in various proportions: tremolite, actinolite, hornblende, chlorite, magnetite and pyrite. The purest material, which may often be more properly called talc schist, is generally found along the contacts of the basic dike and the country rocks; foliated talc is found as veins a few inches in width cutting the basic dikes and commonly associated with chlorite and asbestos. If the dikes are small the entire mass may be altered to a talcose rock, under which condition the material is usually less pure than is that of the contact zones.

There is a large quantity of this material in Georgia, grading from fairly pure schistose talc to soapstone; much of it could be used for foundry facings, and similar purposes, where low-grade powder can be employed. But since the purer deposits are of small extent and difficult to win, they offer little attraction to the miner at the present market prices.

Massive soapstone of a grade suitable for sawing into blocks for various purposes, is present in Georgia; but there are so many circumstances to be considered, such as the suitability of the location for a quarry, transportation facilities, the nature of the rock as regards veins, joints, etc., and the extent of the deposit and the likelihood of the rock becoming too hard for use, that it is difficult to offer even a casual opinion upon the value of an individual deposit. The most promising one, however, composed largely of talc and anthophyllite, is found north of Dallas on the S. M. Harris and adjoining properties. There are a number of other localities which are worthy of consideration and which are described briefly in this report.

Beside the soapstone deposits described in the following pages of this report, numerous others have been described under the heading of asbestos deposits, the most important of which are as follows: The Wykle and Martin properties in Habersham County, and the L. G. Hardman property in Jackson County.

UNION COUNTY

GENERAL RELATIONS

The geological features of the eastern part of Union County are in every respect similar to those in Towns County. The basic rocks, however, which are so prominent in the latter, are present only in the southeastern part of this county, while the Carolina gneiss, with granite intrusions, occupies the western and northwestern parts, with the exception of a small embayment, in its northern part, of the Great Smoky formation of Cambrian age.

Very little work has been done in this county, and only one area of basic rocks will be described; even that one presents no promise of either asbestos or soapstone in commercial quantities.

DESCRIPTION OF PROPERTIES

TRACK ROCK CORUNDUM MINE

The Track Rock corundum mine is located on lot 259, 17th district, on the south side of Track Rock gap, in the northeastern part of Union County.

The formation is from 200 to 250 feet wide and one-half mile or more long, with a strike to the northeast and southwest. The country rock on the west side is a diorite intruded by pegmatites; on the east it is a fine-grained diorite composed largely of hornblende.

The original nature of the intrusion has been entirely lost by subsequent metamorphism. The rocks found here are formed largely of chlorite, talc and actinolite. A sample of the freshest rocks showed in thin section the following minerals, arranged in the order of their abundance: olivine, chlorite, monoclinic amphibole, serpentine, dolomite or magnesite, magnetite, chromite, and talc. Judging from the abundance of olivine, which constitutes about 50 per cent. of the sections, the rock was originally a peridotite, probably approaching a dunite. While the alteration of olivine to chlorite has been observed in a number of cases, here a phenomenal amount seems to be thus developed; not that it is postulated that all the chlorite was formed in that way, because the greater part was formed from an amphibole, which may or may not be secondary to the olivine. Considerable actinolite is found at this locality, but little if any anthophyllite. Some talc is present, but it is very subordinate in amount to chlorite.

WHITE COUNTY

DESCRIPTION OF PROPERTIES

A. M. ALLISON PROPERTY

Five miles northwest of Cleveland, and 2 miles from Asbestos Station on the Gainesville and Northwestern Railroad, there is a deposit of soapstone which has been exploited to a limited extent for local use. It is situated on the property of A. M. Allison. An outcrop projects above the surface some feet, exposing a mass of chloritic soapstone 12 feet or more in width and 100 feet in length. It is a fair grade of soapstone, and very similar to that on the Elisha Castleberry lot, 1½ miles to the southwest. At this latter locality only about 5 feet of chlorite schist or soapstone is exposed, although it has been quarried here to a larger extent than further north.

H. H. DEAN PROPERTY

On the property controlled by H. H. Dean, of Gainesville, there is a large amount of chloritic soapstone exactly similar to that described on the A. M. Allison property, ond probably constituting the northern part of the same belt. This deposit is located one mile south of Hellen and 5 miles west of Nacoochee. The soapstone forms a body at least 40 feet thick and strikes N. 40° E., and dips about vertical. It is exposed near the crest of a small ridge, where it has been quarried for local use, such as in the construction of chimneys, etc. The rock shows a well developed cleavage, and blocks of almost any desired size can be quarried.

Similar deposits are to be found in the same section on the properties of Joe Fain, Charlie Williams and L. G. Hardman.

HABERSHAM COUNTY

DESCRIPTION OF DEPOSITS

ROBERT MCMILLAN PROPERTY

A small amount of soapstone for local use has been quarried on the property of Robert McMillan, 4 miles nortwest of Cornelia. A small opening about 6 feet wide shows a chloritic schist with a strike N. 20° E. and dip 30° E. The nature of the material, and its association with hornblende gneiss, naturally leads to the belief that it was derived from the latter.

The rock from this locality was used locally for tombstones until marble became so cheap that it destroyed the market for the soapstone.

Similar material has been found in the town of Demorest near the residence of C. W. Stambaugh, at the north end of the lake.

STEPHENS COUNTY

GENERAL RELATIONS

Stephens County is underlain largely by Carolina and Roan gneiss, with granite in subordinate quantities. The Roan gneiss is well distributed in narrow bands over the southeastern half of the county, and is relatively most important southwest of Toccoa and near Tugaloo. From 2 to 3 miles southwest of Toccoa the Southern Railway cuts through an area of what appears to be a quartzite, although it may be a very siliceous metamorphosed granite. It is seen when studied in thin section, to contain the following minerals, named in the order of their importance; quarts, feldspar (microcline and probably some albite), biotite, garnet, and apatite. Owing to the high content of quartz, the structure of the rock, and its similarity to the Tallulah Falls quartzite (this so-called quartzite forms the Toccoa Falls), it is believed to be a quartzite, although it grades into what is apparently a gneissic granite, or a feldspathic phase. The most important granite mass in the county, so far as observed, lies just north of the Southern Railway, near where it crosses the Tugaloo River.

A vary coarsely crystalline hornblende gabbro is found on Black Mountain, 1½ miles west of Currahee Mountain.

DESCRIPTION OF PROPERTIES

GLEN DAVIS PROPERTY

The Glen Davis property is located 5 miles southwest of Toccoa, near the Southern Railway. The soapstone is of the chloritic variety, and contains many impurities in the form of amphibole needles and magnetite. It is too hard to be of value except locally. About one-fourth mile southwest of Davis' mill, the soapstone is exposed in the side of the hill, where it shows the following section:

	Feet	Inches
Hornblende gneiss	—	—
Soapstone, light green with amphibole needles	6	—
Chlorite, almost pure	—	4
Hornblende gneiss	—	—

This soapstone is thus seen to be enclosed by hornblende gneiss, from which it was apparently derived. The material can be traced for one-fourth mile in a northeasterly direction.

The hornblende gneiss seems in some places to be interbedded with the quartzite, an anomalous position, since the hornblende gneiss appears by its amount of folding and metamorphism to be much older.

MECKLINE PROPERTY

A conspicuous outcrop of chloritic soapstone is found on the Meckline property, 2 miles north of Toccoa, near the Soapstone schoolhouse. The rock outcrops on a small knoll, and occupies an area of one-fourth of an acre. It was, doubtless, derived from hornblende schist, which is seen as scattered fragments on the surface. The rock contains hornblende needles and grains of magnetite, which make it difficult to saw. A small amount of prospecting has been done at this place, and a few soapstone bricks have been sawed.

E. H. RUSSELL PROPERTY

A very inferior grade of soapstone is found abundantly 8 miles east of Toccoa on the opposite bank of the Tugaloo River from Fort Madison, South Carolina. Here the soapstone is clearly derived from hornblende rocks, into which it grades. The soapstone is largely chlorite, with magnetite and amphibole needles as impurities. On weathering, the amphibole needles stand out forming a network, the softer intervening material having been removed. Although it is found at many other places in the neighborhood, the most conspicuous outcrops of soapstone are seen on the property of E. H. Russell.

BIRD YEARWOOD PROPERTY

Several small prospect pits have been made on the property of Bird Yearwood, 3½ miles northeast of Toccoa, on a branch of Toccoa Creek. In a cut 10 feet long chloritic soapstone, some slip-fiber asbestos and moderately pure talc have been exposed. Fragments of similar material are seen along the strike to the northeast, suggesting either a continuous dike or a number of small ones following a well marked course.

The asbestos gives no promise of commercial value, and the soapstone very little. The soapstone has been much disintegrated by surface waters, to such an extent that the former magnetite crystals are now represented by ocherous spots, which completely honeycomb the rock.

OTHER PROPERTIES IN STEPHENS COUNTY

Chloritic soapstone of very inferior grade is found on numerous other properties in Stephens County, among which may be mentioned: C. F. Anderson, 3 miles northeast of Toccoa; J. E. Brady, 4 miles west of Toccoa; Perry Farrow, 1 mile south of Eastonollee, and T. R. Yow, one-eighth mile north of Martins.

LUMPKIN COUNTY

GENERAL FEATURES

Lumpkin County contains a large amount of basic rocks, ranging in composition from hornblende gneiss to peridotite and pyroxenite. They are associated with the Carolina gneiss, with which they are intimately folded. The Carolina gneiss is also quite variable in composition, and consists largely of mica schist, in some places highly garnetiferous, mica gneiss and slaty schists; a large part of it has the appearance of a highly metamorphosed sedimentary rock. Granites of several periods of intrusion are present, and vary in structure from massive to gneissic.

There is, relatively, a large amount of soapstone of the chloritic type present in this county, and it is very similar to that described from south of Dawsonville, 13 miles east of Elberton, and 8 miles east of Toccoa. Some peridotites and pyroxenites, much altered from their original composition, are present in small areas; at but few places do they give any promise of yielding asbestos or soapstone in commercial quantities.

DESCRIPTION OF PROPERTIES

FOUR MILES EAST OF DAHLONEGA

On the east side of the Chestatee River, 4 miles by air line east of Dahlonega, there are a number of exposures of chloritic soapstone, and several small openings where the rocks have been quarried for local use. One of the main exposures is on lot 121, 15th district, and 1st section.

The width of the soapstone dike reaches a maximum of 200 feet, but further north it decreases to 30 feet. The rock is massive in structure where it is not weathered, and is capable of being cut into blocks of almost any size. Chlorite predominates over talc, and appears to form the body of the rock with, at places, small amounts of magnetite and amphibole needles. The material here exposed is much better than the average of this type found in Georgia, and could be used for many of the purposes for which a medium grade soapstone is employed.

Soapstone from this locality has been used in Dahlonega in the construction of fire-places, such as at the Mountain Club House, and for tombstones, as at the Yellow Creek Church, near Murrayville.

SOAPSTONE RIDGE

The largest quantity of soapstone found in Lumpkin County is located on what is known as Soapstone Ridge, 9 miles northeast of Dahlonega and 7 miles west of Cleveland. The soapstone occurs as parallel bands, the widest of which is several hundred feet, which strike a little east of north and can be traced at least one mile. The soapstone is mainly a greenish, schistose, chlorite rock which, in places, usually near the contact with the country rock, becomes somewhat talcose. There is much variation in the soapstone, and it is found to grade to an amphibolite, or, more exceptionally, to a somewhat massive rock which appears to represent an altered diorite. The best soapstone is found in lenticular form, either enclosed in the less altered rock, or along the contacts with the country rock.

When studied microscopically, the rock is found to contain chlorite, little or no talc, amphiboles (actinolite and probably some anthophyllite), carbonates and magnetite. It is evidently derived from the hornblende schist of the Roan series.

The soapstone has been used locally, and small quarries have been opened. The deposit occurs on the properties of W. M. Grindel, A. C. Bowen and others. (See plate XIX, fig. B.)

Soapstone similar to that described above and to that described as occurring 4 miles east of Dahlonega, is found in an intermediate position on the property of J. R. Dowdey, 5 miles northeast of Dahlonega.

These three localities are in a line represented by the strike of the formation, and may, or may not, represent parts of the same body.

OTHER LOCALITIES IN LUMPKIN COUNTY

A dike of amphibolite (or hornblendite) is found one mile southeast of Porter Springs, a locality where corundum is reported to have been found.[1] The rock is composed almost entirely of hornblende, which is in places partly converted to chlorite. The intrusion is 60 feet wide and at least 300 feet long.

On the property of C. M. Motes, 3½ miles northwest of Porter Springs, there is a small soapstone dike only a few feet wide which consists largely of chlorite.

One mile further west, on the property of William Gooch, there is another dike 200 feet long and 50 feet wide, which is partly a talcose-chloritic rock. It is associated with mica-cyanite schist and hornblende gneiss.

West of Dahlongea, there are numerous small areas of chloritic soapstone similar to those described above. On Earl Davis' place 3½ miles west of Dahlonega, soapstone is found which is clearly derived from an altered, basic rock, probably a gabbro. (Plate XIX, fig. A.)

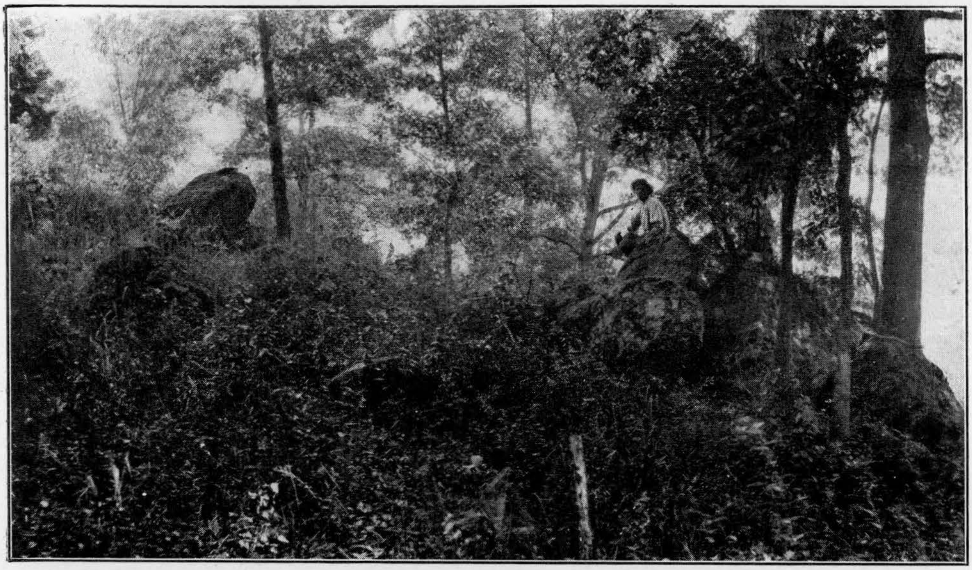
DAWSON COUNTY

GENERAL RELATIONS

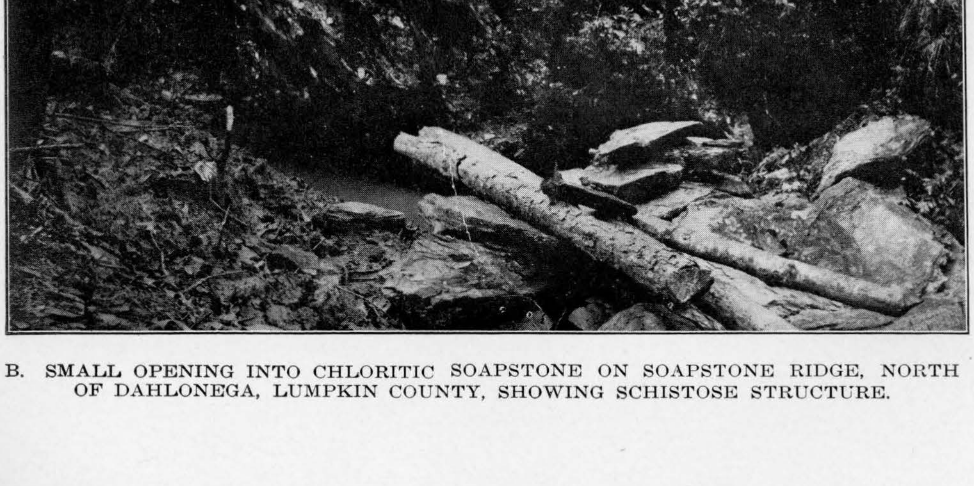
Practically the whole of Dawson County is formed of Carolina and Roan gneisses, with some granite intrusions in the southeastern part near the Etowah River. The general types of the Carolina gneiss are mica schist, in part garnetiferous, and biotite gneiss, all of which give some indications of being of sedimentary origin.

Two prominent bands of hornblende gneiss and some associated soapstone cross the southeastern part of the county, one about 2 miles, and the other 3¼ miles, southeast of Dawsonville. The soapstone associated with these hornblende rocks is of low grade and has been used locally for chimneys, window sills, for walling wells, and similar purposes. It is green in color, possesses a very pronounced schistosity, and for this type of material is moderately free from grit.

[1] King, Francis P., Corundum Deposits of Georgia: Bull. Ga. Geol. Survey, No. 2, 1894, p. 96.



A. OUTCROP OF SOAPSTONE NEAR DAHLONEGA, LUMPKIN COUNTY.



B. SMALL OPENING INTO CHLORITIC SOAPSTONE ON SOAPSTONE RIDGE, NORTH OF DAHLONEGA, LUMPKIN COUNTY, SHOWING SCHISTOSE STRUCTURE.

DESCRIPTION OF PROPERTIES

THREE AND ONE-HALF MILES SOUTHEAST OF DAWSONVILLE

On the Gainesville-Dawsonville road 3½ miles southeast of Dawsonville, there is a dike of chloritic schist, or soapstone, which is 50 to 60 feet wide and can be traced for a distance of one-third mile in a northeast-southwest direction. The dike appears to be an isolated area of what was formerly a hornblende gneiss, and although some of that rock occurs near by, none is seen in connection with it.

A small opening has been made in the southwestern end of the dike, but, judging from the nature of the material exposed here, it will never be of value except locally.

CHEROKEE COUNTY

DESCRIPTION OF DEPOSITS

THE VERD ANTIQUE MARBLE COMPANY

The quarry of the Verd Antique Marble Company is located in the southwest corner of land lot 444, 15th district, 2 miles southwest of Holly Springs. This locality is at present being worked for marble for interior finish and decorative purposes, although soapstone was formerly quarried here in a small way.

The deposit at this locality consists of a lenticular mass a few hundred feet long and a hundred or so feet wide, intruded into mica schist. The entire body, so far as it has been exposed, has been so completely altered that its original composition is not determinable, although it probably was a member of the pyroxenite family.

The intrusive mass is schistose near its contact with the country rock, but its central portion is massive in structure, although extensively cut by jointings and irregular cracks. These joints and cracks are usually filled with either dolomite, talc or serpentine.

The outcrops which originally came to the surface with little or no soil covering were largely soapstone, varying in thickness from 2 to 6 feet; and also along the contact of the intrusive body with the country rock there is a zone of soapstone, while the central core is composed of serpentine rock. This outside layer of soapstone is composed largely of small foliae of talc, light greenish-gray in color and containing a rather high percentage of magnetite.

The talc which occurs as vein material is pure, light green, and foliated. It is seen in veins varying in width up to an inch or more. In some places it is found in irregular-shaped masses. Neither talc nor soapstone occur here in commercial quantity, but the locality is worthy of consideration because soapstone was formerly worked here, and because of the striking occurrence of pure, crystalline, foliated talc.

FRANK HAWS PROPERTY

Another deposit similar to that at the Verd Antique Marble Company's property, is to be found 2 miles southwest of the latter on lot 567, 15th district. Here the intrusion is somewhat smaller, but is lense-shaped and intruded into mica schist. The deposit doubtless represents the alteration of the same kind of rock as at the locality 2 miles to the northeast, and has been altered to about the same extent.

Around the periphery of the intrusion, masses of tremolite needles are to be seen altering to talc; and at other less localized places hornblende can be found in all stages of alteration to chloritic masses. The soapstone here is light green in color, but is hard and contains a large percentage of magnetite. Some foliated talc is also found at this locality.

A thin section of the talcose material when studied under the miscroscope showed talc and serpentine in equal quantities, together with magnetite.

J. J. HOWELL PROPERTY

A small intrusion of material which is now represented largely by soapstone is to be found on J. J. Howell's place, 2 miles northeast of Toonigh, on lot 554, 15th district, 2nd section.

The intrusion has a maximum width of at least 80 feet and extends in a northeast-southwest direction for a hundred yards or more; in this locality the soapstone mass is clearly associated with hornblende gneiss, of which it was originally a basic phase, probably pyroxenite.

Hornblende was observed altering to chlorite. Tremolite is present in somewhat fibrous masses. The soapstone here is coarsely crystalline, and composed of chlorite, talc, magnetite, and carbonates. It is a very poor grade and of no commercial value.

GWINNETT COUNTY

GENERAL RELATIONS

The southeastern half of Gwinnett County, southeast of the Seaboard Air Line Railroad, is underlain in greater part by a biotite granite gneiss. In this area the Roan and Carolina gneisses make their appearance at places, and reveal the fact that they are cut by the granite. To the northwest of the Seaboard Aid Line, the granites become less important, and there is something of a gradation to the schist belt which follows very closely the line of the Southern Railway across the country. This belt is clearly of sedimentary origin and may be correlated with the Brevard schist of Pisgah Folio, North Carolina. Its southwestern continuation crosses the northern part of Fulton County, and is well exposed at Chattahoochee Station, where the Southern Railway crosses the Chattahoochee River. Southeast of Buford this sedimentary belt contains limestone in such a quantity that a lime kiln was constructed there for burning the rock; while somewhat farther on to the southeast a very prominent ridge of quartzite is present.

Toward the northwestern part of the county, the rocks grade into granite gneiss.

Basic rocks of the Roan series are not prominent in this county, although they are rather widely distributed in narrow bands, especially in its southeastern half. Neither soapstone nor asbestos with any commercial promise was found in connection with them.

DESCRIPTION OF PROPERTIES

THOMAS DOSS PROPERTY

On the property of Thomas Doss, formerly owned by Gliss Woodward, 5 miles by public road south of Buford, there is a small exposure of rather pure, schistose soapstone in a small ravine. The exposure is on the south side of Suwanee Creek and about 250 yards east of H. H. Matthews' house.

The country rock is mica schist, which appears to be of sedimentary origin. Included in the schist small beds of soapstone are exposed, varying in thickness from a fraction of a foot up to a maximum of six feet. At the largest exposure the soapstone contains small lenses of what appears to be diabase. The soapstone itself is much yellowed by weathering agencies, but where fresh it has a greyish-green color. From its association in the schists it appears that the soapstone may be derived from dolomitic layers in the country rock, were it not for the fact that some of the material has a decidedly fibrous structure which makes it similar to that derived from anthophyllite.

SOAPSTONE IN NORCROSS

A small dike of soapstone is exposed in the railroad cut 150 yards south of the depot in Norcross. The exposure is not very good, but the dike is about 25 feet wide and possibly 75 to 100 feet long. A microscopic study of a fragment of basic rock found nearby showed a large percentage of olivine. Decomposed hornblende gneiss and granite are exposed in the next cut to the south.

This occurrence is worthy of only passing interest, as it can have no commercial significance.

DEKALB COUNTY

DESCRIPTION OF DEPOSITS

S. D. MOORE PROPERTY

On the property of S. D. Moore, 1½ miles east of Conley, soapstone is well developed. The original rock here was a pyroxenite (?), which has been altered to a mixture of chlorite, talc, amphibole needles and magnetite. The soapstone projects above ground in the form of rough, greyish masses. A small amount of asbestos is present in the form of veins, but not in anything like commercial quantities.

The soapstone here, as at other localities where it has the same origin, has a rather coarse texture and contains magnetite and some amphibole needles. This material, while not good enough for the higher grade of soapstone, could be used for rough work.

Other deposits of similar material occur in the neighborhood.

PAULDING COUNTY

DESCRIPTION OF PROPERTIES

S. M. HARRIS PROPERTY

A conspicuous outcrop of soapstone occurs on lots 1,171 and 1,172, 3rd district, 3rd section, on the property of S. M. Harris, 3½ miles northeast of Dallas.

The dike is at least one mile long and as much as 100 yards wide; and while the largest exposures are to be found on the property of S. M. Harris it is also found on adjoining properties, especially to the north. Over the area numerous large, brownish outcrops are to be seen, showing a variable mineral composition. The dominant type of rock, and the one which offers the best promise of commercial value, is a talcose, anthophyllite rock of varying texture, though usually moderately fine grained. This rock is light gray in color and is relatively free from gritty particles, such as magnetite and hard, amphibole needles. The anthophyllite is fibrous and, in part, altered to talc.

The talcose, anthophyllite rock gives way at places to a rock composed of actinolite needles and more or less chlorite and talc; chlorite schist is abundant at certain places, as well as gradations between all the types of rocks mentioned. The rock is massive and uniform in texture only over localized areas. The position of the rock on the crest of a ridge makes a favorable location for a quarry.

While most of the material from this locality is fibrous, the material is relatively fine grained and would yield a very short fibered pulp. The rock seems best suited for use as a soapstone, either for sawing into blocks or for grinding to powder for foundry facings, etc. The quantity of the material available and its accessibility make the deposit worthy of serious investigation.

J. L. WALTON PROPERTY

A small peridotite intrusion has been found on the property of J. L. Walton, 3 miles northwest of Douglasville; it is in a meadow on the south side of the road near Walton's store.

Associated with hornblende gneiss, the country rock, is a narrow, schistose dike of much altered rock, which strikes northeast and dips, contrary to the ordinary dip of the Piedmont rocks, to the northwest. The metamorphism of the original rock has led to the development of a gneissic structure, and the formation of the following secondary minerals, named in the order of their importance: chlorite, actinolite and possibly a little anthophyllite, talc, magnesite, serpentine, and magnetite. One-half the rock is composed of original olivine. Neither soapstone nor asbestos has been formed at this locality.

DOUGLAS COUNTY

GENERAL RELATIONS

The general features of the northern part of Douglas County are practically identical with those of the area described in Paulding County (see Paulding County under description of asbestos deposits), and the description will not be repeated here. The same area of ancient gneisses and their associated rocks extends from the neighborhood of Powder Springs in Cobb County southwest through the southern part of Paulding, across the northern part of Douglas and into the central part of Carroll to Carrollton. A large granite mass extends from near Winston east to Austell.

DESCRIPTION OF PROPERTIES

T. J. CARNES PROPERTY

A small knoll on the property of T. J. Carnes, 2½ miles east of Villa Rica, between the public road and the Southern Railway, is composed largely of a chloritic schist, which has been used locally as a soapstone.

The chloritic rock outcrops at numerous places in large ledges over an area of some acres. Judging from its nature and its association with altered dioritic rocks, it is naturally concluded that the chloritic schist was derived from an amphibolite.

All the material is very schistose and hard, being penetrated with countless needles of actinolite and hornblende. As a matter of fact, part of the mass is composed of about one-half amphibole and one-half chlorite. The rock is deep green in color.

BUD YANCEY PROPERTY

An old soapstone quarry, from which rock has been taken for local use in the building of fire-places, is located on what was formerly known as the Abercrombie place, but which is now owned by Bud Yancey. It is 6½ miles south of Douglasville, the nearest railroad station. Here, as at other places in the county, the country rock is hornblende gneiss, and the soapstone body is derived from a phase of it. The soapstone is very impure, and is of value for local use only. It is a chloritic, talcose rock with abundant amphibole needles and much magnetite present. The quarry is small and but little stone has been taken out.

ONE-HALF MILE SOUTH OF BROWNSVILLE

A small dike in decomposed hornblende gneiss was observed crossing the road leading north from Douglasville, 1½ miles south of Brownsville. The intrusion is from 40 to 50 feet wide and extends in a northwest-southeast direction for one hundred yards or more. The greater part of the body is a chloritic soapstone with some few veins of brittle, cross-fiber asbestos, which probably belongs to the mineral species actinolite. The soapstone is hard and schistose.

CARROLL COUNTY

GENERAL RELATIONS

In Carroll County a large amount of impure soapstone and a small amount of asbestos and pure talc have been found. The basic rocks and their associated products are found to occupy a belt running through the county from Villa Rica southwest to Carrollton, and from there into Heard County. Another belt, which is composed almost exclusively of chloritic schist formed from hornblende schists and hornblende gneisses, crosses the western part of the county near Burwell and Bowdon. This second belt contains little talcose material, being essentially a mixture of chlorite and hornblende in varying proportions. The eastern belt, on the other hand, contains a large number of small basic intrusions which have been altered to talcose rocks with more or less asbestos. They are most extensively developed near Villa Rica and east and south of Carrollton.

DESCRIPTION OF PROPERTIES

ROGERS AND MCLENDON PROPERTY

A small intrusion of peridotite is found on the property of E. Rodgers and T. J. McLendon, one mile east of Villa Rica at New Hope Spring. The intrusion here has a width of almost 30 feet and is enclosed in hornblende gneiss.

In a small pit asbestos can be seen in cross-fiber veins enclosed between walls of decomposed peridotite (?). The fiber is short and brittle, and occurs in small quantity. Small fragments of both blue and pink corundum were found nearby, some associated with cyanite, which is the alteration product. There is little possibility of commercial asbestos at this place.

MRS. L. C. MCPHERSON PROPERTY

An extensive intrusion of altered peridotite is found immediately west and southwest of Villa Rica. It is most extensively developed on the property of Mrs. L. C. McPherson, three-fourths mile west of town. The intrusion can be traced for nearly one-half mile, and has a maximum width of 300 feet; it is intruded into granite gneiss, and is associated with altered gabbro and diorite.

The original rocks were representatives of both the peridotite and pyroxenite families; some are composed almost entirely of olivine, while others were composed largely of enstatite. The relationship between these two types of rocks is not clear, because of their poor exposures and their much altered condition. Gradations from the one to the other type occur. The alteration products, more than the original rocks, are quite variable. The dominant alteration has led to the formation of talc, although chloritic rocks are present. Talc occurs both in the foliated form and especially as its impure variety, soapstone. Asbestos occurs in the form of veins, usually actinolite, and also as a fibrous anthophyllite. Large masses of long, slender, bright green needles of actinolite are found showing alteration to talc. A small amount of dark green to black serpentine is present, showing chrysotile in veins from a mere thread up to one-tenth of an inch in width. Alteration has progressed much farther, relatively, near the edges than toward the center of the intrusion.

Asbestos is found most abundantly near Wm. Boyd's house in a cut of the public road; but in general soapstone presents better commercial possibilities at this locality than asbestos. Soapstone fragments are abundant along the edge of the intrusion, containing the ordinary impurities, hornblende needles and magnetite.

OTHER PROPERTIES NEAR VILLA RICA

The same intrusion, or smaller intrusions, extends from the McPherson property northeast through the western edge of Villa Rica, crosses the road between the old and new towns, and extends into Douglas County. Northeast of the McPherson property the original character of the rock is completely lost, and the resulting material is almost entirely soapstone. Some of the most conspicuous occurrences of soapstone are on the properties of Grady Roberts and Solomon Kilgore. Still other deposits of the same nature are found farther northeast on the estates of Jane W. Stone and W. B. Candler.

J. W. PITTS PROPERTY

On J. W. Pitts' property, 1½ miles east of Carrollton, there is a large quantity of chloritic and talcose rocks, which have been used locally to a limited extent for fire-places, etc. The rock outcrops on lot 110, 5th district, and adjoining lots.

The country rock is hornblende gneiss, and here, as at other places, local basic phases appear to have given rise to the soapstone. The freshest rock of the basic segregation shows remains of crystals of olivine, now largely altered to amphibole, carbonates and, to a less degree, serpentine. Only along the borders of the intrusions is the alteration to chlorite and talc complete. There is one large dike and numerous other smaller ones. In each, excepting the very smallest, the central core of only partly altered rock projects above the ground.

The largest mass is found on Pitts' property and extends southwest on to J. W. King's place. Other smaller bodies occur further southwest on H. L. Worley's property.

The largest intrusion is one-fourth mile long, has a maximum width of 75 to 100 feet, strikes N. 25° E., and has a vertical dip. The north end of the mass appears to have been completely altered to soapstone, and is represented only by surface fragments. At places long bladed crystals of actinolite are found, and at others corundum, partly altered to margarite, is found encased in chlorite.

Asbestos occurs, in very limited quantity, both as narrow veins and as the fibrous form of masses of actinolite. In both cases the fiber is brittle and short. Actinolite is seen altering to both talc and chlorite.

Near where the intrusion crosses the road, the mass of partly altered peridotite projects out of the ground for 10 or 15 feet, with schistose soapstone occurring along the contacts with the country rock.

The other intrusions are similar to the one described above. Except for local use, this material is not likely to be of value. The presence of fragments of vessels made of soapstone shows that the Indians made use of these deposits.

E. S. LYLE PROPERTY

On lot 252, 5th district, there is a small area of soapstone on the property of E. S. Lyle, 2½ miles south of Carrollton. On this property there is either one continuous dike or numerous smaller ones having the same strike. The soil covering obscures the relationship so that, but for the exception of one small outcrop, only surface fragments are to be seen. The rock is a chloritic, talcose soapstone with a small amount of asbestos fiber present. Near the edges, this soapstone is much contorted. Some schistose, much-altered olivine rock suggests that the original material was a peridotite.

There is no evidence here that either soapstone or asbestos occurs in commercial quantities.

J. W. STALLINGS PROPERTY

On the property of J. W. Stallings, 3½ miles south of Carrollton, lot 32, 10th district, there is a conspicuous outcrop of basic rocks. A thick covering of residual soil obscures the relationship of the intrusive mass to the country rock and makes the limits of the former hypothetical; but judging from the fragments covering the surface, the intrusion is from 60 to 80 yards wide and possibly as much as one-half mile long. At one place the central core projects above the ground 12 to 15 feet and has a width of 30 feet and a length of 150 yards. Around this hard central mass the surface is covered with fragments of soapstone.

The only original minerals which have been found in this intrusion are olivine and enstatite. There are apparently all variations present from rocks largely olivine, peridotite, to rocks composed almost entirely of enstatite, pyroxenite. The olivine-rich rocks at this locality appear to alter to soapstone, in which chloritic material predominates over talc, and carbonates are particularly abundant. The olivine has given rise to anthophyllite to only a small degree; the anthophyllite has been partly altered to talc. The result is a complex mixture of primary, secondary, and even tertiary minerals.

The enstatite rock is in large part massive, but at places it has altered to mass-fiber anthophyllite.

A small amount of prospecting has been done on this property, but nothing of value was brought to light. It is very doubtful whether asbestos has been formed in commercial quantities, unless the processes involving its formation have progressed farther at lower levels than at the surface. The prospect for commercial talc along the sides of the intrusion is somewhat brighter.

W. A. FREEMAN PROPERTY

Immediately south of J. W. Stallings' property and possibly representing the southern end of the same intrusion, is a prominent exposure on the farm of W. A. Freeman. Although the exposure is by no means continuous from one place to the other, surface fragments can be found over almost the entire distance. The exposures on the two properties are on the same land lot.

The conditions on the two places are almost identical, except that the exposure to the north is much larger, and relatively more soapstone has been formed.

W. W. SMITH PROPERTY

One-half mile south of Burwell Station, on the Bowdon Railway, there is a conspicuous exposure of chloritic schist, locally called soapstone, on the property of W. W. Smith. There are all gradations from chloritic schist to amphibolite, and finally to hornblende gneiss, from which the series of alteration products were derived. The rock outcrops on both sides of the railroad, but the largest amount of relatively pure chloritic schist is exposed on the south side. The schist can be traced continuously for a distance of 100 yards and has a width of at least 80 feet. It is dark green in color, and in places is comparatively free from grit. Along the strike, N. 50° W., hornblendic rock occurs which doubtless represent the northern continuation. Corundum and margarite are reported from this locality by J. A. Hearn.

OTHER PROPERTIES NEAR BURWELL STATION

Deposits similar to those on W. W. Smith's property are present west of Burwell Station at a number of places, but as a rule the chlorite is intimately mixed with amphibole needles. One of the most conspicuous exposures of this material, and one where the alteration can be seen best, is on Bert Crawford's place, 5 miles northwest of Burwell, on the east side of Little Indian Creek. Here the hornblendic and chloritic rocks are associated with mica schist, composed of muscovite, biotite, quartz and garnets. From Crawford's place the band of material extends southwest past Bowdon, and farther.

HEARD COUNTY

GENERAL RELATIONS

The eastern part of Heard County is underlain by granite, while the western part is formed largely of mica schist with beds of graphitic schist. The general absence of hornblende gneiss from this region is worthy of note.

There is a single locality in the county where peridotite is known to occur, although hornblende gneiss and its alteration products are present in the central part of the county to a limited extent.

DESCRIPTION OF PROPERTIES

W. A. HYATT PROPERTY

Several small areas of basic, magnesian rocks have been found on the property of W. A. Hyatt on Lot 44, 13th district, 3½ miles northwest of Centralhatchee. They are located in the bluff on the north side of Deer Creek, near its junction with Centralhatchee Creek.

The country rock is grey, biotite granite, in which there are three distinct basic areas. The one farthest to the southwest is in the form of a dike about 15 feet wide, and appears to be an altered peridotite. The second outcrop is a short distance north of the former and is composed of soapstone. At this locality some prospecting was done for corundum, and several boulders were discovered weighing 50 to 100 pounds. The corundum was associated with long crystals of tourmaline and flakes or margarite. Also, some veins of cross-fiber asbestos occur here, but in very limited quantity. The third outcrop is composed of soapstone.

HARRIS COUNTY

GENERAL RELATIONS

As is the case in Troup County, granite gneisses underlie the greater part of Harris County; but running through its northern part there are two diverging belts of sedimentary rocks. The northern belt extends across the entire width of the county in a northeastern direction to Warm Springs, while the other, beginning near Hamilton, runs almost directly east. These sedimentary belts are composed largely of quartzites, which cause them to form prominent ridges, although schists with graphitic beds are also to be found.

Basic rocks of the Roan gneiss series are not prominently developed in this county; there is one belt 3 miles north of Hamilton running west parallel to the sedimentary belt to the north. Besides this area, there are other scattered and less prominent ones. The types of basic rocks found in this county are hornblende gneisses and peridoties (?).

DESCRIPTION OF PROPERTIES

TWO AND ONE-HALF MILES SOUTH OF HAMILTON

Near the northern edge of a belt of hornblende gneiss and 2½ miles south of Hamilton, there is a small dike of soapstone, which is exposed in the public road and also in a railroad cut nearby. The dike is only from 6 to 8 feet wide and is formed of talcose, chloritic soapstone of schistose structure.

MRS. LIZZIE SPENCE PROPERTY

Several small intrusions of altered, basic rocks occur on the property of Mrs. Lizzie Spence, 7 miles northwest of Hamilton on the north side of Mountain Creek, on lot 157, 20th district.

There are at least three separate intrusions here, one of which extends to the east on William Crawford's property, one to the west on John Koon's property, and the third half way between the other two.

The eastern intrusion is about 70 yards long by 20 to 30 yards wide, judging from the distribution of fragments of soapstone over the surface. The middle intrusion forms a bluff along the north bank of Mountain Creek, and is composed of a massive serpentine rock. There appears to be no talc or asbestos associated with it. The western area is composed of both soapstone and serpentine rock. An outcrop of soapstone 15 feet wide is exposed in a small gulley. It is much discolored by surface water, but otherwise, with the exception of a moderate amount of magnetite, it is of a fairly good grade. The area here covered by talcose rocks is probably 100 by 15 feet. At all the exposures it was noted that a certain amount of silicification had taken place, especially at the western outcrop. The soapstone appears to be pure enough to grind for foundry facings, etc.

Other small areas of soapstone are reported to occur in the neighborhood.

JOHN THRAILKILL PROPERTY

On the property of John Thrailkill, 1½ miles southeast of Chipley, there are a number of small areas over which fragments of soapstone and some asbestos are scattered. The country rock here is granite gneiss, and the talcose rocks appear to have been formed from the dikes of basic rocks which cut it.

Some small veins of asbestos were seen traversing a much altered peridotite (?). The asbestos is poorly fibrous and brittle, probably belonging to the mineral species, actinolite. Talcose rocks are present showing gradations to amphibolite, from which it was derived. There are at least three areas here, of an acre or so each, over which this material is scattered.

Besides these, there are similar deposits on the property of R. F. Myham, one mile east of Chipley.

OTHER DEPOSITS IN HARRIS COUNTY

Deposits similar to those described on John Thrailkill's property have been found or reported at numerous other places in Harris County. Among these may be mentioned the properties of L. H. Zachary, 5½ miles southwest of Chipley, and of Hall Bryant, 6 miles southwest of Chipley. These areas of talcose rock are small, and are represented only by scattered fragments on the surface.

MERIWETHER COUNTY

DESCRIPTION OF DEPOSITS

SIM WOODRUFF PROPERTY

One-half mile northwest of St. Marks and 6 miles east of Hogansville, there is a small soapstone prospect on the property of Sim Woodruff.

The country rock is mica schist, cut by quartz veins. No hornblende gneiss was found in the neighborhood, although some was seen between this point and Hogansville. The dike is probably not more than 10 feet wide and outcrops at two places 100 yards apart. There is no evidence as to the original nature of the rock; only massive talcose rock showing traces of amphibole crystals can be seen. The exposures are poor, but from what can be seen there is little possibility of commercial soapstone.

MONROE AND JASPER COUNTIES

GENERAL RELATIONS

A prominent belt of basic rocks, including hornblende gneiss, gabbro-diorite, etc., extends across the southeastern part of Monroe County, through the northwestern corner of Jones County, and through Jasper County between Adgaleville and Monticello, and farther to the northeast into Morgan County. This belt was probably continuous with that to the northeast, beginning near Union Point and extending into Elbert County; but the connection has been broken, or at least obscured, by the intrusion of a great mass of granite near Union Point.

Asbestos occurs in these two counties but sparsely; a chloritic variety of soapstone is very abundant. The asbestos is limited to rather small veins of brittle fiber; the soapstone, on the other hand, contains large quantities of amphibole needles and more or less magnetite.

DESCRIPTION OF DEPOSITS

MRS. M. J. KIMBELL PROPERTY

Nine miles east of Forsyth on the property of Mrs. M. J. Kimbell, lot 154 (?), 5th district, Monroe County, there is an area of diorite, or hornblende gabbro, with which are associated asbestos and soapstone. The general country rock is Carolina gneiss interbedded with Roan gneiss. The diorite is associated with the latter, but is doubtless somewhat later in origin.

A few very narrow veins of amphibole asbestos occur in the mass of the rock, which has altered to a variable degree to chloritic soapstone. The soapstone is hard and impure, and of no value except for local use.

JOHN MCELHENNY PROPERTY

On the property of John McElhenny, 7 miles southwest of Monticello, Jasper County, there is a prominent exposure of chloritic soapstone representing the northern continuation of that described on the Kimbell place east of Forsyth. There is a large area of gabbro-diorite at this locality which has associated with it an aplitic granite, composed essentially of quartz, orthoclase and a little mica. The granite is variable in texture, often grading into a pegmatitic phase It is younger than the gabbro-diorite, which, in turn, is younger than the hornblende gneiss associated with the granite gneiss of the Carolina series. Diabase dikes are seen somewhat farther north toward Monticello.

The soapstone has been used in the neighborhood for fireplaces, for building chimneys, etc. It is too hard to saw, and consequently of little commercial value.

GREENE COUNTY

GENERAL RELATIONS

Granite gneisses, granites and one belt of basic rocks underlie the greater part of Greene County. The belt of basic rocks extends from southeast of Union Point northeast through Wilkes and the eastern edge of Oglethorpe and into the southeastern part of Elbert County, where it is extensively developed. The rocks are similar, almost to identity, with those described under Monroe and Jasper counties, and for this reason this belt is considered to be their northern continuation. Hornblende gneiss and gabbro-diorite are the rocks which constitute this series. The gneiss occurs in long, narrow bands, while the gabbro-diorite tends to form irregular-shaped masses, but usually elongated in the northeast-southwest direction. So far as known, there are no peridotites nor pyroxenites in this area; if any are present they have been so much altered that they have lost their distinguishing features. No asbestos of any consequence has been found; soapstone of the chloritic type is extensively developed. Diabase dikes are found at numerous places cutting through the other rocks.

This series of rocks has been studied near Union Point and east of Elberton, but little work has been done on the intervening area.

DESCRIPTION OF DEPOSITS

CHLORITIC SOAPSTONE NEAR UNION POINT

The area of basic rocks crosses the Georgia Railroad one mile east of Union Point and just east of the Ogeechee Brick Company's plant. Here it has a width of from one-fourth to one-half mile. Not much soapstone is to be seen here, but the partly altered rock outcrops along the road. One mile northeast of this place, and 3 miles northeast of Union Point, on the Daniel Springs road, there is a large area, probably 50 acres, strewn with hard, chloritic rock and a small amount of softer, greyish to greenish soapstone.

A microscopical study of a sample of the freshest rock obtainable showed the following minerals: labradorite and diallege as original minerals, together with hornblende, chlorite, magnetite, talc and carbonates. The alteration is first to hornblende and then to chlorite; but, owing to the original composition of the rock, many impurities are to be found in the resulting soapstone.

Chloritic soapstone occurs on the properties of Mrs. Lee Thornton, H. T. Overton, Miss Bessie Asbury, J. T. Hester and others.

A similar deposit of chloritic soapstone is to be encountered over the Greene County line in Taliaferro County, 8 miles northwest of Crawfordville on the property of Miles Hackney. Here it has been quarried for local use for door-steps, fire-places, etc.

ELBERT COUNTY

GENERAL RELATIONS

The southeastern part of Elbert County, from near Middleton to the Savannah River, is underlain in large measure by basic rocks, which are considered the northeastern continuation of the belt so well developed near Union Point. Along the western edge of this belt the basic rocks contain many off-shoots of the Elberton granite; while to the east aplitic granites and diabase are seen cutting them. The central and western part of the county is formed largely of granites and granite gneisses.

Associated with the basic rocks, which are in large part gabbro-diorites, some talcose soapstone and much chloritic soapstone are found. Both types are impure and doubtfully of other than local value.

In the area just south of the Seaboard Air Line, the exposures are comparatively good, but in the southern part of the county, the "flat-woods" country, exposures are rare and unsatisfactory.

DESCRIPTION OF PROPERTIES

T. P. JONES PROPERTY

One of the most prominent outcrops of soapstone found in the county occurs on the property of T. P. Jones, on lot 190, Longstreet district, 13 miles east of Elberton and one-fourth mile east of Bethlehem Church.

The country rock is largely gabbro-diorite or a phase of it. On the top of a small knoll from 20 to 30 feet of soapstone show on the surface, and a few smaller exposures are found in the hollow to the west. Along with the soapstone is found chloritic schist with magnetite crystals as much as one-eighth of an inch in diameter. A small amount of hard, somewhat fibrous, mineral is present. Some slip-fiber asbestos is found along planes of movement in the rock. The soapstone is yellowed by the action of weathering agencies, but it represents as good a prospect as any in the county.

Other exposures of chloritic rocks are to be found on the properties of L. R. Robinson, J. N. Worley and Paul Blackwell.

J. E. CALHOUN ESTATE

The estate of J. E. Calhoun is located 15 miles east of Elberton near where Beaver Dam Creek enters the Savannah River, and one mile south of the Seaboard Air Line Railroad.

No talcose rocks are present, but a large amount of greenish-gray, chloritic rock is to be found projecting above the ground and scattered over the surrounding surface. There is quite a variation in the hardness of the rock, but the greater portion is too hard to be of value as a soapstone. The rock is striking to the northeast and dipping almost vertically; at places the material is extensively jointed. The area underlain is large.

Other occurrences of similar nature are to be found in the neighborhood.

LINCOLN COUNTY

GENERAL RELATIONS

The northern part of Lincoln County south to within a few miles of Lincolnton, is underlain largely by granites, which, although varying widely in texture, are very similar in mineral composition, being formed largely of feldspar, quartz and biotite. This granite area contains near its southern limit some Carolina gneiss and areas of coarsely crystallized gabbro-diorite (?); and 3½ miles north of Lincolnton diabase dikes were seen cutting a very coarse-grained granite. From Lincolnton south to Little River there are a variety of rocks present; granite intrusions are rare or absent, and gneiss, quartzite, graywacke, slates and finally sericite schists form the country rocks. Near Little River some diabase dikes were observed cutting the schists.

Basic rocks are not abundant in this county, aside from the gabbro-diorite mentioned above, which is almost identical with that found southwest of Toccoa, both in mineral composition and texture. It closely resembles that east of Elberton and northeast of Union Point.

Associated with the quartzite which appears conspicuously on Graves Mountain and at Thomas Leroy's place, 7½ miles east of Lincolnton, pyrophyllite is found in small quantities. Owing to its resemblance in physical properties, notwithstanding its wide difference in chemical composition, as compared with talc, its occurrence will be described briefly.

DESCRIPTION OF PROPERTIES

GEORGE F. KUNZ PROPERTY

The top of Graves Mountain, which was prospected years ago for rutile, is owned by George F. Kunz, of Tiffany Company, New York. Graves Mountain is located 6 miles southwest of Lincolnton and 12 miles east of Washington. It is formed largely of quartzite and stands up prominently above the surrounding country, forming a monadnock upon the Tertiary (?) peneplain. The southern slope is very steep with cliffs near the crest, but the northern approach is somewhat more gentle. It is one mile long and half a mile wide.

The quartzite is white and quite variable in texture; at places it is fine grained and at others it approaches a medium-grained conglomerate. It has been much acted on by solutions, which have led to the development of a honey-comb structure at places. It is cut by veins of milky quartz. The following minerals have been found at this locality; lazulite, cyanite, rutile, and pyrophyllite. Lazulite occurs in pyramidal crystals from one inch to 1¼ inches long, and possessing a sky-blue color. It occurs in scattered crystals in the massive quartzites, with a tendency toward collection in bunches.

Rutile is found with cyanite in well formed reddish-brown crystals. These two minerals may together constitute a vein, or quartz may be associated with them. They were also observed in the quartzite itself.

Pyrophyllite occurs in solid veins and also as a constituent of quartz veins in the form of pockets. It occurs in much less abundance scattered through the quartzite. Judging from the size of the specimens which can be found there, the pyrophyllite veins are not more than 10 to 12 inches in thickness as a maximum; some of the veins are highly brecciated and the interstices are filled with iron oxide.

Considerable prospecting has been done on the crest of the mountain for rutile for museum specimens with good success; the pyrophyllite, however, does not occur in large enough quantities to be of commercial value.

The limitation of the pyrophyllite, in a large measure, to veins, demonstrates that the material was carried to its present position in solution; on the other hand, the scattered masses in the quartzite suggest that a part was formed from material originally contained in the quartzite, probably feldspar. It seems quite possible that all the minerals found here were formed from material contained in the original quartzite, which was collected together in veins or pockets through the action of solutions during the period or periods of metamorphism which the rock has suffered.

THOMAS LEROY PROPERTY

A deposit in many ways similar to that on Graves Mountain is found on the property of Thomas Leroy, 7½ miles east of Lincolnton, although neither lazulite nor rutile were observed at this locality. In the quartzite occur veins of pyrophyllite and cyanite with more or less quartz. The exposure is poor and the area covered is doubtless small.

A prospect shaft was sunk here about 1860 in search of copper, but with no success. Pyrophyllite occurs here in more limited quantity than at Graves Mountain.

COLUMBIA COUNTY

GENERAL RELATIONS

The same general belt of basic rocks which is described as occurring in Hancock County has its eastern continuation in Columbia County. A clearly defined belt of basic rocks associated with gneiss and granite masses crosses through the center of the county, extending from Phinizy south to near Appling. Schists of undoubted sedimentary origin are found to the north and south of this belt. To the south they become concealed beneath Coastal Plain deposits, while to the north they extend into Lincoln County.

Aside from the typical hornblende gneiss, there are larger areas of more massive rock, which represent what was formerly a gabbroic rock, but may now be termed amphibolite, pyroxene gneiss and amphibole-pyroxene gneiss, depending on the amount of alteration that has taken place. Only a small amount of asbestos has been developed, and by no means in commercial quantities. The dominant alteration has been to an amphibolite and finally to a talcose rock, and in some cases to fairly pure talc. The value of the talc deposits is somewhat doubtful for many reasons, the amount of silicification being the most important.

From the Savannah River the deposits are found more or less continuously west to Dr. W. B. Crawford's property, 2 miles southwest of Phinizy, a total distance of 11 miles. Farther west the same rock is found less frequently, but is present in McDuffie County and at places in Hancock County.

DESCRIPTION OF PROPERTIES

SOAPSTONE NEAR WALNUT GROVE CHURCH

One of the largest exposures of soapstone in Columbia County is found south of Phinizy at Walnut Grove Church. The soapstone outcrop has an east-west direction and a width of perhaps 150 yards. The material shows on the surface for a distance of about one-half mile both east and west of the church, mainly on the properties of H. D. Ramsey, Julius Hill and Buck Story.

As previously stated, the talc owes its origin to the alteration of an amphibolite, and there is material showing all stages in the transition. Few natural outcrops are to be seen, but the surface is thickly strewn with greyish, rounded fragments of soapstone. Mingled with the soapstone there is much silicified material representing talc, asbestos and the partly altered rock, together with encrustations of quartz. Only occasionally does the hard rock appear at the surface. The relative amount of soapstone present can not be determined under the present circumstances, but it seems possible that commercial deposits might be encountered along the edges of the intrusion.

Small veins of short, brittle fibered asbestos are present. No corundum has been found. A small outcrop of similar material is present on Dr. W. B. Crawford's place one mile farther west.

The soapstone has been used locally for foundation stones, fireplaces, chicken troughs, etc.

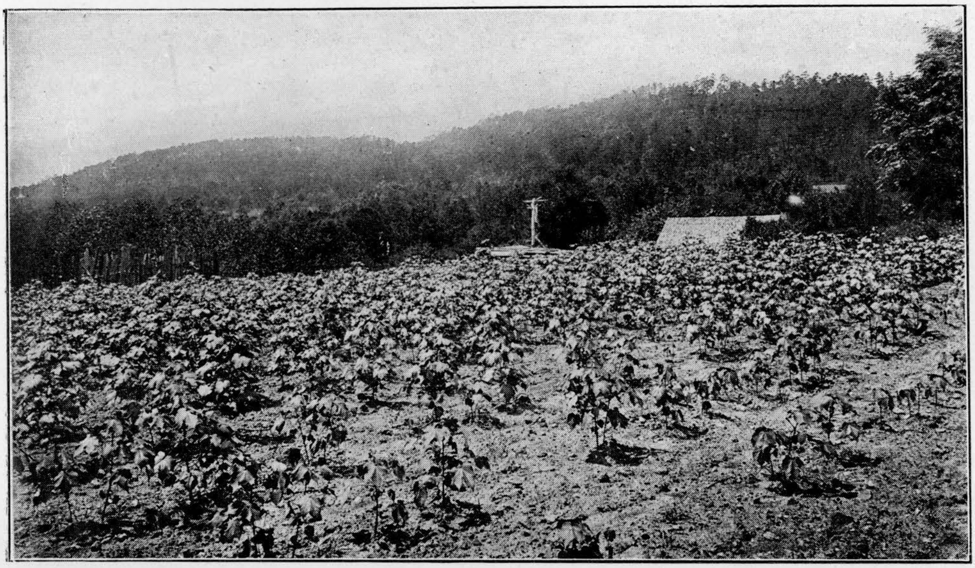
BURTE AND DIXIE MOUNTAINS

Five miles east of Phinizy there is a ridge rising 100 feet or more above the general level of the surrounding country, which has two prominent points called Burte and Dixie mountains. This ridge is characterized by its scrubby growth of trees, which reflects the nature of the rocks composing it. The ridge is 2½ miles long, and one-fourth mile wide. It represents the eastern end of the belt of basic rocks which crosses Columbia County. The ridge is formed of altered gabbroic rock, partly amphibolite and partly pyroxene gneiss, together with masses of serpentine rock and silicified material of various kinds. The western end of Burte Mountain is covered with siliceous material, or flint, with very little soapstone. This flint is usually massive and compact, but may be cellular and veined, often containing fine quartz crystals. Its color is usually yellowish brown. In the gap between the two mountains, and on the east side of Dixie Mountain, there is quite an extensive development of serpentine, which contains megascopic crystals of magnetite. At various points on the ridge rocks showing augite and remnants of plagioclase are to be seen, which point to the origin of the material from gabbroic rock.[1] Only along the edge of the mass is soapstone developed to any extent. Here it is not exposed in place, but fragments are strewn over the surface. (See plate XX, figs. A, B.)

In the public road near the house of Granderson Johnson, there is an exposure of talcose rock 40 yards wide. This is not a part of the mass which forms Burte and Dixie mountains, but is smaller and runs parallel to it. Part of the exposure in the road is of light green talc, which is cut by veins of what was originally asbestos, running in all directions. Part of the talc is silicified, and the asbestos has been converted into talc. This small exposure shows the best grade of talc found in the county.

Beginning at the Savannah River, this basic rock and its alteration products are found intermittently to the west for 11 miles. The conditions are everywhere almost identical, except that silicification has

[1] See description of this rock on pages 22-24.



A. BURT MOUNTAIN, COLUMBIA COUNTY, FORMED OF ALTERED GABBROIC ROCKS.

B. FLINT DERIVED FROM THE ALTERATION OF THE GABBROIC ROCKS AT THE WEST END OF BURT MOUNTAIN, COLUMBIA COUNTY.

been developed more at some places than at others. The outcrops are represented by scattered fragments of soapstone and flint, or encrustations of quartz.

OTHER DEPOSITS IN COLUMBIA COUNTY

On the properties of Julian Lampkin and D. H. Howell, one mile northeast of Appling, there are several small areas strewn with soapstone fragments. The material is in every way like that described as occurring a few miles farther north near Phinizy. The areas here are small, not more than one-half acre in either case.

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APPENDIX

THE SERICITE AND CHLORITE SCHISTS OF PICKENS AND CHEROKEE COUNTIES

INTRODUCTION

In Pickens and Cherokee counties, Georgia, there are a number of closely associated localities where chlorite and sericite schists occur in such purity, and consequently possessing such a light color and a high degree of softness, that they have attracted much attention locally, where they have been termed talc or soapstone. West of Canton a quarry of considerable size has been opened and slabs quarried for local use as soapstone; west of Jasper, on the other hand, similar material has been termed talc; and during 1912, four carloads of the material were shipped to Hewitt, North Carolina, where it was ground and sold on the market under the trade name "pyrophyllite." The haul of 5 miles to Jasper, the freight from Jasper to Hewitt, and the milling and reshipping were not justified by the price the material brought on the market, and since then the property has lain idle, although recently an attempt has been made by the Capitol Stone Company of Atlanta to put it on the market.

LOCATION AND GENERAL GEOLOGY

The deposits under discussion have been studied 5½ miles southwest of Jasper in Pickens County and 5 miles west of Canton in Cherokee County, but not in the intervening area, a distance of approximately 12 miles. The two localities occur in the Great Smoky formation, and possibly at or near the same horizon. The rocks of the district consist of graywacke, mica schist, quartzite and slate, in large measure a series of shallow water deposits. These rocks, which alternate in beds of varying widths from a few feet up to 50 or more, have been much changed from their original character by the intense folding which the region has suffered, leading to the formation of numerous parallel, northeast-southwest folds.

The chlorite and sericite schists occur in the natural succession of strata, but usually associated with quartzite, with which they are often interbedded and into which they show gradations.

NATURE OF THE MATERIAL

Although the appearance of the material from near Jasper is very similar to that from near Canton, there is a marked difference in them in regard to their chemical composition as the following analyses of samples from these two localities will reveal:

Analyses of Sericite and Chlorite Schists

	1	2	3	4	5
SiO_2	46.75	45.45	46.31	31.20	29.14
Al_2O_3	34.94	33.38	34.43	24.04	24.12
Fe_2O_3	1.04	3.70 (Fe₂O₃ and FeO)	2.00	3.24	6.72 (Fe₂O₃ and FeO)
FeO	2.00		1.04	5.40	
MgO	1.15	.10	.30	24.16	29.66
CaO	none	none	trace	none	--------
Na_2O	.32	1.40	.73	.80	.40
K_2O	10.31	10.50	10.49	1.02	.15
H_2O-	.40	--------	.05	.80	.06
H_2O+	3.18	4.45	3.93	8.20	6.80
TiO_2	.20	.14	.40	1.40	1.08
P_2O_5	trace	--------	--------	.05	--------
S	.07	--------	--------	.02	--------
MnO	none	--------	none	trace	--------
	100.36	99.12	99.68	100.33	98.13

1 and 2. Sericite schist, Gabriel Martin property, 5½ miles west of Jasper.
3. Sericite schist, Densmore property, 4½ miles west of Jasper.
4 and 5. McAffee soapstone quarry, 5 miles west of Canton.

The material from both localities varies from light grey to greenish-grey to almost white in color; it is composed of very fine scales in parallel arrangement, thus giving the rock a well-developed schistosity; it is very soft and when pulverized it yields a very unctuous powder. If beaten to pieces, rather than ground to powder, and screened, the material yields fine scales of high luster. While varying much in purity, the material near Jasper is somewhat superior to that at Canton, and probably occurs in larger quantities.

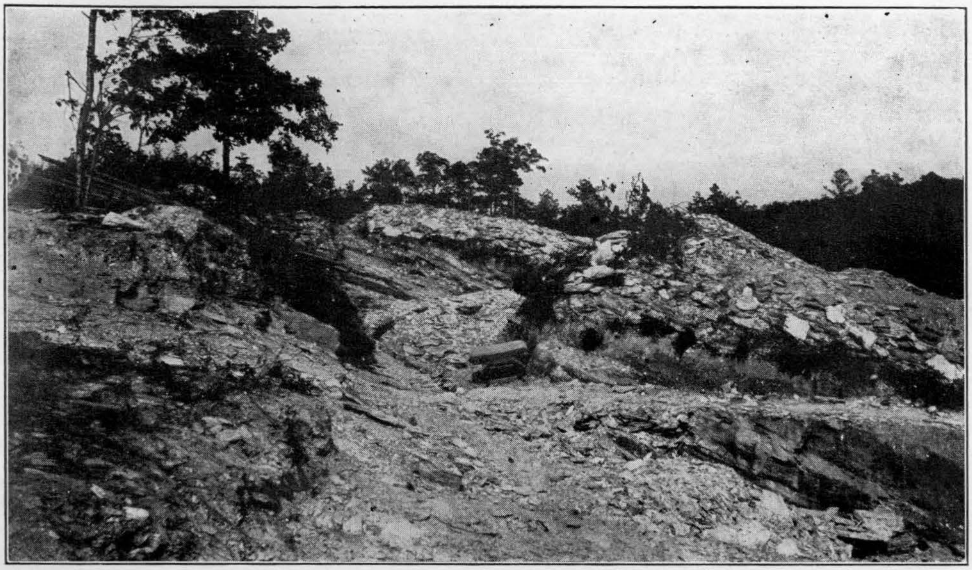
Deposits at both places were evidently formed from the recrystallization of original sedimentary rocks; the high content of potash in those near Jasper is to be explained by the fact that their origin is due to the alteration of potash feldspar, orthoclase, which is to be found in the adjoining quartzites in partly-altered form.

USES

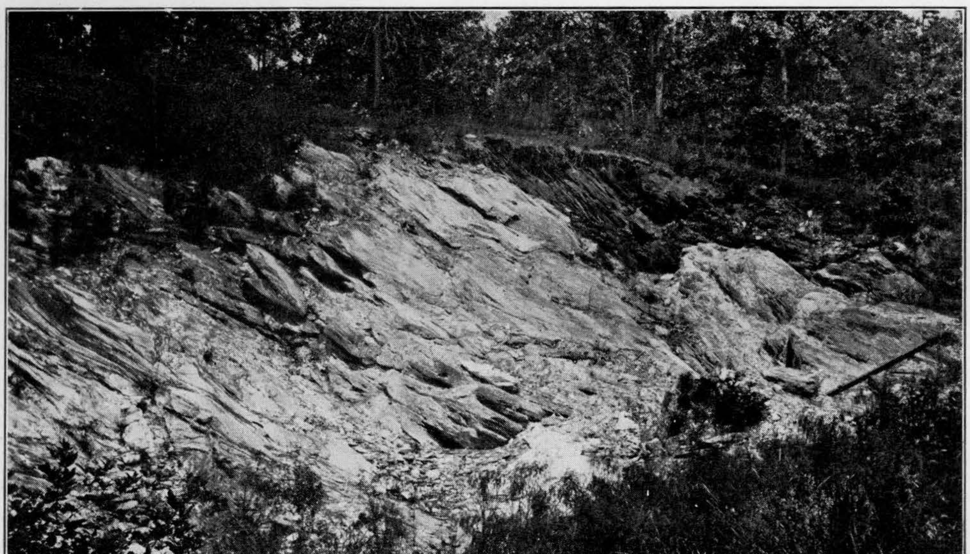
The close resemblance, in physical properties, of this material to talc leads naturally to the conclusion that it might be used in the same way. The laminated form of the material excludes the possibility of its use in making pencils, gas tips and such like, even if it were otherwise suitable. It is evident that it can be most advantageously used in a pulverized or disintegrated form. Since the fusibility of both chlorite and sericite is not very different from that of talc, they might be employed for foundry facings. The unctuous nature of these materials when pulverized makes it possible to substitute them for some of the other uses of talc, such as for dressing leather, as a base for the cheaper grade of soap, etc.

The fact that the material can be milled so as to yield fine but highly lustrous scales suggests its use for the same purposes as ground mica—as a lubricant, in the manufacture of wall paper, etc. Some of the material, especially from near Jasper, may be free enough from grit, to be used with grease or oils to form a lubricant for axles and other bearings; the fine scales properly prepared would, it is believed, serve to add luster to wall papers. The coarsely disintegrated material could be used advantageously to coat the surface of composition roofing to prevent its sticking together when rolled for shipment, one of the uses of ground, or "bran" mica. The material near Jasper is essentially a mica and could be used for many of the purposes for which ground mica is used.

Further, it is possible that some of the material, either in block or disintegrated form, might be used for insulating purposes in the same way as scrap mica, as it will be seen from the analysis that the iron content of the Pickens County material is rather low.



A. OPENING INTO THE SERICITE SCHIST ON THE PROPERTY OF J. W. ALLRED, NEAR JASPER, PICKENS COUNTY.



B. CHLORITE SCHIST ON THE PROPERTY OF THE SOUTHERN TALC COMPANY, NEAR CANTON, CHEROKEE COUNTY.

DESCRIPTION OF PROPERTIES

PICKENS COUNTY

GABRIEL MARTIN PROPERTY

On this property, which is located on lot 120, 13th district, 2nd section, 5½ miles southwest of Jasper, there are three principal openings and several smaller ones, besides natural exposures showing in the creek bottom. All the openings are roughly in line and are found east of Martin's house on the south side of a small branch. The sericite schist occurs in beds, from a few feet up to ten or more in thickness, which alternate and grade into quartz-sericite schist and quartzite. The softest material occurs in the stream bottom, where it has been acted on by water. The purest sericite schist varies in color from silvery-white to greenish-grey; its schistosity makes a considerable angle with the bedding; and later than the development of the schistosity, the rock has at places been minutely wrinkled in two directions, approximately at right angles to each other.

Some years ago the mineral right on the uplands of this property was purchased by a Chicago company, and 9 car loads of the material is said to have been shipped there; but who received the material and what use was made of it could not be learned. At the present time this property is under lease by the Capital Stone Company of Atlanta.

J. W. ALLRED PROPERTY

This property is located on lot 122, 13th district and 2nd section, adjoining the Martin property on the east. On it there is an open cut showing 15 feet of sericite schist and a shaft nearby which shows 8 feet of decomposed material and 5 feet of unweathered, sericite schist. (See plate XXI, fig. A.)

As exposed in the open cut, the sericite schist varies considerably in its purity, but it is all of a fair grade. Its location on a hill slope, from a working standpoint, is good, because no trouble would be caused by the presence of water. It was from this opening that 4 carloads of material were shipped in 1912 to Hewitt, North Carolina.

W. K. PADGETT PROPERTY

The W. K. Padgett property is located one mile northwest of Gabriel Martin's. No work has been done here, but near his house there is an exposure of 3 feet of material, similar to that previously described, outcropping naturally with neither the top nor the bottom of the bed exposed.

WILLIAM RICHARDS PROPERTY

The William Richards property is located on lot 96, 13th district, 2nd section, north of J. W. Allred's property. Here a small cut in the hillside exposes a section of much weathered sericitic material of varying purity, arranged in alternating layers. A considerable quantity of sericite schist of good quality is reportetd to have been found on this property since the writer's visit.

CHEROKEE COUNTY

THE SOUTHERN TALC COMPANY

The Southern Talc Company has been recently organized and has as its source of raw material what has been formerly called the McAffee soapstone quarry, located 5 miles west of Canton.

The occurrence of the material and even its physical properties are in every way similar to those of the material described from west of Jasper; however, as shown by the chemical analyses quoted, this rock may be more properly termed a chlorite schist. A quarry has been opened here with a length of 48 feet in the direction of the dip of the rock, which is about 30° to the east. Both above and below, the chlorite schist grades into quartzite, and is itself interbedded with narrow bands of siliceous material showing roughly the following succession: (See plate XXI, fig. B.)

Section of Chloritic Schist, Five Miles West of Canton

		Feet
	Quartzite	
9.	Quartzite and chlorite schist	3
8.	Chlorite schist	10
7.	Quartzite with some chlorite schist	4
6.	Chlorite schist	7
5.	Quartzite with some thin layers of chlorite schist	6
4.	Chlorite schist	5
3.	Alternating layers of chlorite schist and quartzite	6
2.	Chlorite schist	3
1.	Alternating layers of chlorite schist and quartzite	4
	Quartzite.	

Besides the quartzite layers, the material is cut by quartz veins at irregular intervals. The entire series of rock has been much crushed and wrinkled since the development of the present mineral constituents and the schistose structure.

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